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Topical Questions and Examinations: Practical Geography

Ngaiza Series of Advanced Geography

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PREFACE

This book was written because you deserve better.

Advanced Level Geography rewards understanding, yet many students arrive at the practical paper having learned to copy a method they cannot explain and to reproduce a diagram they cannot read. Practical Geography feels safe, because measuring a distance, drawing a graph and describing a photograph look like skills you already own, so it is easy to believe you have mastered it when you have only rehearsed it. Students memorise a procedure, sit examinations that ask them to measure, compute and interpret on an unfamiliar map, and leave believing practical Geography is a set of drills to be repeated under pressure. That is not practical Geography. That is imitation dressed as skill.

Practical Geography is the craft of measuring, mapping and interpreting the real world: surveying a piece of land, framing a research question and answering it with evidence, drawing out the story hidden in a column of figures, and reading the ground from a photograph and a map. It is the science of your own country made visible, in a levelling line run across a field near Dodoma, a dot map of the regions, an aerial photograph of the coast, and a 1:50,000 sheet of the Kilombero valley. It is exact, rooted in real places, and far more logical than its reputation suggests. But mastering it under examination conditions takes more than a textbook to read. It takes practice: working real questions, computing and plotting and drawing and interpreting, and learning, answer by answer, how to turn skill into marks. That is what this book sets out to give you.

Why a book of questions and answers?

You do not learn to survey by reading about a chain, and you do not learn to read a map by reading someone else's interpretation. You learn by attempting a question, getting it wrong, finding out exactly why, and trying again. This book is built entirely around that truth. Every technique in the Practical Geography syllabus is turned into questions you must work yourself, each followed by a full model solution that shows not only the correct answer but the working, the units, the diagram and the interpretation that earn examination marks. Used honestly, with the solution covered until you have worked your own, it trains the four things the examination really tests: choosing the right method, carrying it out with precision, presenting it by the rules, and interpreting what it shows.

How this book is organised

The book covers the whole Practical Geography branch, Forms Five and Six, in five chapters: Land Surveying, Geographical Research, Geographical Data Analysis and Interpretation, Techniques of Photograph Interpretation, and Maps and Map Interpretation.

The first part, Topical Questions and Answers, takes each chapter in turn. Every question is followed at once by its model answer, so you can attempt it and then check yourself immediately. Within each chapter the questions rise through three tiers.

BINDER questions anchor the core technique. Even here they ask you to work and to reason, never merely to name a tool or recite a definition. If you can answer these, you own the skill.

REAL questions carry the technique into real Tanzanian and African settings, from a survey near the Rufiji to a dot map of the regions and an aerial photograph of the coast, where the subject actually lives.

HOT questions push you to examination standard and beyond, drawing several techniques together and demanding genuine judgement rather than routine.

The second part, the Examination Questions, brings together sixty multi-part short-answer questions and eighty essays at full examination standard. The questions come first, and their model solutions follow in a separate part, so that every question in this book, from the first to the last, has a complete, worked answer you can learn from, but only after you have attempted it with the solutions closed.

Before the questions begin, a short Student Survival Guide shows you how to work this book and how to beat the two habits, the near miss that scores nothing and description in place of interpretation, that quietly cost good students their marks. Read it first. It is the shortest and most important part of the book.

The team behind this book

Enjoy and Master Advanced Geography is the work of the Ngaiza Education Hub, built by a team of experienced geography educators who share one conviction: that Tanzanian students deserve world-class materials written for their context, their syllabus, and their aspirations.

Writers: Mr. Lazaro Kinabo and Mr. Jonas Joram.

Editors: Mr. Ahmed Karim.

Designer: Mr. Frank Mwita.

I am grateful to every member of this team for their dedication, their expertise, and their refusal to settle for "good enough." I thank too the students whose hard questions and honest struggles shaped every answer in this book. They reminded us, again and again, that a question a student cannot learn from has failed, no matter how correct its geography may be.

To every student of Advanced Geography opening this book for the first time: practical Geography is not as hard as its reputation, and it is not as easy as it first feels. It is as exact as the instruments you will learn to trust, and as satisfying as a measurement that comes out true. Give it your honest effort, with the solution covered and your pencil moving, and this book will give you its honest best in return.

Ngaiza, Lusima
Series Creator and Director

STUDENT SURVIVAL GUIDE

How to turn what you know into marks.

Why Practical Geography Looks Safe, Then Betrays You

Practical Geography is the paper most candidates believe they cannot fail. There are no long theories to recite, only a map to read, a graph to draw, a sum to work and a photograph to describe. It looks like the safe paper, the one built of skills you have practised since O-Level, and that comfortable feeling is exactly the trap, because this paper is marked not on whether you know the method but on whether you carry it out with precision and set it down by the rules.

The first trap is the near miss. In an explanation paper a half-right answer earns half the marks; in a practical paper it often earns none. A bearing given with the wrong sign, a distance read against the wrong edge of the scale, a reduced level carried down the page with one figure miswritten, a dot placed where it cannot be counted, and the whole answer falls even though you knew exactly what to do. A distance that should read 4.2 kilometres is not almost right at 420; it is simply wrong, and accuracy, not effort, is what the mark scheme rewards.

The second trap is describing when you were asked to interpret. Set a map extract or an aerial photograph before you and the pen begins to report what is there, the contours are close, a river runs through, houses line the road, and then it stops, when the examiner is paying for what those things mean. Description answers what; the marks live in why and in what it shows. To say that the contours are close earns almost nothing; to say that the close contours are a steep scarp, which is why the road climbs in hairpins and the village keeps to the gentler spur, earns the marks.

The same question, answered by two candidates.

> *The question.* Study the map extract and explain the relationship between relief and settlement.
>
> *The answer that fails.* The west of the map is high with many contour lines, and the settlements are in the east where the land is lower. A river flows down the middle. (It reports the scene and explains nothing, and it scores almost nothing.)
>
> *The answer that scores.* In the west the contours are packed close and rise above 1,600 metres, a steep and cool highland that is hard to build on and to farm; so settlement gathers on the gentler, better-drained land east of the river, where the slope is easy, the soil is worked and water is close at hand, the very pattern seen along the floor of the Kilombero valley.

Both candidates saw the same map; only the second read it, and only the second scores. That gap, repeated across a three-hour paper of measuring, plotting and interpreting, is the distance between a pass and a distinction, and this book is built to close it.

How to Use This Book

This is not a book to read. It is a book to work, with a pencil in your hand and your instruments beside you. A model solution you have only read feels learned and is gone by morning; one you have struggled toward, and then checked against your own, is learned for good. Work every question in four steps.

Cover the model solution. Read the question, then answer it in full on paper, computing, plotting or drawing exactly as you would in the hall, before you look at anything.

Uncover and compare. Read the solution twice, once for the method and once for the way it is set down, its working, its units, its diagram and its furniture. Did you use the right technique? Did you reach the same figure, and present it as cleanly?

Mark yourself honestly. Award a mark only where your answer truly earned it. A plot a little off, a missing unit or a dropped sign is a lost mark, not a near one.

Fix one thing, then move on. Correct your single biggest error in your own hand, and carry that lesson into the next question.

Climb the ladder, and do not skip the bottom rung. Each chapter rises through three tiers. BINDER builds the core technique, often with a worked table or diagram; REAL carries that technique into real Tanzanian settings, from a levelling line near Dodoma to a dot map of the regions; and HOT pushes into judgement and multi-step problems, weighing one method against another. Work the five chapters in order, Land Surveying, Geographical Research, Geographical Data Analysis, Photograph Interpretation and Maps, for each skill rests on the ones before it.

Treat the examination questions as real examinations. Part Two sets sixty multi-part short-answer questions, the first twenty worth twenty-five marks and the rest worth fifteen, and eighty essays worth twenty marks each. Sit them in a quiet room, against the clock, with your instruments ready and the solutions in Part Three closed, then mark yourself. That is the closest rehearsal for the real day you can get.

How to Write Practical Geography for Marks

Even in a practical paper, many marks are won in words: in the explanation beside a calculation, the comment under a graph and the essay that argues a practical theme. The same three habits carry most of them.

Lead with the point, then explain it. State the technique, the reason or the finding the question asks for first, in a few words, then give the reasoning behind it. The examiner is trained to find the point, tick it, and read on. Bury it at the end of a long sentence and a tired examiner must hunt for it, and a point that cannot be found cannot be marked.

Join your ideas with the words that carry cause and effect. because, so, as a result, which in turn, therefore. A practical explanation is a chain from evidence to conclusion, and these words are what turn a list of true statements into an argument that scores.

Anchor every answer in a real, named place. Name the region, the river, the town or the instrument, the Rufiji, Mbeya, a prismatic compass, a 1:50,000 sheet of Kilombero, rather than writing in the abstract. A method tied to a real Tanzanian example is worth more than the same method floating free.

In the essays, plan before you write, open with a short introduction that defines the terms, give each point its own paragraph led by its key idea, and close with a brief conclusion. A planned essay of six developed points scores more than a longer one written without a plan.

How to Score in Calculations

A calculation is marked on its working as much as its answer, for the marks live in the steps between the question and the result. Six habits protect them.

State the formula first. Write the rule before the figures, FB = BB ± 180° for a back bearing, mean = $\Sigma fx \div \Sigma f$ for an average, gradient = vertical interval ÷ horizontal distance for a slope. A stated formula earns its own mark and steadies the work that follows.

Substitute and work step by step. Put the figures into the formula and show every line; never jump from the question to the answer. The examiner marks the method even when the final figure slips.

Carry the units, and convert on purpose. Keep the unit on every line and change it deliberately, centimetres on the map to centimetres on the ground by the scale, then to kilometres. Most wrong answers are right numbers wearing the wrong unit.

Round at the end, to the precision asked. Keep full figures through the working and round only the answer, and only to the precision the question sets, a whole number of dots, two decimal places of a metre, the nearest minute of a bearing.

Check the size of your answer. Ask whether the result is possible. A gradient of one in two across a plain, a village of four million people, a distance of 400 kilometres on a district sheet, each is a signal to look again.

State the answer in full, with its unit. End with a clear line, the distance is 4.2 kilometres, so the answer stands exactly where the examiner expects to tick it.

The same calculation, worked two ways.

The question. On a 1:50,000 map two towns are 8.4 centimetres apart. Find the distance between them on the ground.

The careless way. 8.4 × 50,000 = 420,000, so 420 kilometres. (The method is right, but the unit is dropped and the size is never checked, so the answer is absurd and scores little.)

The way that scores. Ground distance = map distance × scale = 8.4 cm × 50,000 = 420,000 cm; and 420,000 cm ÷ 100,000 = 4.2 km. The towns are 4.2 kilometres apart, a sensible distance on a 1:50,000 sheet. (Formula, working, units and a checked answer, and it earns every mark.)

Notice that both candidates multiplied correctly. The marks turned on the unit and the check, not the arithmetic, and that is true across the whole paper.

How to Draw Practical Geography for Marks

Graphs, maps and sections are answers made of lines, and they are marked as strictly as sentences. Most candidates give these marks away.

Choose the right diagram for the data. A divided circle for the parts of a whole, a bar graph to compare quantities, a dot map or a choropleth for a distribution, a line graph for change over time. The wrong choice is capped however neatly it is drawn.

Draw to an accurate, stated scale, and plot each value exactly. Work out the scale, write it down, and place every point where its figure falls. On a dot map the dots must be equal in size and few enough to count.

Give every diagram its furniture. A title, a key, a scale, a north point on any map and the source of the data each carry a mark, and a diagram without them is capped. Add them first, not as an afterthought.

Use single, clean, ruled lines. One firm line, not a furry sketch built from many strokes, a sharp pencil, and a ruler for every straight edge, the axes, the frame and the sides of a divided rectangle.

Rule your label lines, and never let them cross. Each label line is straight, drawn with a ruler, and touches the exact feature it names.

A few diagrams return again and again, among them the divided circle, the dot map, the cross-section, the traverse plot and the rise-and-fall table. Practise each until you can lay it out cleanly, with its furniture, in a few minutes.

How to Read Maps and Photographs

A map extract and a photograph are not pictures to admire but evidence to question, and the marks go to the candidate who reasons from them. Read them in order.

Orient yourself first. On a map, read the scale, the north point, the grid and the marginal information before anything else. On a photograph, decide its type, vertical, oblique or ground, and find the direction of the light and a sense of scale, because every later reading depends on it.

Gather the evidence and name it. Take the relief and drainage first, then settlement, communication and land use, and pin each to a grid reference or a direction, not to here and there.

Then interpret, moving from what you see to what it means. Close contours mean a steep slope; a braided channel means a gentle, load-heavy river; a nucleated village at a route junction means trade; dark, rough-textured cover casting tall shadows means forest, not water. For every feature you name, add the because.

Measure by the rules. A four-figure then a six-figure grid reference; distance stepped along a road and converted by the scale; area by the complete-and-part-square method; a bearing read from grid north with the protractor; a gradient as vertical interval over horizontal distance.

On a photograph, weigh all the clues together. tone, texture, shape, size, shadow, pattern, association and site. One clue alone misleads; taken together they identify.

The commonest loss on both is stopping at description. Do not write that the photograph shows many trees; write that the dark, rough-textured cover casting tall shadows is closed forest, sited on the steep ground the map marks above 2,000 metres, which is why no farms appear there. That move, from seeing to meaning, is the whole skill.

How to Fail Productively

You will get questions wrong. Every strong candidate does. What decides your grade is the five minutes after.

The unproductive response is to rub out your attempt, read the solution, nod and move on. Your page looks tidy and your hand has learned nothing, because you only watched someone else work.

The productive response is to stop, and not erase. Set your answer beside the model and find the exact point where they part, then name the cause. Was it the method, because you chose the wrong technique or formula; the accuracy, because the method was right but a figure, a sign or a reading was wrong; the presentation, because the working, the units or the diagram's furniture were missing; or the interpretation, because you described where you should have reasoned? Those four faults need four different cures, and naming yours is half of it. A wrong answer you have diagnosed is worth more than a right one you copied.

How to Revise on Your Own

Most revision feels productive and is not. Re-reading worked solutions and copying them out neatly let your eyes move while your memory rests. These methods work instead.

Sit the examination questions under the clock. The questions in Part Two are your single best revision tool. Work a set in a quiet room, timed, with instruments and the solutions closed, then mark yourself.

Rework every calculation from a blank page. Do not re-read a solved sum; solve it again from nothing, until your hand knows the steps and the sign rules without prompting.

Draw the recurring diagrams to time, from memory, with their furniture. the divided circle, the dot map, the cross-section and the rise-and-fall table.

Interpret a fresh map or photograph aloud. Move from evidence to reason in spoken sentences; where you can only describe is exactly what you have not yet understood.

Learn the formulae, conventions and units. the back-bearing sign rule, the arithmetic check for levelling, the furniture of a graph, as carefully as the ideas themselves.

Revise your weakest skill first, not your favourite. The skill you enjoy is the one you already own; the one you avoid is the one the paper will test.

How to Face the Examination

The examination does not test how clever you are. It tests whether you can measure, compute, draw and interpret, accurately, by the rules and against the clock. That is a set of skills, and skills can be practised.

Bring your instruments. a ruler, two sharp pencils, an eraser, a protractor, a pair of compasses, a set square, a piece of string and a calculator. A candidate who cannot measure, plot or draw loses those marks before the paper is read.

Read every question twice before you write. The second reading catches the unit, the count or the command word the first one missed.

Obey the command word. Each asks for a particular kind of answer, and giving the wrong kind loses marks even when your work is sound. The table below sets out what each demands.

Scale your answer to the marks. A twenty-five-mark question in several parts wants a full, multi-part answer, not a paragraph; when six points are asked, give six developed points.

Show your working and label everything. every step of a calculation, every unit, and every diagram's title, key, scale and north point.

Watch the clock, and leave nothing blank. a stated formula or a single plotted point earns more than an empty space, so spend your time by the marks and reach every question.

The night before, check your instruments and rest. a calm hand measures true, and a rested mind reads a map faster than a tired one.

Command word	**What it asks for**
Calculate; Compute; Find	Work out the value in full, showing the formula and every step, and state the answer with its unit.
Measure	Take the value from the map or photograph with the right instrument, to the precision asked.
Construct; Draw; Plot	Produce the diagram accurately to a stated scale, with its title, key, scale and, on a map, a north point.
Reduce; Enlarge	Redraw to the new scale, changing every distance by the correct ratio.
Convert; Express	Change to the units or form asked, a scale to a statement, or a bearing to its back bearing.
Describe	Give an orderly account of what is shown, the pattern, trend or distribution, without reasons.
Interpret; Comment on; Account for	Give the reason and the meaning behind what is shown; every such answer needs a because.
Distinguish; Differentiate	Give the differences directly, side by side, not two separate descriptions.
With the aid of a diagram	A diagram is compulsory and carries its own marks; an answer without one is capped.

You now carry what the strongest practical candidates bring into the hall and most never receive: a way to work this book that turns reading into doing, the discipline to compute and present for full marks, the eye to read a map and a photograph and say what they mean, an honest method of revision, and a clear plan, and a full pencil case, for the examination itself. Sharpen your pencil, open your instruments, cover the first model solution, and begin. The ground is Tanzania, and it is waiting to be measured.

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PART ONE
TOPICAL QUESTIONS AND ANSWERS

Chapter 1

LAND SURVEYING

Land surveying is the first skill of Practical Geography and the foundation of every map that follows, because a map can show only what a survey has first measured. This chapter trains you to fix the position and the height of points on the ground using the basic instruments: the chain, the prismatic compass, the plane table and the level. Master these by hand and the modern total station and GPS become easy, because they apply exactly the same principles. The chapter runs in three tiers and is best worked in order.

A practical answer is not an essay; it is a worked method you can copy under examination conditions. So in the BINDER tier you state the method or formula first, show the working line by line carrying the unit at every step, give the answer to the correct precision, and interpret it in one line. The REAL tier then sets the same techniques on real Tanzanian field data and asks you to spot the wrong method, and the HOT tier asks you to choose the right method and reason from combined evidence.

BINDER QUESTIONS

Question 1

A surveyor pegging out the boundary of a new estate in the Kilombero Valley is practising a discipline older than writing itself. Explain what land surveying is, and account for why it is described at once as a science, an art and a technology.

Model Answer

Land surveying is the science, art and technology of determining the relative positions of points on, above or below the earth's surface by measuring distances and angles and presenting them as a plan or a set of figures.

It is a science: because it rests on measured, repeatable distances and angles and on geometry, so that every result can be checked against another and trusted rather than guessed.

It is an art: because the surveyor must judge where to place stations, how to get a line past an obstacle and how to read the lie of the ground, a skill that grows only with field practice.

It is a technology: because it applies instruments, from the chain and the prismatic compass to the level, the theodolite and the satellite receiver, to capture the measurements and turn them into a plan.

In the Kilombero Valley the surveyor fixes each boundary corner as a position relative to known control points, then converts those measurements into a plan the land office can register, which shows the three facets working together as one task.

Question 2

Before a single pillar of the Julius Nyerere Hydropower Project could be cast, the dam site had to be surveyed. Account for the importance of land surveying in the development of Tanzania.

Model Answer

Land surveying is important because it supplies the accurate spatial framework on which boundaries, engineering works and maps all depend.

1) **Boundary demarcation:** it fixes and re-establishes the boundaries of land parcels, so that titles can be issued and disputes settled, as in the village land titling carried out across rural districts.

2) **Engineering setting-out:** it positions and sets out large structures such as dams, roads, railways and bridges, for example the Julius Nyerere Hydropower Project and the Standard Gauge Railway.

3) **Map making:** it supplies the control framework on which topographic maps and plans are built, so that every later map of an area traces back to a survey.

4) **Planning and land management:** it lays out streets, water-supply networks and plots for housing and farming, guiding the orderly growth of towns such as the new capital, Dodoma.

5) **Resource development:** it provides the preliminary surveys needed for mineral exploration and for siting wells, pipelines and power lines.

Because each of these tasks needs positions fixed to a known accuracy, none of them can proceed safely until the survey is done, which is why the survey of the Julius Nyerere dam site came before the construction.

Question 3

A surveyor mapping a large farm near Mbozi never begins with the small detail; he fixes the big framework first. Explain the two governing principles that keep a survey accurate and self-checking.

Model Answer

Surveying obeys two governing principles: always work from the whole to the part, and always provide an independent check on every measurement.

1) **Work from the whole to the part:** a few high-accuracy control points are established over the whole area first, and the detail is then fixed within that framework, so that any error is contained within a small area instead of being allowed to accumulate across the survey.

2) **Provide an independent check:** every measurement is verified by a second, independent one, such as a back bearing, a closed traverse or a tie line, so that a mistake reveals itself at once and can be corrected before the plan is drawn.

At Mbozi the surveyor lays a control framework across the whole farm and then surveys each field inside it; because the framework is fixed first and every line is checked, a slip in one field cannot distort the rest of the plan.

Question 4

When a team is sent to survey a new college site at Dodoma, the work falls into three ordered stages long before any plan is drawn. Explain the three procedures of a land survey and state what each one delivers.

Model Answer

A land survey is carried out in three ordered procedures: reconnaissance, fieldwork and office work.

1) **Reconnaissance:** the surveyor first gets a general view of the area and gathers information, then plans the methods, instruments, manpower and budget; this stage decides how the survey will be done.

2) **Fieldwork:** the actual measurement of distances and angles, the booking of readings in the field notebook, the drawing of field sketches and simple field calculations; this stage produces the raw data.

3) **Office work:** the reduction of levels, the computation of coordinates, areas and volumes, and the drawing of the finished plan or map; this stage produces the deliverable.

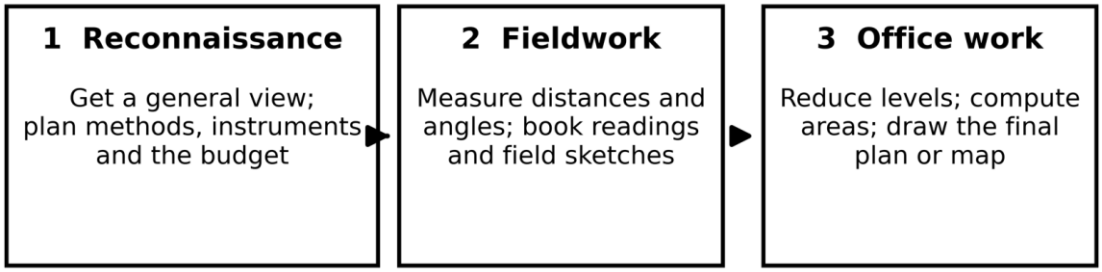


Figure 1.1: *The three procedures of a land survey*

At the Dodoma site the reconnaissance decides whether a compass or a plane-table survey suits the ground before the team commits a single day to fieldwork, which is why the stages must run in this order.

Question 5

The rope the ancient Egyptians stretched to re-mark their fields after the Nile flood and the satellite receiver a surveyor carries at Bagamoyo today do the same job. Account for how distance-measuring instruments have developed and why their accuracy has improved.

Model Answer

Distance measurement has developed from the marked rope and the chain, through the tape, to electronic and satellite methods, each step trading manual effort for greater speed and accuracy.

1) **Chain and Gunter's chain:** linked metal bars measured a line directly, but they were heavy, stretched and had to be laid repeatedly, so the work was slow and prone to human error.
2) **Steel band and tape:** a continuous steel band stretched far less than a chain and gave a smoother, more accurate reading over each bay.
3) **Electromagnetic Distance Measurement (EDM):** measures distance from the travel time of an electromagnetic wave to a reflector and back, removing the need to lay anything along the ground.
4) **GPS and GNSS:** fix distance and position from the ranges to orbiting satellites, giving high accuracy in minutes and in almost any terrain.

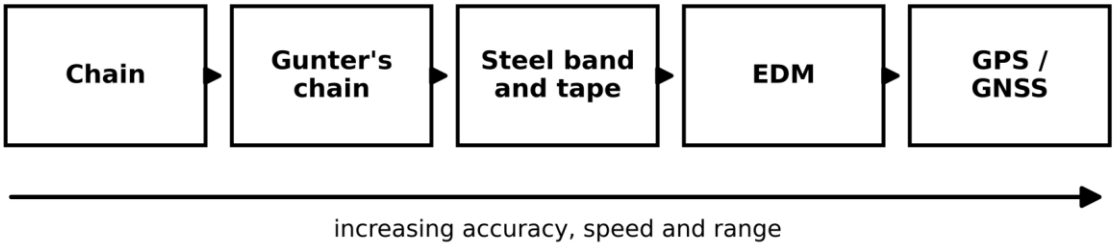


Figure 1.2: *Evolution of distance-measuring instruments*

A surveyor at Bagamoyo now fixes a distance by satellite receiver in seconds that a chain crew would have taken hours to measure and re-measure, which shows why each new instrument replaced the one before.

Question 6

From the Egyptian groma to the total station set up over a control point at Kilimanjaro International Airport, the measurement of angles has steadily become more precise. Account for the development of angle-measuring instruments.

Model Answer

Angle measurement has developed from simple sighting frames to the electronic total station, each stage more accurate and more automatic than the last.

1) **Groma:** an early Roman sighting frame of crossed arms and plumb lines used to set out right angles, accurate only to the eye.
2) **Dioptra and astrolabe:** sighting instruments that improved the measurement of angles to objects and stars.
3) **Sextant:** measured angles by reflection with far greater precision, and was used in navigation.
4) **Magnetic compass:** gave the bearing of a line from magnetic north directly, which made simple angular survey possible in the field.
5) **Theodolite:** measured horizontal and vertical angles accurately through a telescope on graduated circles.

6) **Total station:** combines a theodolite with electronic distance measurement, so that angles and distances are read and recorded together in one instrument.

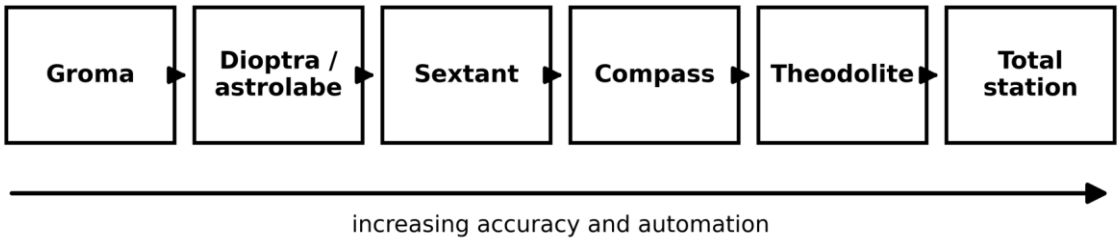


Figure 1.3: *Evolution of angle-measuring instruments*

The total station set up at Kilimanjaro International Airport reads in one sighting both the angle and the distance to a target, work that once needed a separate theodolite and a chain crew.

Question 7

A surveyor mapping the whole Lake Victoria basin and one pegging a quarter-acre plot in Mwanza cannot make the same assumption about the shape of the earth. Distinguish geodetic from plane surveying, and account for the assumption behind each.

Model Answer

Geodetic surveying treats the earth as a curved, ellipsoidal surface, whereas plane surveying treats the earth's surface as flat.

1) **Shape assumed:** in geodetic survey the lines joining stations are treated as arcs on a curved surface, whereas in plane survey they are treated as straight lines on a flat one.

2) **Extent of the area:** geodetic methods are used for large areas, while plane methods are used for small areas; the usual dividing line is an area of about 250 square kilometres.

3) **Accuracy and instruments:** because it must account for the curvature, geodetic survey demands high-precision instruments and computation, while plane survey is satisfied by ordinary field instruments.

In practice the curvature of the earth is small enough to ignore only when the area is below the threshold, that is when Area < 250 km^2, so plane surveying is used; above it the curvature error grows and geodetic survey is required.

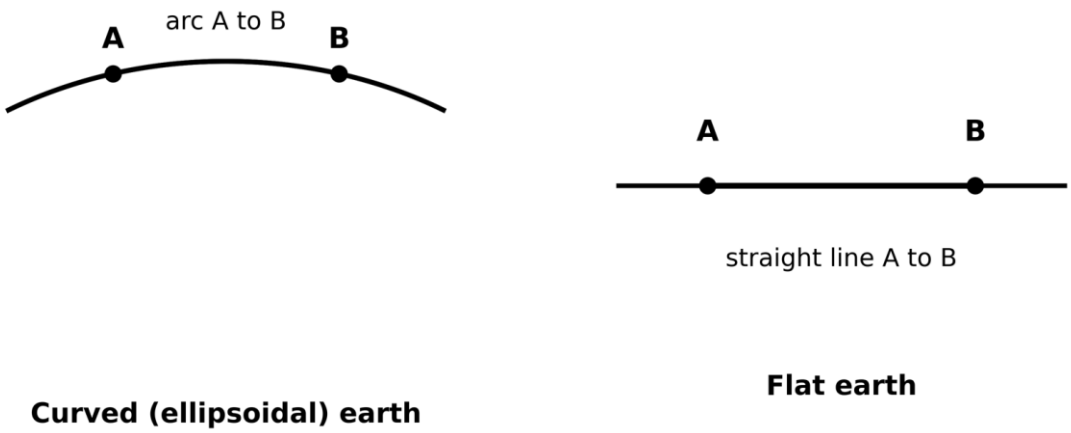


Figure 1.4: *Geodetic survey assumes a curved earth; plane survey assumes a flat earth*

So the quarter-acre plot in Mwanza is surveyed as a plane, while a framework spanning the whole Lake Victoria basin must be surveyed geodetically.

False Confidence Alert
It is wrong to say that plane surveying ignores the earth's curvature because the curvature does not exist. The curvature is real; it is simply negligible over a small area. Below about 250 square kilometres the error from treating the ground as flat is smaller than the measurement itself, so it is safely ignored; over a large area such as the Lake Victoria basin it is not, and geodetic survey must be used.

Question 8

Two survey teams in Tanga describe their work differently: one names it by the instrument it carries, the other by the purpose it serves. Explain the criteria by which land surveys are classified.

Model Answer

Land surveys are classified by three main criteria: the surface or field surveyed, the instrument used, and the purpose the survey serves.

1) **By the field surveyed:** this separates land surveying on the ground from hydrographic surveying of water bodies and astronomical surveying by the stars, according to where the survey is done.
2) **By the instrument used:** this names the survey after its principal instrument, giving chain survey, compass survey, plane-table survey, levelling and theodolite survey.
3) **By the purpose served:** this names the survey after its object, giving cadastral survey for boundaries, topographic survey for maps, engineering survey for construction and mine survey for underground work.

So the two Tanga teams are not in conflict; one is classifying its work by instrument and the other by purpose, and a single job is often described by both, for example a cadastral survey carried out with a prismatic compass.

Question 9

The harbour at Dar es Salaam, a village boundary in Singida and a tunnel in a mine are each surveyed by a different specialised method. Account for the main specialised types of survey and what each is for.

Model Answer

Surveys are specialised according to the surface surveyed and the object in view, and each type is named after the device or the task that defines it.

1) **Chain or tape survey:** measures small, fairly flat areas by linear measurement, fixing detail by offsets from a chain line.
2) **Compass survey:** fixes positions by bearings from magnetic north, and so suits larger and rougher ground than the chain alone can manage.
3) **Plane-table survey:** plots the ground graphically in the field as it is measured, which suits small areas where a quick plan is wanted.
4) **Levelling:** determines the relative heights of points, and so is used wherever elevation matters, such as drainage and road work.
5) **Hydrographic survey:** maps water bodies, depths and coastlines, for example the approaches to the port of Dar es Salaam.
6) **Topographic and cadastral survey:** the first records relief and detail for maps, the second fixes boundaries for land titles, as in the titling of village land in Singida.
7) **Mine, aerial and satellite survey:** serve underground work, mapping from photographs, and positioning from orbiting satellites respectively.

Question 10

A surveyor at a control point near Dodoma switches on a receiver that listens to satellites thousands of kilometres above. Explain how satellite positioning works and name the main systems in use.

Model Answer

Satellite positioning fixes a point by measuring its distance from several satellites whose positions are known, a method provided worldwide by the global navigation satellite systems (GNSS).

1) **Signals and ranges:** the receiver picks up signals from the satellites and, from the time each signal takes to arrive, computes its distance, or range, to that satellite.
2) **Fixing the position:** the ranges to at least four satellites are intersected so that only one point on the earth satisfies them all, and that point is the position of the receiver.
3) **Reliability:** the systems work by day and night and in any weather, and need no cleared line between ground stations, only a clear view of the sky.

The main systems are GPS (United States), GLONASS (Russia), Galileo (European Union), BeiDou (China), QZSS (Japan) and IRNSS (India). A fix needs the ranges to at least 4 satellites.

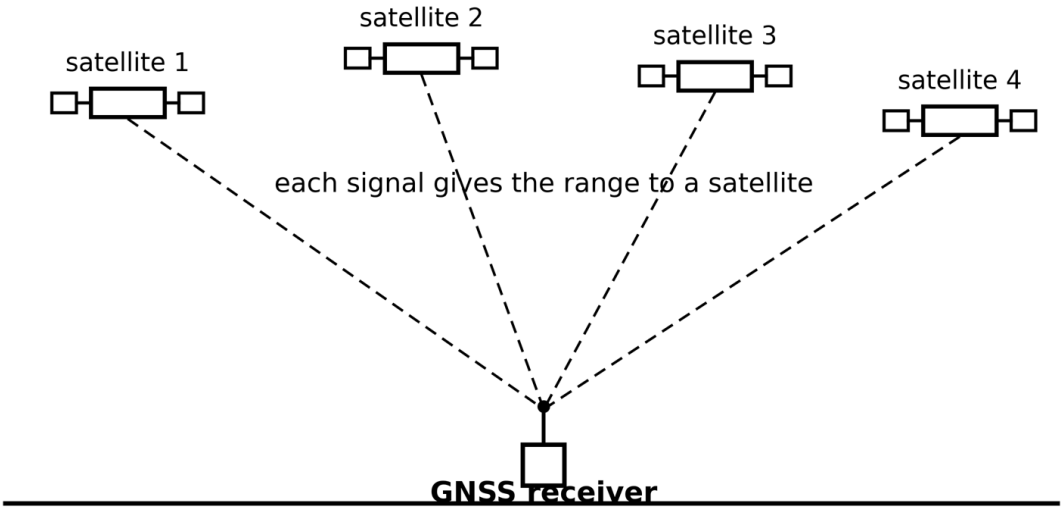


Figure 1.5: *Satellite positioning: ranges from several satellites fix the receiver*

So the receiver near Dodoma fixes the control point from the satellites overhead in minutes, a position that an older survey would have carried overland from a distant origin.

False Confidence Alert
GPS and GNSS are not the same thing, and using the words as synonyms costs marks. GPS is one system, the one operated by the United States. GNSS is the inclusive term for all such systems together, including GLONASS, Galileo and BeiDou, so a receiver that uses several of them is a GNSS receiver, not merely a GPS receiver.

Question 11

A team mapping a small, fairly flat field at the University of Dodoma divides the ground into triangles before measuring a single piece of detail. Explain the principle on which chain surveying rests and account for why it gives a framework that can be checked.

Model Answer

Chain surveying rests on the principle of triangulation: the area is covered by a framework of connected triangles, because a triangle is the only figure whose shape is fixed completely by the lengths of its three sides.

1) **Network of triangles:** the ground is divided into a few large triangles whose corners are survey stations, and measuring the three sides of each triangle fixes its shape exactly when it is plotted.
2) **Well-conditioned triangles:** the triangles are kept near to equilateral, with no angle smaller than about 30 degrees or larger than about 120 degrees, because a long thin triangle plots inaccurately.
3) **Base line and check line:** one well-measured line forms the base of the framework, and a separate check line is measured across it so that, when the survey is plotted, the check line confirms the work or exposes an error.

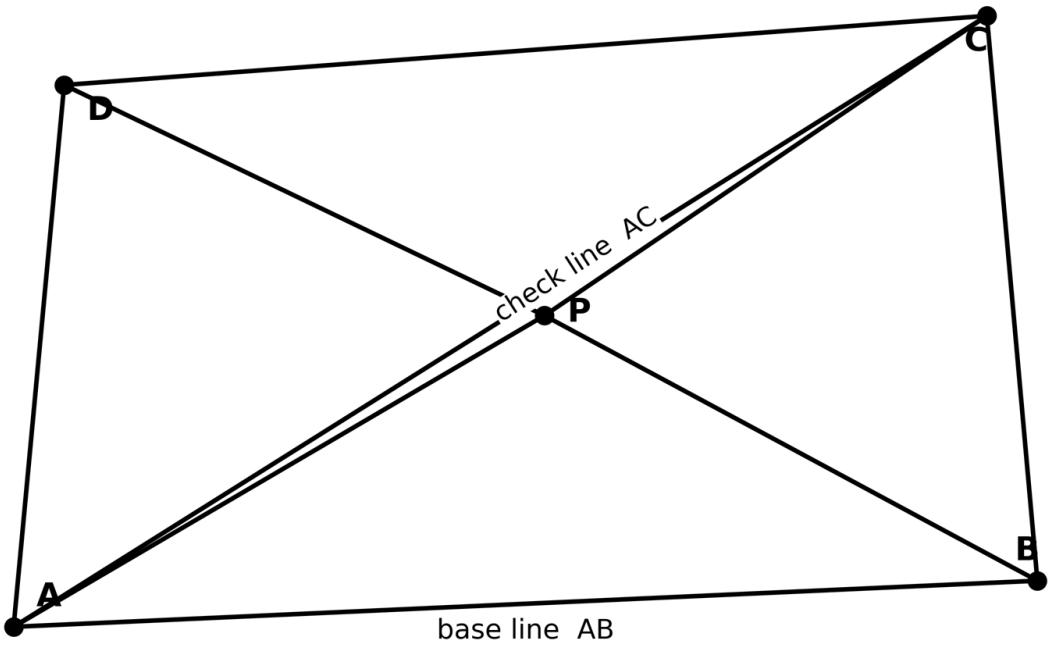


Figure 1.6: *A chain-survey framework of well-conditioned triangles over a field*

So at the Dodoma field the surveyor first lays the triangle framework and a check line, and only then fixes the detail by offsets, which keeps the whole plan consistent.

False Confidence Alert
It is wrong to think chain surveying is simply measuring lengths with a chain. Lengths alone cannot be plotted into a shape unless they form triangles, and without a check line a mistake cannot be detected, so the triangulation and the check line are what make the method a survey rather than a set of measurements.

Question 12

Before the chaining of a plot begins at Morogoro, the team lays out its simple kit on the ground. Describe the equipment used in a chain survey and the job that each item does.

Model Answer

A chain survey uses a small kit of simple equipment, each item with one clear job in measuring or marking the survey lines.

1) **Chain or tape:** measures the distances along the survey lines; the steel band or tape is preferred where greater accuracy is needed than a linked chain can give.
2) **Arrows:** thin steel pins pushed into the ground to mark the end of each chain length, so that the lengths can be counted and added without losing count.

3) **Ranging rods:** tall striped poles set up at the stations and along a line to keep the chaining straight, because the chain must follow a true straight line between stations.
4) **Cross-staff or optical square:** sets out offsets at a right angle to the chain line, so that detail can be tied to the line accurately.
5) **Pegs and a plumb bob:** mark the stations permanently and transfer a point vertically to the ground.

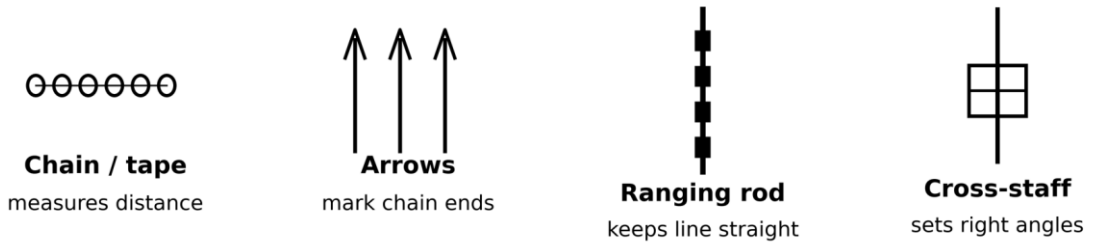


Figure 1.7: *The main chain-survey equipment and the job of each*

At the Morogoro plot the ranging rods are planted first to fix the line, then the chain is laid along it and the cross-staff is used wherever a right-angle offset to a building or path is needed.

Question 13

While chaining the boundary of a coffee plot at Mbinga, a surveyor must fix the position of a tree and a building corner that lie off the chain line. Explain what an offset is and distinguish a perpendicular offset from an oblique offset.

Model Answer

An offset is a lateral measurement from the chain line to a point of detail, taken so that the detail can be fixed in its correct position relative to the line.

Perpendicular offset: is measured at a right angle to the chain line, the right angle being set out by a cross-staff or optical square; it is kept short so that a small error in the direction does not displace the point.

Oblique offset: is measured directly to the point from two known chainages on the line, forming a tie; it is used when a right angle cannot be set conveniently or when the point is too far for a reliable perpendicular offset.

Limiting length: offsets are kept within a short limiting length, because beyond it a small angular error at the chain line swings the plotted point well out of position.

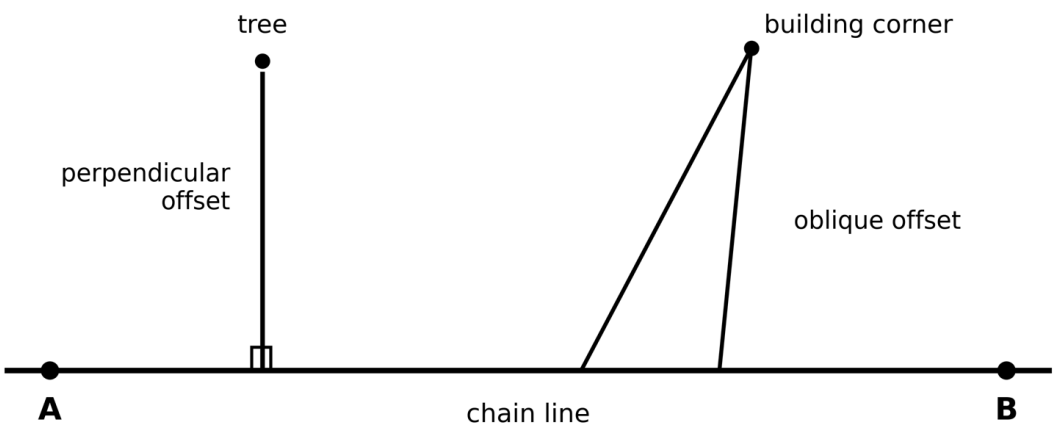


Figure 1.8: *A perpendicular offset and an oblique offset from the chain line*

So at the Mbinga plot the tree near the line is fixed by a short perpendicular offset, while the more distant building corner is fixed by an oblique tie from two chainages.

False Confidence Alert
A long perpendicular offset judged by eye is a common cause of lost marks, because the longer the offset the more a small error in the right angle displaces the point. Beyond the limiting length, take an oblique offset as a tie from two chainages, or move the chain line nearer the detail.

Question 14

A surveyor chaining a 50 metre line from A to B at a school in Singida meets, in turn, an electric post, a road and a well. Show how these are entered in a double-line field book.

Model Answer

In a double-line field book the chainages are written up the centre between two ruled lines, and the offsets to detail are entered on the side of the line on which they lie.

Set up the book. Draw the double central column; the start station A is at the bottom and the finish station B at the top, so that the chainage increases up the page as the survey advances.

Enter each chainage and offset. At chainage 5 m, the electric post lies 10 m to the right, so it is booked on the right; the road crosses obliquely from chainage 15 m to chainage 18 m and is sketched across; at chainage 30 m the well lies 5 m to the left and is booked on the left.

Sketch the detail. Each object is drawn in its place beside its offset, so that the booker, or anyone reading the book later, can reconstruct the ground.

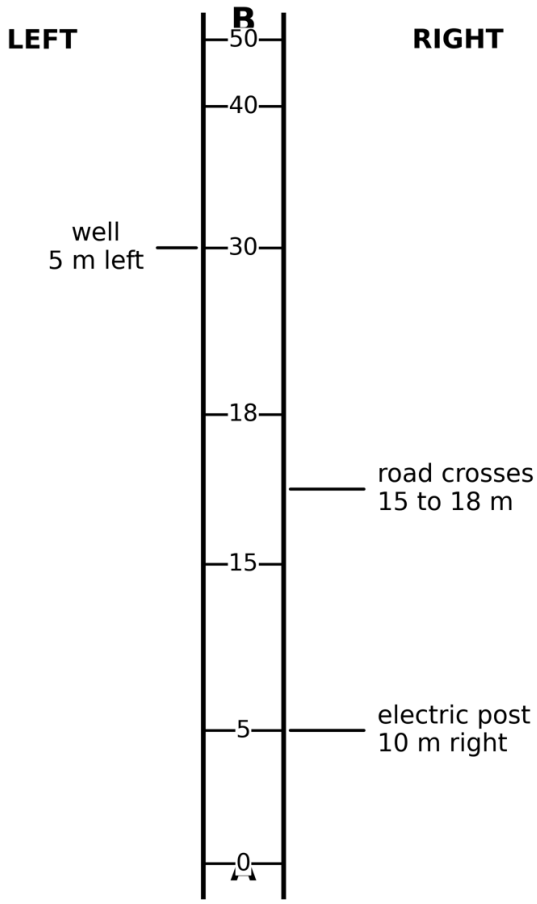


Figure 1.9: *The three offsets entered in a double-line field book*

Booked this way, the Singida line can be plotted exactly, because every object is tied to a measured chainage and a measured offset on a known side of the line.

Question 15

A geologist beginning a mineral reconnaissance near Mpanda must fix the position of an outcrop without laying a chain to it. Explain how a compass survey fixes the position of a point, and name the methods by which it does so.

Model Answer

A compass survey fixes a point by measuring the bearing of the line of sight to it, that is the angle of that line measured from magnetic north.

The compass is set over a station and the needle settles on magnetic north; the angle from that north to the line of sight to the object is read off as the bearing. Repeating this from known stations fixes the object, because two bearings to it cross at one point.

1) **Traverse:** the surveyor runs a connected series of lines, reading the bearing and measuring the length of each, and so carries the position forward from station to station.
2) **Intersection:** the object is fixed by reading the forward bearing to it from two known stations, the point of crossing of the two lines being its position.
3) **Resection:** the surveyor at an unknown point reads bearings to three known points and works back to fix the unknown station.

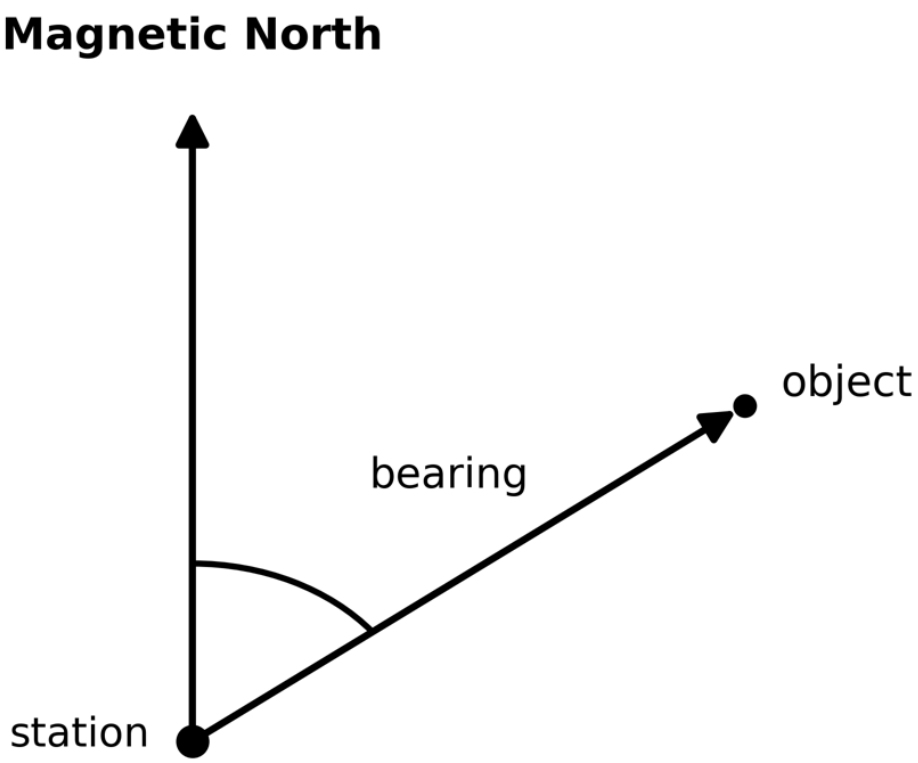


Figure 1.10: *A compass measures the bearing of a line as the angle from magnetic north*

So the geologist near Mpanda can fix the outcrop by intersection, reading its bearing from two stations whose positions are already known, without ever chaining a line to it.

Question 16

Two surveyors at Tabora open their cases: one carries a prismatic compass, the other a surveyor's compass. Distinguish the two instruments by their parts and by the bearing each one reads.

Model Answer

The prismatic compass and the surveyor's compass differ mainly in how they are sighted and read, and in the bearing system each uses.

1) **Reading system:** the prismatic compass reads the whole circle bearing, graduated continuously from 0 to 360 degrees, whereas the surveyor's compass reads the quadrant bearing, graduated from north or south towards east or west.

2) **Sighting:** the prismatic compass carries a prism beside the eye vane, so the graduation and the object are seen together and read at the instant of sighting; the surveyor's compass uses open sights and is read after the needle settles.

3) **The moving part:** in the prismatic compass the graduated ring is attached to the needle and turns with it, whereas in the surveyor's compass the ring is fixed to the box and the needle moves over it.

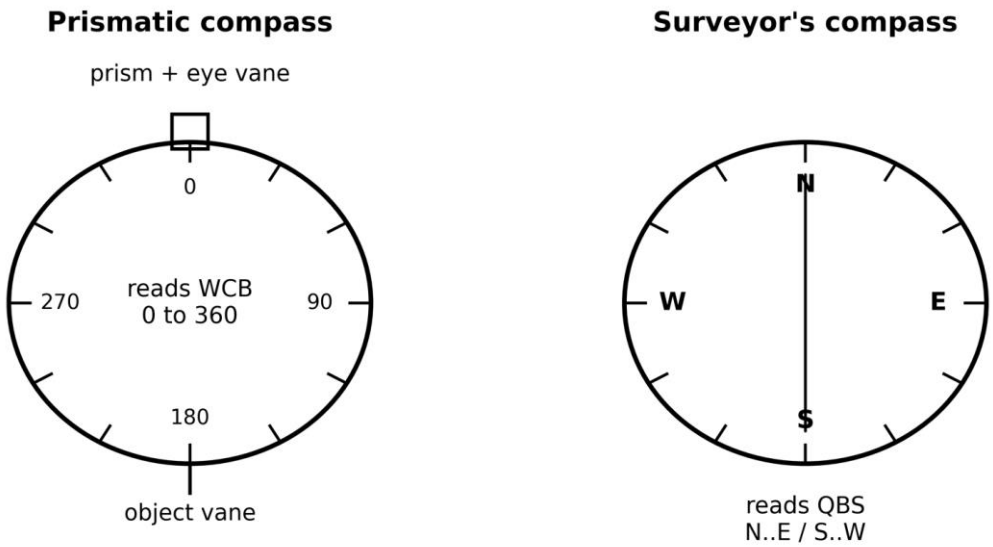


Figure 1.11: *The prismatic compass and the surveyor's compass*

So the surveyor at Tabora who needs a quick whole-circle bearing reaches for the prismatic compass, the more common instrument in ordinary field survey.

Question 17

Asked for the bearing of the same survey line, one student writes 135 degrees and another writes S 45 E. Explain the whole circle bearing and the quadrant bearing systems, and account for why both answers can be correct.

Model Answer

A bearing can be designated in two systems: the whole circle bearing, measured all the way round, and the quadrant bearing, measured within a quadrant.

Whole circle bearing (WCB): the bearing is measured clockwise from north, through a full range of 0 to 360 degrees; it is the system of the prismatic compass and is also called the azimuth.

Quadrant bearing (QBS): the bearing is measured from north or from south, whichever is nearer, towards east or west, so it ranges only from 0 to 90 degrees and carries a letter prefix and suffix, as in N 45 E.

The two are the same direction written two ways. A line of 135° whole circle bearing lies in the south-east quadrant, 180° - 135° = 45° from south towards east, which is written S 45° E.

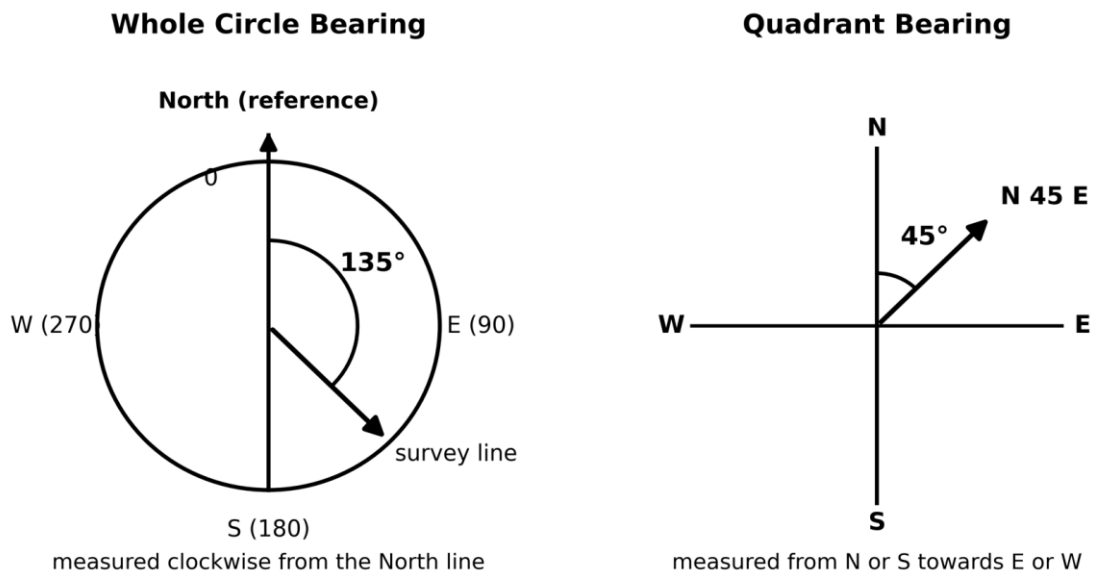


Figure 1.12: *The same line in the whole circle and quadrant bearing systems*

So both students are right; one has given the Mwanza line in whole circle bearing and the other in quadrant bearing.

Question 18

Reading a line from A to B, a surveyor near Iringa records one bearing at A and a different one at B, yet the two must agree. Explain the fore bearing and the back bearing of a line and the relationship that checks them.

Model Answer

The fore bearing of a line is its bearing read in the direction of the survey, and the back bearing is its bearing read in the reverse direction; the two must differ by exactly 180 degrees.

Because the back bearing is the same line looked at the opposite way, the relationship is FB = BB ± 180°, taking plus when the back bearing is below 180 degrees and minus when it is above.

Method:

$$FB = BB \pm 180°$$

Working:

$$BB = 45° \text{ gives } FB = 45° + 180° = 225°$$

$$BB = 225° \text{ gives } FB = 225° - 180° = 45°$$

Interpretation. So a forward bearing of 45 degrees and a back bearing of 225 degrees describe one and the same line; if the two do not differ by 180 degrees, the station is in error or under local attraction.

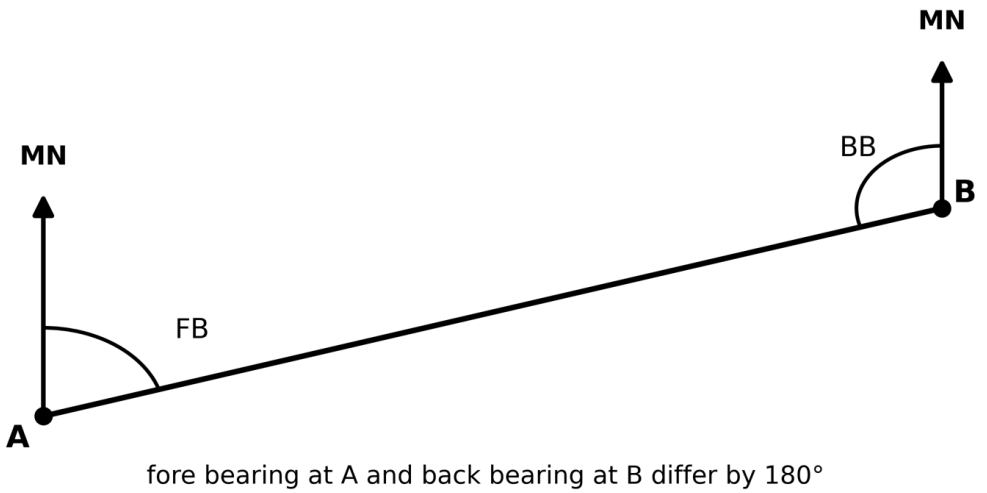


Figure 1.13: *Fore bearing at A and back bearing at B differ by 180 degrees*

False Confidence Alert

It is a mistake to treat the fore and back bearings as two different directions to be averaged blindly. They are the same line; their difference should be exactly 180 degrees, and any departure is the error to be found and corrected, not smoothed over.

Question 19

An old plan near Sumbawanga lists its lines in whole circle bearings, but the field party works in quadrant bearings. Convert the whole circle bearings below to the quadrant bearing system, showing the rule for each quadrant.

Model Answer

A whole circle bearing is converted to a quadrant bearing by deciding which quadrant it falls in and measuring from the nearer of north or south.

Method:

N..E: QBS = WCB | S..E: QBS = 180° - WCB | S..W: QBS = WCB - 180° | N..W: QBS = 360° - WCB

Working:

WCB 40° (first quadrant) = N 40° E

WCB 135° (second quadrant) = S (180° - 135°) E = S 45° E

WCB 210° (third quadrant) = S (210° - 180°) W = S 30° W

WCB 300° (fourth quadrant) = N (360° - 300°) W = N 60° W

Interpretation. So each whole circle bearing names a quadrant first, then the acute angle from north or south to the line, which is the quadrant bearing the field party needs.

Question 20

Before reading a single bearing at a station near Babati, a surveyor must prepare the prismatic compass. Explain the temporary adjustments carried out at each station.

Model Answer

The temporary adjustments are the settings made afresh at every station before reading: centring, levelling and focusing the prism.

1) **Centring:** the compass is set so that its centre is exactly over the station mark, using a plumb line or a dropped pebble, because a bearing read off-centre is taken from the wrong point.
2) **Levelling:** the compass is brought horizontal, by the ball-and-socket on the tripod or by hand, so that the graduated ring swings freely and the needle is not dragged.
3) **Focusing the prism:** the prism is raised or lowered until the graduations are seen sharp and clear, so that the bearing is read exactly and not guessed.

Only when the compass at the Babati station is centred, level and focused is it ready to give a reliable bearing, so these adjustments come before every reading.

Question 21

Two field parties describe their routes: one walked a line of stations from the school gate to the river and stopped, the other walked right round a coffee estate at Mbozi and returned to the start. Distinguish an open from a closed traverse.

Model Answer

A traverse is a connected series of survey lines; it is open when it does not return to its start and closed when it does.

Open traverse: the line of stations runs from one point to a different finishing point, as along a road or a river; it cannot be checked within itself, so it must be tied to known points to be controlled.

Closed traverse: the line of stations returns to its starting point, or runs between two known points, so that it forms a circuit; the circuit provides its own check, because any failure to close reveals an error.

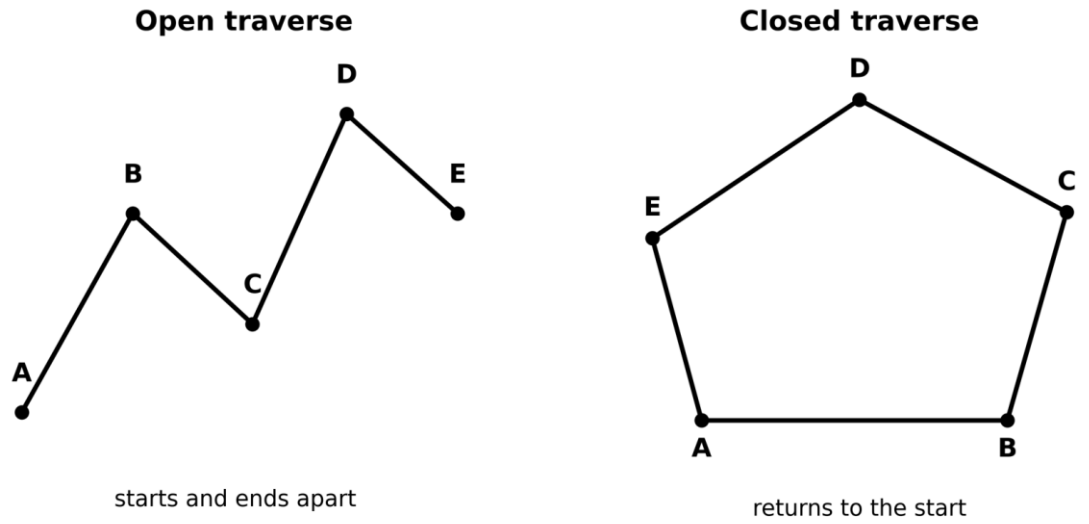


Figure 1.14: *An open traverse and a closed traverse*

So the party that walked round the Mbozi estate ran a closed traverse, which can be checked for misclosure, while the route from gate to river is an open traverse that cannot.

Question 22

Near an iron-roofed store at Shinyanga a surveyor finds that the fore and back bearings of a line refuse to differ by 180 degrees. Explain local attraction, its causes, and how it is detected.

Model Answer

Local attraction is the deflection of the compass needle away from magnetic north by nearby magnetic material, so that the bearings read at the affected station are all wrong by the same amount.

Causes: magnetic rocks and iron ore, and iron objects such as cables carrying current, electric poles, railway lines, steel structures and even the surveyor's own steel tape or watch, pull the needle aside.

Effect: because every bearing at the affected station is swung by the same amount, the included angles remain correct, but the bearings themselves are false.

It is detected from the 180 degree check: if the fore and back bearings of a line satisfy FB - BB = 180°, both its stations are free of local attraction; if they do not, one or both stations are affected and must be found and corrected.

So at the Shinyanga store the surveyor concludes that the station near the iron roof is under local attraction, and corrects its bearings against a line that the test shows to be clean.

False Confidence Alert
Local attraction does not put a random error into one reading. It swings every bearing taken at the affected station by the same angle, so the included angles still look right; that is exactly why it slips past a careless check and must be hunted with the 180 degree test on each line.

Question 23

A line near Mtwara reads 75 degrees 30 minutes on the compass, but the true bearing wanted for the map is different, because magnetic north is not true north. Explain magnetic declination and use it to convert the magnetic bearing to a true bearing.

Model Answer

Magnetic declination is the horizontal angle between true north and magnetic north at a place, and it must be applied to turn a magnetic bearing into a true one.

The compass points to magnetic north, which lies east or west of true north by the declination, so the declination is the difference Magnetic declination = True bearing - Magnetic bearing.

Method:

True bearing = Magnetic bearing + Magnetic declination

Working:

Magnetic bearing = 75° 30', declination = 3° 15' E

True bearing = 75° 30' + 3° 15' = 78° 45'

Interpretation. So the line near Mtwara, read as 75 degrees 30 minutes on the compass, is plotted on the map as a true bearing of 78 degrees 45 minutes, an east declination being added.

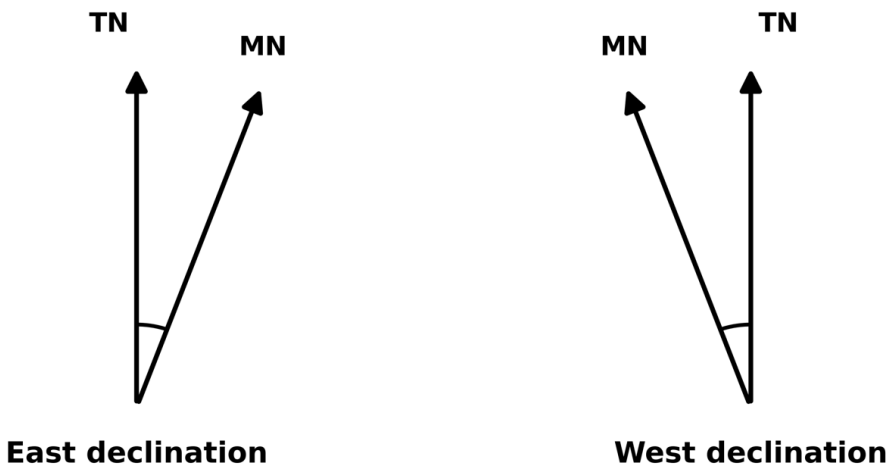


Figure 1.15: *East and west magnetic declination*

Question 24

A surveyor consulting an old chart near Kigoma notes that its magnetic declination is dated, because declination does not stand still. Account for the variations of magnetic declination and explain the magnetic dip.

Model Answer

Magnetic declination at a place does not stay constant; it changes in four ways, and the needle also dips out of the horizontal.

1) **Secular variation:** a slow swing of the declination over centuries, the largest and most important variation for the surveyor, which is why an old chart's declination cannot be trusted without updating.
2) **Annual variation:** a small change from year to year, of the order of a minute or two.
3) **Diurnal variation:** a daily change as the declination departs from and returns to its mean over 24 hours, depending on the place, the season and the time of day.
4) **Irregular variation:** sudden, unpredictable shifts caused by magnetic storms and similar disturbances.
5) **Magnetic dip:** the angle at which the needle tips below the horizontal, because the earth's field is not horizontal; it is why one end of a balanced needle has to be weighted to keep it level.

So the surveyor near Kigoma updates the old declination to the year of the survey before using it, because the secular variation alone may have moved it appreciably since the chart was drawn.

Question 25

Surveying a small school plot at Korogwe, a plane-table party draws the finished plan in the field as the measurements are made, with no separate booking. Explain what plane table surveying is and the principle of parallelism on which it rests.

Model Answer

Plane table surveying is a graphical method in which the field observation and the plotting are done at the same time, so the plan is drawn on the ground itself while the area is in view.

Observation and plotting together: the surveyor sights each point through the alidade and at once draws its ray and scales its distance on the sheet, so the plan grows as the survey proceeds and little can be left out.

The principle of parallelism: the table must be set in the same orientation at every station as it held at the first, so that each line on the sheet stays parallel to the matching line on the ground; the rays to detail are drawn from the plotted position of the station, so all of them pass through that one point.

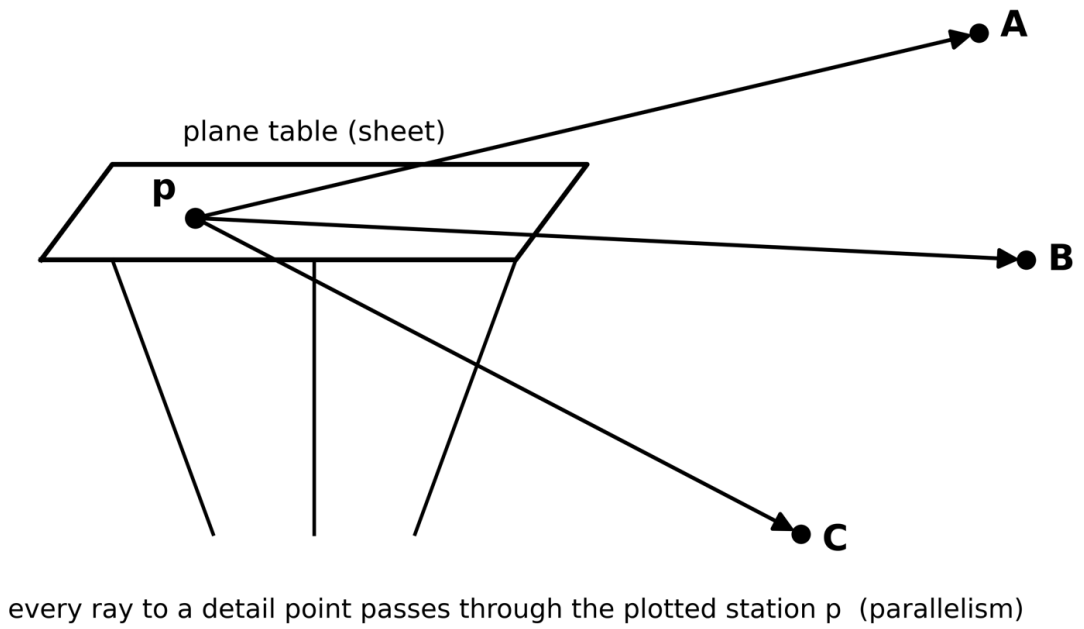


Figure 1.16: *Plane tabling: rays to detail drawn from the plotted station (parallelism)*

So at the Korogwe plot the party can hand over a finished plan as they leave the field, because the plotting was done as the measuring was done.

False Confidence Alert
Plane tabling is not free-hand drawing of the ground. Its accuracy depends wholly on keeping the same orientation at every station; if the table is turned between stations and not re-oriented, parallelism is broken and the plan is distorted even though each ray looks correct.

Question 26

A group leader laying out the plane-table kit at Bukoba is asked to name what each piece is for. Describe five items of plane-table equipment and the job each one does.

Model Answer

The plane-table outfit is built around the table and tripod, with an alidade and a few accessories that fix, orient and level it.

1) **Plane table and tripod:** a drawing board carrying the survey sheet, mounted on a tripod so that it can be set level and clamped over a station.
2) **Alidade:** a straight-edged ruler fitted with sights, used to sight each point and to draw its ray along the fiducial edge.
3) **Trough compass:** a small boxed needle used to mark the magnetic meridian on the sheet and to orient the table to north.
4) **U-fork and plumb bob:** a fork that hangs a plumb bob below the table, used to set the plotted point exactly over the ground station (centring).
5) **Spirit level:** placed on the board in two directions to bring the table horizontal before any sight is taken.

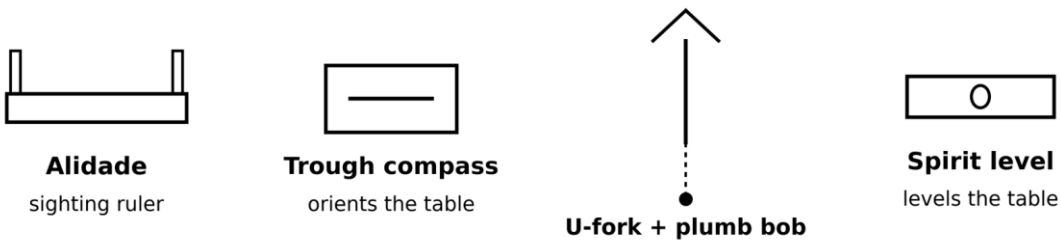


Figure 1.17: *The main plane-table equipment and the job of each*

So at Bukoba the leader sets the table on its tripod, centres it with the U-fork and plumb bob, levels it with the spirit level, orients it with the trough compass, and sights with the alidade.

Question 27

Arriving at the first station on a farm at Iringa, a surveyor must do three things to the plane table before any point can be plotted. Explain how a plane table is set up and oriented at a station.

Model Answer

Setting up a plane table involves three operations at the station: centring, levelling and orientation.

1) **Centring:** the table is placed so that the plotted position of the station on the sheet lies exactly over the ground station, checked with the U-fork and plumb bob.
2) **Levelling:** the board is brought horizontal with the spirit level, tested in two directions at right angles, so that the alidade rests true.
3) **Orientation:** the table is turned until it holds the same direction it had at the first station, so that parallelism is preserved.

Orientation is done in one of two ways: by the trough compass, turning the table until the needle lies on the marked meridian, which is quick but fails where iron causes local attraction; or by back-sighting, laying the alidade along an already-plotted line and turning the table until it sights the previous station, which is the more reliable method.

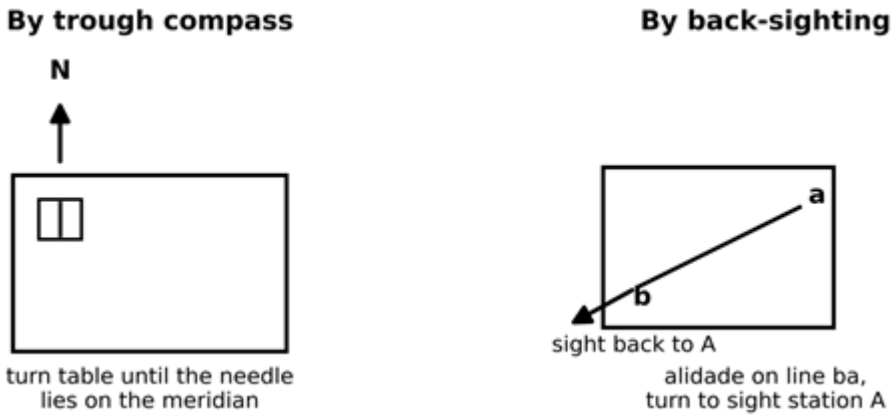


Figure 1.18: *Orienting a plane table by trough compass and by back-sighting*

So at the Iringa station the surveyor centres, levels and then orients the table by back-sighting the line just drawn, and only then begins to plot new detail.

Question 28

From a single point in the middle of a small farm at Mufindi, all the boundary corners can be seen. Explain how the corners are fixed by the radiation method of plane tabling.

Model Answer

In the radiation method the table is set at one station from which every point is visible, and each point is fixed by a ray and a scaled distance from that station.

1) **Set up once:** the table is centred, levelled and oriented at the central station, whose plotted position is marked on the sheet.
2) **Sight and scale each point:** the alidade is laid on the plotted station and turned to each corner in turn; a ray is drawn, the ground distance is measured, and it is scaled along the ray to fix the point.
3) **Join the points:** the fixed corners are joined to produce the plan of the farm.

The distances are reduced to the sheet by the chosen scale, for example a scale of 1 cm to 10 m, so a corner 40 m away is plotted 4 cm along its ray.

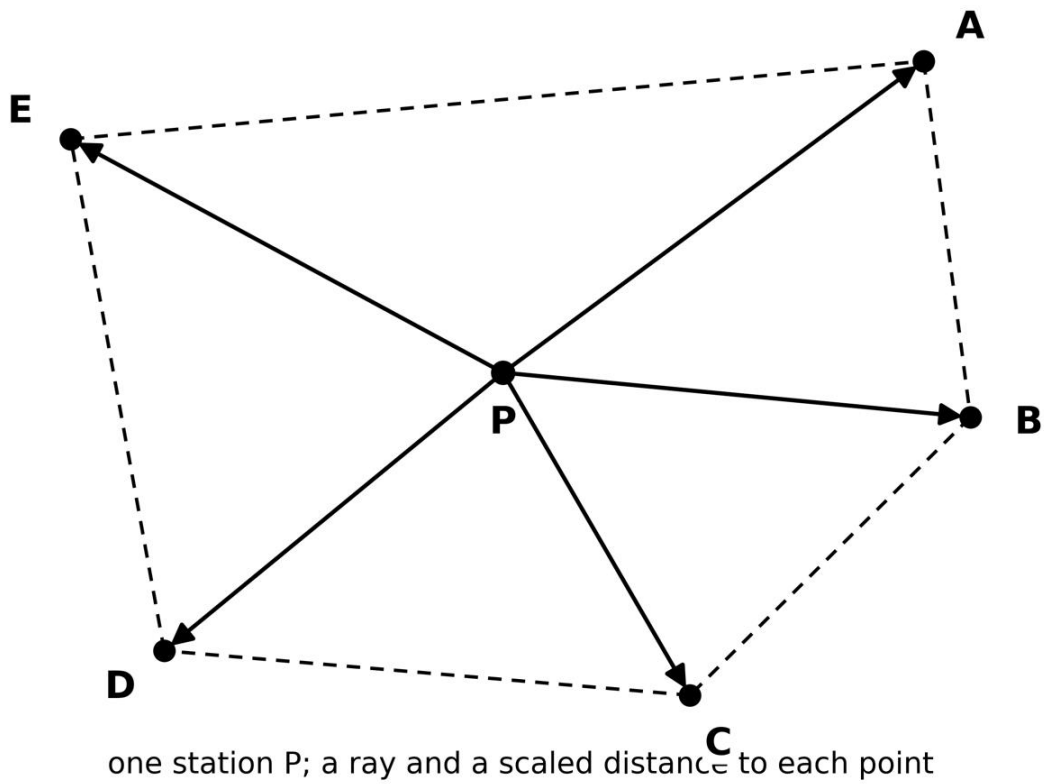


Figure 1.19: *Radiation: one station, a ray and a scaled distance to each corner*

So radiation suits the Mufindi farm exactly, because every corner is visible from one station and its distance can be measured.

Question 29

A surveyor at Mwanza must fix a building on the far side of a creek that cannot be crossed to measure a distance. Explain how the intersection method of plane tabling fixes such a point.

Model Answer

In the intersection method a point is fixed by drawing a ray to it from each of two stations on a measured base line, the point lying where the two rays cross, so no distance to the point is needed.

1) **Plot the base line:** two stations are chosen so that the point is visible from both, and the distance between them is measured and plotted to scale as the base line on the sheet.
2) **Ray from the first station:** the table is set and oriented at the first station, the alidade is sighted to the point, and a ray is drawn.

3) **Ray from the second station:** the table is moved to the second station, oriented, and a ray is drawn to the same point; where the two rays intersect is its plotted position.

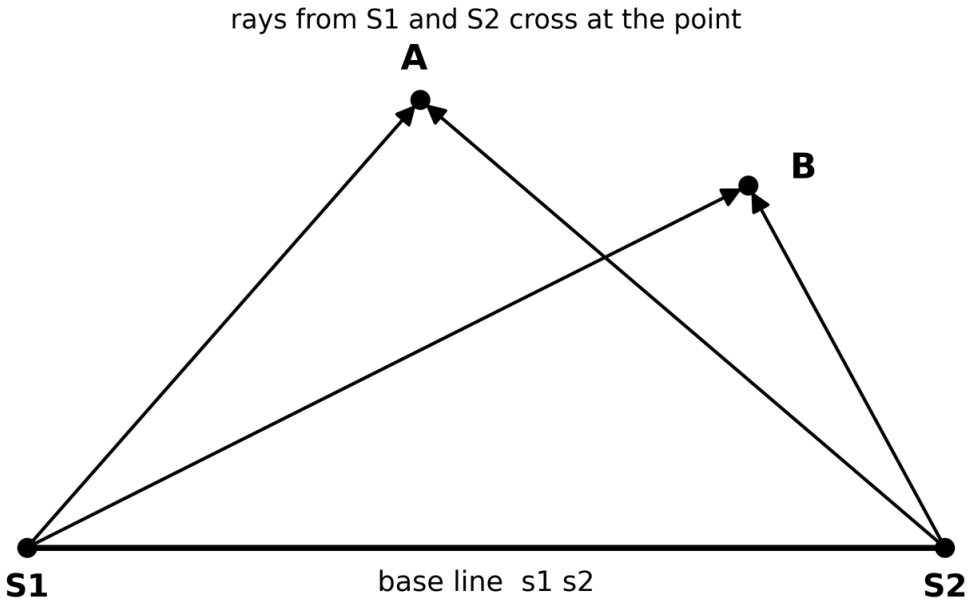


Figure 1.20: *Intersection: two rays from a measured base line cross at the point*

Question 30

The corners of a farm at Njombe cannot all be seen from any one point, so the surveyor must move the table round the boundary. Explain how the corners are fixed by the traverse method of plane tabling.

Model Answer

In the traverse method the table is set up at each station in turn and the survey lines are plotted one after another as the table moves round the boundary.

1) **Start at the first corner:** the table is set at corner A, a sight is taken to corner B, and the line is drawn and scaled from the measured distance AB.

2) **Move and orient by back-sighting:** the table is moved to B, centred and levelled, and oriented by laying the alidade on the plotted line and back-sighting A, so parallelism is kept.

3) **Carry the survey round:** from B a sight is taken to C and the line drawn and scaled, and the process is repeated for the remaining corners until the boundary is closed.

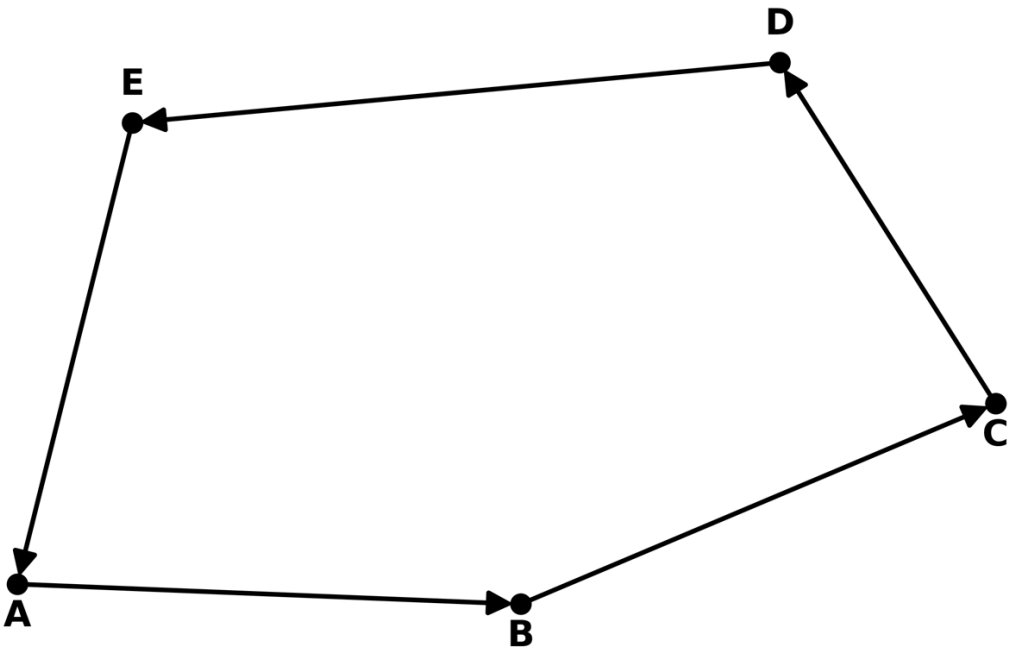


table set at each station; oriented by back-sighting the last line

Figure 1.21: *Traverse method: the table is moved from station to station round the farm*

So the Njombe farm, whose corners cannot all be seen at once, is surveyed by carrying the table round the boundary, orienting at each station by back-sighting the line just drawn.

Question 31

Lost on a hillside at Mbeya with only the plane table and three distant landmarks of known position, a surveyor must find where the table itself stands. Explain the resection method and the triangle of error.

Model Answer

Resection fixes the unknown position of the table itself by drawing rays back from three points of known position; where the rays meet is the station.

1) **Sight the known points:** the table is set up, oriented as well as can be managed by compass, and the alidade is laid to each of the three known points in turn, a ray being drawn back from each.
2) **Look for the meeting point:** if the table is correctly oriented, the three rays meet at a single point, which is the plotted position of the station.
3) **The triangle of error:** if the orientation is slightly wrong, the three rays do not meet but enclose a small triangle, called the triangle of error; the orientation is adjusted and the rays redrawn until the triangle shrinks to a point.

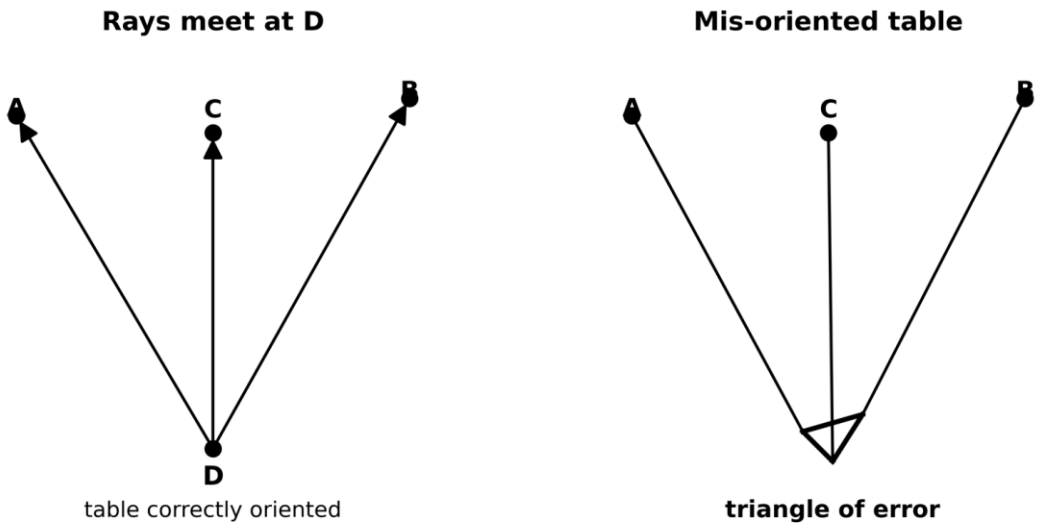


Figure 1.22: *Resection: well-oriented rays meet at the station; a mis-oriented table leaves a triangle of error*

Question 32

Laying a water pipe across a shallow valley at Njombe, an engineer must know how much higher one end of the line is than the other. Explain what levelling is and the meaning of the main terms used in a level book.

Model Answer

Levelling is the operation of finding the difference in height between points, by reading a graduated staff against the horizontal line of sight of a level.

1) **Bench mark and reduced level:** a bench mark (BM) is a point of known height, and the reduced level (RL) of any point is its height above the chosen datum; levelling carries the RL from the bench mark to the new points.

2) **Back sight and fore sight:** the back sight (BS) is the first reading taken after the level is set up, on a point of known RL, and the fore sight (FS) is the last reading taken before the level is moved.

3) **Intermediate sight:** an intermediate sight (IS) is any reading taken between the back sight and the fore sight while the level stays at one setting.

4) **Change point and line of collimation:** a change point carries both a fore sight from the old setting and a back sight from the new one when the level is moved; the line of collimation is the horizontal line of sight, and its height is the height of collimation.

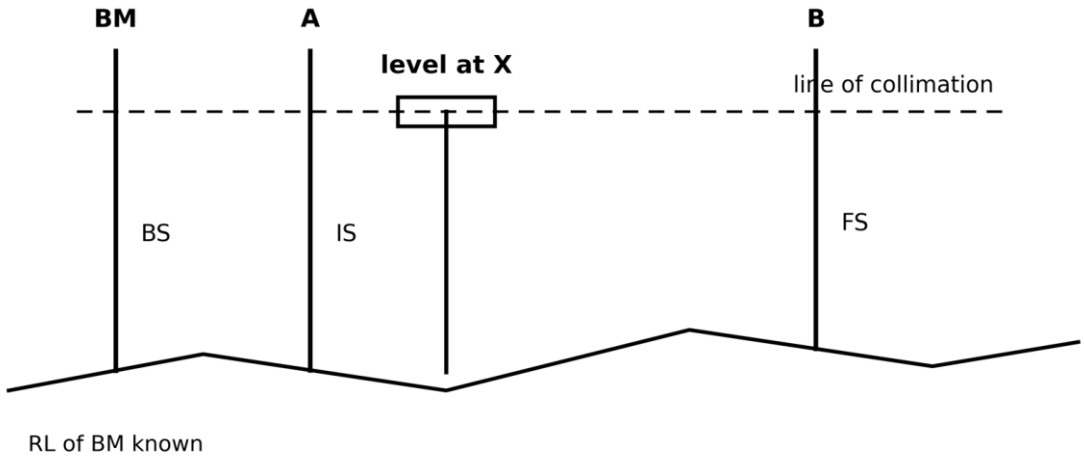


Figure 1.23: *A levelling set-up: back sight, intermediate sight and fore sight on the line of collimation*

So at the Njombe line the engineer starts from a bench mark of known RL and carries the height across the valley, reading the staff at each point, to find the difference in level between the two ends.

Question 33

A survey class at Moshi opens the levelling case and lays out its three essential pieces of equipment. Describe the equipment used in a levelling survey and the job that each does.

Model Answer

A levelling survey needs three pieces of equipment: a level, a levelling staff and a tripod.

1) **The level:** an instrument with a telescope and a bubble tube that provides a horizontal line of sight; it exists as the dumpy level, with the telescope fixed to the spindle, the tilting level, whose telescope tilts slightly on a screw for each sight, and the automatic level, which uses a compensator to make the sight horizontal on its own.
2) **The levelling staff:** a graduated rod, read in metres against the line of sight, whose reading is the vertical distance from the line of collimation down to the point.
3) **The tripod:** the three-legged stand that carries the level firmly and at a convenient height during the work.

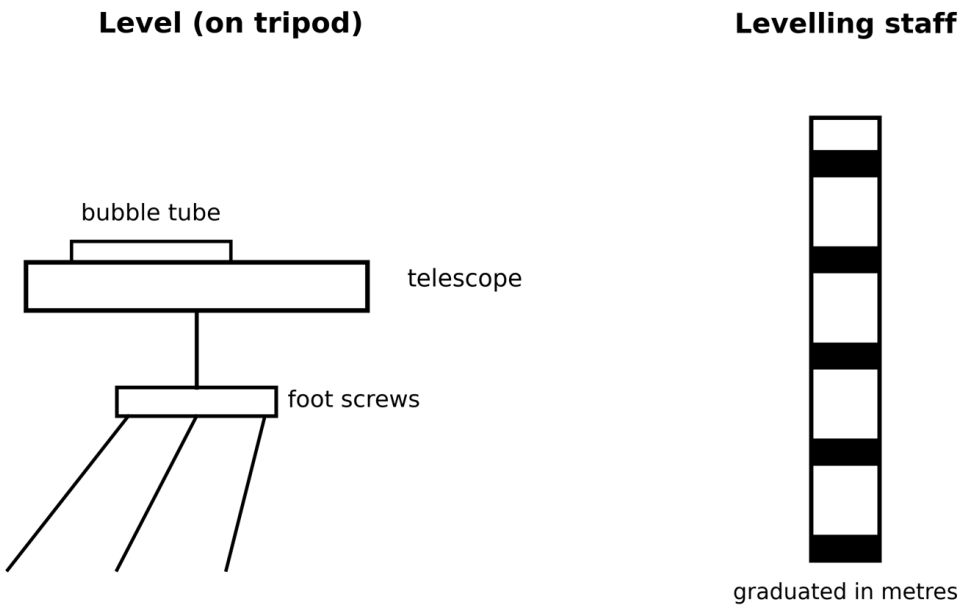


Figure 1.24: *A level on its tripod, and the levelling staff*

So the Moshi class sets the level on its tripod, brings it level, and reads the staff held in turn on each point of the survey.

Question 34

One survey at Tanga wants only the difference in height between two far-apart points, while another wants the height of every point along a road line. Distinguish differential levelling from profile levelling.

Model Answer

Both are forms of direct levelling, but differential levelling carries height between two points, whereas profile levelling records the height of many points along a line.

Differential levelling: determines the difference in level between two points that are too far apart for one set-up, by moving the level along the route through change points and taking only a back sight and a fore sight at each setting; the intermediate ground is not of interest.

Profile levelling: determines the reduced level of a series of points along a chosen line, so a back sight, a fore sight and as many intermediate sights as needed are taken; it is used for roads, pipelines and drainage, where the shape of the ground along the line matters.

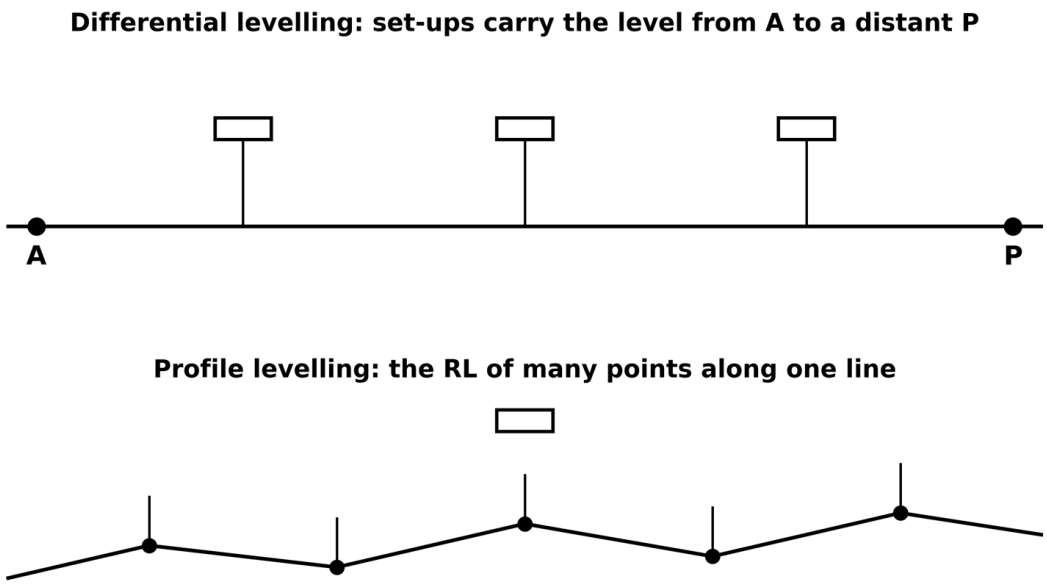


Figure 1.25: *Differential levelling (point to point) and profile levelling (along a line)*

So the Tanga survey that needs only the height difference uses differential levelling, while the road survey that needs the ground profile uses profile levelling.

Question 35

Before reading the staff at a station near Songea, a surveyor must adjust the level and clear the parallax. Explain the temporary and permanent adjustments of a level and what parallax is.

Model Answer

A level is adjusted in two ways: temporary adjustments are made afresh at every station, and permanent adjustments correct faults built into the instrument.

Temporary adjustment: carried out at each set-up: fixing the level on the tripod and setting it roughly level, bringing the bubble central with the foot screws, and removing parallax before any reading.

Permanent adjustment: carried out occasionally to correct instrument faults, chiefly the bubble-tube error, when the line of sight is not truly horizontal with the bubble central, and the collimation error.

Parallax: the apparent shift of the staff image against the cross hairs when the eye is moved; it is removed by first focusing the eyepiece on the cross hairs and then focusing the telescope on the staff, so that image and cross hairs lie in the same plane.

Only when the level near Songea is set, levelled and free of parallax is a reading reliable, so these adjustments come before the staff is read.

Question 36

A profile levelling near Dodoma gives the staff readings in the table below, the bench mark having a reduced level of 50.00 m. Reduce them by the rise-and-fall method and prove the work by the arithmetic check.

Station	BS (m)	IS (m)	FS (m)	Remarks
BM	2.10			Bench mark, RL 50.00 m
A		1.50		
B	2.40		0.90	Change point
C		1.80		
D			2.00	Last point

Model Answer

In the rise-and-fall method each staff reading is subtracted from the one before it on the same set-up; a positive difference is a rise and a negative one is a fall, and the reduced level is carried forward by adding the rise or subtracting the fall.

Method:

Rise or fall = previous staff reading - present staff reading

Working:

RL of A = RL of BM + Rise = 50.00 + 0.60 = 50.60

RL of D = RL of C - Fall = 51.80 - 0.20 = 51.60

Station	BS	IS	FS	Rise	Fall	RL (m)	Remarks
BM	2.10					50.00	Bench mark
A		1.50		0.60		50.60	
B	2.40		0.90	0.60		51.20	Change point
C		1.80		0.60		51.80	
D			2.00		0.20	51.60	Last point

At the end the work is proved by the arithmetic check, which for the rise-and-fall method compares three differences that must all be equal.

Method:

$$\text{Sum of BS - Sum of FS = Sum of Rise - Sum of Fall} = RL_{last} - RL_{first}$$

Working:

$$4.50 - 2.90 = 1.80 - 0.20 = 51.60 - 50.00 = 1.60$$

Interpretation: All three differences equal 1.60 m, so the booking and the reduction are arithmetically correct, and the ground rises 1.60 m from the bench mark to the last point.

Question 37

A levelling line gives the staff readings in the table below, the bench mark having a reduced level of 50.00 m. Reduce them by the height-of-collimation method and prove the work by its check.

Station	BS (m)	IS (m)	FS (m)	Remarks
BM	2.10			Bench mark, RL 50.00 m
A		1.50		
B	2.40		0.90	Change point
C		1.80		
D			2.00	Last point

Model Answer

In the height-of-collimation method the height of the line of sight is found at each set-up by adding the back sight to the reduced level, and every other point is reduced by subtracting its staff reading from that height.

Method:

$$\text{Height of collimation} = RL + BS \qquad RL = \text{Height of collimation - staff reading}$$

Working:

$$\text{HC at first set-up} = 50.00 + 2.10 = 52.10$$

$$\text{RL of A} = 52.10 - 1.50 = 50.60$$

$$\text{HC at second set-up} = 51.20 + 2.40 = 53.60$$

$$\text{RL of C} = 53.60 - 1.80 = 51.80$$

Station	BS	IS	FS	HC (m)	RL (m)	Remarks
BM	2.10			52.10	50.00	Bench mark
A		1.50			50.60	
B	2.40		0.90	53.60	51.20	Change point
C		1.80			51.80	
D			2.00		51.60	Last point

The check for this method compares two quantities only.

Method:

$$\text{Sum of BS - Sum of FS} = RL_{last} - RL_{first}$$

Working:

$$4.50 - 2.90 = 51.60 - 50.00 = 1.60$$

False Confidence Alert
The height-of-collimation check is weaker than it looks. Because it only compares the sums of back and fore sights with the change in reduced level, it does not test the intermediate sights at all; a mistake in an intermediate reading can pass this check unnoticed, whereas the rise-and-fall check would catch it.

Question 38

To plan a small irrigation scheme at Kilosa, a surveyor must draw contours on the plan of the field. Explain what a contour is and the methods of contouring.

Model Answer

A contour is a line on the plan joining points of equal reduced level, and contouring is the work of locating those points on the ground and on the plan.

1) **Direct method:** points that lie on a chosen contour value are found on the ground by levelling and pegged out, and their horizontal positions are then surveyed; it is accurate but slow, because the ground is searched for each contour.
2) **Indirect method, grid:** the area is divided into a grid of squares, the reduced level of each grid corner is found by levelling, and the contours are interpolated between the spot heights; it suits gentle, fairly open ground.
3) **Indirect method, radiation:** radiating lines are set out from a central point on a hill, spot heights are taken at intervals along them, and the contours are interpolated; it suits a small hill.

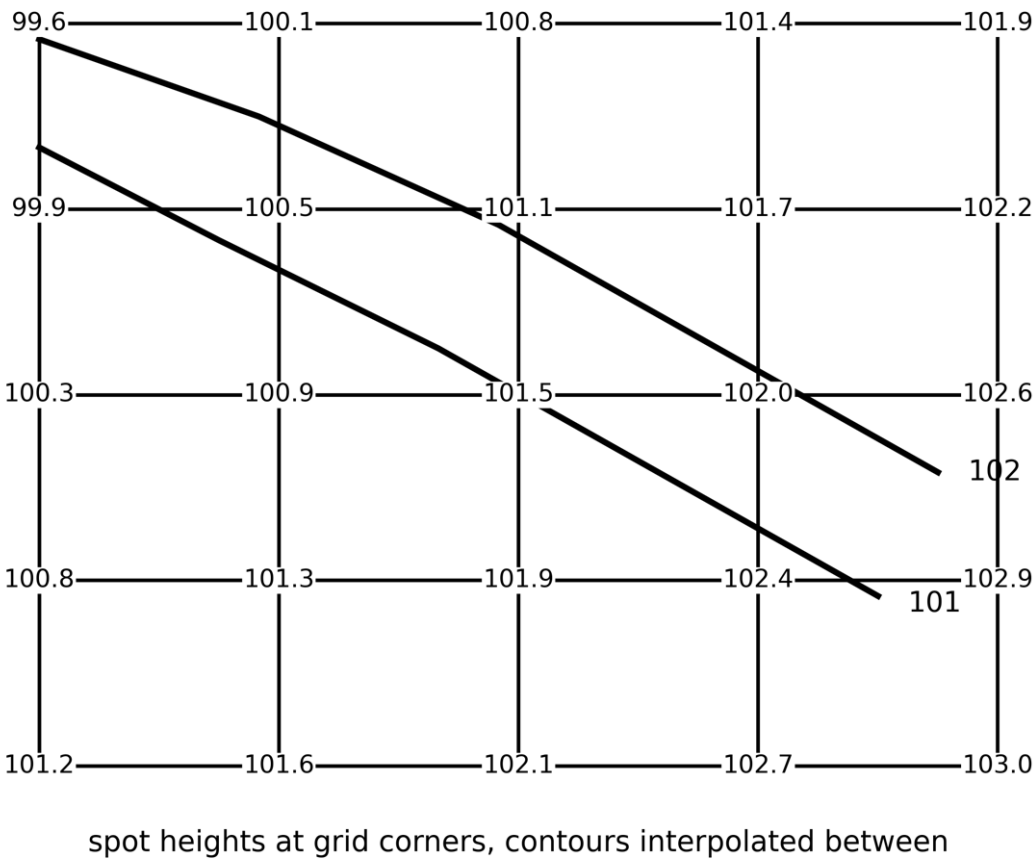


Figure 1.26: *Contouring by the grid method: spot heights interpolated into contours*

So at the Kilosa field the surveyor levels a grid of spot heights and interpolates the contours between them, which is quicker than pegging each contour on the ground by the direct method.

REAL QUESTIONS

Question 39

From the title deed for a town plot in Mwanza to the setting-out of the Standard Gauge Railway, land surveying stands behind the country's development. Explain five ways in which land surveying serves the development of Tanzania.

Model Answer

Land surveying serves development by supplying the accurate positions on which land, works and maps all depend.

1) **Securing land rights:** cadastral survey fixes the boundaries of parcels so that title deeds can be issued and disputes settled, as in the titling of village and town land across the country.
2) **Setting out engineering works:** survey positions and sets out roads, railways, dams and bridges, for example the Standard Gauge Railway and the Julius Nyerere Hydropower Project.
3) **Providing the mapping framework:** survey establishes the control points on which national topographic maps are built, so that every later map rests on measured positions.
4) **Guiding town planning:** survey lays out streets, water mains and plots in growing towns such as the new capital, Dodoma, keeping the growth orderly.
5) **Opening up resources:** survey provides the preliminary work for mineral exploration and for siting wells, pipelines and power lines, as around the gas fields of Mtwara.

Because each of these depends on positions fixed to a known accuracy, the survey always comes first, which is why surveying underpins so much of Tanzania's development.

Question 40

A survey firm in Arusha must choose between a theodolite and a total station to set out a new road, and wonders where a satellite receiver would fit in. Advise which instrument to choose, with reasons, and explain how a GNSS receiver would change the work.

Model Answer

For setting out a road the total station is the better choice, because it measures both the angle and the distance to a point and records them together, whereas a theodolite measures only angles.

1) **Theodolite:** reads horizontal and vertical angles accurately, but a separate measurement is needed for distance, so the work is slower and the booking is in two parts.
2) **Total station:** combines the theodolite with electronic distance measurement, so a single sighting gives the angle and the distance and stores them, which speeds the setting-out of the many points along a road.
3) **GNSS receiver:** fixes position directly from the satellites, so it needs only a clear view of the sky and no cleared line between ground stations; it is ideal for carrying control across the country to the road, though it is checked against ground marks for fine setting-out.

So the Arusha firm sets out the road with a total station for speed and a complete record, and uses a GNSS receiver to bring the control framework to the site.

Question 41

One project is to map the whole of the Selous, while another is to peg a half-acre plot in Morogoro town. Decide which class of survey suits each, and give the reason in each case.

Model Answer

The Selous project calls for geodetic survey and the Morogoro plot for plane survey, the difference turning on the size of the area and whether the earth's curvature matters.

The Selous, geodetic: the area is far larger than the usual threshold of about 250 square kilometres, so the curvature of the earth is no longer negligible and the lines joining stations must be treated as arcs, which is geodetic survey.

The Morogoro plot, plane: the half-acre is tiny, well below the threshold, so the curvature is negligible and the ground can be treated as flat, which is plane survey with ordinary instruments.

The deciding test is the area: plane survey is used while Area < 250 km^2, and geodetic survey above it.

So the same country is surveyed two ways: the Selous geodetically and the Morogoro plot as a plane.

Question 42

Four tasks land on a surveyor's desk in one week: charting the approaches to Dar es Salaam harbour, mapping the workings of a gold mine at Geita, fixing a farm boundary at Iringa, and setting the levels for a new road. Match the right specialised survey to each task, with a reason.

Model Answer

Each task is matched to the specialised survey defined by its surface or its purpose.

1) **Dar es Salaam harbour, hydrographic survey:** because the work is on water and needs depths and the line of the coast, which is the field of hydrographic survey.
2) **Geita gold mine, mine survey:** because the workings are underground, which mine survey is designed to map.
3) **Iringa farm boundary, cadastral survey:** because the purpose is to fix a boundary for a land title, which is the object of cadastral survey, often carried out with a chain or compass.
4) **Road levels, levelling:** because the task is to determine heights along a line, which is the work of levelling.

So the surveyor reaches for a different method for each job, because the surface and the purpose decide the specialised survey required.

Question 43

Faced with a small, fairly flat plot at Dodoma and a simple kit, a surveyor decides to chain it rather than send for a theodolite. Outline the merits and the demerits of chain surveying.

Model Answer

Chain surveying is chosen for its simplicity and low cost, but it is limited to small, open and fairly level ground.

1) **Merit, simple and cheap:** the equipment is inexpensive and needs no skilled operator, so a small team can carry it out, as on the Dodoma plot.
2) **Merit, direct and checkable:** distances are measured directly, and the triangulation with a check line lets the work be proved on plotting.
3) **Demerit, slow and limited:** it is slow and suits only small areas; over large, rough, wooded or built-up ground the chaining is obstructed and the triangles cannot be laid well.
4) **Demerit, errors accumulate:** without the angular control of a compass or theodolite, errors build up over a long line, so chain survey is not used for precise or extensive work.

So chaining serves the small flat plot at Dodoma well, but the surveyor would turn to compass or theodolite survey for anything larger or rougher.

Question 44

Chaining a line towards the Ruvu river, a survey party reaches the water and cannot lay the chain across it. Classify the obstacles met in chaining, and show how the width of the river is found without chaining across it.

Model Answer

Obstacles in chaining are classified by whether they stop the chaining, the ranging, or both; a river stops the chaining but not the ranging, so its width is found by setting out a right-angled base on the near bank.

Obstacles to chaining only: such as a river or a pond, where the line can still be seen across but the chain cannot be laid.

Obstacles to ranging only: such as a low hill, where the chain can be laid but the far station cannot be seen over the top.

Obstacles to both: such as a building or a patch of forest, where neither the chain nor the line of sight can pass.

For the river, the line AB is to cross the water. A base AC is set out along the near bank at a right angle to AB, its length is measured, and the angle at C to the far point B is read; the width AB then follows from the right-angled triangle, so the chain never crosses the water.

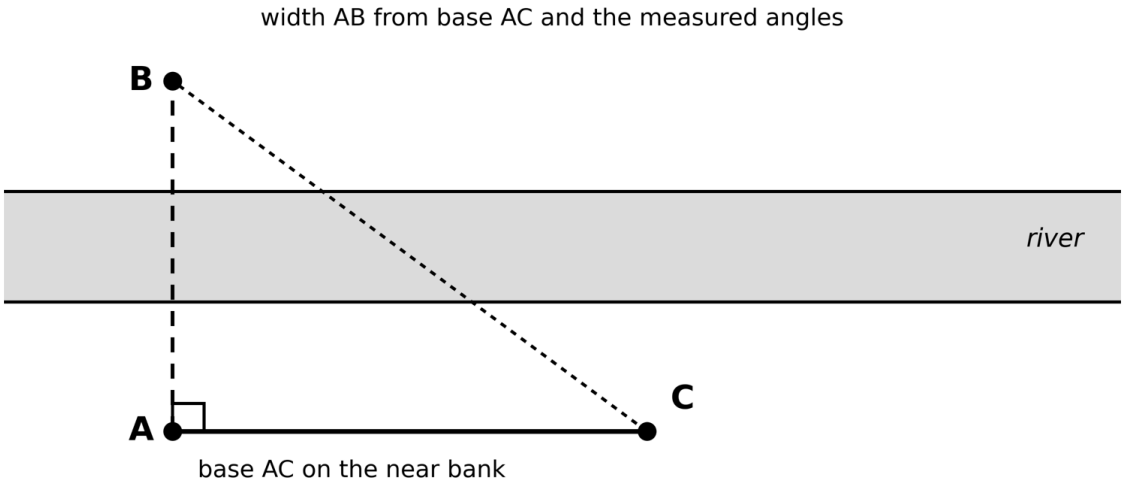


Figure 1.27: *Finding the width of a river without chaining across it*

Question 45

Before a single chain length is laid on a plot at Singida, an experienced surveyor spends the first hour walking the ground. Explain the preparations made before a chain survey begins.

Model Answer

Before chaining begins the surveyor prepares by reconnaissance, by choosing and marking the stations, and by drawing a reference sketch of the framework.

1) **Reconnaissance:** the surveyor walks over the whole plot to learn the ground, the obstacles and the best lines, so that the survey can be planned before any measuring.
2) **Selecting stations:** stations are placed so that they are intervisible and form well-conditioned triangles, with a long, clear line chosen as the base.
3) **Marking and sketching:** the stations are pegged and a reference or index sketch is drawn showing the framework and the main detail, to guide the chaining and the later plotting.

So the hour spent walking the Singida plot is not wasted; it fixes the framework and the plan of work, which makes the chaining that follows quick and reliable.

Question 46

A survey team runs an open traverse of four lines from station A near Manyoni. Line AB has a whole circle bearing of 45 degrees and a length of 400 m; line BC, 100 degrees and 300 m; line CD, 60 degrees and 450 m; and line DE, 80 degrees and 500 m. (a) Tabulate the lines with their fore and back bearings. (b) Plot the traverse to a scale of 1:10 000. (c) State the type of traverse, with a reason. (d) Give five causes of error in such a traverse and how each is reduced.

Model Answer

The back bearing of each line is found from the fore bearing, the traverse is plotted to scale, and because it ends at a different point it is an open traverse.

(a) Fore and back bearings: Each fore bearing here is below 180 degrees, so the back bearing is found by adding 180 degrees.

Working;

$$AB: BB = 45° + 180° = 225°$$

$$BC: BB = 100° + 180° = 280°$$

$$CD: BB = 60° + 180° = 240°$$

$$DE: BB = 80° + 180° = 260°$$

Line	Length (m)	Fore bearing	Back bearing
AB	400	45°	225°
BC	300	100°	280°
CD	450	60°	240°
DE	500	80°	260°

Back bearing = Fore bearing + 180° (open traverse A to E)

(b) Plot to scale: At a scale of 1:10 000, one centimetre represents 100 m, so each length is reduced before plotting.

Working:

$$AB = \frac{400 \text{ m}}{10\,000} = 4 \text{ cm at } 45°$$

$$DE = \frac{500 \text{ m}}{10\,000} = 5 \text{ cm at } 80°$$

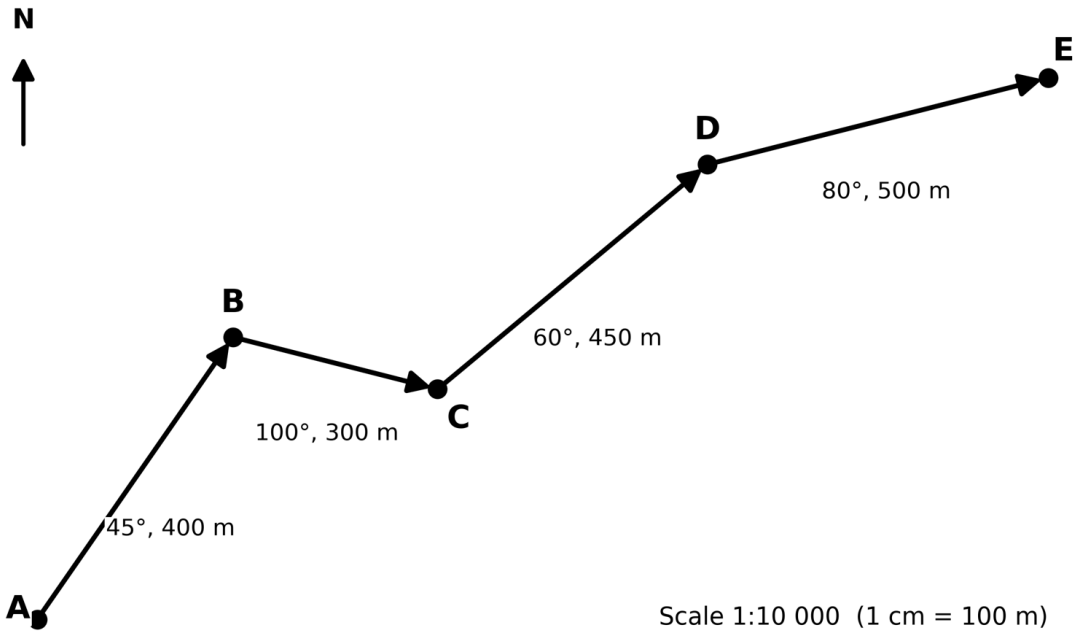


Figure 1.28: *The open traverse plotted to a scale of 1:10 000*

(c) Type of traverse: It is an open traverse, because the line of stations starts at A and ends at a different point E, without returning to close on itself.

(d) Five causes of error, and how each is reduced. Instrumental error, from a faulty or sluggish compass, reduced by testing the compass beforehand; personal error, from careless sighting or reading, reduced by repeating each reading; local attraction, from iron or magnetic rock, reduced by the fore-and-back-bearing check and by avoiding such ground; natural error, from wind shaking the needle, reduced by shielding the compass; and plotting error, from the protractor or scale, reduced by careful drawing and an independent check.

Question 47

A surveyor near Mafinga records the fore bearing of a line as 87 degrees and its back bearing as 263 degrees, yet the two should differ by exactly 180 degrees. (a) Correct the discrepancy. (b) State the importance of the back bearing.

Model Answer

The fore and back bearings differ by 176 degrees instead of 180, so there is a discrepancy of 4 degrees, which is shared equally to correct the line.

(a) The difference should be 180 degrees; the shortfall is shared between the two readings.

Working:

$$BB - FB = 263° - 87° = 176°$$

$$\text{Discrepancy} = 180° - 176° = 4°$$

$$\text{Corrected FB} = 87° - 2° = 85°$$

$$\text{Corrected BB} = 263° + 2° = 265°$$

Interpretation: The corrected bearings, 85 degrees and 265 degrees, now differ by exactly 180 degrees.

(b) The back bearing checks the fore bearing through the 180 degree test, so it exposes a reading error or local attraction, and it is also needed to carry the survey forward from the next station.

False Confidence Alert
The discrepancy is not corrected by trusting one reading and discarding the other. With no reason to prefer the fore or the back bearing, the 4 degree error is shared equally between them, so each is moved by 2 degrees to make the difference exactly 180 degrees.

Question 48

In a compass traverse PQRS near Nzega, the fore and back bearings of two lines fail the 180 degree test while one line passes it. Detect the station affected by local attraction and correct the bearings.

Model Answer

The line PQ passes the 180 degree test, so its stations are free; the other two lines fail, and the station common to both, R, is the one affected by local attraction.

Detect the affected station. For each line the difference between the back and fore bearings should be 180 degrees.

Working:

PQ: 304° - 124° = 180° (free)

QR: 251° - 68° = 183° (3° out)

RS: 330° - 153° = 177° (3° out)

PQ is free, so Q is free; both faulty lines QR and RS meet at R, so R carries the local attraction, and every bearing taken at R is in error by the same 3 degrees.

Correct the bearings at R. The bearings observed at R are brought back by 3 degrees.

Working:

QR: back bearing 251° - 3° = 248°

RS: fore bearing 153° - 3° = 150°

Line	FB obs	BB obs	BB - FB	Remark	Corrected
PQ	124°	304°	180°	free	124° / 304°
QR	68°	251°	183°	R affected	BB to 248°
RS	153°	330°	177°	R affected	FB to 150°

PQ checks, so Q is free; R is common to the faulty lines, so R is corrected by 3°

Question 49

A closed compass traverse ABCDA round a coffee estate at Mbozi does not quite close; a small gap remains when it is plotted. Explain how the closing error is adjusted by the Bowditch rule.

Model Answer

The Bowditch rule adjusts a closed traverse by distributing the closing error among the lines in proportion to their lengths, because the longer a line, the more error it is likely to carry.

Method:

$$\text{Correction to a line} = \text{closing error} \times \frac{\text{length of the line}}{\text{perimeter of the traverse}}$$

Take a closing error of 0.62 m on a traverse whose lines are AB 400 m, BC 300 m, CD 500 m and DA 350 m, so that the perimeter is 1 550 m. The correction to each line follows from the rule.

Working:

$$\text{AB: } 0.62\text{ m} \times \frac{400\text{ m}}{1550\text{ m}} = 0.16\text{ m}$$

$$\text{BC: } 0.62\text{ m} \times \frac{300\text{ m}}{1550\text{ m}} = 0.12\text{ m}$$

$$\text{CD: } 0.62\text{ m} \times \frac{500\text{ m}}{1550\text{ m}} = 0.20\text{ m}$$

$$\text{DA: } 0.62\text{ m} \times \frac{350\text{ m}}{1550\text{ m}} = 0.14\text{ m}$$

Interpretation: The four corrections add up to 0.62 m, the whole closing error, so applying them swings the traverse shut and the estate boundary plots as a closed figure.

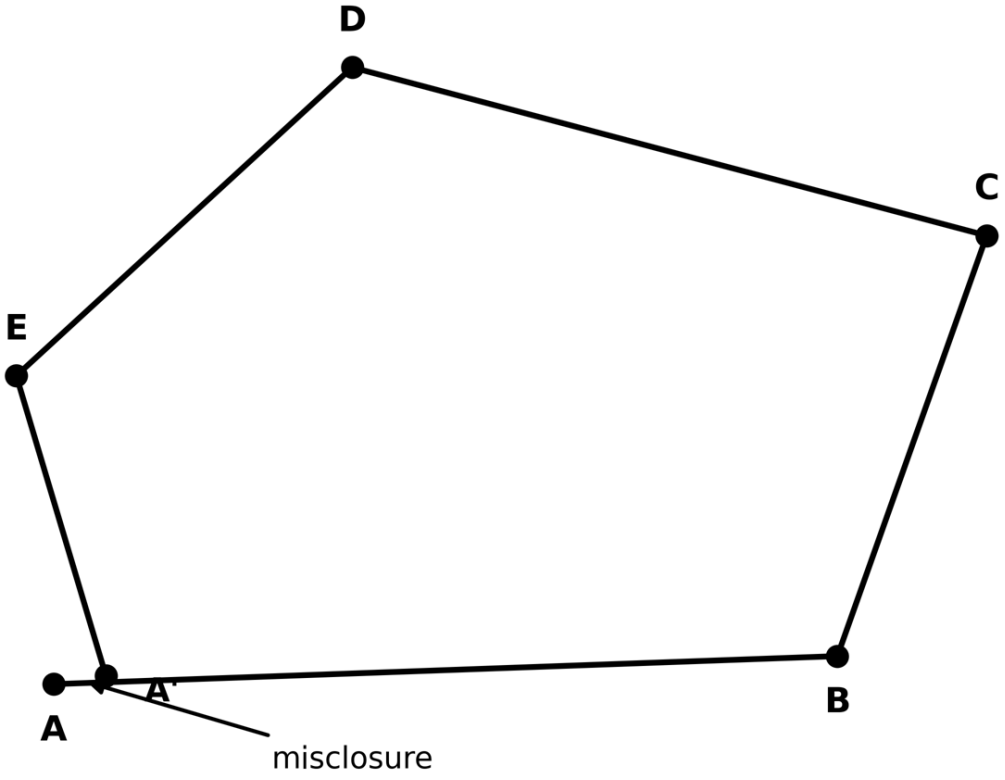


Figure 1.29: *The closing error of a closed traverse, adjusted by the Bowditch rule*

Question 50

From a hill near Mwanza a watcher sees smoke at a bearing of 45 degrees, and from a second hill another sees the same smoke at 315 degrees. Explain how the source of the smoke is fixed by intersection.

Model Answer

The smoke is fixed by intersection: a ray is drawn from each hill along the observed bearing, and the point where the two rays cross is the source, so no distance to the smoke is needed.

1) **Plot the two stations:** the two hills, whose positions are known, are plotted and joined by a base line to a suitable scale.
2) **Draw a ray from each:** from the first hill a ray is drawn at 45 degrees and from the second a ray at 315 degrees, each measured from north.
3) **Fix the source:** the point where the two rays intersect is the position of the smoke.

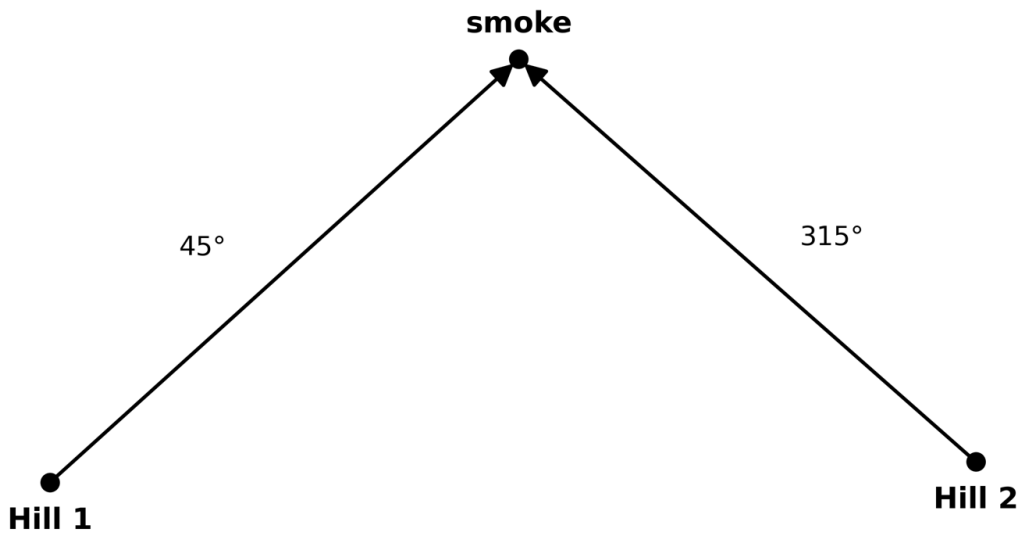


Figure 1.30: *Fixing the source of smoke by intersection from two hills*

So the fire is located from two distant hills without anyone approaching it, because two bearings to the same point cross at one place.

Question 51

A chart of a place near Tabora, drawn in June 2019, gives the magnetic variation as 3 degrees 30 minutes west and notes that it is increasing by 6 minutes each year. A survey line there has a true bearing of 210 degrees. Find the magnetic variation and the magnetic bearing of the line in June 2023.

Model Answer

The variation is brought up to date by adding the yearly change for the time elapsed, and the magnetic bearing then follows from the true bearing and the updated west variation.

Update the variation: From June 2019 to June 2023 is 4 years, so the change is added to the 2019 value.

Working:

$$\text{Change} = 4 \text{ years} \times 6' = 24'$$

$$\text{Variation in 2023} = 3° \, 30' + 24' = 3° \, 54' \text{ W}$$

Find the magnetic bearing: For a west variation the magnetic bearing is the true bearing plus the variation, since the compass reads to the west of true north.

Method:

$$\text{Magnetic bearing} = \text{True bearing} + \text{West variation}$$

Working:

$$\text{Magnetic bearing} = 210° + 3° \, 54' = 213° \, 54'$$

Interpretation: So in June 2023 the variation is 3 degrees 54 minutes west and the line reads 213 degrees 54 minutes on the compass, even though its true bearing is unchanged at 210 degrees.

Question 52

Reviewing a compass survey carried out near Singida, a supervisor lists what could have gone wrong and weighs the method against others. Explain how errors are avoided in compass surveying, and assess its advantages and disadvantages.

Model Answer

Errors in compass survey are avoided chiefly by checking every line and by keeping iron away from the needle, and the method is valued for speed but limited by local attraction.

Avoiding errors: check every reading with its back bearing, hold the compass steady and level, keep clear of iron, steel and electric lines, and avoid metal spectacles or a steel tape near the instrument.

Advantages: it is rapid in the field, it can be checked line by line through the back bearing, and it suits larger and rougher ground than the chain alone.

Disadvantages: it is less accurate than the theodolite, and it is unreliable wherever local attraction from iron or magnetic rock deflects the needle.

So a careful surveyor at Singida keeps the compass clear of iron and checks each line, accepting the method's modest accuracy in return for its speed.

Question 53

Appointed to lead a plane-table survey of a small farm at Kilosa whose five corners are all visible from one central point, you must show your team the equipment and the procedure. Set out the equipment to be used and the steps you would follow to complete the survey.

Model Answer

The farm is surveyed by the radiation method, since every corner is visible from one station, and the work needs the plane table and its usual accessories.

Equipment: the plane table and tripod, the alidade for sighting and drawing rays, the trough compass for orientation, the U-fork and plumb bob for centring, the spirit level for levelling, and a tape for the distances.

1) **Set up at the central station:** centre the table over the station with the U-fork and plumb bob, level it with the spirit level, and orient it with the trough compass, marking the station on the sheet.
2) **Radiate to each corner:** lay the alidade on the plotted station, sight each corner in turn, draw its ray, measure the ground distance and scale it along the ray.
3) **Complete the plan:** join the fixed corners to give the boundary, and add the scale and the north point.

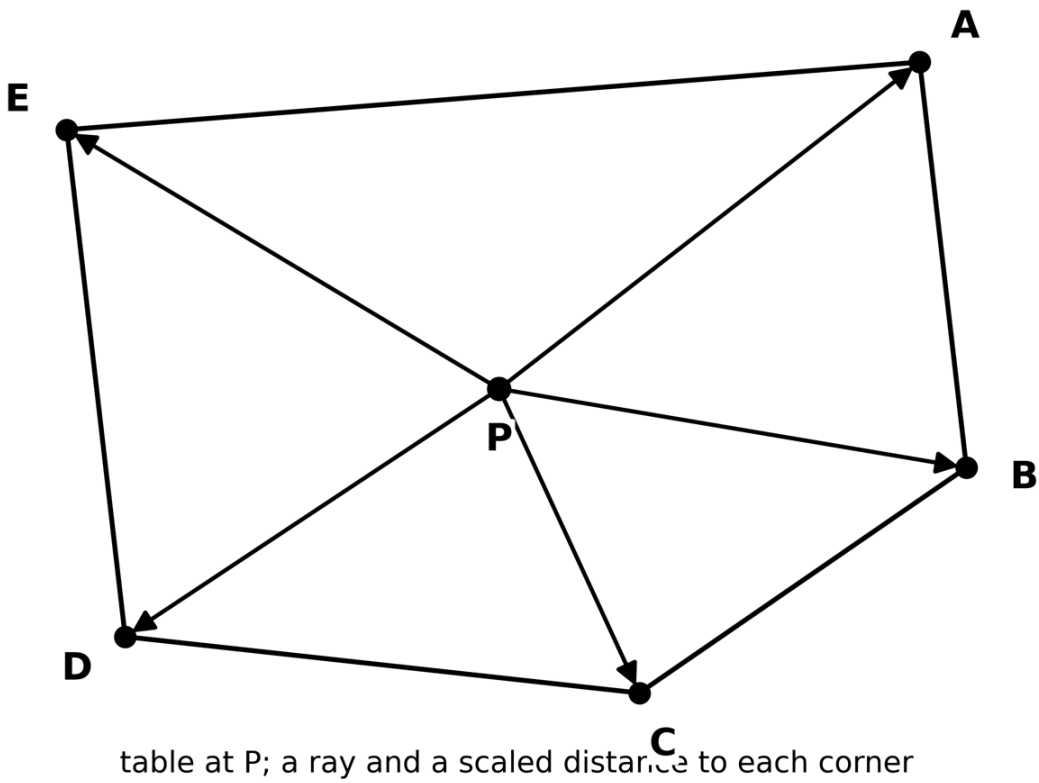


Figure 1.31: *Surveying the farm by radiation from a central station*

So the Kilosa farm is mapped from one set-up, because the radiation method suits corners that are all visible from a single point.

Question 54

On one job at Babati the boundary marks are visible from a single station; on another at Hanang they are not. Choose the plane-table method for each, and justify your choice.

Model Answer

The Babati boundary, visible from one station, is surveyed by radiation, while the Hanang boundary, not so visible, is surveyed by traverse.

Babati, radiation: because all the marks are visible from one point, a single set-up with a ray and a scaled distance to each mark fixes the whole boundary.

Hanang, traverse: because the marks cannot all be seen at once, the table is carried from station to station round the boundary, each line being drawn and scaled and the table oriented by back-sighting.

So the visibility of the marks decides the method: radiation from one station where all are seen, traverse round the boundary where they are not.

Question 55

Setting a plane table near an iron-roofed store at Shinyanga, a surveyor finds the trough compass unreliable. Explain why, and decide how the table should be oriented there.

Model Answer

Near iron the trough compass is unreliable because the needle is pulled aside by local attraction, so the table should be oriented by back-sighting instead.

Why the compass fails: the iron roof deflects the magnetic needle, so orienting the table to the needle would set it in a false direction and break the parallelism between the sheet and the ground.

Orient by back-sighting: lay the alidade along an already-plotted line and turn the table until it sights the previous station, which fixes the orientation by the survey itself and not by the disturbed needle.

So at the Shinyanga store the surveyor trusts the back-sight, not the compass, to orient the table, because iron makes the needle a false guide.

Question 56

A levelling run near Dodoma starts from a bench mark of reduced level 100.00 m and gives the staff readings in the table below. Reduce them by the rise-and-fall method and by the height-of-collimation method, and prove each by its check.

Station	BS (m)	IS (m)	FS (m)	Remarks
BM	1.50			Bench mark, RL 100.00 m
A		2.30		
B		0.90		
C	2.40		1.20	Change point
D		1.60		
E			2.00	Last point

Model Answer

Both methods carry the reduced level from the bench mark through the run; the rise-and-fall method works from the difference between successive readings, and the height-of-collimation method from the height of the line of sight.

Rise-and-fall method. Each reading is subtracted from the one before it on the same set-up, and the reduced level is carried forward by the rise or the fall.

Station	BS	IS	FS	Rise	Fall	RL (m)	Remarks
BM	1.50					100.00	Bench mark
A		2.30			0.80	99.20	
B		0.90		1.40		100.60	
C	2.40		1.20		0.30	100.30	Change point
D		1.60		0.80		101.10	
E			2.00		0.40	100.70	Last point

Working:

$$\text{Sum of BS} - \text{Sum of FS} = 3.90 - 3.20 = 0.70$$

$$\text{Sum of Rise} - \text{Sum of Fall} = 2.20 - 1.50 = 0.70$$

$$RL_{last} - RL_{first} = 100.70 - 100.00 = 0.70$$

Height-of-collimation method. The height of collimation is the reduced level plus the back sight at each set-up, and every other point is the height of collimation minus its reading.

Working:

HC (first set-up) = 100.00 + 1.50 = 101.50

RL of A = 101.50 - 2.30 = 99.20

HC (second set-up) = 100.30 + 2.40 = 102.70

RL of D = 102.70 - 1.60 = 101.10

Working:

Check: Sum of BS - Sum of FS = $RL_{last} - RL_{first} = 0.70$

Station	BS	IS	FS	HC (m)	RL (m)	Remarks
BM	1.50			101.50	100.00	Bench mark
A		2.30			99.20	
B		0.90			100.60	
C	2.40		1.20	102.70	100.30	Change point
D		1.60			101.10	
E			2.00		100.70	Last point

Interpretation: Both methods give the same reduced levels and the same closing difference of 0.70 m, so the ground rises 0.70 m from the bench mark to the last point and the reduction is correct.

Question 57

A class at Karatu takes a levelling staff to a point A of known height 645.00 m above the datum, reads 5.50 m on it, and then reads 2.40 m, 1.60 m and 2.00 m on points B, C and D from the same set-up. State the reduced level of B, C and D.

Model Answer

The reading at A fixes the height of the line of sight, and the reduced level of each other point is that height less its own reading.

Method:

Height of collimation = RL of A + reading at A

Working:

Height of collimation = 645.00 m + 5.50 m = 650.50 m

Method:

RL of a point = Height of collimation - reading at the point

Working:

RL of B = 650.50 m - 2.40 m = 648.10 m

RL of C = 650.50 m - 1.60 m = 648.90 m

$$\text{RL of D} = 650.50 \text{ m} - 2.00 \text{ m} = 648.50 \text{ m}$$

B, C and D stand at 648.10 m, 648.90 m and 648.50 m above the datum; the larger the staff reading, the lower the point beneath the one line of sight.

Question 58

A profile levelling along a proposed pipe line at Iringa gives the reduced levels of six points A to F, pegged at 14 m intervals, with A at 100.00 m and F at 100.70 m. Draw the idea of the profile and find the average gradient of the ground from A to F.

Model Answer

The profile is the line of reduced levels along the route, and the average gradient from A to F is the rise between them divided by the distance between them.

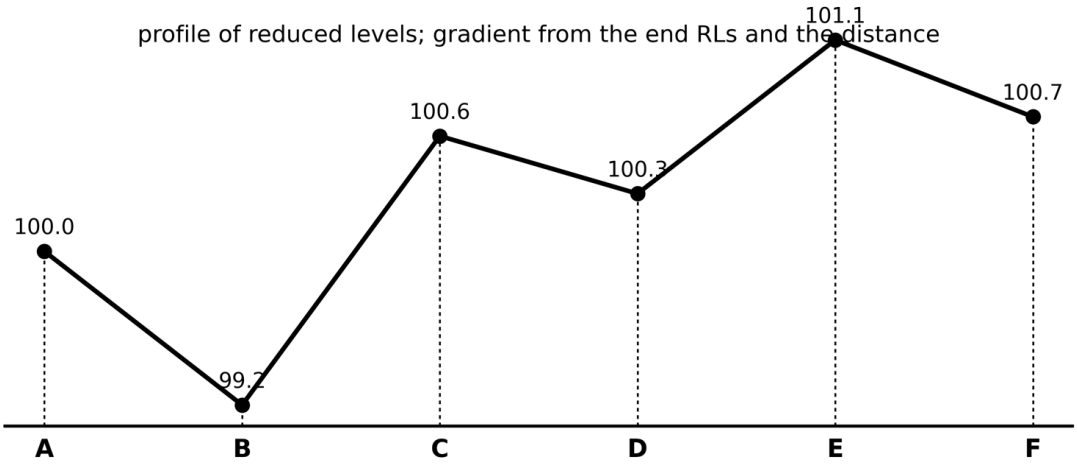


Figure 1.32: *The profile of reduced levels, from which the gradient is found*

Method:

$$\text{Gradient} = \frac{\text{Vertical interval}}{\text{Horizontal distance}}$$

Working:

$$\text{Vertical interval} = 100.70 \text{ m} - 100.00 \text{ m} = 0.70 \text{ m}$$

$$\text{Horizontal distance} = 5 \times 14 \text{ m} = 70 \text{ m}$$

$$\text{Gradient} = \frac{0.70 \text{ m}}{70 \text{ m}} = \frac{1}{100}$$

So the ground rises on average 1 m in every 100 m from A to F, a gentle slope of 1 in 100, which the pipe line can be designed to follow.

Question 59

After a long levelling line near Mufindi closes with a larger error than expected, the team asks how the work could have been kept truer. Suggest six ways in which errors are minimised in levelling.

Model Answer

Levelling errors are minimised mainly by balancing the sights and by careful handling of the level and staff.

1) **Keep back and fore sights equal:** setting the level midway between the staff positions cancels the collimation error and the effect of curvature and refraction.

2) **Hold the staff vertical:** the staff is kept plumb, by a bubble or by waving it and taking the lowest reading, so that it gives the true vertical height.
3) **Avoid very long sights:** short sights keep the staff graduations clear and reduce reading error.
4) **Remove parallax and read carefully:** focus the eyepiece and the staff so image and cross hairs coincide, and read and book each value at once.
5) **Guard against settlement:** set the level and the change points on firm ground so neither sinks between the back sight and the fore sight.
6) **Close on a known bench mark:** run the line back to a bench mark of known level so that any closing error is found and the work can be checked.

So the Mufindi team balances its sights, keeps the staff plumb and closes on a known mark, which together would have held the closing error down.

HOT QUESTIONS

Question 60

A young surveyor argues that the chain, the compass and the level belong in a museum, because a satellite receiver now reads a position in seconds. Assess whether the basic surveying skills still matter.

Model Answer

The basic surveying skills still matter, because satellite positioning depends on the same principles and must be understood and checked by them.

It is true that a GNSS receiver is fast and accurate, fixes position without a cleared line between stations, and carries control across great distances, so for open country it has largely replaced the chain and the compass.

Yet the receiver needs a clear view of the sky, so it fails under a forest canopy, in a deep valley or indoors, where the surveyor must fall back on compass, chain and level; and its results have to be checked against ground marks and understood in terms of bearings, levels and error, which only the basic skills teach.

So the basic methods are not obsolete but foundational: in the miombo woodland of Tabora, where the canopy blocks the signal, the surveyor still reaches for the compass, and everywhere the satellite fix is trusted only because the principles behind it are understood.

Question 61

Land surveying is called at once a science, an art and a technology. Evaluate which of the three dominates.

Model Answer

All three are essential, but the science dominates, because it is the measurement and geometry that make a survey trustworthy rather than a sketch.

The science gives repeatable, checkable measurement of distance and angle, from which positions are computed and proved; this is what separates a survey from a guess, and the art and the technology exist to serve it.

Yet the science cannot be applied without the art of judging where to place stations and how to pass an obstacle, nor without the technology of the instruments that capture the measurements, so in practice the three are inseparable.

So the science dominates as the foundation that makes the result reliable, but a surveyor at Dodoma who lacked the art or the instruments could not turn that science into a plan, which is why the definition keeps all three.

Question 62

Because the earth is a sphere, a student insists that plane surveying is always wrong. To what extent is this claim true?

Model Answer

The claim is true in principle but wrong in practice for small areas, because the curvature error is negligible below a limiting size.

In principle the student is right that the earth is curved, so treating its surface as flat must introduce some error into a survey.

In practice, however, over a small area that error is smaller than the measurement itself, so it is safely ignored; plane survey is justified while Area $< 250\ km^2$, and only above that size does the curvature become significant and geodetic methods are required.

So plane surveying is not wrong; it is a sound approximation within its limit. The half-acre plot in Morogoro is rightly surveyed as a plane, while a framework over the whole Lake Victoria basin must be geodetic.

Question 63

If geodetic methods are the most accurate, a planner asks why every survey does not simply use them. Assess the trade-off between accuracy and cost.

Model Answer

The accuracy of a survey is chosen to fit its purpose, because higher accuracy is bought with more time, money and skill than most jobs need.

Geodetic precision demands costly instruments, careful procedure and heavy computation, which are justified for a national framework but wasteful for an ordinary plot.

A farm boundary at Iringa does not need national-grid accuracy; to survey it geodetically would spend resources for no gain, while to survey a national framework by plane methods would fail the purpose, so the level of accuracy is matched to the use.

So the planner does not maximise accuracy but fits it to purpose: enough to serve the job, not more than the job is worth.

Question 64

A contractor wants one cheap survey method for every job. Assess when chain surveying is the right choice and when it fails.

Model Answer

Chain surveying is the right choice only for small, flat, open areas, and it fails on large, rough, obstructed or precise work.

On a small level plot it is cheap, simple and direct, and the triangulation with a check line lets the work be proved, so it serves a town plot at Dodoma well.

But where buildings, water or bush obstruct the lines the triangles cannot be laid; over a long line the errors accumulate for want of angular control; and where high accuracy is needed the chain cannot give it, so the method fails on anything large, rough or exact.

So the contractor cannot use one method for every job: chaining is the right tool only within its narrow range, and compass, plane-table or theodolite survey takes over beyond it.

Question 65

A traverse will not close. One surveyor reaches at once for the local-attraction correction, another for the Bowditch rule. Assess which is appropriate, and why the choice depends on the cause.

Model Answer

The right correction depends on the cause of the error: the local-attraction correction for bearings disturbed by iron, the Bowditch rule for the general misclosure of a closed traverse.

The local-attraction correction works on the bearings of the stations that the fore-and-back-bearing test shows to be affected, and it applies to open or closed traverses; the Bowditch rule, by contrast, distributes the linear misclosure of a closed traverse among its lines in proportion to their length.

So if the error comes from iron near one station, applying Bowditch would wrongly smear that local fault across every line; and if the error is a general misclosure with no local attraction, the local-attraction correction has nothing to grip.

So the surveyor must first diagnose the cause with the 180 degree test, then choose: correct the affected station for local attraction, or adjust the whole circuit by Bowditch, never reaching for one rule by habit.

Question 66

Pressed for time, a surveyor plots his magnetic bearings straight onto a national map without applying the declination. Assess the consequence of this shortcut.

Model Answer

Ignoring the declination rotates the whole survey off true north by the declination angle, so it will not fit a map drawn to true north.

The compass reads magnetic north, which differs from true north by the declination, so the true bearing must be recovered from True bearing = Magnetic bearing + Magnetic declination before the survey is plotted on a true-north map.

On a small, isolated plan that is never tied to true north, the uncorrected bearings might pass; but the moment the work is fitted to a national map or grid, every line is wrong by the declination and the survey will not register.

So the shortcut is false economy: the declination must be applied whenever the survey meets true north, or the plan, however neatly drawn, will not fit the map of Tanzania.

Question 67

To fix a point in the field, a surveyor must choose between traverse, intersection and resection. Explain how the situation, not the surveyor's preference, decides which method is used.

Model Answer

The method is decided by what is known and what can be reached: traverse to carry a position along a route, intersection to fix a point that cannot be reached, and resection to fix one's own unknown position.

1) **Traverse:** when the survey must run a connected line of stations, as along a road or a boundary, each bearing and distance carrying the position forward.
2) **Intersection:** when the point is visible but cannot be reached to measure a distance, as with an island or a column of smoke, so it is fixed by two bearings from known stations.
3) **Resection:** when the surveyor stands at an unknown point but can see several known points, and works back to fix the station itself.

So at a site near Mwanza the geometry of the problem chooses the method: a route calls for a traverse, an unreachable point for intersection, an unknown station for resection.

Question 68

Two field parties fix points by plane table, one by radiation and one by intersection. Compare the two methods and judge when each is preferred.

Model Answer

Both fix points from the table, but radiation measures a distance along each ray while intersection needs none, so intersection suits points that cannot be reached.

In radiation a single station is set, and each point is fixed by a ray and a measured, scaled distance, which is quick where the points are close and reachable; in intersection two stations on a measured base are used, and each point is fixed where its two rays cross, needing no distance to the point itself.

So radiation is preferred where every point is visible and its distance can be measured, as on a small farm at Mufindi, while intersection is preferred where the point cannot be reached, such as a building across a creek at Mwanza.

Question 69

In a resection the three rays often meet not at a single point but in a small triangle. Reason out what this triangle of error means and how the surveyor should respond.

Model Answer

The triangle of error means the table is not correctly oriented, not that the measurements are wrong, so the response is to re-orient, not to average.

With the table correctly oriented the three rays from the known points meet at one place, the station; a slight error in orientation throws each ray aside by a little, and the three then enclose a small triangle instead of meeting.

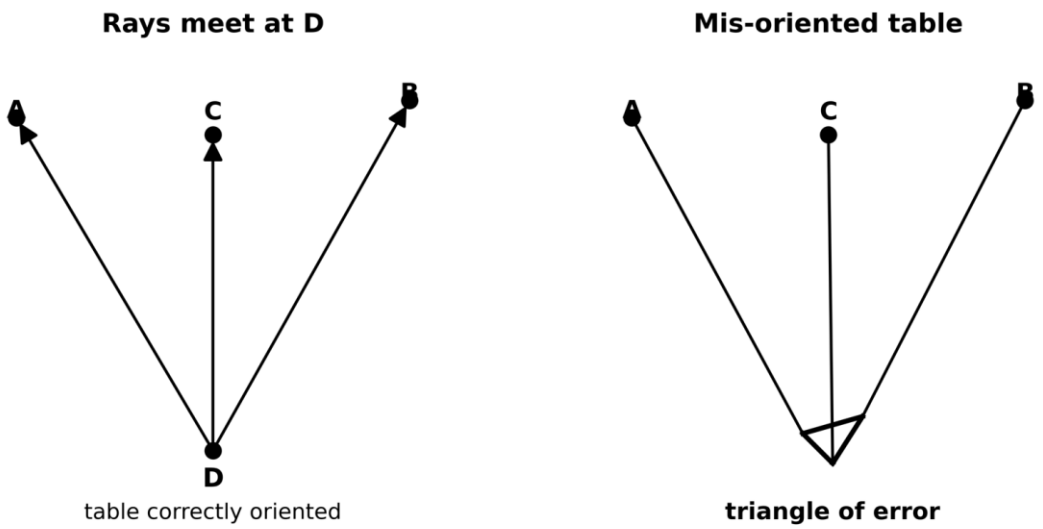


Figure 1.35: *A triangle of error: the rays of a mis-oriented table fail to meet at one point*

The surveyor responds by adjusting the orientation, by trial or by Bessel's method, and redrawing the rays until the triangle shrinks to a point; the size of the triangle shows how far the orientation is out.

So the triangle is read as a diagnostic of orientation; a surveyor on a hill at Mbeya clears it by turning the table a little and trying again, until the rays close on the point.

Question 70

Plane tabling is heavy to carry, useless in wind and rain, and ruined by a single error in the base line. Evaluate whether it is still worth using.

Model Answer

Despite its drawbacks plane tabling is still worth using for small surveys where a plan is wanted on the spot, because plotting in the field prevents omissions and needs little computation.

Its strengths are real: the plan is drawn as the ground is measured, so features are rarely left out, the skills needed are simple, and no separate booking or office computation is required.

But its weight makes it awkward to move, wind and rain stop the work and spoil the sheet, and because the whole survey hangs on the base line, one error there distorts the entire plan, so it cannot be trusted for large or precise jobs.

So plane tabling is worth using within its niche, a small, fair-weather survey such as updating a school plan at Korogwe, but the surveyor turns to other methods for large, wet or exact work.

Question 71

A level book can be reduced by the rise-and-fall method or by the height-of-collimation method. Judge which is better, and on what the choice depends.

Model Answer

The rise-and-fall method is the safer choice for important work, because its check tests every reading, while the height-of-collimation method is faster but checks only the back and fore sights.

The height-of-collimation method is quicker, with less arithmetic, and is convenient where there are many intermediate sights; the rise-and-fall method is slower but reduces every reading against the one before it.

The difference lies in the check. The height-of-collimation check, Sum of BS - Sum of FS = RL_{last} - RL_{first}, does not test the intermediate sights at all, whereas the rise-and-fall check, Sum of BS - Sum of FS = Sum of Rise - Sum of Fall, tests every reading, so it catches a mistake the other would miss.

So for a road or canal survey near Kilosa, where accuracy matters, the rise-and-fall method is preferred for its full check, while the height-of-collimation method is chosen for speed where intermediate sights are many and the work is less critical.

Question 72

Levelling can look like a narrow office skill. Assess how much it really matters in everyday Tanzanian life.

Model Answer

Levelling matters greatly, because the success of drainage, roads, canals, water supply and building all turns on knowing relative heights.

1) **Water that must flow:** an irrigation canal at Kilombero or a water pipe must fall steadily in the right direction, which only levelling can set.
2) **Roads and railways:** need gentle, even gradients for safety and drainage, fixed by levelling along the line.
3) **Building and drainage:** floors must be level and storm water must run away, so heights are set out by the level.
4) **Planning the land:** contour maps, drawn from levelled spot heights, guide where to place fields, dams and settlements.

So levelling is a quiet but decisive skill behind much of development: wherever water must flow or a surface must sit true, a levelling result lies underneath the decision.

Question 73

A careful surveyor near Mufindi always sets the level midway between the two staff stations and always closes the line back on a known bench mark. Evaluate why these two precautions matter.

Model Answer

Balancing the sights and closing on a bench mark are the two precautions that keep levelling true, because the first cancels the systematic errors and the second proves the work.

Setting the level midway makes the back-sight and fore-sight distances equal, so that any collimation error, and the effects of the earth's curvature and refraction, cancel between the two readings instead of biasing the result.

Closing the line back on a bench mark of known reduced level reveals any error that has accumulated along the run, for the line should return to the known value; a gap is the closing error, to be checked and distributed.

So the two precautions work together: balancing removes the systematic error at each set-up, and closing on a known mark proves that nothing has gone wrong along the way, which is why the careful surveyor never omits them.

Chapter 2

GEOGRAPHICAL RESEARCH

Geographical research is the disciplined way a geographer turns a question about the land and its people into a tested answer. This chapter follows that work from end to end: deciding what is worth studying and stating it as a research problem, planning the study in a proposal, choosing variables and the right kind of data, drawing a representative sample, collecting the data with the proper tool, and reporting the findings. The chapter runs in three tiers and is best worked in order.

BINDER QUESTIONS

Question 1

A Form Five student in Dodoma notices that boreholes in one ward dry up faster than in the next and wants to find out why. Explain what geographical research is and why it must be carried out systematically.

Model Answer

Geographical research is a systematic search for knowledge about the earth and human-environment relationships in order to discover the truth.

1) **Systematic search:** it follows ordered steps from defining a problem to writing a report, so the findings can be trusted rather than guessed.
2) **Real-world data:** it collects evidence from the actual environment, such as measuring water levels across the Dodoma ward, not from opinion alone.
3) **Purpose driven:** it sets out to explain, describe or predict a phenomenon, so the borehole question is answered with reasons.
4) **Verifiable:** because every step is recorded, another researcher can repeat the study and reach the same conclusion.

So research is carried out systematically because only an ordered, recorded procedure yields evidence that others can check, as in the Dodoma groundwater study.

Question 2

Researchers studying soil erosion on the slopes of Kilimanjaro leave the laboratory and work on the actual hillsides. Explain field research and the main methods it uses.

Model Answer

Field research is the study of geographical phenomena in their natural setting rather than in a laboratory or classroom.

1) **Observation:** watching events as they happen in the natural setting, such as recording gully growth on the Kilimanjaro slopes.
2) **Archival study:** drawing on existing records, such as past rainfall data, to support the field evidence.
3) **Field experiment:** testing a relationship in the field, for example fencing one plot to compare its erosion with an open plot.
4) **Survey:** asking farmers questions about their land use to gather data on actions and attitudes.

So field research draws first-hand evidence from the real environment, which is why it suits a problem like hillside erosion.

Question 3

A district education officer rejects a study because, he says, anyone repeating it would reach a different answer. Explain the qualities that make geographical research good.

Model Answer

Good research meets established scientific criteria so that its findings can be trusted.

1) **Systematic:** it follows clear, ordered steps from problem to report.
2) **Empirical:** its conclusions rest on real evidence that is collected and observed, not on opinion.
3) **Replicable:** another researcher using the same methods reaches the same result, which answers the officer's complaint.
4) **Objective:** it avoids bias, drawing conclusions only from the available evidence.
5) **Logical:** it reasons soundly, using both induction and deduction.
6) **Generalisable:** a well drawn sample allows the conclusions to extend to the wider population.

So research is judged good when it is systematic, empirical and above all replicable, as a study of maize yields in Iringa should be.

Question 4

Before any formal study, farmers in a Sukuma village already know which season to plant. Account for the main sources from which human beings acquire knowledge.

Model Answer

People acquire knowledge mainly from authority, tradition and experience.

1) **Authority:** knowledge taken from a trusted source such as a teacher, parent, expert, book or website.
2) **Tradition:** knowledge handed down through culture, such as Sukuma planting calendars learned from forefathers.
3) **Experience:** knowledge gained from one's own encounters and problem solving over time.

So research builds on these everyday sources but tests them against evidence, which is why traditional planting wisdom can later be verified scientifically.

Question 5

Two students argue: one trusts only what she can see and measure, while the other trusts reasoned argument. Distinguish the approaches used in acquiring knowledge.

Model Answer

Knowledge is acquired through three approaches: empiricism, rationalism and fideism.

1) **Empiricism:** it relies on the senses, so we link falling temperature to rising altitude by observing it on Mount Kilimanjaro.
2) **Rationalism:** it relies on reasoned mental links, such as concluding that good farm management should raise yields.
3) **Fideism:** it relies on belief and emotion, such as knowledge accepted from religious teaching.

So the first student is an empiricist and the second a rationalist, and research leans mainly on empiricism because its evidence can be tested.

Question 6

An agricultural officer asks why anyone should spend money studying a cassava pest that farmers already complain about. Explain the purposes of doing geographical research.

Model Answer

Research is done to generate and validate knowledge, and it serves four main purposes.

1) **To gain familiarity:** to obtain fresh insight into a phenomenon, such as a newly arrived cassava pest.

2) **To describe:** to set out accurately the characteristics of a situation, group or place.
3) **To determine frequency:** to find how often something occurs, such as the rate of pest outbreaks.
4) **To test relationships:** to test a hypothesis or cause-and-effect link between variables, so that theories can be built.

So studying the cassava pest is worthwhile because it turns farmers' complaints in the cassava fields of Mtwara into tested knowledge that guides control measures.

Question 7

Studying flood impacts in Kilosa, one researcher records how people feel while another counts the damaged houses. Distinguish qualitative from quantitative research.

Model Answer

The two differ in the kind of data they use.

Qualitative research: it deals with non-numerical data such as opinions and feelings, gathered by observation and interview, and it describes characteristics.

Quantitative research: it deals with numerical data such as the number of damaged houses, and it makes inferences from a sample to a population.

Analysis: qualitative data are described in words, while quantitative data are counted and analysed statistically.

So in the Kilosa flood study the feelings are qualitative and the house counts quantitative, and using both gives the fuller picture.

False Confidence Alert
Numbers are not automatically more scientific. Qualitative data on people's experience are valid evidence; the better choice depends on the research question, not on whether the data can be counted.

Question 8

A researcher on water access in Singida fears that numbers alone will hide people's real struggles. Explain mixed methods research and why it is used.

Model Answer

Mixed methods research combines qualitative and quantitative data in a single study.

It collects numbers, such as the distance to the nearest water point, together with words, such as users' accounts of their daily struggle. It is used to cross-check results, so that a weakness in one type of data is covered by the other, and it shows both the scale of a problem and its human meaning.

So a Singida water study that uses both counts and interviews is more convincing than either kind of data on its own.

Question 9

One scientist studies why rivers meander, while another designs bank protection for the Pangani. Distinguish basic from applied research.

Model Answer

They differ in their aim and in the use of their findings.

Basic (pure) research: it seeks fundamental truths or principles, such as why rivers meander, and its findings are general and widely applicable.

Applied (action) research: it seeks new uses of knowledge to solve a practical problem, such as protecting the Pangani bank, and its findings serve those who face that problem.

Relationship: applied research draws on the principles that basic research first discovers.

So the meander study is basic and the bank-protection design is applied, and the second depends on the first.

Question 10

To track the shrinking ice on Kilimanjaro, one team returns every few years, while another visits many glaciers once. Distinguish longitudinal from cross-sectional research.

Model Answer

They differ in how data are collected over time.

Longitudinal research: it studies the same site at intervals over time to establish change, such as repeated surveys of Kilimanjaro's ice cap.

Cross-sectional research: it collects data at one point in time from several sites, giving a snapshot.

Use: longitudinal research suits trends and history, while cross-sectional research suits a quick current picture.

So the repeat glacier survey is longitudinal, while visiting many glaciers once is cross-sectional.

Question 11

A geography club lists many study designs and becomes confused. Using the basis of objective perspective, explain the main types of geographical research.

Model Answer

By objective perspective, research is grouped into four main types.

1) **Descriptive:** it explains the conditions of variables as they are found, and it includes observational, survey and case-study research.
2) **Correlational:** it finds the extent to which two or more variables are associated.
3) **Explanatory:** it gives the reasons and mechanisms behind a relationship.
4) **Exploratory:** it investigates a situation that is little understood.

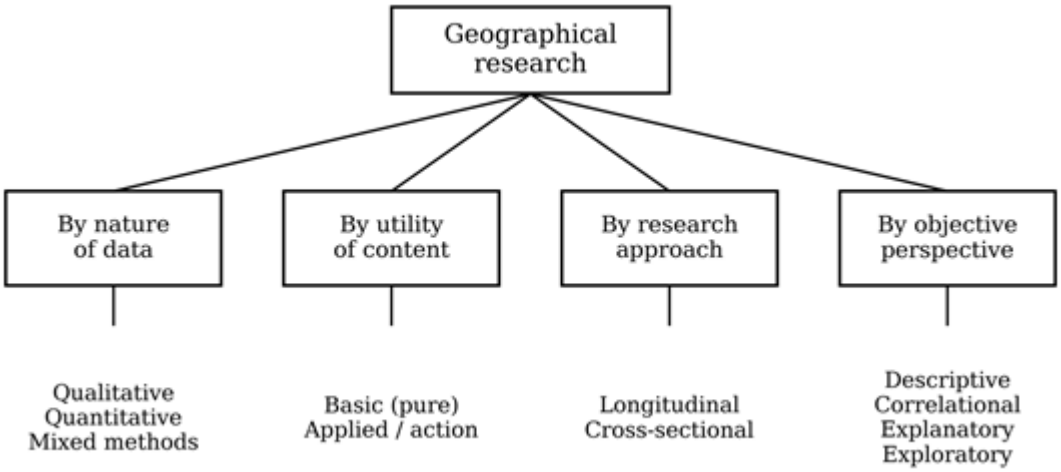


Figure 2.1: *Types of geographical research*

So a study of rainfall and crop yield in Mbeya would be correlational, while asking why the link exists would be explanatory (Figure 2.1).

False Confidence Alert
A correlation is not an explanation. Finding that rainfall and yield rise together is correlational research; it does not say why, and treating the link itself as the reason is a common error.

Question 12

A regional planner in Mwanza asks how research helps anyone beyond the university. Account for the importance of geographical research.

Model Answer

Research matters because it produces knowledge that guides decisions.

1) **Solving problems:** it studies real issues and proposes evidence-based solutions.
2) **Verifying knowledge:** it provides a way to check what we think we already know.
3) **Planning and policy:** it gives government a sound basis for plans and policies, such as siting markets or roads in Mwanza.
4) **Improving sectors:** it improves practice in farming, trade, services and the environment.
5) **Understanding the world:** it widens understanding of phenomena such as climate change and its effects.

So research serves the Mwanza planner directly, because good decisions rest on tested evidence.

Question 13

A first-time researcher in Morogoro does not know where a study begins or ends. State and explain, in order, the stages of the geographical research process.

Model Answer

Research follows ordered stages from problem to report.

1) **Background and problem:** identify the issue and state the research problem.
2) **Objectives and hypotheses:** set what the study will achieve and the relationships to be tested.
3) **Literature review:** read related work to locate the gap.
4) **Research design:** plan how the study will be carried out.
5) **Sampling:** choose a representative sample from the population.
6) **Data collection:** gather the data in the field.
7) **Data analysis:** organise, analyse and interpret the data.
8) **Report writing:** present the findings, conclusions and recommendations.

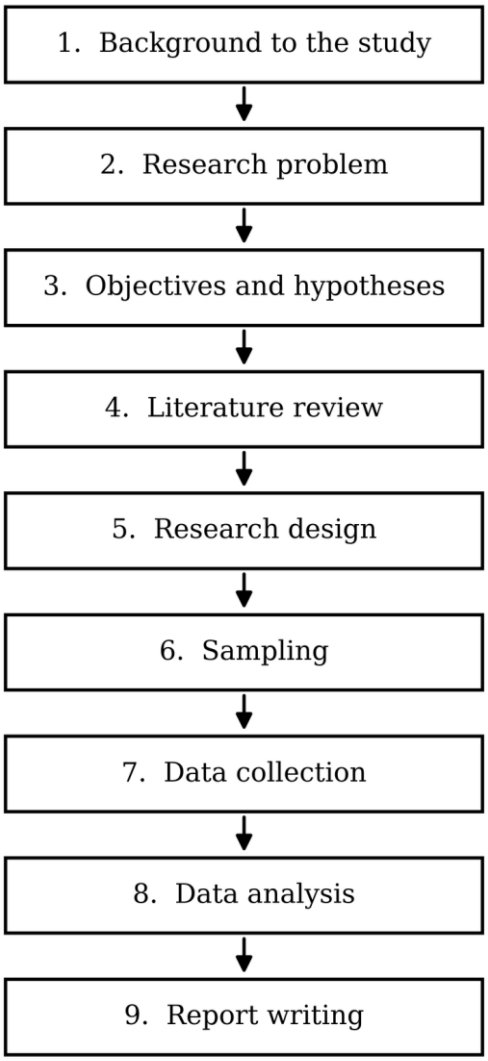


Figure 2.2: *The geographical research process*

So a Morogoro land-use study moves step by step from a clear problem to a written report (Figure 2.2).

Question 14

An examiner says a student's study jumps straight to the problem with no context. Explain what the background to a study should contain.

Model Answer

The background sets the scene and leads the reader to the gap.

1) **Funnel from global to local:** it describes the phenomenon at world, regional and Tanzanian levels, down to the study area.
2) **Extent of the issue:** it shows the size of the problem with figures, such as the share of households without safe water.
3) **Causes and measures:** it notes the causes and any laws or programmes already in place.
4) **Known and unknown:** it states what is already documented and what is not, which becomes the gap.

So a background on water scarcity moves from the world to the specific ward before naming the gap the study will fill.

Question 15

Before collecting any data on tourism in Arusha, a researcher first draws up a plan. Explain what a research design is and why it is prepared.

Model Answer

A research design is the overall plan for conducting a study.

It is the conceptual structure that guides sampling, data collection, analysis and reporting. It is prepared so that the work runs smoothly and avoids wasted time and money, and it is matched to the nature of the study, since different questions call for different designs.

So the Arusha tourism study is planned first, because a clear design keeps the whole research on track.

Question 16

A researcher must choose between studying one village deeply or many villages once. Distinguish the main types of research design.

Model Answer

Designs differ in how and when data are collected.

1) **Snapshot or case study:** an in-depth study of a single person, group or place, whose findings are not generalised.
2) **Cross-sectional:** data collected once from a population in order to describe it.
3) **Longitudinal:** data collected from the same area at intervals to track change.
4) **Experimental:** variables are controlled or manipulated to establish cause and effect.

So studying one village deeply is a case-study design, while comparing many villages once is cross-sectional, as in a land-use survey across Kigoma.

Question 17

A student wants to do research but says she has no problem to study. Explain what a research problem is and where one comes from.

Model Answer

A research problem is the issue or gap that a study sets out to address.

1) **Meaning:** it states what needs to be researched by showing what is known, what is not known, and what needs documenting.
2) **From conversations:** insights from people reveal imbalances and gaps worth studying.
3) **From interventions:** reviewing past projects and programmes shows what has not worked.
4) **From experience:** evaluating a phenomenon, such as recurring water scarcity, reveals an area worth researching.

So the student finds a problem by examining gaps in local projects or daily experience, such as why a village water scheme in Shinyanga keeps failing.

Question 18

Two studies overlap because both restate what is already known about Lake Victoria pollution. Explain how a research problem is formulated.

Model Answer

A problem is formulated by locating the gap in existing knowledge.

1) **State what is known:** summarise what past studies have already documented.

2) **State what is not known:** identify what they left out, which is the research gap.
3) **State what needs documenting:** turn that gap into the issue the study will address.
4) **Keep it focused:** narrow it so that it is specific and researchable.

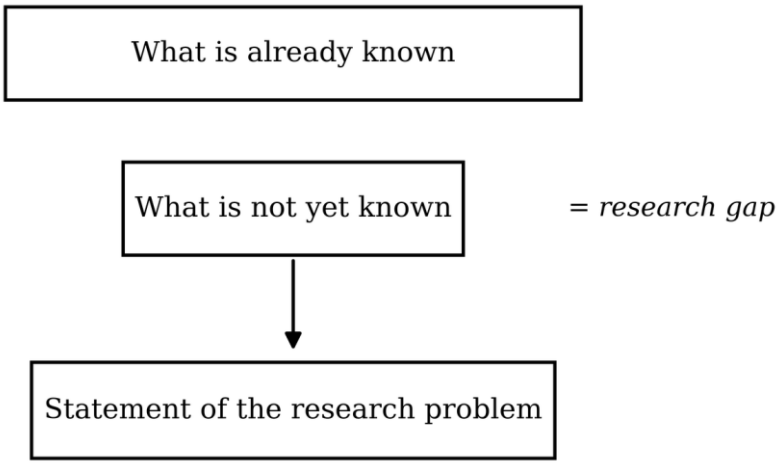


Figure 2.3: *The research gap and the research problem*

So a new Lake Victoria study must target the unstudied gap rather than repeat known facts, which avoids duplication.

False Confidence Alert
A topic is not a research problem. "Pollution in Lake Victoria" names a topic; the problem is the specific question that past studies have left unanswered.

Question 19

A panel rejects a research topic as not worth the money. Explain the qualities of a good research problem.

Model Answer

A good research problem meets several qualities.

1) **Novel:** it offers a new process, product or principle.
2) **Interesting:** it draws the attention and interest of others.
3) **Innovative:** it improves the current state of affairs.
4) **Cost-effective:** it gives good value for the money, time and resources spent.
5) **Relevant:** it addresses a real problem in the community.

So a topic on low-cost rainwater harvesting in semi-arid Dodoma would pass, because it is novel and gives clear value for money.

Question 20

A student picks the huge topic of climate change in Africa and cannot finish it. Account for what a researcher should consider when selecting a research problem.

Model Answer

Several factors guide the choice of a manageable problem.

1) **Interest:** the area should motivate the researcher throughout the study.
2) **Magnitude:** it must be narrowed to fit the available time and resources.

3) **Measurable:** its concepts and indicators must be measurable and verifiable.
4) **Knowledge and skills:** the researcher should have the skills to address it.
5) **Fills a gap:** it should add new knowledge and improve practice.
6) **Ethics:** it must respect ethical issues, especially in sensitive areas.

So the student should narrow the topic to, say, drought coping in one Dodoma ward, which is both manageable and measurable.

Question 21

An examiner notes that a student's objectives do not match the problem. Distinguish general from specific research objectives.

Model Answer

Objectives state what the study intends to achieve.

General objective: the broad aim of the study, stating overall what it seeks to achieve.

Specific objectives: the smaller, measurable steps that show how the general aim will be attained.

Link to the problem: both must flow directly from the research problem and guide data collection.

So a study of fish stocks in Lake Tanganyika has one general aim and several specific objectives that break it into measurable parts.

Question 22

A supervisor crosses out “to understand” and “to appreciate” in a student's objectives. Explain why research objectives use action verbs.

Model Answer

Objectives are written with measurable action verbs.

Action verbs such as to compare, to assess, to determine, to identify and to measure can be evaluated, so it is clear when an objective has been met, and they also guide what data to collect. Vague verbs such as to understand, to appreciate and to know describe states of mind that cannot be measured in the field.

So “to determine the rate of deforestation in Mufindi” is a usable objective, while “to understand deforestation” is not.

False Confidence Alert
“To understand” looks like a strong aim but cannot be marked. If you cannot say what evidence would show the objective was met, the verb is too vague for an objective.

Question 23

A researcher begins collecting data without reading any earlier studies and repeats work already done. Explain the role and functions of a literature review.

Model Answer

A literature review surveys earlier related work.

1) **Avoids duplication:** it shows what has already been done, so effort is not wasted repeating it.
2) **Identifies the gap:** it reveals what is missing, which sharpens the research problem.
3) **Refines methods:** it shows how others collected and analysed data, guiding the design.
4) **Broadens knowledge:** it situates the study against related research.

So reading earlier Rufiji wetland studies first would have shown the researcher the real gap and saved the repeated work.

Question 24

A literature review is rejected because it just agrees with every past study. Explain the marks of a good literature review.

Model Answer

A good literature review meets several criteria.

1) **Shows trends:** it outlines the current situation and what has been documented in the area.
2) **Weighs strengths and weaknesses:** it assesses the methods and conclusions of past studies instead of merely agreeing.
3) **Identifies the gap:** it points to what is missing, which justifies a new study.
4) **Uses recent sources:** it draws on the most recent literature to position the work.

So a sound review of coastal erosion studies in Tanga would weigh and question them, not simply repeat their findings.

Question 25

A researcher must state a testable guess about population growth and development before collecting data. Distinguish a null from an alternative hypothesis.

Model Answer

A hypothesis is a tentative statement about the relationship between variables.

Null hypothesis: it states that there is no relationship, for example that there is no relationship between population growth and development.

Alternative hypothesis: it states the expected relationship, for example that there is a relationship between population growth and development.

Testing: data are collected to reject or retain the null hypothesis, which keeps the test objective.

So the researcher states both, then uses Tanzanian census data to see which one the evidence supports.

False Confidence Alert
A hypothesis is not proved. Data are used to reject or retain it, and a sound study reports the result honestly even when the null hypothesis stands.

Question 26

Before a study on tourism in Zanzibar can receive funding, the researcher must first submit a written plan. Explain what a research proposal is and why it is prepared.

Model Answer

A research proposal is a written plan that sets out how a study will be carried out.

1) **Meaning:** it states what the researcher intends to do, how it will be done, and the resources needed.
2) **Focuses the study:** it makes the researcher decide the questions, the data and the methods in advance.
3) **Guides the work:** it acts as a guide from the start of the research to its completion and allows budgeting.
4) **Anticipates problems:** it lets the researcher foresee difficulties and plan how to solve them.

So the Zanzibar tourism study is planned in a proposal first, because a clear plan makes the research efficient and fundable.

Question 27

A first-time applicant does not know which sections a proposal should contain. Set out the format of a research proposal.

Model Answer

A proposal follows a set format in three parts.

1) **Preliminaries:** the title page, abstract, table of contents and list of tables.
2) **Main body:** the introduction (background, statement of the problem, objectives, questions or hypotheses, significance, scope and limitations), the literature review, and the methodology.
3) **End matter:** the references and the appendices, such as the data-collection tools, the time frame and the budget.

So a proposal on Rufiji wetlands moves from the title and abstract, through the problem and methodology, to the references and appendices.

Question 28

After fieldwork on Lake Nyasa fisheries, a researcher must write up the study. Set out the components of a research report.

Model Answer

A research report is written in a set five-chapter structure.

1) **Chapter One, Introduction:** background, statement of the problem, objectives and questions or hypotheses.
2) **Chapter Two, Literature review:** related works and the gap that the study fills.
3) **Chapter Three, Methodology:** the study area, design, sampling, and how data were collected and analysed.
4) **Chapter Four, Results and discussion:** the findings, compared and interpreted against other works.
5) **Chapter Five, Summary, conclusion and recommendations:** followed by the references and the appendices.

So the Lake Nyasa report runs from the introduction to the recommendations, with references and appendices at the end.

Question 29

A student confuses the plan she wrote before fieldwork with the account she wrote after it. Distinguish a research proposal from a research report.

Model Answer

They differ mainly in purpose and timing.

1) **Purpose:** a proposal is a plan written to gain approval and funding, while a report is a summary of the completed study with its findings.
2) **Timing:** a proposal is written before the fieldwork, a report after it.
3) **Content:** a proposal says what will be done and why, while a report says what was done, the results and what they mean.
4) **Tense:** a proposal is in the future tense, a report in the past.

So the plan written before fieldwork is the proposal, and the account written after it is the report, as in a salt-making study in Mtwara.

Question 30

An examiner notes that a student wrote her whole proposal in the past tense. Explain the tenses used in proposal and report writing.

Model Answer

Tense follows the timing of the document.

A proposal is written mainly in the future tense, because it is a plan of what will be done, for example that the study will sample 300 households. A report is written mainly in the past tense, because the work is complete, for example that the study sampled 300 households. Using the wrong tense, as the student did, makes a plan read as though the work were already finished.

So the student's proposal should be in the future tense, since the study has not yet been carried out, for example a survey planned in Tabora.

Question 31

A student measures the height of many maize plants in Iringa and records each value. Explain what a variable is and how it differs from data.

Model Answer

A variable is any characteristic that can be measured or counted and that varies in magnitude.

1) **Variable:** the property that varies, such as plant height, weight or age.
2) **Data:** the actual values recorded for that property, such as the measured heights.
3) **Relationship:** the variable is the property, while the data are its observed values.

So in the Iringa study height is the variable, while the recorded centimetres are the data.

Question 32

A researcher records both the number of cattle a household owns and the breed it keeps. Distinguish numerical from categorical variables.

Model Answer

Variables differ by the kind of value they take.

Numerical variables: they take number values, and are either continuous (any value in a range, such as weight) or discrete (whole counts, such as the number of cattle).

Categorical variables: they take non-number values such as text, and are either ordinal (ranked, such as small, medium and large) or nominal (unordered, such as breed).

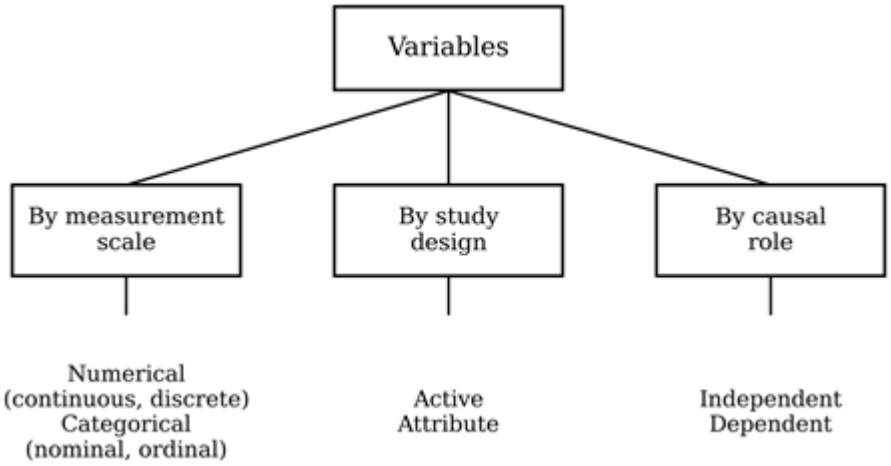


Figure 2.4: *Classification of variables*

So the number of cattle is a discrete numerical variable, while the breed is a nominal categorical variable, as recorded among the cattle keepers of Shinyanga.

Question 33

In a fertiliser trial in Mbeya, the amount of fertiliser is set by the researcher while the soil type cannot be changed. Distinguish active from attribute, and independent from dependent variables.

Model Answer

Variables differ by whether they can be manipulated and by their causal role.

Active variable: one that can be manipulated or controlled, such as the amount of fertiliser applied.

Attribute variable: one that cannot be changed, such as soil type, age or sex.

Independent variable: the presumed cause, not affected by other factors, such as the fertiliser dose.

Dependent variable: the effect, which changes in response, such as the maize yield.

So in the Mbeya trial the fertiliser is the active, independent variable, while the yield is the dependent variable.

Question 34

A researcher in Dodoma counts people, measures rainfall, and groups households by age band. Distinguish the natures of data.

Model Answer

Data take four natures.

1) **Discrete:** whole-number counts, such as the number of people or houses.
2) **Continuous:** measured values that may carry decimals, such as rainfall or temperature.
3) **Individual:** an exact value given for each item, such as each school's enrolment.
4) **Grouped:** values placed in classes, such as ages 1 to 5, 6 to 10 and so on.

So counting people gives discrete data, measuring rainfall gives continuous data, and age bands give grouped data, as in a Dodoma household survey.

Question 35

An examiner asks a student to sort a mixed set of field data. Explain how geographical data are classified.

Model Answer

Geographical data are classified on three bases.

1) **By sorting:** ungrouped raw data that are unsorted, or grouped data arranged into classes.
2) **By unit of measurement:** categorical data (qualitative, nominal or ordinal) or numerical data (quantitative, discrete or continuous).
3) **By method and source:** primary data collected first-hand from the field, or secondary data taken from existing records.

So a set of rainfall figures is numerical, continuous and primary if the student measured it herself, for example rainfall recorded in Tabora.

Question 36

Writing on Dar es Salaam floods, a researcher uses both her own field measurements and figures from the meteorological office. Distinguish primary from secondary data.

Model Answer

The two differ by who first collected the data.

Primary data: first-hand data the researcher collects directly from the field, original and reliable but costly and slow.

Secondary data: second-hand data collected earlier by others, cheap and quick but harder to verify.

Use: many studies combine both so that each checks the other.

So her own flood measurements are primary data, while the meteorological office figures are secondary data, in the Dar es Salaam flood study.

False Confidence Alert
Secondary data are not automatically inferior. They save time and money and may be the only long record available; what matters is checking their source and accuracy before use.

Question 37

A researcher wonders whether rainfall and crop yield rise together, move oppositely, or show no pattern at all. Explain the types of correlation between variables.

Model Answer

Correlation describes how two variables change together, in three ways.

1) **Positive correlation:** both rise together, so the plotted points climb from the lower left to the upper right.
2) **Negative correlation:** one rises as the other falls, so the points fall from the upper left to the lower right.
3) **No relationship:** the points show no pattern, so a change in one does not move the other.

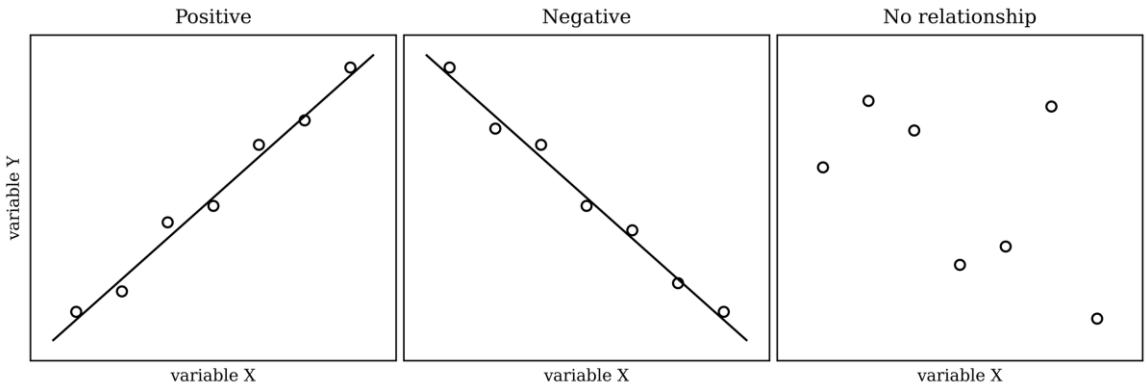


Figure 2.5: *Positive, negative and no correlation*

So rainfall and yield in Mbeya usually show a positive correlation, while temperature and altitude show a negative one (Figure 2.5).

Question 38

A researcher in Geita keeps confusing the people she wants to study with the few she will actually visit. Define the main terms used in sampling.

Model Answer

Sampling uses a set of related terms.

1) **Target population:** the whole group the findings should represent, such as all mining households in Geita.

2) **Sampling frame:** the actual list of units from which the sample is drawn, such as a village register.

3) **Elements:** the individual persons or units about which data are collected.

4) **Sample:** the subset of the population that is actually studied, selected from the frame.

So in Geita the mining households are the target population, the village register is the frame, and the households visited are the sample.

Question 39

A researcher who has listed 1 200 households in a ward of Dodoma must decide how many to study at a margin of error of 0.05. Determine the sample size and state what it means.

Model Answer

State the formula, substitute the values, then round up to a whole respondent.

$$n = \frac{N}{1 + N e^2}$$

where N is the population of 1 200 households and e is the margin of error of 0.05.

$$n = \frac{1\,200}{1 + 1\,200 \times 0.05^2} = \frac{1\,200}{4} = 300$$

Interpretation. So 300 randomly selected households represent the Dodoma ward; a smaller sample raises the error, while a larger one wastes time and money.

False Confidence Alert
Round a sample size up, never down. A result such as 286.4 becomes 287, because you cannot study a fraction of a person.

Question 40

A researcher has a numbered list of 800 secondary-school students in Mbeya and wants a sample of 50 spread evenly across the list. Determine the sampling interval and show how the sample is picked.

Model Answer

Find the interval, choose a random start, then take every Kth student.

$$K = \frac{N}{n} = \frac{800}{50} = 16$$

Random start: pick one number between 1 and 16 by lot, say 7, so the first student sampled is number 7.

Selection: then take every 16th student: 7, 23, 39, 55 and so on, to the end of the list.

Interpretation. So 50 students taken at an interval of 16 are spread evenly across all 800 students in Mbeya.

Question 41

To pick four students from a class of twelve for a study, a teacher writes each code on paper, rolls them, mixes and draws. Explain simple random sampling, its strengths and its limits.

Model Answer

Simple random sampling gives every member an equal chance of selection.

Equal chance: each element is chosen entirely by chance, as with the rolled papers.

Unbiased: it represents the population fairly, so conclusions can be generalised.

Limitation: it needs a complete list of the population, so it is impractical for a very large or scattered group, and it may miss small minorities.

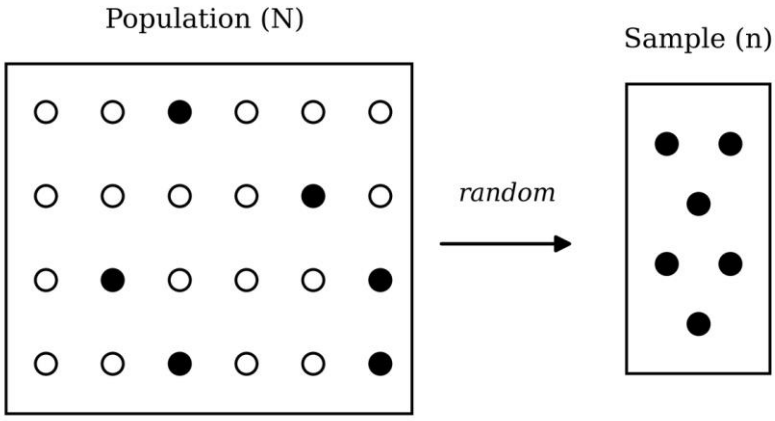


Figure 2.6: *Simple random sampling*

So drawing four codes by lot is simple random sampling, fair but practical only for a small, listed group such as a single class in Moshi.

Question 42

A researcher studying service in a Kariakoo market cannot list every customer but can pick them at a fixed interval as they arrive. Explain systematic sampling with the aid of a diagram.

Model Answer

Systematic sampling selects members at a regular interval after a random start.

Interval: it uses a sampling interval found by dividing the population by the sample size.

Random start: the first member is chosen at random within the first interval.

Even spread: every Kth member is then taken, so the sample is spread evenly across the list.

Caution: it can mislead if a hidden pattern in the list matches the interval.

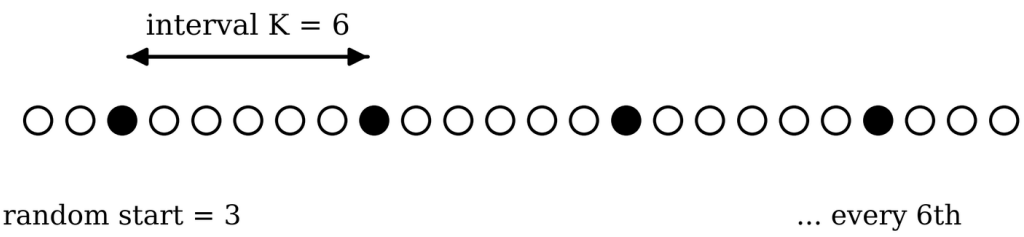


Figure 2.7: *Systematic sampling*

So taking every sixth customer after a random start is systematic sampling, simple and evenly spread, as in the Kariakoo market study (Figure 2.7).

False Confidence Alert
Systematic sampling is random only if the start is random. Always taking the first member and then every Kth is not random selection and biases the sample.

Question 43

A study of a school needs the views of boys, girls and staff in fair proportion. Explain stratified sampling.

Model Answer

Stratified sampling divides the population into sub-groups, then samples from each.

Strata: the population is split into homogeneous sub-groups, such as boys, girls and staff.

Proportional pick: a random sample is drawn from each stratum in proportion to its size.

Strength: every group is represented, which lowers the error of estimation.

Limitation: it needs every member classified into one stratum, which can be demanding.

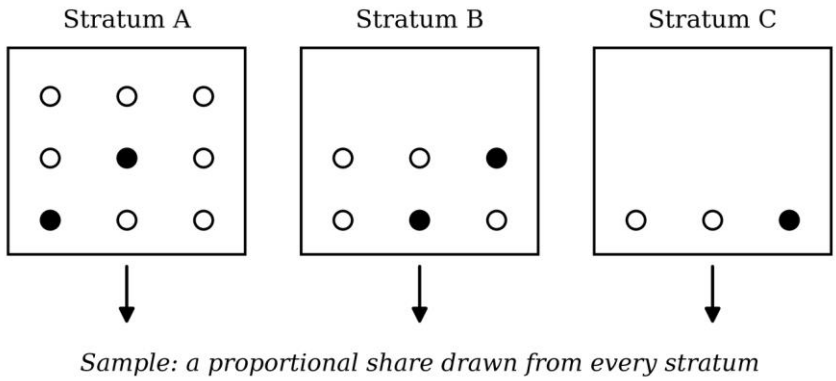


Figure 2.8: *Stratified sampling*

So sampling boys, girls and staff in proportion is stratified sampling, which keeps each group represented, as in a school survey in Arusha (Figure 2.8).

Question 44

A researcher must study households across a large district but cannot list them all. Explain cluster sampling.

Model Answer

Cluster sampling divides a large area into clusters, then samples whole clusters.

Clusters: the area is split into small, non-overlapping clusters, such as wards.

Random clusters: some clusters are picked at random and studied in full.

Strength: it is cheaper and quicker over a large area and needs no full list of the population.

Limitation: clusters may differ from one another, which can raise the sampling error.

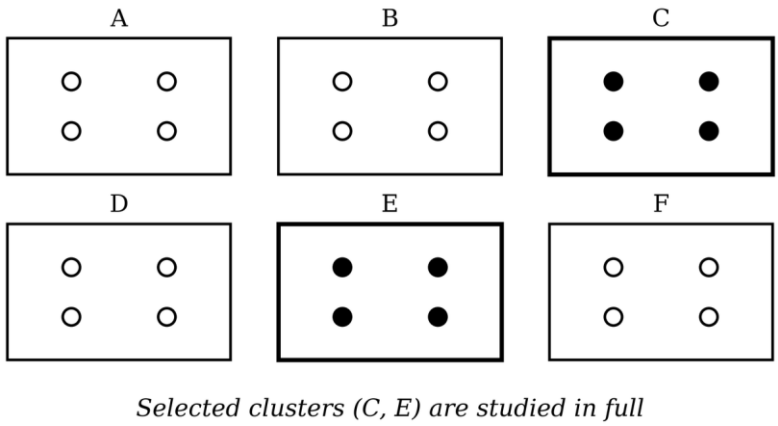


Figure 2.9: *Cluster sampling*

So picking a few wards and studying all their households is cluster sampling, suited to a large district such as Chunya.

Question 45

A national household study cannot reach every region at once. Explain multi-stage sampling and show how the final sample is reached.

Model Answer

Multi-stage sampling selects the sample in nested random stages.

Stages: it samples in steps, narrowing from large units to small ones.

Example: choose 5 regions, then 4 districts in each, then 4 wards in each, then 2 villages in each, and finally 5 households in each.

In all this gives 5 × 4 × 4 × 2 × 5 = 800 households.

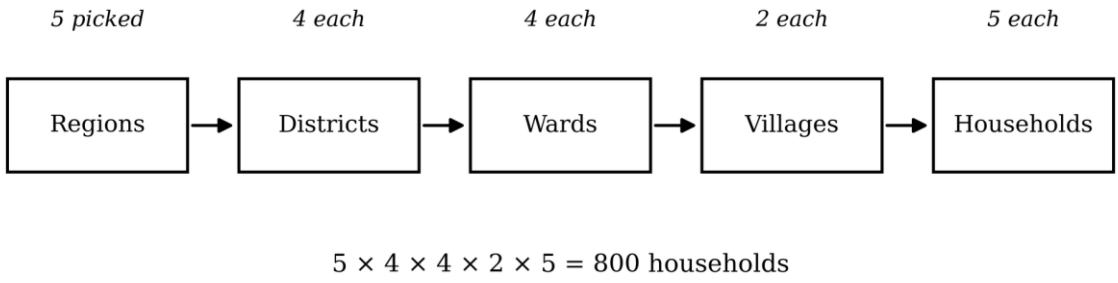


Figure 2.10: *Multi-stage sampling*

So the sample is built stage by stage to 800 households, which suits a population spread across the country from Mwanza to Mtwara.

Question 46

Studying illegal charcoal makers, a researcher cannot list them and must rely on referrals. Distinguish the main non-probability sampling techniques.

Model Answer

In non-probability sampling members have no equal chance of selection.

1) **Quota:** the interviewer fills set quotas from each group at his or her own discretion.
2) **Convenience:** it takes whoever is available at the time, such as passers-by.
3) **Purposive:** it selects only cases judged typical or knowledgeable about the topic.
4) **Snowball:** initial subjects refer others, which suits rare or hidden groups such as charcoal makers.

So the charcoal study uses snowball sampling, since respondents are hidden and must be reached through referrals, as in a charcoal-making study in Morogoro.

Question 47

A village leader asks why a researcher does not simply study every household. Explain why research uses a sample rather than the whole population.

Model Answer

A sample is studied because it represents the population at far less cost.

1) **Saves resources:** it saves time, money and labour compared with a full count.

2) **Manageable data:** a smaller, well-chosen set is easier to collect and analyse accurately.

3) **Representative:** a properly selected sample lets conclusions extend to the whole population.

4) **Sometimes necessary:** a full study is impossible where the population is very large or scattered.

So studying a representative sample of the village gives reliable findings without the cost of reaching every household, as in a Singida village study.

False Confidence Alert
A bigger sample is not always better. Past a point it only adds cost; what matters is that the sample is representative, not merely large.

Question 48

Before going to the field in Tanga, a researcher plans how the data will be gathered. Explain data collection and its sources.

Model Answer

Data collection is the gathering of information needed to answer the research problem.

Primary sources: first-hand data collected directly from the field by the researcher, through survey, observation, interview or focus group discussion.

Secondary sources: data already collected by others, such as books, journals and office records.

Choice: the method is chosen to fit the type of data and the way the study is conducted.

So a Tanga fisheries study may combine its own field counts with existing landing records.

Question 49

To learn how Mwanza households manage waste, a researcher administers a written set of questions to many of them. Explain the household survey and its questionnaire.

Model Answer

A household survey collects data by administering a questionnaire to many respondents.

Purpose: it gathers data on perceptions, opinions and practices across a sample.

Structured questionnaire: prepared questions with set answers, the closed-ended type, easy to fill and to analyse.

Unstructured questionnaire: mostly open-ended questions, which give richer data but are harder to analyse.

Limitation: it can be less accurate for behaviour and may suffer low response rates.

So the Mwanza waste study suits a structured questionnaire, because the large sample makes set answers easier to analyse.

Question 50

Assessing a water project, a researcher needs detailed views from the project officer rather than from the whole village. Explain the interview method and its guide.

Model Answer

An interview collects qualitative data from a knowledgeable person on the topic.

Key informant: it targets people with a stake in or knowledge of the topic, such as the project officer.

Interview guide: a set of prepared questions guides the conversation.

Strength: it gives deep, first-hand information and can overcome language barriers face to face.

Limitation: its data are qualitative, hard to generalise, and time consuming to gather.

So interviewing the project officer with a guide yields depth that a questionnaire alone would miss, as in a water-project study in Babati.

Question 51

To explore villagers' shared views on a water committee, a researcher gathers a small group to discuss together. Explain the focus group discussion and its tool.

Model Answer

A focus group discussion collects qualitative data from a small group exploring a topic together.

Small homogeneous group: a few similar people discuss to share their experiences and ideas.

Checklist: a set of pre-designed questions, the checklist, guides the discussion.

Strength: it is quick and flexible and brings out different perspectives.

Limitation: a few members may dominate, and the group may not represent all villagers.

So a focus group discussion on the water committee surfaces shared views quickly, though its data must be read with care, as in a Kilombero water-committee study.

Question 52

Studying how a market operates, a researcher watches and records what actually happens rather than asking. Explain the observation method and its guide.

Model Answer

Observation collects data by watching phenomena directly in the field.

Direct recording: the researcher records events as they happen, using an observation guide, a recording sheet and field notes.

Forms: it may be structured or semi-structured, depending on what is being watched.

Strength: it gives direct, real-time data and physical evidence.

Limitation: it can be observer-biased and is labour intensive.

So observing the market directly captures real behaviour that respondents might not report accurately, as in an Arusha market study.

Question 53

To record land use across a village, a researcher walks a fixed path with local people, noting features along the way. Explain the transect walk.

Model Answer

A transect walk is a team field walk along a fixed path to collect data by direct observation.

Fixed path: the team walks a defined line across the area together with local people.

Activity: they observe, ask, listen and watch, recording features along the route.

Output: it produces a transect map or diagram of what was seen.

Need: it demands good observation skills and uses an observation guide and field notes.

So a transect walk across a village records the real spread of land use, from valley farms to hilltop bush, as on a transect across the Uluguru hills.

Question 54

A student's draft questionnaire on solid waste in Mwanza asks two things in one line and pushes respondents toward a chosen answer. Explain how a good questionnaire item is designed.

Model Answer

A good questionnaire asks one clear idea per item in neutral language.

1) **One idea per item:** ask one thing at a time, since a double-barrelled question cannot be answered cleanly.
2) **Neutral wording:** avoid leading questions that push the respondent toward an answer.
3) **Response format:** use closed items for easy analysis and a few open items for depth.
4) **Logical order:** place simple, non-sensitive questions first and group related items together.

   Closed item: *Do you sort your household waste? Yes / No*

   Open item: *What makes waste sorting difficult in your area?*

So a short, neutral and well-ordered questionnaire yields data that can actually be analysed, as in the Mwanza waste study.

False Confidence Alert
A double-barrelled question hides a trap. "Do you sort and burn your waste?" cannot be answered by someone who does one but not the other, so the reply cannot be scored.

REAL QUESTIONS

Question 55

A college tutor in Mbeya tells students that geographical research is just collecting stories from the field. Examine the extent to which geographical research is a scientific phenomenon.

Model Answer

Geographical research is largely scientific, because it follows the scientific method, though it has limits.

Systematic procedure: it moves through ordered steps from problem to report, like any science.

Empirical evidence: its conclusions rest on observed, measured data, such as discharge readings on the Great Ruaha.

Objectivity: it removes bias and draws conclusions only from the evidence.

Replicability: another researcher repeating the method reaches the same result.

Limit: because it often studies people, full control of variables is not always possible, so some findings carry uncertainty.

So research is scientific in its method and evidence, even where human behaviour makes it less exact than a laboratory science, as in a study of farming decisions in Mbeya.

Question 56

A village elder, a textbook and a personal measurement give three different figures for a river's flood level. Classify the sources of knowledge and judge how far each may be trusted.

Model Answer

Knowledge comes from authority, tradition and experience, each trusted to a different degree.

Authority: the textbook, trusted where the author is credible and the work recent, but it can be out of date.

Tradition: the elder's account, valuable for long memory, but it may be exaggerated or unverified.

Experience: the personal measurement, the most directly testable, though one reading may not represent every flood.

Verification: research trusts a source only after checking it against evidence.

So the measured level is the most reliable for a study of flooding on the Kilombero, while the elder and the textbook are useful only once checked.

False Confidence Alert
An old textbook figure is not automatically correct. A printed source can be dated or mistaken, so in research it is weighed and checked, not simply believed.

Question 57

Mr Rogwa, an environmentalist in Jozani, Zanzibar, hears that charcoal making is clearing the forest and decides to study it. Suggest the type of research he should use and justify your choice.

Model Answer

Rogwa should use applied (action) research, beginning with an exploratory and descriptive approach.

Applied: the aim is to solve a practical problem, the loss of forest, not to find a general principle.

Exploratory first: little may be documented locally, so he must first explore the extent and drivers of clearing.

Descriptive and field-based: he then describes the rate and pattern of clearing using field observation and interviews.

Why: this combination fits a real, local, poorly-documented problem that needs an actionable answer.

So action research, beginning with exploration, suits Rogwa's charcoal study in Jozani, because it targets a real local problem and points to a solution.

Question 58

A regional officer doubts that research has any place in government planning. Show how the government of Tanzania can use geographical research as a basis for planning and decision-making.

Model Answer

Research gives government tested evidence on which to plan.

1) **Siting services:** studies of population and access guide where to place schools, dispensaries and markets.
2) **Resource management:** research on water, soil and forests informs policy, such as protecting the Rufiji catchment.
3) **Disaster planning:** studies of floods and drought guide early warning and relief, as in flood-prone Kilosa.
4) **Monitoring:** research evaluates whether a policy is working and where to adjust it.
5) **Budgeting:** evidence helps direct limited funds to the greatest need.

So the officer's plans are sounder when based on research, because evidence shows where need and resources truly lie in his region.

Question 59

A parent asks why her daughter should study research methods when she will not become a scientist. Discuss the roles of geographical research in daily life.

Model Answer

Research touches everyday decisions far beyond the laboratory.

1) **Weather and farming:** it turns weather data into forecasts that guide when farmers in Dodoma plant and harvest.
2) **Health:** studies of disease spread guide where to focus clean water and mosquito nets.
3) **Markets:** research on prices and demand helps traders decide what to sell.
4) **Settlement:** studies of hazards guide where it is safe to build.
5) **Everyday judgement:** it teaches anyone to question a claim and check evidence before acting.

So even a non-scientist gains from research, because it improves the daily choices of farmers, traders and families across Tanzania.

Question 60

A Form Six student in Singida is asked to design a study of why a local water scheme fails, but does not know the steps. State, in order, the stages she should follow.

Model Answer

Research follows ordered stages, which she should apply to the water scheme.

1) **Identify the problem:** state why the Singida scheme keeps failing as the research problem.
2) **Set objectives and hypotheses:** decide what to find out and the relationships to test.
3) **Review literature:** read earlier studies of rural water schemes to find the gap.
4) **Choose a design and sample:** plan the study and select the households to include.
5) **Collect data:** gather evidence through survey, interview and observation at the scheme.
6) **Analyse and report:** organise the data, interpret it, and write the findings with recommendations.

So she moves from a clear problem to a written recommendation, which gives the Singida village an evidence-based answer.

Question 61

A researcher must decide whether to study coffee yields in Mbozi at one harvest or across several years. Choose the research design that fits and justify it.

Model Answer

The design depends on whether the question is about a single point or about change over time.

For a snapshot: a cross-sectional design collects data at one harvest to describe current yields.

For change: a longitudinal design collects data across several seasons to track a trend.

For cause: an experimental design compares treated and untreated plots to test what raises yield.

Choice: if the question is whether a new method raises yield, the experimental design fits best.

So a study testing a new coffee practice in Mbozi should use an experimental design, because only controlled comparison shows cause and effect.

False Confidence Alert
A one-season snapshot cannot show a trend. Claiming that yields are rising from a single cross-sectional study confuses one point in time with change over time.

Question 62

A researcher rushes to state a hypothesis without reading or thinking, and his whole study drifts. Account for the problems that a poorly formulated hypothesis is likely to cause.

Model Answer

A poorly formulated hypothesis weakens the whole study.

1) **Wrong focus:** it points the study at the wrong variables, so the data collected do not answer the question.
2) **Untestable:** if it is vague or unmeasurable, it cannot be tested, and the study reaches no clear conclusion.
3) **Wasted resources:** it leads to collecting irrelevant data, wasting time and money.
4) **Misleading findings:** a biased hypothesis can push the researcher toward a predetermined answer.
5) **Lost direction:** it fails to delimit the study, so the work spreads and never closes.

So a careless hypothesis derails a study of fish decline in Lake Victoria, because every later step depends on it.

Question 63

A student keeps confusing a vague worry with a researchable problem. Explain the procedure a researcher follows to obtain a good research problem.

Model Answer

A good problem is reached through an orderly procedure.

1) **Identify a broad area:** start from a field of interest, such as water access in semi-arid areas.
2) **Review what exists:** read literature and projects to see what is known and not known.
3) **Narrow the focus:** reduce the broad area to one specific, manageable issue.
4) **Check feasibility:** confirm it is measurable, ethical and within the available time and skills.
5) **State it clearly:** write the problem as a precise statement of what needs documenting.

So moving from a broad worry about drought to a precise question about coping strategies in one Dodoma ward gives a sound research problem.

Question 64

Madam Ringo, a geography teacher, insists her students review past research projects before collecting any data. Account for the reasons behind her insistence.

Model Answer

Reviewing past work before fieldwork serves several purposes.

1) **Avoids duplication:** it shows what has already been done, so students do not repeat it.
2) **Finds the gap:** it reveals what is missing, which sharpens their own problem.
3) **Borrows methods:** it shows how others collected and analysed data, guiding their design.
4) **Saves resources:** it prevents wasted field trips on questions already answered.
5) **Builds knowledge:** it makes students familiar with the topic before they face respondents.

So Madam Ringo is right, because a class studying soil erosion in Kondoa works far better once it knows what earlier studies found.

Question 65

Your village asks you to conduct research to solve its problems, but you must first choose a sound problem. Explain the meaning of a research problem and the six criteria of a good one.

Model Answer

A research problem is the specific issue a study sets out to answer, and a good one meets six criteria.

1) **Clear:** it is stated precisely, not vaguely.
2) **Researchable:** it can be answered with data that can be collected.
3) **Significant:** it addresses a real need in the village.
4) **Manageable:** it fits the available time and resources.
5) **Ethical:** it respects the people and the area studied.
6) **Original:** it adds new knowledge rather than repeating known facts.

So a problem such as why the borehole in Manyoni ward fails in the dry season meets these criteria and is worth researching.

Question 66

After stating a hypothesis on truancy and performance, a researcher must turn it into questions the data can answer. Distinguish the types of research questions with examples.

Model Answer

Research questions come in three types.

1) **Descriptive:** it asks about the nature of one phenomenon, for example what the truancy rate is in a Mwanza school.
2) **Difference:** it asks whether groups differ, for example whether truants perform worse than non-truants.
3) **Relationship:** it asks how two variables are linked, for example whether truancy is related to performance.

So the truancy study uses all three, moving from describing the rate to testing its link with performance.

Question 67

A funder says a study's reliability is decided before any data are collected. Giving reasons, explain the rationale for a quality research proposal in producing reliable research output.

Model Answer

A quality proposal is what makes the later findings reliable.

1) **Clear problem and objectives:** it fixes exactly what will be studied, so the data answer the question.
2) **Sound methodology:** it states the design, sampling and tools in advance, which keeps the data valid.
3) **Planned resources and time:** it budgets the work, so the study is completed properly rather than rushed.
4) **Anticipates problems:** it foresees difficulties and plans for them, reducing error in the field.
5) **Allows review:** it lets others judge the plan before money is spent.

So a strong proposal for a study of irrigation in Usangu secures reliable results, because reliability is built into the plan, not added later.

Question 68

You have been appointed to assess the quality of Form Six students' research proposals. Explain the attributes you would consider in the assessment.

Model Answer

A sound proposal is judged on several attributes.

1) **Clear problem:** the research problem is precise and researchable.
2) **Matching objectives:** the objectives flow from the problem and use measurable verbs.
3) **Adequate literature:** the review shows the gap and draws on recent sources.
4) **Suitable methodology:** the design, sample and tools fit the problem.
5) **Feasibility:** the study is manageable in time, cost and ethics.
6) **Clarity and format:** it follows the proper structure and is clearly written.

So a proposal on waste management in Tanga scores well when its problem, objectives and methods line up and the study is feasible.

Question 69

A student treats the introduction and the literature review of her report as the same chapter. Compare the introduction and the literature review as chapters in a research report.

Model Answer

The two chapters do different jobs.

Purpose: the introduction sets the scene and states the problem, while the review surveys what others have done.

Content: the introduction gives background, objectives and significance, while the review weighs related studies and finds the gap.

Direction: the introduction moves toward the problem, while the review moves toward the methods the study will use.

Link: the review extends the background but does not repeat it.

So in a study of coastal erosion in Tanga the introduction frames the problem, while the review shows what earlier studies missed.

Question 70

Mr Chacha studies the effect of group discussion on students' performance in his school. From his study, establish the relationship between the variables, state which is dependent and which is independent, and give other variables that may affect performance.

Model Answer

Identify the variables, then read the relationship from the evidence.

Independent variable: group discussion, the factor Wambura studies as the presumed cause.

Dependent variable: students' performance, the effect that responds.

Positive relationship: as group discussion increases, performance rises, so the points climb.

Negative relationship: by contrast, as absences increase, performance falls, so those points descend.

Other variables: teaching quality, study time, health and home environment can also affect performance.

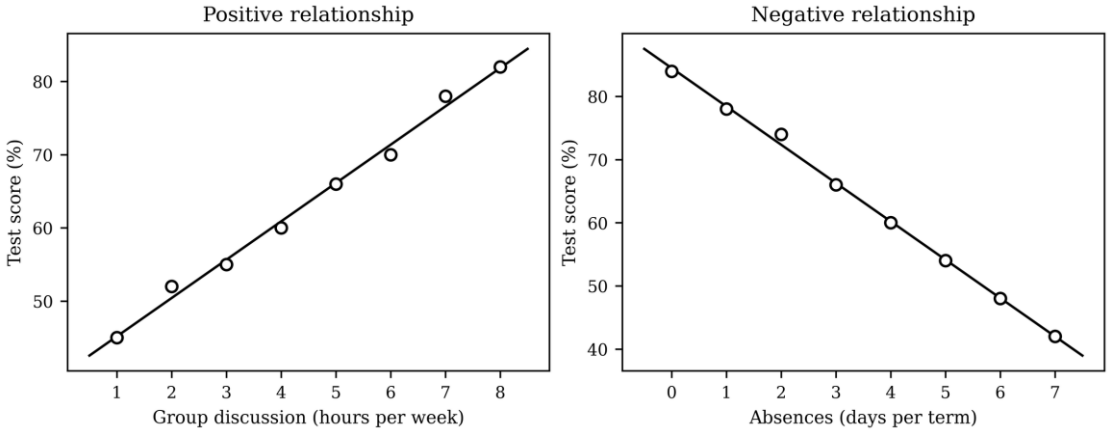


Figure 2.11: *Positive and negative relationships in Chacha's study*

So performance is the dependent variable driven by group discussion, although Chacha must allow for other influences in his school.

Question 71

Students confuse several pairs of field-research terms in their reports. Differentiate the following pairs: field work and field research; research method and research methodology; qualitative and quantitative research.

Model Answer

Each pair contrasts two related but distinct ideas.

Field work vs field research: field work is the actual data-gathering activity in the field, while field research is the whole scientific study carried out in the natural setting.

Method vs methodology: a research method is a single technique such as the interview, while methodology is the reasoned study of why those methods are chosen.

Qualitative vs quantitative: qualitative research uses non-numerical data such as opinions, while quantitative research uses numerical data such as counts.

So a student surveying farmers in Iringa does field work within a wider field research, choosing each method for a reasoned methodology.

Question 72

Writing on population change, a researcher leans heavily on published census figures instead of collecting her own data. Show the merits and demerits of secondary data to a researcher.

Model Answer

Secondary data bring both advantages and drawbacks.

1) **Merit, low cost:** it is cheap and quick to obtain, saving fieldwork.
2) **Merit, ready record:** some is already analysed and gives a long record, such as census trends.
3) **Merit, wide coverage:** it can cover a whole country, which one researcher could not survey.
4) **Demerit, hard to verify:** its accuracy cannot easily be checked.
5) **Demerit, not tailored:** it was collected for another purpose and may not fit the new question.
6) **Demerit, may be dated:** it can be old and no longer represent the present.

So census figures help a population study of Tanzania, but the researcher must check their age and fit before relying on them.

Question 73

For eight small catchments in the Rufiji basin a researcher recorded the annual rainfall and the runoff it generated, shown below. Plot the data, then describe and interpret the relationship.

Model Answer

Catchment	1	2	3	4	5	6	7	8
Rainfall (mm)	400	500	600	700	800	900	1000	1100
Runoff (m^3/s)	55	80	100	130	150	185	210	245

Plot the pairs, fit one straight line, then name the relationship and its strength.

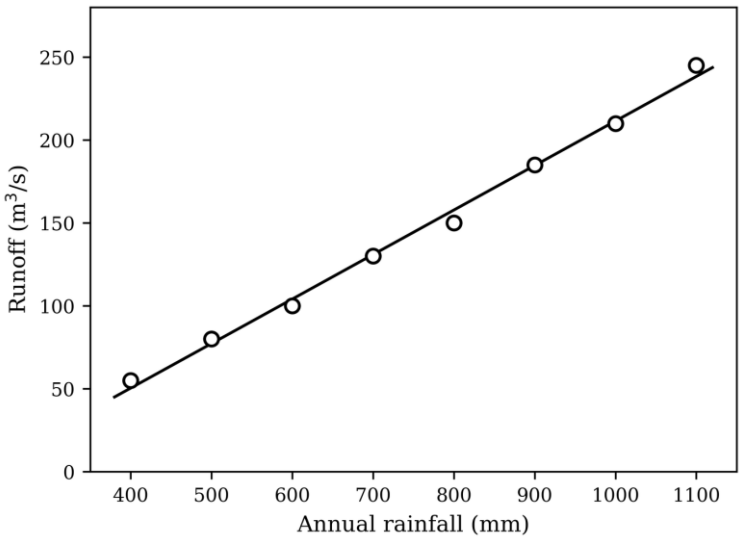


Figure 2.12: *Rainfall against runoff for eight Rufiji catchments*

Pattern: as rainfall rises, runoff rises, so the points climb from the lower left to the upper right.

Relationship: this is a positive correlation, because the two increase together.

Strength: the points lie close to a single straight line, so the relationship is strong.

Caution: rainfall is not the only cause, since relief and soil also raise runoff.

So the Rufiji data show a strong positive relationship between rainfall and runoff (Figure 2.12).

False Confidence Alert
A strong correlation is not proof of cause. Relief, soil and vegetation also raise runoff, so the graph shows association, not that rainfall alone produces the runoff.

Question 74

An examiner gives a student mixed data and asks her to sort them by type. State the differences between the following pairs: categorical and numerical; single and grouped; discrete and continuous data.

Model Answer

Each pair separates two kinds of data.

Categorical vs numerical: categorical data describe qualities in words or labels, such as soil colour, while numerical data are values in numbers, such as rainfall.

Single vs grouped: single data give an exact value for each item, such as each school's enrolment, while grouped data place values in classes, such as ages 1 to 5.

Discrete vs continuous: discrete data are whole counts, such as the number of houses, while continuous data are measured and may carry decimals, such as temperature.

So a student sorting field data from Iringa labels colours as categorical, counts as discrete, and measured rainfall as continuous.

Question 75

Appointed to lead a household study in Geita, you must explain your sampling to the team. Describe four types of sampling techniques and outline the importance of sampling.

Model Answer

Four sampling techniques are commonly used, and sampling itself brings clear benefits.

1) **Simple random:** every member has an equal chance, which gives an unbiased sample.
2) **Systematic:** members are taken at a fixed interval after a random start, spreading the sample evenly.
3) **Stratified:** the population is split into groups and sampled in proportion, so each group is represented.
4) **Cluster:** the area is divided into clusters and some are studied in full, which suits a large area.

Importance of sampling: it saves time and money, makes data manageable, and still lets the findings represent the whole population.

So in Geita a stratified or cluster sample lets the team study mining households reliably without counting every one.

Question 76

Research assistants in Tanga blame their principal researcher for sending them to collect data from only a few people when they could have reached everyone. Give the reasons the principal researcher had for sampling rather than studying all.

Model Answer

The principal researcher sampled for good reasons.

1) **Saves resources:** studying everyone in Tanga would cost far more time, money and labour.
2) **Speed:** a sample gives results quickly, while a full count is slow.
3) **Manageable data:** a smaller set is easier to collect and analyse accurately.
4) **Accuracy:** a well-chosen sample can be checked carefully, while a huge count invites errors.
5) **Representation:** a properly drawn sample already represents the whole region.
6) **Practicality:** reaching every person is often impossible where the population is large or scattered.

So the assistants were wrong to complain, because a sound sample of Tanga gives reliable findings at far less cost than a full count.

False Confidence Alert
Studying everyone is not more accurate by default. A rushed full count usually carries more errors than a careful sample, and it wastes resources for no real gain.

Question 77

A researcher in Morogoro has a sampling frame of 2 000 households in a ward and wants a margin of error of 0.05. Determine the sample size she should study.

Model Answer

State the formula, substitute the frame values, then round up to a whole respondent.

$$n = \frac{N}{1 + N e^2}$$

where N is 2 000 households and e is the margin of error of 0.05.

$$n = \frac{2\,000}{1 + 2\,000 \times 0.05^2} = \frac{2\,000}{6} = 333.3$$

Interpretation. So she should study 334 households, rounding up to a whole respondent, and this sample represents the Morogoro ward at the chosen margin of error.

Question 78

A national study must reach households spread across the whole country, and no full list exists. Choose a sampling technique and show how the final sample is built.

Model Answer

Multi-stage sampling fits a large, dispersed population with no full list.

Why: it needs no complete list and reaches a scattered population in stages.

Stages: choose 5 regions, then 4 districts in each, then 4 wards in each, then 2 villages in each, and finally 5 households in each.

$$5 \times 4 \times 4 \times 2 \times 5 = 800$$

Interpretation. So the national sample is built stage by stage to 800 households, which suits a population scattered across Tanzania.

Question 79

In the 2022 National Census, Tanzania collected data from every household, which differs from a questionnaire survey. Explain how the census method of data collection differs from a questionnaire.

Model Answer

The census and the questionnaire differ in coverage and purpose.

Coverage: the census counts every person and household, while a questionnaire reaches only a sample.

Frequency: the census is conducted once about every ten years, while a questionnaire can be used at any time.

Scale and cost: the census is national and very costly, while a questionnaire is smaller and cheaper.

Administration: the census uses trained enumerators visiting all homes, while a questionnaire may be self-completed or given to a sample.

Purpose: the census gives a complete population count, while a questionnaire gathers specific data on a topic.

So the 2022 Census covered all of Tanzania at once, whereas a questionnaire would study only a sample for a particular question.

Question 80

A teacher sends students to collect information on the importance of vaccination through interviews. Explain the conditions to consider for a successful interview.

Model Answer

A successful interview depends on several conditions.

1) **Preparation:** a clear interview guide of relevant questions is prepared beforehand.

2) **Right informant:** the person chosen has knowledge of or a stake in the topic.
3) **Rapport:** a friendly, respectful manner puts the respondent at ease to speak freely.
4) **Clear language:** questions are asked in language the respondent understands.
5) **Neutral manner:** the interviewer avoids leading the respondent toward an answer.
6) **Accurate recording:** responses are recorded faithfully, with the respondent's consent.

So students interviewing villagers in Bagamoyo about vaccination get reliable answers when they prepare, build rapport and stay neutral.

Question 81

Planning fieldwork in Mbeya, a researcher must justify each data-collection method she will use. Account for the following methods used in field research: household survey, interview and focus group discussion.

Model Answer

Each method suits a different data need.

Household survey: it administers a questionnaire to many households, giving broad, comparable data on practices and opinions across a sample.

Interview: it draws deep, qualitative information from a knowledgeable key informant on the topic.

Focus group discussion: it explores the shared views of a small group, surfacing issues and themes through discussion.

So the Mbeya study uses a survey for breadth, interviews for depth, and a focus group to explore shared views, each adding what the others miss.

Question 82

A researcher is unsure which tool fits which situation. Explain the circumstances in which you would opt to use observation, a household survey, an interview, and a focus group discussion.

Model Answer

Each method fits particular circumstances.

Observation: when behaviour must be seen directly, such as how a market operates, rather than reported.

Household survey: when broad, comparable data are needed from many respondents, such as waste habits across Mwanza.

Interview: when deep information is needed from a few knowledgeable people, such as a project officer.

Focus group discussion: when shared community views are needed, such as opinions on a water committee.

So the researcher matches the tool to the need, observing behaviour, surveying for breadth, interviewing for depth and using a focus group for shared views.

HOT QUESTIONS

Question 83

A student claims that people only seek knowledge when they are paid or forced to. To what extent is the urge to know intrinsic to human beings?

Model Answer

The urge to know is largely intrinsic, though circumstances shape how it is pursued.

Case for intrinsic: curiosity about the environment is natural, since children everywhere ask why and traditional societies built planting calendars without any reward.

Qualification: the direction of inquiry is shaped by need, since a farmer studies the rains because livelihood depends on them.

Balance: external pressures channel curiosity but do not create it.

So the drive to know is intrinsic, while need and reward only decide what is studied, as when a Dodoma farmer turns natural curiosity toward the timing of the rains.

Question 84

A tutor in Iringa asks which single criterion of good research most separates it from everyday opinion. Assess.

Model Answer

Empirical grounding is the most fundamental divider, with replicability its visible test.

1) **Empirical evidence:** research rests on observed data while opinion rests on belief, so this is the root difference.
2) **Replicability:** because the method is recorded, others can repeat and verify it, which opinion cannot offer.
3) **Support:** objectivity reinforces both by removing bias.

So while replicability is the visible test, empirical evidence is what most separates a study of soil fertility in Iringa from a mere opinion about it.

Question 85

A student says that once you know the type of research, the problem is as good as solved. To what extent is knowing the research type a step toward solving a research problem?

Model Answer

Knowing the type is a necessary step, but far from the whole solution.

Case for: the type guides the design, data and tools, so a wrong type derails the study from the start.

Qualification: the type alone collects no data and answers nothing; the problem is solved only by sound fieldwork and analysis.

Balance: it is one early decision among many.

So choosing the right type begins a study of fish decline in Lake Victoria well, but the answer still depends on the work that follows.

False Confidence Alert
Naming the research type does not solve the problem. It only sets the approach, while the answer still requires data, analysis and interpretation.

Question 86

Two researchers given the same topic design very different studies. How far does the research purpose shape the whole study?

Model Answer

The research purpose shapes almost every later choice.

1) **Type and design:** a purpose to describe needs a survey, while a purpose to explain needs comparison.
2) **Data and tools:** the purpose decides what is collected and how.
3) **Depth and scope:** it sets how far the analysis goes.
4) **Qualification:** resources and ethics also constrain the study.

So two studies of tourism in Zanzibar differ because their purposes differ, one describing visitor numbers and the other explaining their decline.

Question 87

A researcher blames poor results on bad luck, but the fault lies in the design. Assess how far the research design governs the data and the method.

Model Answer

The design largely governs both the data and the method.

Method: an experimental design requires controlled comparison while a survey does not.

Data: the design fixes what data are collected and how, so a weak design yields weak data.

Qualification: even a sound design fails if the fieldwork is careless.

So a flawed design, not bad luck, usually explains poor results, as in a coffee study in Mbozi that sampled one season and called it a trend.

Question 88

A student wants to collect data first and define the problem later. Why can the stages of the research process not be reordered or skipped?

Model Answer

The stages are sequential because each depends on the one before it.

1) **Problem first:** it decides which data are relevant, so it must come before collection.
2) **Review before design:** without it the study may repeat work already done.
3) **Sampling before collection:** without a defined group there is no one to study.

Consequence: skipping a stage breaks the chain and wastes the fieldwork.

So collecting data before defining the problem, as the student wants, would gather facts that answer no question and doom a study in Morogoro from the start.

Question 89

Candidates often treat a hypothesis and a research question as the same thing. Judge how the two differ in their role.

Model Answer

They play different roles, though both guide a study.

Hypothesis: a testable statement of an expected relationship, used mainly in natural-science studies.

Research question: an open question the data will answer, common in social studies.

Outcome: a hypothesis is rejected or retained, while a question is simply answered.

So a study of rainfall and yield in Mbeya may state a hypothesis to test or pose a question to answer, but it should not confuse the two.

Question 90

A first-time researcher in Kondoa is discouraged by the difficulties of fieldwork. Examine the main challenges of conducting geographical research and how they may be managed.

Model Answer

Research faces several challenges, but each can be managed.

1) **Choosing a problem:** difficulty in narrowing a topic, managed by reviewing the literature first.

2) **Resources:** limited time and funds, managed by sampling and a clear budget.

3) **Data quality:** unreliable or biased responses, managed by good tools and cross-checking.

4) **Access and ethics:** reluctant or sensitive respondents, managed by rapport and consent.

So the Kondoa researcher need not be discouraged, because planning, sampling and ethics turn each challenge into a manageable step.

Question 91

A supervisor says a weak literature review sinks an otherwise good study. How far does a good review situate and strengthen a study?

Model Answer

A good review strongly strengthens a study by positioning it.

Locates the gap: so the study addresses something genuinely new.

Borrows tested methods: which improves the design.

Avoids duplication: which saves time and resources.

Qualification: a review cannot rescue weak fieldwork or analysis.

So a strong review sets up a study of the Rufiji wetlands well, although the study must still be carried out soundly.

Question 92

A donor argues that a good proposal is already half the solution to a problem. Evaluate how a quality research proposal is a step toward solving a real challenge.

Model Answer

A quality proposal advances a solution, though it does not deliver it.

Defines the problem: so effort targets the real issue.

Plans sound methods: so the eventual evidence is reliable.

Anticipates difficulties: which reduces failure in the field.

Qualification: it is still only a plan; the solution comes from the completed study and action on it.

So a strong proposal on irrigation in Usangu is a real step forward, but the challenge is solved only when the study is done and acted upon.

Question 93

A student values the report and dismisses the proposal as mere paperwork. Judge whether the proposal or the report matters more.

Model Answer

Both matter, because they serve different and complementary roles.

Proposal: it secures approval and plans the work, deciding its quality in advance.

Report: it delivers the findings and recommendations that others use.

Dependence: neither replaces the other, since a poor plan yields a poor report.

So the student is wrong to dismiss the proposal, because a sound study of waste in Tanga depends first on a good plan and then on a clear report.

Question 94

A researcher insists on using only her own field data and refuses all published figures. To what extent are both primary and secondary data of paramount importance?

Model Answer

Both are important, and the strongest studies use them together.

Primary data: give original, first-hand evidence tailored to the question.

Secondary data: give context, long records and wide coverage cheaply.

Together: they cross-check each other, strengthening the findings.

Qualification: each must be checked for accuracy and fit.

So refusing published figures weakens a population study of Tanzania, because the census records and her own fieldwork are strongest combined.

False Confidence Alert
Primary data are not always superior. They can be narrow in scope and time, so dismissing secondary data throws away a valuable and often longer record.

Question 95

A newspaper claims that because crime and ice-cream sales rise together, ice cream causes crime. Judge why a strong correlation need not mean cause.

Model Answer

A strong correlation shows association, not cause.

Third factor: hot weather raises both ice-cream sales and the outdoor activity linked to crime.

Direction: correlation alone does not show which variable, if any, drives the other.

Proof of cause: cause is established only by controlled study, not by co-movement.

So the newspaper is wrong, just as a researcher in Mbeya cannot claim rainfall alone causes high yields merely because the two rise together.

Question 96

A researcher must study a population that falls into clear groups but is also spread over a wide area. Compare cluster and stratified sampling and choose between them.

Model Answer

The choice depends on whether the priority is representing groups or covering an area.

Stratified sampling: splits the population into groups and samples each in proportion, best when group representation matters.

Cluster sampling: divides a wide area into clusters and studies some in full, best when no full list exists and the area is large.

Trade-off: stratified gives precision, while cluster gives reach at lower cost.

So for clear groups within a small area stratified sampling is better, while for a wide district such as Chunya cluster sampling is the practical choice.

Question 97

A reviewer dismisses a study as unscientific simply because it used non-probability sampling. Judge which family of sampling fits a given geographical challenge.

Model Answer

The right family depends on the problem, not on prestige.

Probability sampling: best when the population is listed and findings must be generalised, as in a household survey.

Non-probability sampling: best when the group is rare or hidden, as with illegal charcoal makers reached by snowball.

Multi-stage sampling: combines techniques to reach a large, scattered population.

So the reviewer is wrong, because a snowball sample of hidden charcoal makers in Morogoro is the correct choice, not an unscientific one.

False Confidence Alert
Non-probability sampling is not unscientific. For rare or hidden populations it is often the only workable method, and rejecting it would leave the problem unstudied.

Question 98

A village leader argues that there is no need to sample, since the whole population could simply be studied. Comment on the statement.

Model Answer

The statement is mistaken except in very small populations.

Case for the leader: where the population is tiny, studying everyone is indeed best and most accurate.

Against: for a large or scattered population a full study wastes time and money and invites more errors.

Better way: a sound sample already represents the whole at far less cost.

So the leader is right only for a small village, but for a region such as Tanga a representative sample is both cheaper and more reliable than counting everyone.

Question 99

Mr Ahmed, an environmentalist in Mkomazi, Tanga, decides to research the rate of deforestation from charcoal making in his village. Choose the type of research he should use, the basic requirements he must consider, and the problems he may encounter.

Model Answer

Ahmed should use applied field research, carefully prepared for a sensitive topic.

Type: applied, exploratory and descriptive research, since the aim is to solve a real, poorly-documented local problem.

Requirements: a clear problem and objectives, a suitable design, the right sampling, and proper tools such as observation and interview guides.

Sampling: snowball or purposive sampling, since charcoal makers are few and may hide.

Problems: reluctant or evasive respondents, sensitivity and risk, limited funds, and difficulty measuring forest loss accurately.

So Ahmed's Mkomazi study works best as careful applied research, anticipating that a sensitive topic needs trust, the right sample, and honest handling of its limits.

Question 100

With limited time and money, a researcher must pick one main data-collection method. Judge which method best balances accuracy, cost and bias.

Model Answer

No single method is best for all, so the balance depends on the data needed.

Household survey: broad and comparable, but it can miss depth and suffer low response.

Interview: deep and accurate, but costly per respondent and hard to generalise.

Observation: direct and free of self-report bias, but observer-biased and slow.

Balance: a survey backed by a few interviews often gives the best mix of breadth, depth and cost.

So for a waste study in Mwanza a household survey supported by a few interviews balances accuracy, cost and bias better than any single method alone.

Chapter 3

GEOGRAPHICAL DATA ANALYSIS AND INTERPRETATION

Geographers rarely deal in single facts; they deal in sets of figures, such as rainfall totals for a dozen stations, crop yields across the regions, or the ages of everyone in a village, and those figures speak only once they are organised, summarised, pictured and read. This chapter builds that skill. It begins with the nature of geographical data and how raw data is processed and analysed. It then teaches the two summaries at the heart of statistics: the measures of central tendency (the mean, median and mode), which find the value a set clusters around, and the measures of dispersion (the range, mean deviation, variance and standard deviation), which measure how widely the set is spread. From numbers it turns to pictures, constructing the full range of statistical graphs and charts and the statistical maps (dot, isoline, choropleth and flow-line) that show how a quantity varies across space. It closes with the interpretation of results: turning a figure or a finished diagram into a geographical statement, and the care a trustworthy conclusion demands. Throughout, the worked answers use Tanzanian data and explain every step, because in this chapter marks are won or lost on execution. As always, the chapter runs in three tiers and is best worked in order.

BINDER QUESTIONS

Question 1

A district officer in Mwanza keeps two kinds of record about every lakeshore fishing village: where each village lies on the shore of Lake Victoria, and how many boats, people and tonnes of fish it has. Explain the meaning of geographical data and distinguish the two types the officer is keeping.

Model Answer

Geographical data are facts about places and phenomena on the earth's surface, collected and recorded so that they can be measured, mapped and analysed. They fall into two types.

1) **Locational (spatial) data:** state where a feature is, given as points (a single village), lines (a road or river) or areas (the lake itself), and usually fixed by coordinates or a grid reference.
2) **Descriptive (attribute) data:** state what a feature is like, the qualities or quantities tied to that place, such as the number of boats, the population and the tonnes of fish landed, and are set out in tables.

So the officer's shore positions are locational data while the boat, population and fish figures are descriptive data, and a full picture of the Lake Victoria fishery needs both together.

> **False Confidence Alert**
> A value is not yet geographical data until it is tied to a place. Recording "four hundred tonnes of fish" without saying which village or shore it belongs to gives a bare number, not geographical information.

Question 2

Before mapping soil erosion in the Uluguru Mountains near Morogoro, a research team must first obtain its data. Describe the main sources from which geographical data are obtained.

Model Answer

Geographical data are drawn from two broad kinds of source, and each is gathered by its own methods.

1) **Primary (first-hand) sources:** the researcher collects the data directly in the field, fixing positions by ground and GPS survey or aerial photography, and gathering attributes by observation, questionnaires, interviews and focus-group discussion.
2) **Secondary (second-hand) sources:** the data have already been collected by other people and are taken from published maps, census and meteorological records, reports and office files.

So the Uluguru team fixes the eroded sites by field and GPS survey while drawing past rainfall figures from meteorological records, combining primary and secondary data to map the problem.

Question 3

A student returns from fieldwork in Dodoma with a pile of filled questionnaires and rough field notes. Before any analysis can begin, the raw data must be processed. Explain what the processing of geographical data involves.

Model Answer

Processing turns raw field material into an orderly form ready for analysis, through four linked steps.

1) **Editing:** checking the raw returns for errors, gaps and inconsistencies and putting them right, so that faulty entries never enter the analysis.
2) **Coding:** giving numbers or symbols to the answers and categories so that they can be counted and handled quickly.
3) **Classification:** sorting the coded data into groups or classes, for example by size, type or area.
4) **Tabulation:** arranging the classified data into frequency tables that are ready for analysis.

So the student's Dodoma questionnaires move from loose notes to clean tables; because every later result rests on this stage, careless processing carries errors straight through to the conclusion.

False Confidence Alert
Processing is not mere copying out. If editing is skipped, a single miswritten figure survives into every average and graph that follows, so the finished result looks tidy yet is wrong.

Question 4

Two students study the same market in Arusha. One counts the customers and records the prices of goods; the other records what shoppers feel about the market's services. Distinguish quantitative from qualitative analysis of geographical data.

Model Answer

The two students are using the two families of analysis, which differ in the kind of information each handles.

Quantitative analysis: works with numbers and measurable quantities such as counts, prices and areas, using arithmetic and statistics to find totals, averages, ratios and patterns.

Qualitative analysis: works with non-numeric information such as opinions, perceptions and descriptions, which are grouped by theme and meaning rather than counted.

So the first Arusha student's counts and prices are handled quantitatively while the second student's opinions are handled qualitatively, and many strong studies use the two together.

Question 5

Quantitative analysis of geographical data is not a single method. Explain the main approaches a geographer uses when analysing numerical data.

Model Answer

Numerical geographical data are analysed through three main approaches.

1) **Spatial (geometric) analysis:** measures distance, direction, area and shape and examines how features are spread across space, for example how evenly settlements are distributed on the central plateau.
2) **Arithmetic analysis:** uses basic calculation such as totals, differences, ratios and percentages, for example the percentage change in a region's maize output between two years.
3) **Statistical analysis:** summarises and interprets the data with measures of central tendency and dispersion, and tests relationships where inference is required.

So a study of rainfall across the regions might map its distribution (spatial), work out its percentage change (arithmetic) and find its mean and standard deviation (statistical).

Question 6

A geographer measures the rainfall of all thirty recording stations in a region, then wants to say something about the wider zone she did not measure. Distinguish descriptive from inferential statistics.

Model Answer

Statistics are used in two ways, which differ in how far beyond the collected data they reach.

Descriptive statistics: organise, summarise and describe the data actually collected, using averages, measures of spread, tables and graphs, and make no claim beyond that set.

Inferential statistics: use a sample to draw conclusions about a larger population that was not fully measured, estimating values and testing ideas about it.

So summarising the thirty stations she measured is descriptive, while generalising from them to the whole zone is inferential.

False Confidence Alert
A description of a sample is not proof about the whole population. Treating the average of thirty stations as a settled fact for an entire region ignores the uncertainty that inferential statistics exist to handle.

Question 7

When a report states that the "average" maize yield in Iringa was eighteen bags per hectare, it replaces thousands of different farm figures with a single value. Explain what a measure of central tendency is and why geographers use one.

Model Answer

A measure of central tendency is a single value that represents the centre of a set of data, the value around which the other values cluster.

Purpose: it summarises a whole set of figures in one representative value, so that large amounts of data can be compared and communicated quickly.

The three measures: the mean, the median and the mode each locate that centre in a different way, and each suits a different kind of data.

So the Iringa "average" stands in for every farm's yield, letting the region be compared with others at a glance; the rest of this section shows how each measure is found.

Question 8

A weather station at Kigoma recorded these midday temperatures over one week (in degrees Celsius): 28, 30, 29, 31, 27, 30 and 29. Calculate the mean temperature.

Model Answer

The mean shares the total of the values equally among them, so we add the values and divide by their number.

Step 1: State the formula. For an ungrouped set, the mean is the sum of the values divided by how many there are:

$$\bar{x} = \frac{\sum x}{n}$$

Step 2: Add the values. Sum all seven readings, because the mean needs the total amount of heat recorded:

$$\sum x = 28 + 30 + 29 + 31 + 27 + 30 + 29 = 204$$

Step 3: Divide by the number of values. There are n = 7 readings, so divide the total by seven:

$$\bar{x} = \frac{204}{7} = 29.14$$

Interpretation. The mean midday temperature for the week is about 29.14 degrees Celsius, a single value that represents the whole week's heat at Kigoma.

Question 9

In a survey of household size in a Singida village, the number of people per household was recorded as the frequency table below. Calculate the mean household size.

Household size (x)	**2**	**3**	**4**	**5**	**6**	**7**
Frequency (f)	4	7	10	9	6	4

Model Answer

When each value carries a frequency, we weight each value by how often it occurs, so we total the products and divide by the total frequency.

Step 1: State the formula. The mean of a frequency distribution is the total of the products divided by the total frequency:

$$\bar{x} = \frac{\sum fx}{\sum f}$$

Step 2: Build the products and total the columns. Multiply each size by its frequency and add the columns, because Σfx is the total number of people and Σf the total number of households.

Household size x	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Frequency f	4	7	10	9	6	4	40
f x	**8**	**21**	**40**	**45**	**36**	**28**	**178**

Step 3: Substitute and divide. Divide the total number of people by the total number of households:

$$\bar{x} = \frac{178}{40} = 4.45$$

Interpretation. The mean household size is about 4.45 people, so a typical household in the village has between four and five members.

Question 10

The daily number of customers at a Mbeya market stall over thirty days was grouped as below. Using the direct method, calculate the mean number of customers per day.

Customers	**0 - 10**	**10 - 20**	**20 - 30**	**30 - 40**	**40 - 50**
Days (f)	3	7	10	6	4

Model Answer

For grouped data the exact values are unknown, so each class is represented by its midpoint, and the mean is found as for a frequency distribution.

Step 1: State the formula. The grouped mean by the direct method uses the class midpoint in place of each value:

$$\bar{x} = \frac{\sum fx}{\sum f}$$

Step 2: Find each midpoint, build the products, and total. The midpoint is the average of a class's lower and upper limits; multiplying by the frequency estimates the total for that class.

Class	Midpoint x	Frequency f	f x
0 - 10	5	3	15
10 - 20	15	7	105
20 - 30	25	10	250
30 - 40	35	6	210
40 - 50	45	4	180
Total		**30**	**760**

Step 3: Substitute and divide. Divide the grand total by the number of days:

$$\bar{x} = \frac{760}{30} = 25.33$$

Interpretation. The mean number of customers is about 25.33 per day, the single figure that represents the stall's month of trade.

Question 11

A Geography teacher in Tabora recorded the test scores of fifty students in five classes as below. Using the assumed-mean method, calculate the mean score.

Score	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60
Students (f)	6	10	16	12	6

Model Answer

The assumed-mean method measures how far each midpoint lies from a chosen convenient value, so the arithmetic stays light.

Step 1: State the formula. The mean equals the assumed mean plus the average of the frequency-weighted deviations:

$$\bar{x} = A + \frac{\sum fd}{\sum f}$$

Step 2: Choose the assumed mean and find the deviations. Take $A = 35$, the midpoint of the largest class, because deviations from a central value are smallest. For each class, $d = x - 35$.

Class	Midpoint x	Frequency f	d = x − 35	f d
10 - 20	15	6	−20	−120
20 - 30	25	10	−10	−100
30 - 40	35	16	0	0
40 - 50	45	12	10	120
50 - 60	55	6	20	120
Total		**50**		**20**

Step 3: Substitute and simplify. Divide the total of the deviation-products by the total frequency and add it to the assumed mean:

$$\bar{x} = 35 + \frac{20}{50} = 35 + 0.4 = 35.4$$

Interpretation. The mean score is 35.4 marks, so the Tabora class scored on average a little above the middle of the 30 to 40 band.

False Confidence Alert
The assumed mean is only a computing device. Whatever value you assume, the final mean comes out the same; choosing a central midpoint merely keeps the deviations small and the arithmetic tidy.

Question 12

Rainfall recorded at forty stations was grouped as below. Calculate the mean rainfall, and confirm that the direct and assumed-mean methods give the same answer.

Rainfall (mm)	0 - 40	40 - 80	80 - 120	120 - 160	160 - 200
Stations (f)	5	9	13	8	5

Model Answer

A mean should not depend on the method used to reach it, so we work it both ways and check that they agree.

Step 1: Set out both methods in one table. Take $A = 100$, the midpoint of the middle class, and build both the product column (direct method) and the deviation column (assumed-mean method).

Class	Midpoint x	f	f x	d = x − 100	f d
0 - 40	20	5	100	−80	−400
40 - 80	60	9	540	−40	−360
80 - 120	100	13	1300	0	0
120 - 160	140	8	1120	40	320
160 - 200	180	5	900	80	400
Total		**40**	**3960**		**−40**

Step 2: Direct method. Divide the total of the products by the total frequency:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{3960}{40} = 99$$

Step 3: Assumed-mean method. Add the average of the deviation-products to the assumed mean:

$$\bar{x} = A + \frac{\sum fd}{\sum f} = 100 + \frac{-40}{40} = 100 - 1 = 99$$

Interpretation. Both methods give a mean rainfall of 99 mm, so the working is confirmed; the assumed-mean route simply reaches it with smaller numbers.

Question 13

Two short series of monthly rainfall were recorded at a station. Series A: 30, 45, 25, 60 and 40 mm. Series B: 30, 45, 25, 60, 40 and 50 mm. Find the median of each series.

Model Answer

The median is the middle value once the data are arranged in order; when the count is even it is the average of the two middle values.

Step 1: State the rule for the position. For an ordered set the median lies at position:

$$\frac{n+1}{2}$$

Step 2: Series A (odd count). Arrange in order: 25, 30, 40, 45, 60. With $n = 5$ the median is the third value, $\frac{5+1}{2}$, which is 40 mm.

Step 3: Series B (even count). Arrange in order: 25, 30, 40, 45, 50, 60. With $n = 6$ the middle two are the third and fourth values, 40 and 45, so the median is their average:

$$\frac{40+45}{2} = 42.5$$

Interpretation. The median of Series A is 40 mm and of Series B is 42.5 mm; adding one wetter month shifts the middle only slightly, which is why the median resists extreme values.

Question 14

The monthly incomes (in thousand shillings) of fifty traders in Kariakoo were grouped as below. Calculate the median income.

Income	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100
Traders (f)	6	10	14	12	8

Model Answer

For grouped data the median is found by locating the class that contains the middle trader, then measuring how far into that class the middle lies.

Step 1: State the formula. The grouped median uses the lower boundary L of the median class, the cumulative frequency cf before it, the class frequency f and the class width i:

$$\text{Median} = L + \frac{\frac{n}{2} - cf}{f} \times i$$

Step 2: Build cumulative frequencies and locate the median class. Half the total is $\frac{n}{2} = 25$, so the cumulative frequencies show where the 25th trader falls.

Class	Frequency f	Cumulative frequency
0 - 20	6	6
20 - 40	10	16
40 - 60	14	30
60 - 80	12	42
80 - 100	8	50

Step 3: Read the values and substitute. The 25th value lies in the 40 to 60 class, so $L = 40$, $cf = 16$, $f = 14$ and $i = 20$:

$$\text{Median} = 40 + \frac{25 - 16}{14} \times 20 = 40 + \frac{9}{14} \times 20 = 52.86$$

Interpretation. The median income is about 52.86 thousand shillings, so half the Kariakoo traders earn less than this and half earn more.

Question 15

The ages of sixty members of a Mwanza fishing cooperative were grouped as below. Calculate the median age.

Age (years)	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
Members (f)	8	15	20	12	5

Model Answer

As before, we locate the class of the middle member and measure how far into it the median falls.

Step 1: State the formula. The grouped median formula is:

$$\text{Median} = L + \frac{\frac{n}{2} - cf}{f} \times i$$

Step 2: Build cumulative frequencies and locate the median class. Half the total is $\frac{60}{2} = 30$, so find the class holding the 30th member.

Class	Frequency f	Cumulative frequency
20 - 30	8	8
30 - 40	15	23
40 - 50	20	43
50 - 60	12	55
60 - 70	5	60

Step 3: Read the values and substitute. The 30th member lies in the 40 to 50 class, so $L = 40$, $cf = 23$, $f = 20$ and $i = 10$:

$$\text{Median} = 40 + \frac{30 - 23}{20} \times 10 = 40 + \frac{7}{20} \times 10 = 43.5$$

Interpretation. The median age is 43.5 years, the age of the middle member of the cooperative.

Question 16

The number of goats owned by ten households in a Shinyanga village was 4, 6, 5, 4, 7, 4, 6, 5, 8 and 6. State the mode, and explain what happens when a set has more than one mode.

Model Answer

The mode is the value that occurs most often, so we count how many times each value appears.

Step 1: Tally the frequencies. Counting each value: 4 appears three times, 6 appears three times, 5 appears twice, and 7 and 8 appear once each.

Step 2: Identify the mode. Two values, 4 and 6, each occur three times, more often than any other, so the set has two modes.

Interpretation. The data are bimodal, with modes of 4 and 6 goats. A set may be unimodal (one mode), bimodal (two) or multimodal (several), and if no value repeats there is no mode at all.

False Confidence Alert
The mode is not the middle value nor the largest value; it is the most frequent. Unlike the mean, a set of data can have two modes, several, or none, so never assume there is exactly one.

Question 17

The daily catch (in kilograms) of forty-five fishermen on Lake Tanganyika was grouped as below. Calculate the modal catch.

Catch (kg)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50
Fishermen (f)	5	12	18	7	3

Model Answer

For grouped data the mode lies in the class with the highest frequency, and its position within that class is found from how much the modal frequency exceeds its neighbours.

Step 1: State the formula. The grouped mode uses the lower boundary L of the modal class, the class width i, and the differences Δ_1 and Δ_2 between the modal frequency and the classes before and after it:

$$\text{Mode} = \text{L} + \frac{\Delta_1}{\Delta_1 + \Delta_2} \times \text{i}$$

Step 2: Identify the modal class and the differences. The modal class is 20 to 30 (frequency 18), so $\text{L} = 20$, $\text{i} = 10$, $\Delta_1 = 18 - 12 = 6$ (over the preceding class) and $\Delta_2 = 18 - 7 = 11$ (over the following class).

Step 3: Substitute. Place the values into the formula:

$$\text{Mode} = 20 + \frac{6}{6 + 11} \times 10 = 20 + \frac{6}{17} \times 10 = 23.53$$

Interpretation. The modal catch is about 23.53 kg, the most typical daily catch among the Lake Tanganyika fishermen.

Question 18

The heights (in centimetres) of fifty maize plants on a Kilombero farm were grouped as below. Calculate the modal height.

Height (cm)	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200
Plants (f)	6	14	20	7	3

Model Answer

Again the mode lies in the tallest class, positioned by how far the modal frequency stands above its neighbours.

Step 1: State the formula. The grouped mode formula is:

$$\text{Mode} = \text{L} + \frac{\Delta_1}{\Delta_1 + \Delta_2} \times \text{i}$$

Step 2: Identify the modal class and differences. The modal class is 140 to 160 (frequency 20), so $L = 140$, $i = 20$, $\Delta_1 = 20 - 14 = 6$ and $\Delta_2 = 20 - 7 = 13$.

Step 3: Substitute. Insert the values:

$$\text{Mode} = 140 + \frac{6}{6+13} \times 20 = 140 + \frac{6}{19} \times 20 = 146.32$$

Interpretation. The modal height is about 146.32 cm, the most common height among the maize plants.

Question 19

The number of passengers per bus trip on the Dar es Salaam to Morogoro route was grouped as below. Draw a histogram and use it to estimate the mode.

Passengers	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
Trips (f)	8	14	22	10	4

Model Answer

On a histogram the mode is found graphically by joining the corners of the tallest bar to its neighbours and reading where the lines cross.

Step 1: Draw the histogram. Plot each class against its frequency as bars of equal width, so the tallest bar shows the modal class, 40 to 50.

Step 2: Draw the two construction lines. From the top-left corner of the modal bar, draw a line to the top-left corner of the next bar; from the top-right corner of the modal bar, draw a line to the top-right corner of the previous bar.

Step 3: Drop a vertical from the crossing point. Where the two lines cross, drop a perpendicular to the horizontal axis and read the value, as shown in Figure 3.1.

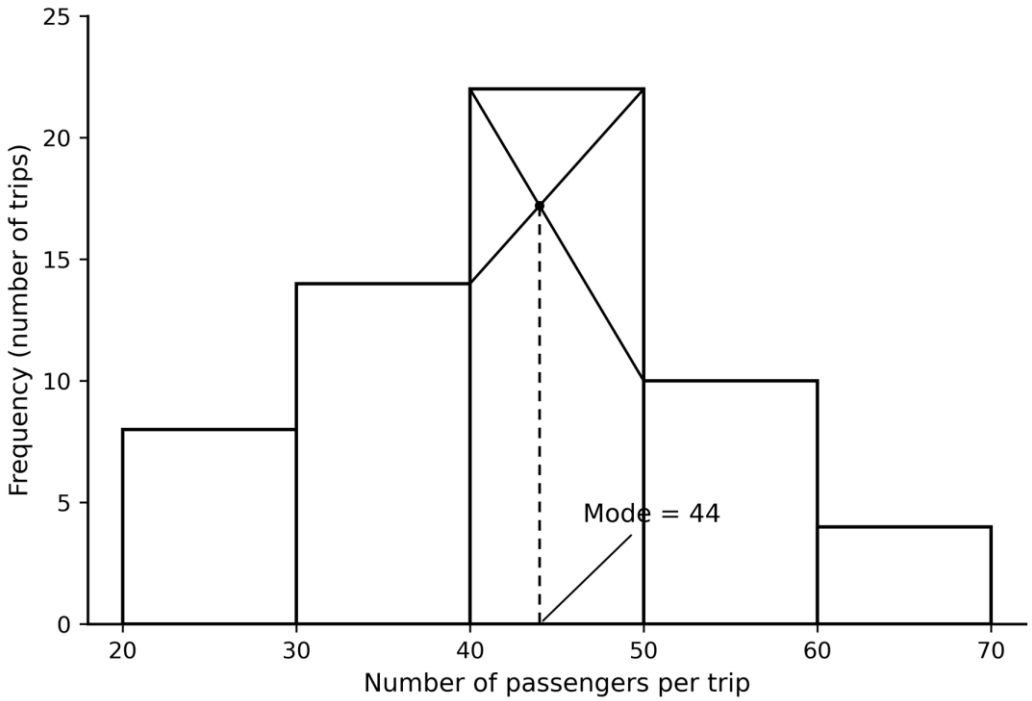


Figure 3.1: *Estimating the mode from a histogram (Dar es Salaam to Morogoro passengers)*

Confirm with the formula. The reading agrees with the grouped-mode formula, with $\Delta_1 = 8$ and $\Delta_2 = 12$:

$$\text{Mode} = 40 + \frac{8}{8+12} \times 10 = 44$$

Interpretation. The mode is about 44 passengers per trip, read from the histogram and confirmed by calculation.

False Confidence Alert
The mode is not simply the midpoint of the tallest bar (45 here). The construction lines lean the estimate toward the taller neighbour, giving 44, so reading the plain midpoint is a common slip.

Question 20

The examination marks of forty candidates at a Solya Girls Secondary School were grouped as below. From this single table, find the mean, the median and the mode.

Marks	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80
Candidates (f)	4	9	14	8	5

Model Answer

All three averages can be drawn from one working table that carries the midpoints, the products and the cumulative frequencies.

Build the combined working table. Set out the midpoint, the frequency, the product and the cumulative frequency for every class.

Class	Midpoint x	f	f x	Cumulative f
30 - 40	35	4	140	4
40 - 50	45	9	405	13
50 - 60	55	14	770	27
60 - 70	65	8	520	35
70 - 80	75	5	375	40
Total		**40**	**2210**	

Mean (direct method). Divide the total of the products by the total frequency:

$$\bar{x} = \frac{2210}{40} = 55.25$$

Median. Half the total is 20; the 20th candidate lies in the 50 to 60 class, with $L = 50$, $cf = 13$, $f = 14$ and $i = 10$:

$$\text{Median} = 50 + \frac{20 - 13}{14} \times 10 = 55$$

Mode. The modal class is 50 to 60 (frequency 14), with $\Delta_1 = 5$ and $\Delta_2 = 6$:

$$\text{Mode} = 50 + \frac{5}{5+6} \times 10 = 54.55$$

Interpretation. The mean is 55.25, the median 55 and the mode 54.55; because the three lie so close and fall in the order mean above median above mode, the distribution is nearly symmetrical with only a slight positive skew.

Question 21

A student claims the mean is always the best average to use. Assess the mean, the median and the mode by giving the main advantage and the main disadvantage of each.

Model Answer

No single average is best for every data set; each has a strength and a weakness that fit different kinds of data.

Mean: uses every value and is easy to compute and compare, but is pulled off centre by extreme values, so a few very large farms can inflate a district's mean yield.

Median: is unaffected by extreme values and works even for open-ended classes, but it ignores the actual sizes of most values and requires the data to be ordered first.

Mode: shows the most common value and is not disturbed by extremes, but a set may have no mode or several, and it ignores most of the data.

So the claim is wrong: the mean suits symmetrical data, the median suits skewed or open-ended data such as incomes, and the mode suits the most typical category, so the right choice depends on the data in hand.

Question 22

Two districts both report a mean annual rainfall of 900 mm, yet one enjoys steady rain every year while the other swings between drought and flood. Explain what a measure of dispersion is and why the mean alone is not enough.

Model Answer

A measure of dispersion shows how widely the values in a set are spread about their average, so two sets with the same mean can still differ greatly.

What it measures: dispersion measures the scatter of the data around the centre, and so tells us how well the average represents the set.

Why it matters: a small dispersion means the values cluster near the mean, so the average is reliable, while a large dispersion means they are widely scattered, so the average hides big differences.

So the two districts share a mean of 900 mm but differ in dispersion; the steady district has a small spread and the erratic one a large spread, which is why farmers need both the average and its spread.

False Confidence Alert
Equal means do not mean equal conditions. Reporting only the average rainfall of the erratic district hides the drought-and-flood swings that a measure of spread would at once reveal.

Question 23

Over one week a weather station at Same recorded these maximum temperatures (in degrees Celsius): 31, 28, 34, 27, 30, 33 and 29. Calculate the range.

Model Answer

The range is the simplest measure of spread, the gap between the largest and smallest values.

Step 1: State the formula. The range is the largest value minus the smallest:

$$R = L - S$$

Step 2: Identify the largest and smallest. Ordering the readings, the largest is $L = 34$ and the smallest is $S = 27$.

Step 3: Subtract. Take the difference:

$$R = 34 - 27 = 7$$

Interpretation. The range is 7 degrees Celsius, the full spread of the week's maximum temperatures at Same.

Question 24

The monthly water bills (in thousand shillings) of forty households in Moshi were grouped into the classes below. Calculate the range by the three accepted methods.

Bill	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50
Households (f)	5	9	12	8	6

Model Answer

For grouped data the exact largest and smallest values are unknown, so the range is estimated three ways, from the class limits, the class boundaries, or the midpoints.

Method 1: Upper-limit method. Subtract the lower limit of the lowest class from the upper limit of the highest class:

$$R = 50 - 1 = 49$$

Method 2: Real-limit (boundary) method. The true boundaries reach half a unit beyond the stated limits, so use 50.5 and 0.5:

$$R = 50.5 - 0.5 = 50$$

Method 3: Midpoint method. Take the difference between the midpoint of the highest class and that of the lowest:

$$R = 45.5 - 5.5 = 40$$

Interpretation. The three methods give 49, 50 and 40 thousand shillings; they differ because each uses a different edge of the two end classes, so the method chosen must always be stated.

Question 25

The ages (in years) of fifty pupils at a Sabasaba primary school were grouped into the classes below. Find the range by the three methods.

Age	5 - 9	10 - 14	15 - 19	20 - 24
Pupils (f)	8	15	18	9

Model Answer

The same three methods apply, each reading a different edge of the end classes.

Upper-limit method: Subtract the lower limit of the lowest class from the upper limit of the highest:

$$R = 24 - 5 = 19$$

Real-limit method: Using the boundaries 24.5 and 4.5:

$$R = 24.5 - 4.5 = 20$$

Midpoint method: The difference between the midpoint of the highest class and that of the lowest:

$$R = 22 - 7 = 15$$

Interpretation. The range is 19, 20 or 15 years depending on the method, a spread of about two decades across the school.

Question 26

Two markets record daily tomato prices per kilogram. Market A ranges from 200 to 600 shillings and Market B from 500 to 900. Both have a range of 400, yet their price stability differs. Calculate the coefficient of range for each and compare.

Model Answer

Because the absolute range ignores the size of the values, we use the coefficient of range, a relative measure that allows a fair comparison.

Step 1: State the formula. The coefficient of range divides the range by the sum of the largest and smallest values:

$$\text{Coefficient of range} = \frac{L - S}{L + S}$$

Step 2: Market A. With $L = 600$ and $S = 200$:

$$\frac{600 - 200}{600 + 200} = \frac{400}{800} = 0.5$$

Step 3: Market B. With $L = 900$ and $S = 500$:

$$\frac{900 - 500}{900 + 500} = \frac{400}{1400} = 0.29$$

Interpretation. Although both markets share the same absolute range of 400 shillings, Market A's coefficient (0.5) is higher than Market B's (0.29), so prices at Market A are relatively more variable.

Question 27

The marks of five students in an Iringa class were 2, 3, 4, 5 and 6. Calculate the mean deviation.

Model Answer

The mean deviation is the average distance of the values from their mean, taken as absolute values so that the deviations do not cancel out.

Step 1: State the formula. The mean deviation of ungrouped data is the sum of the absolute deviations divided by their number:

$$MD = \frac{\sum |x - \bar{x}|}{n}$$

Step 2: Find the mean. Add the marks and divide by five:

$$\bar{x} = \frac{2 + 3 + 4 + 5 + 6}{5} = \frac{20}{5} = 4$$

Step 3: Find the absolute deviations and total them. Take each mark's distance from the mean, ignoring sign, and add them.

Mark x	Deviation (x − 4)	Absolute deviation |x − 4|
2	−2	2
3	−1	1
4	0	0
5	1	1
6	2	2

Total		**6**

Step 4: Divide by the number of marks. Divide the total by five:

$$\text{MD} = \frac{6}{5} = 1.2$$

Interpretation. The mean deviation is 1.2 marks, so the marks lie on average 1.2 marks away from the mean of 4.

Question 28

The Geography scores of thirty-four students at Mwanza Girls Secondary School were grouped as below. Calculate the mean deviation.

Score	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50
Students (f)	4	8	10	8	4

Model Answer

For grouped data each class is represented by its midpoint, and each absolute deviation is weighted by the class frequency.

Step 1: State the formula. The grouped mean deviation is the sum of the frequency-weighted absolute deviations divided by the total frequency:

$$\text{MD} = \frac{\sum f|x - \bar{x}|}{\sum f}$$

Step 2: Find the mean, then the weighted absolute deviations. The mean comes from the products; the columns below then give each class's contribution:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{850}{34} = 25$$

Class	Midpoint x	f	f x	$\lvert x - 25\rvert$	f $\lvert x - 25\rvert$
0 - 10	5	4	20	20	80
10 - 20	15	8	120	10	80
20 - 30	25	10	250	0	0
30 - 40	35	8	280	10	80
40 - 50	45	4	180	20	80
Total		**34**	**850**		**320**

Step 3: Substitute and divide. Divide the total of the last column by the total frequency:

$$\text{MD} = \frac{320}{34} = 9.41$$

Interpretation. The mean deviation is about 9.41 marks, so the scores lie on average 9.41 marks from the mean of 25.

Question 29

The daily incomes (in thousand shillings) of forty traders in Tanga were grouped as below. Calculate the mean deviation.

Income	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100
Traders (f)	5	8	14	8	5

Model Answer

The method is the same: find the mean, then average the frequency-weighted absolute deviations.

Step 1: State the formula. The grouped mean deviation is:

$$MD = \frac{\sum f|x - \bar{x}|}{\sum f}$$

Step 2: Find the mean and the weighted absolute deviations. The mean comes from the products; the columns below carry each class's contribution:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{2000}{40} = 50$$

Class	Midpoint x	f	f x	$\lvert x - 50\rvert$	f $\lvert x - 50\rvert$
0 - 20	10	5	50	40	200
20 - 40	30	8	240	20	160
40 - 60	50	14	700	0	0
60 - 80	70	8	560	20	160
80 - 100	90	5	450	40	200
Total		**40**	**2000**		**720**

Step 3: Substitute and divide. Divide by the total frequency:

$$MD = \frac{720}{40} = 18$$

Interpretation. The mean deviation is 18 thousand shillings, so the traders' incomes lie on average 18 thousand from the mean of 50.

Question 30

Five students scored 4, 8, 6, 10 and 12 in a Practical Geography test. Calculate the variance of the scores, both as a population and as a sample.

Model Answer

The variance is the mean of the squared deviations from the mean; the population form divides by the number of values and the sample form by one less.

Step 1: State the formulae. For a population, dividing by N, and for a sample, dividing by n - 1:

$$\sigma^2 = \frac{\sum (x - \bar{x})^2}{N}, \quad s^2 = \frac{\sum (x - \bar{x})^2}{n - 1}$$

Step 2: Find the mean. Add the scores and divide by five:

$$\bar{x} = \frac{40}{5} = 8$$

Step 3: Square the deviations and total them. Subtract the mean, square, and add.

Score x	Deviation (x − 8)	Squared deviation
4	−4	16
8	0	0
6	−2	4
10	2	4
12	4	16
Total		**40**

Step 4: Divide. Divide the total by N for the population variance and by n - 1 for the sample variance:

$$\sigma^2 = \frac{40}{5} = 8, \quad s^2 = \frac{40}{4} = 10$$

Interpretation. The population variance is 8 and the sample variance 10 (in marks squared); the sample form is a little larger because it divides by one fewer.

False Confidence Alert
The variance is in squared units (marks squared here), not the original marks, which is why the standard deviation, its square root, is usually reported instead.

Question 31

The rainfall (in mm) at thirty stations was grouped as below. Calculate the variance.

Rainfall	0 - 20	20 - 40	40 - 60	60 - 80
Stations (f)	6	9	9	6

Model Answer

For grouped data the variance uses class midpoints, weighting each squared deviation by its frequency.

Step 1: State the formula. The grouped variance is the sum of the frequency-weighted squared deviations divided by the total frequency:

$$\sigma^2 = \frac{\sum f(x - \bar{x})^2}{\sum f}$$

Step 2: Find the mean and the weighted squared deviations. The mean comes from the products; the columns below give each class's contribution:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{1200}{30} = 40$$

Class	Midpoint x	f	f x	(x − 40)²	f (x − 40)²
0 - 20	10	6	60	900	5400
20 - 40	30	9	270	100	900

40 - 60	50	9	450	100	900
60 - 80	70	6	420	900	5400
Total		**30**	**1200**		**12600**

Step 3: Substitute and divide. Divide the total of the last column by the total frequency:

$$\sigma^2 = \frac{12600}{30} = 420$$

Interpretation. The variance is 420 $(\text{mm})^2$; its square root, about 20.49 mm, is the standard deviation in the original units.

Question 32

The number of customers served each hour at a Dodoma shop over eight hours was 2, 4, 4, 4, 5, 5, 7 and 9. Calculate the standard deviation.

Model Answer

The standard deviation is the square root of the variance, so it returns the spread to the original units of the data.

Step 1: State the formula. For ungrouped data:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

Step 2: Find the mean. Add the values and divide by eight:

$$\bar{x} = \frac{40}{8} = 5$$

Step 3: Square the deviations and total them. Subtract the mean from each value, square, and add.

Customers x	Deviation (x − 5)	Squared deviation
2	−3	9
4	−1	1
4	−1	1
4	−1	1
5	0	0
5	0	0
7	2	4
9	4	16
Total		**32**

Step 4: Divide and take the square root. Divide by the number of values to get the variance, then take its root:

$$s = \sqrt{\frac{32}{8}} = \sqrt{4} = 2$$

Interpretation. The standard deviation is 2 customers, the typical distance of an hour's count from the mean of 5.

Question 33

The examination marks of forty students at a Musoma school were grouped as below. Calculate the standard deviation.

Marks	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
Students (f)	3	8	18	8	3

Model Answer

For grouped data the standard deviation is the root of the frequency-weighted mean squared deviation.

Step 1: State the formula. The grouped standard deviation is:

$$s = \sqrt{\frac{\sum f(x - \bar{x})^2}{\sum f}}$$

Step 2: Find the mean and the weighted squared deviations. The mean comes from the products; the columns below give each class's contribution:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{1800}{40} = 45$$

Class	Midpoint x	f	f x	$(x - 45)^2$	$f(x - 45)^2$
20 - 30	25	3	75	400	1200
30 - 40	35	8	280	100	800
40 - 50	45	18	810	0	0
50 - 60	55	8	440	100	800
60 - 70	65	3	195	400	1200
Total		**40**	**1800**		**4000**

Step 3: Substitute, divide and take the root. Divide the total by the total frequency, then take the square root:

$$s = \sqrt{\frac{4000}{40}} = \sqrt{100} = 10$$

Interpretation. The standard deviation is 10 marks, so the marks lie on average 10 marks from the mean of 45.

Question 34

The heights (in centimetres) of fifty seedlings at a Njombe nursery were grouped as below. Calculate the standard deviation.

Height	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50
Seedlings (f)	6	12	14	12	6

Model Answer

The same grouped formula applies: find the mean, weight the squared deviations, average them and take the root.

Step 1: State the formula. The grouped standard deviation is:

$$s = \sqrt{\frac{\sum f(x - \bar{x})^2}{\sum f}}$$

Step 2: Find the mean and the weighted squared deviations. The mean comes from the products; the columns below carry each class's contribution:

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{1250}{50} = 25$$

Class	Midpoint x	f	f x	$(x - 25)^2$	$f(x - 25)^2$
0 - 10	5	6	30	400	2400
10 - 20	15	12	180	100	1200
20 - 30	25	14	350	0	0
30 - 40	35	12	420	100	1200
40 - 50	45	6	270	400	2400
Total		**50**	**1250**		**7200**

Step 3: Substitute, divide and take the root. Divide by the total frequency, then take the square root:

$$s = \sqrt{\frac{7200}{50}} = \sqrt{144} = 12$$

Interpretation. The standard deviation is 12 cm, the typical distance of a seedling's height from the mean of 25 cm.

Question 35

Once geographical data have been summarised, they must be presented so that others can read them at a glance. Outline the main methods of presenting geographical data.

Model Answer

Presented data fall into three families, each suited to a different message.

1) **Graphical methods (charts):** line graphs, bar graphs and population pyramids, which show trends and comparisons on a pair of axes.

2) **Diagrammatic methods:** divided circles and rectangles, proportional symbols and wind roses, which show the composition or proportions of a total.

3) **Map (statistical) methods:** dot, isoline, choropleth and flow-line maps, which show how a quantity varies from place to place.

So the method depends on the message: trends over time suit graphs, proportions suit diagrams, and spatial patterns suit maps; this section builds the graphical family.

Question 36

The table shows the maize production of Njombe region over six years. Draw a simple line graph to present the data.

Year	2018	2019	2020	2021	2022	2023
Production ('000 tonnes)	40	45	42	50	55	60

Model Answer

A simple line graph shows how one quantity changes over time by joining plotted points.

Step 1: Choose and scale the axes. Put time on the horizontal axis and production on the vertical, because production depends on the year, and choose even scales that fit the data.

Step 2: Plot the points. Mark each year's production against its year with a small dot.

Step 3: Join, label and title. Join the dots with straight lines, label each axis with its quantity and unit, and title the graph, as in Figure 3.2.

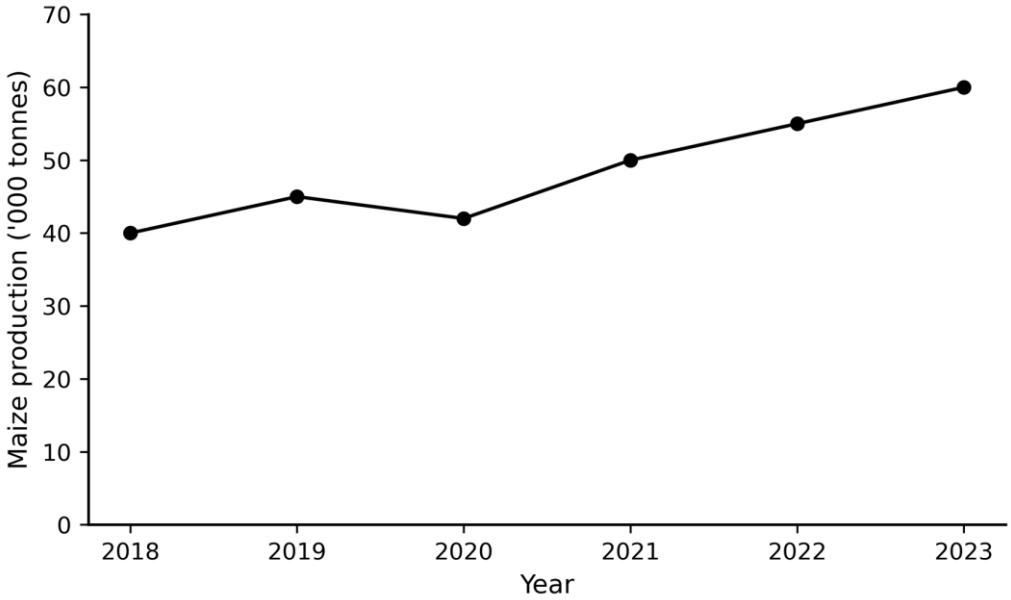


Figure 3.2: *Simple line graph of Njombe maize production*

Interpretation. Maize production rose overall from 40 to 60 thousand tonnes, an upward trend broken only by a dip in 2020.

Question 37

The table shows the rainfall recorded at three stations over five months. Draw a grouped (multiple) line graph to compare them.

Month	Jan	Feb	Mar	Apr	May
Mbeya (mm)	200	180	150	120	90

Iringa (mm)	160	150	130	100	70
Dodoma (mm)	120	110	90	70	50

Model Answer

A grouped line graph plots several series on the same axes so they can be compared directly.

Step 1: Set up the axes. Put the months on the horizontal axis and rainfall on the vertical, with one scale that covers the largest value.

Step 2: Plot each station in turn. Plot and join the points for Mbeya, then Iringa, then Dodoma, on the same axes.

Step 3: Distinguish the lines and add a key. Draw each station's line in a different style (solid, dashed, dotted) and add a key, as in Figure 3.3.

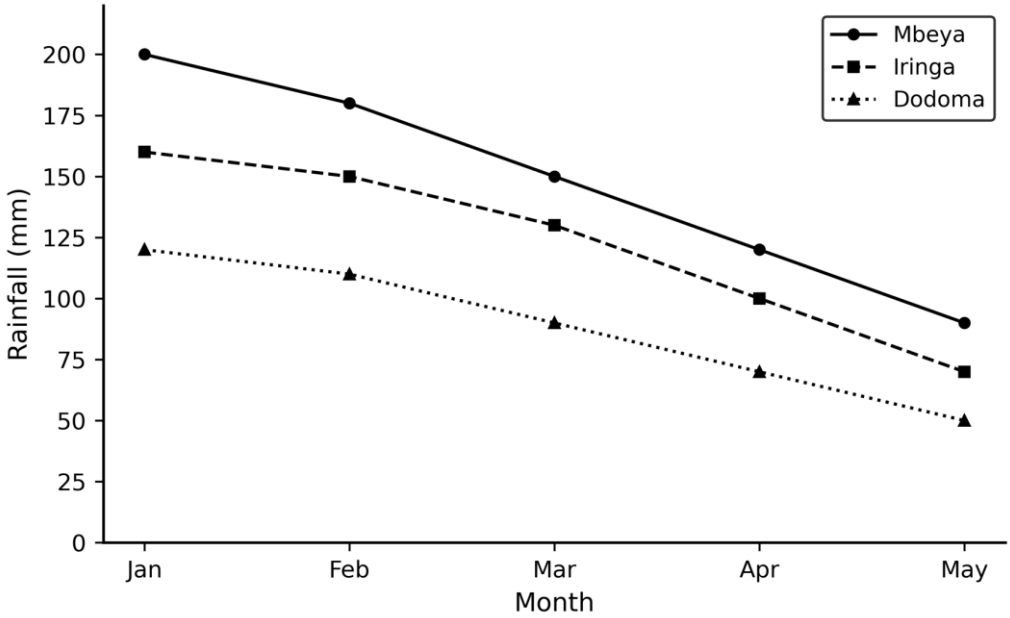


Figure 3.3: *Grouped line graph of rainfall at three stations*

Interpretation. All three stations show rainfall falling steadily from January to May, and Mbeya is the wettest throughout, so the three share one rainfall regime differing only in amount.

Question 38

The table shows electricity generated from three sources over four years. Draw a compound line graph.

Year	2020	2021	2022	2023
Hydro ('000 MWh)	30	32	35	38
Gas ('000 MWh)	20	25	28	30
Solar ('000 MWh)	5	8	10	14

Model Answer

A compound line graph adds the components on top of one another, so the bands between the lines show each part and the top line shows the total.

Step 1: Find the cumulative totals. Plot hydro first, then hydro plus gas, then all three added together, so each line lies above the one below.

Step 2: Plot the three cumulative lines. Join each set of cumulative points across the years.

Step 3: Label the bands and add a key. Shade or name the band for each source between the lines, as in Figure 3.4.

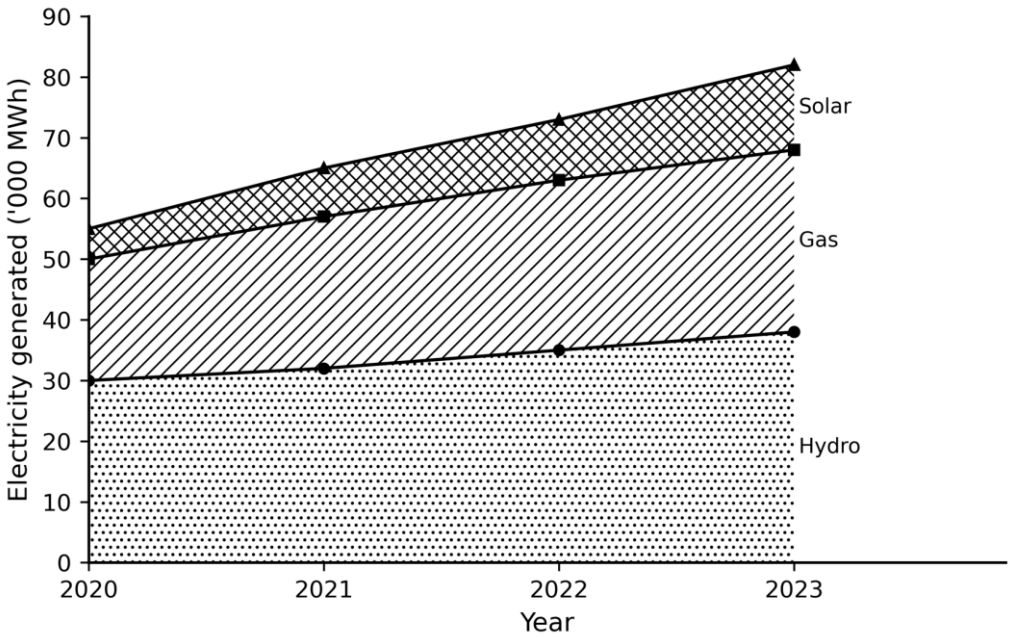


Figure 3.4: *Compound line graph of electricity generation by source*

Interpretation. Total generation rose from 55 to 82 thousand MWh; the widening solar and gas bands show that these newer sources grew fastest.

Question 39

The table shows the trade balance (exports minus imports) of a country over six years; some years show a surplus and others a deficit. Draw a divergent line graph.

Year	2018	2019	2020	2021	2022	2023
Trade balance (billion shillings)	5	−3	8	−6	10	4

Model Answer

A divergent line graph is drawn about a zero base line, so values rise above it as a surplus and fall below it as a deficit.

Step 1: Draw the zero base line. Rule a horizontal line for zero across the middle of the graph, with positive values above and negative below.

Step 2: Plot each year and join. Plot each year's balance above or below the base line and join the points.

Step 3: Label and title. Label both axes and title the graph, as in Figure 3.5.

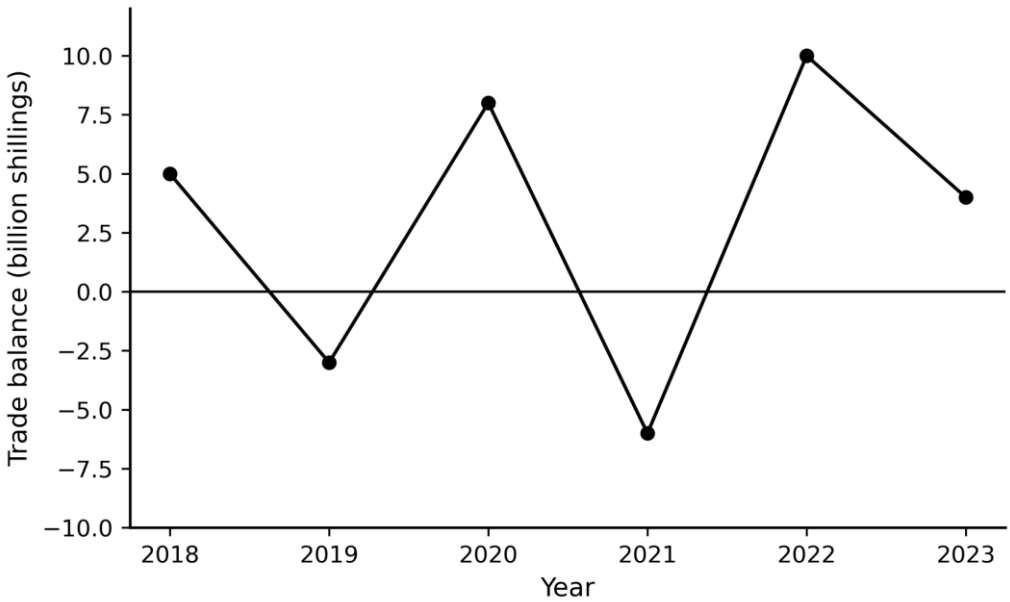


Figure 3.5: *Divergent line graph of the trade balance*

Interpretation. The balance swung repeatedly between surplus and deficit, with deficits in 2019 and 2021, but ended in surplus, so the country's trade was unstable yet improving.

Question 40

The table shows the number of tourists visiting four national parks in two years. Draw a grouped bar graph.

National park	Serengeti	Ngorongoro	Manyara	Ruaha
2022 ('000)	250	180	90	60
2023 ('000)	300	210	110	80

Model Answer

A grouped bar graph places the bars for the two years side by side within each park, so the two can be compared at once.

Step 1: Set up the axes. Put the parks on the horizontal axis and the number of tourists on the vertical, scaled to the largest value.

Step 2: Draw paired bars. For each park draw two bars of equal width side by side, one for each year, resting on the axis.

Step 3: Distinguish the years and add a key. Shade the two years differently and add a key, as in Figure 3.6.

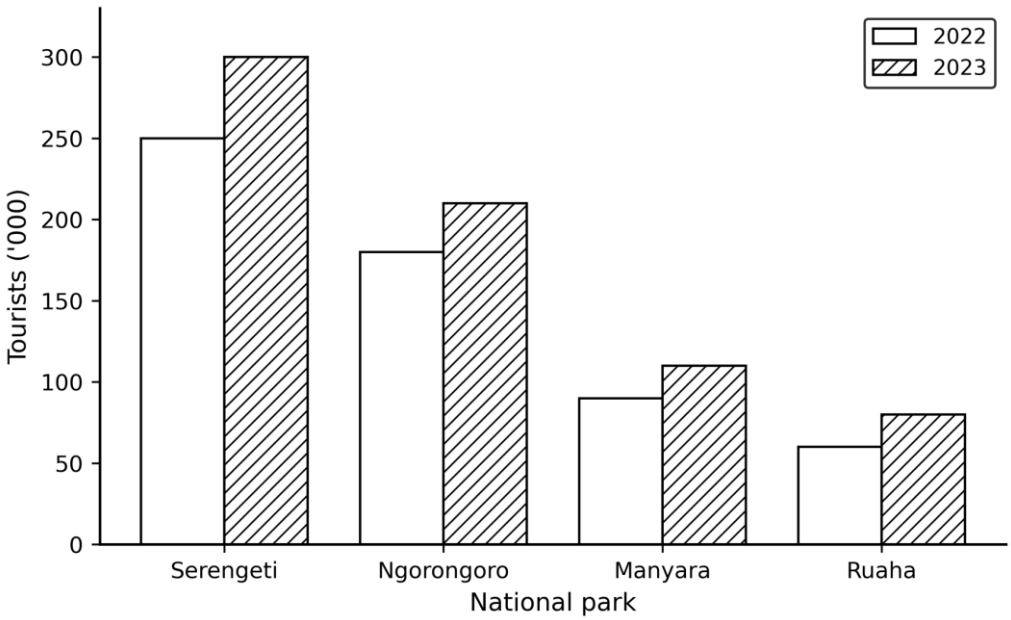


Figure 3.6: *Grouped bar graph of tourist numbers*

Interpretation. Every park gained tourists from 2022 to 2023, and Serengeti drew by far the most, so tourism grew across all four parks.

False Confidence Alert
The bars must be equal in width and evenly spaced. Making one bar wider than another exaggerates its value and distorts the comparison a bar graph is meant to make.

Question 41

The table shows the production of three crops in three regions. Draw a compound (component) bar graph.

Region	Mbeya	Iringa	Njombe
Maize ('000 t)	40	35	50
Rice ('000 t)	20	15	10
Beans ('000 t)	10	12	8

Model Answer

A compound bar graph stacks the parts of each total in a single bar, so it shows both the total and its make-up.

Step 1: Set up the axes. Put the regions on the horizontal axis and production on the vertical, scaled to the largest total.

Step 2: Build each bar in parts. For each region draw one bar and divide it into maize, rice and beans stacked in order, each part scaled to its value.

Step 3: Shade the parts and add a key. Shade each crop differently and add a key, as in Figure 3.7.

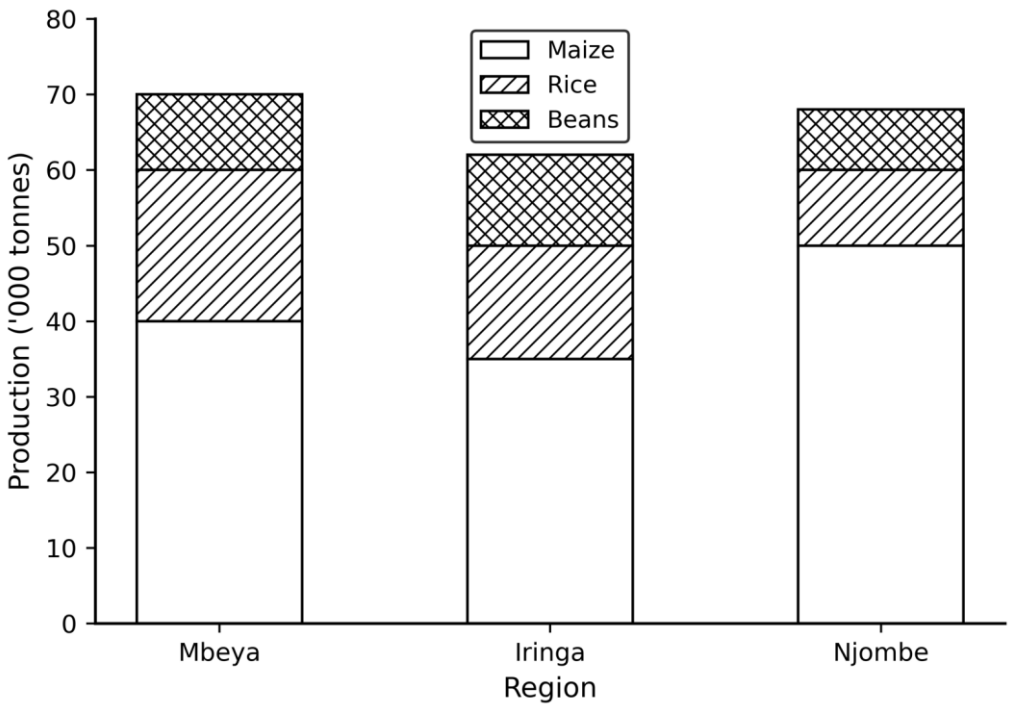


Figure 3.7: *Compound bar graph of crop production by region*

Interpretation. Njombe has the largest total output and maize is the leading crop in every region, so the three regions share a maize-based farming pattern.

Question 42

The table shows the percentage of households using each energy source in urban and rural areas. Draw a compound bar graph.

Area	Firewood (%)	Charcoal (%)	Electricity (%)
Urban	20	40	40
Rural	70	25	5

Model Answer

Because each area's shares add to 100 per cent, a compound bar shows the whole make-up of each area in one bar.

Step 1: Set up the axes. Put the two areas on the horizontal axis and percentage on the vertical, running to 100.

Step 2: Stack the shares. For each area stack firewood, charcoal and electricity so the bar reaches 100 per cent.

Step 3: Shade and add a key. Shade each source differently and add a key, as in Figure 3.8.

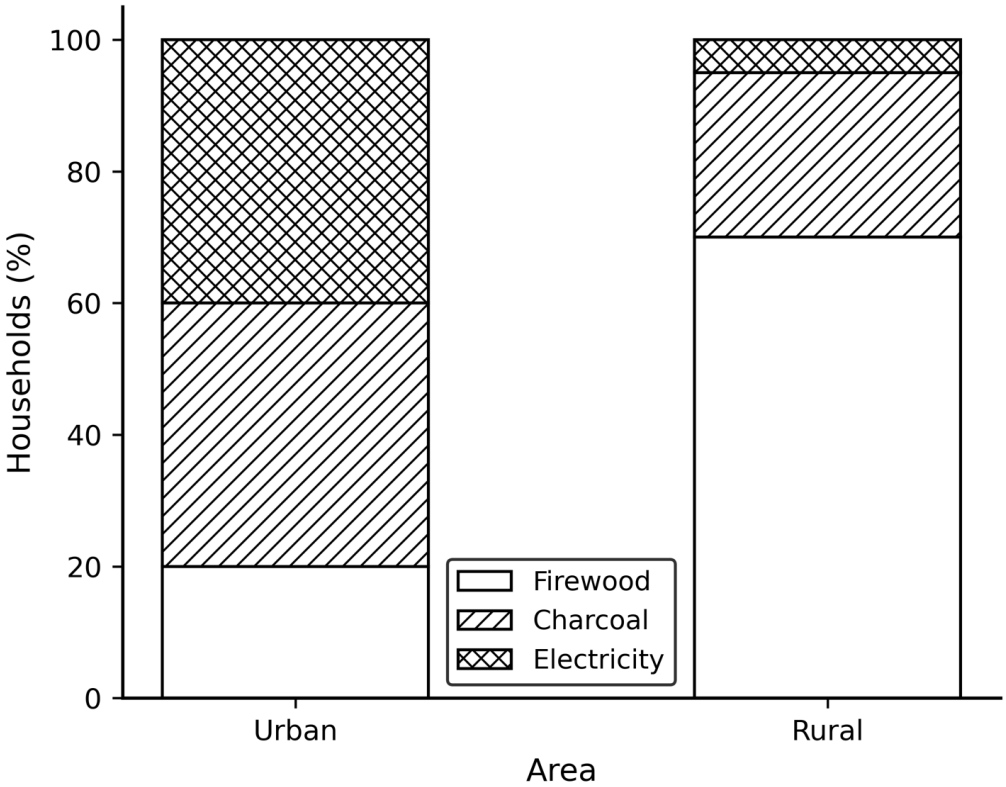


Figure 3.8: *Compound bar graph of household energy sources*

Interpretation. Rural households depend mostly on firewood while urban households rely on charcoal and electricity, showing a clear town-and-country contrast in energy use.

Question 43

The table shows the population change of five regions in one year; some grew and others declined. Draw a divergent bar graph.

Region	Mbeya	Tabora	Geita	Lindi	Kagera
Change (%)	3	−1	5	−2	4

Model Answer

A divergent bar graph draws bars above and below a zero line to show gains as positive and losses as negative.

Step 1: Draw the zero line. Rule a horizontal zero line, with growth plotted upward and decline downward.

Step 2: Draw each bar. Draw each region's bar of equal width from the zero line to its value, above or below.

Step 3: Label and title. Label the axes and title the graph, as in Figure 3.9.

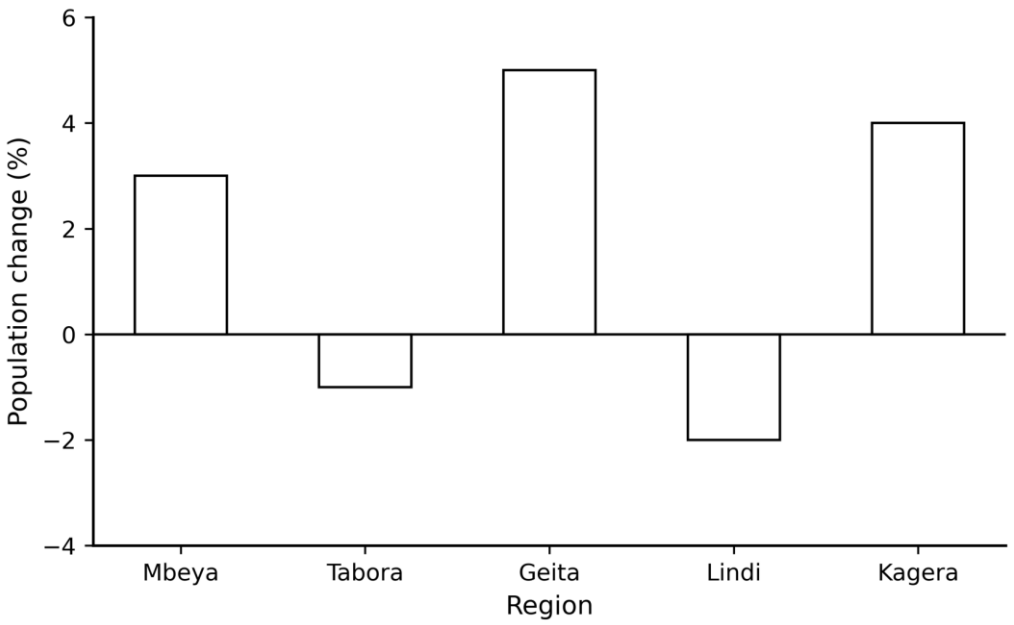


Figure 3.9: *Divergent bar graph of regional population change*

Interpretation. Geita grew fastest at five per cent while Lindi declined, so the divergent bars separate the growing regions from the shrinking ones at a glance.

Question 44

The table shows a national budget balance over five years. Draw a divergent bar graph.

Year	2019	2020	2021	2022	2023
Balance (billion shillings)	2	−4	6	−3	5

Model Answer

As before, bars are drawn above a zero line for a surplus and below it for a deficit.

Step 1: Draw the zero line. Rule the zero base line across the middle of the graph.

Step 2: Draw the bars. Draw each year's bar from the base line to its value, above or below.

Step 3: Label and title. Label the axes and title the graph, as in Figure 3.10.

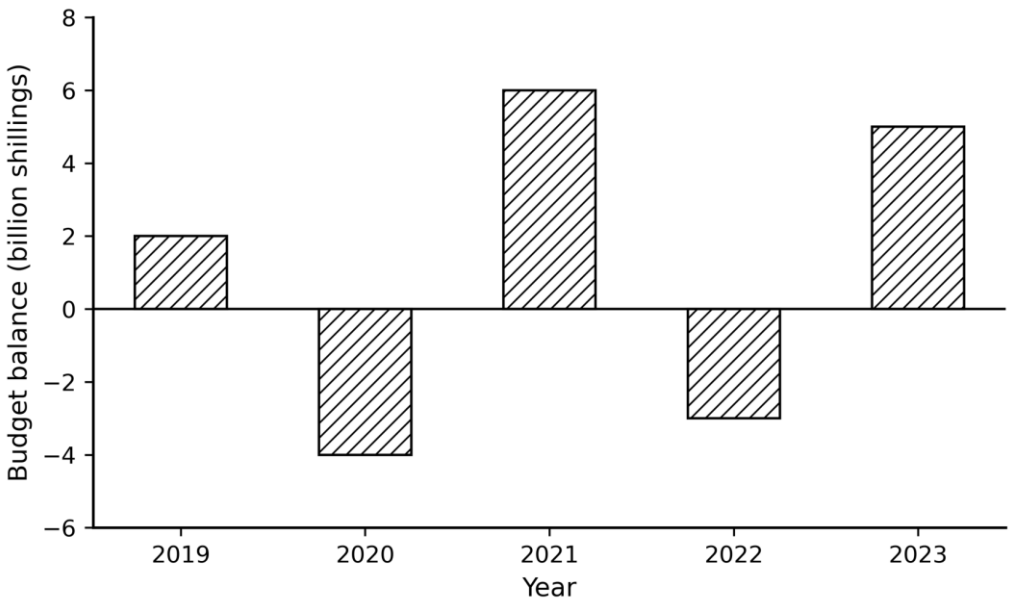


Figure 3.10: *Divergent bar graph of the budget balance*

Interpretation. The budget alternated between surplus and deficit but ended with a surplus of five billion shillings, so public finances were unsteady yet recovering.

Question 45

The table shows the monthly rainfall and temperature at a station. Draw a combined line-and-bar graph.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	150	140	120	90	40	20	15	20	40	90	130	160
Temp (°C)	26	26	25	24	22	20	20	21	23	25	26	26

Model Answer

A combined line-and-bar graph shows two related variables together, one as bars and one as a line, using two vertical axes.

Step 1: Set up two vertical axes. Put months on the horizontal axis, rainfall on the left axis for the bars, and temperature on the right axis for the line.

Step 2: Draw the rainfall bars. Draw a bar for each month's rainfall against the left axis.

Step 3: Plot the temperature line. Plot each month's temperature against the right axis and join the points, then add a title, as in Figure 3.11.

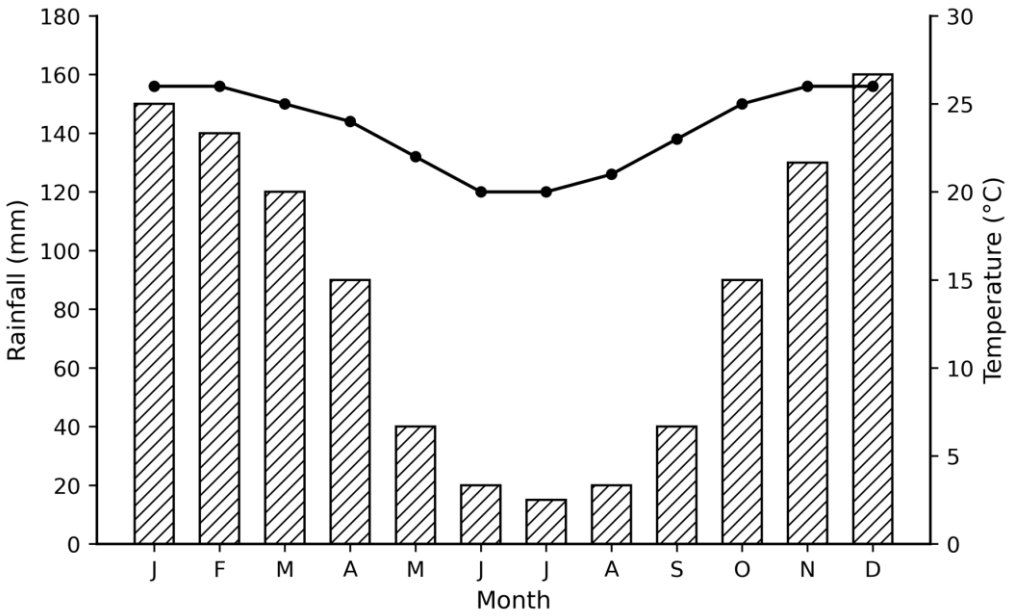


Figure 3.11: *Combined line-and-bar graph (climate graph) of a station*

Interpretation. This is a climate graph: rainfall is high in the wet months from November to April and low in the cool middle months, showing the tropical wet-and-dry climate of much of Tanzania.

Question 46

The table shows the male and female population by age group in a district. Draw a population pyramid.

Age group (years)	0-14	15-29	30-44	45-59	60+
Male ('000)	800	600	400	250	150
Female ('000)	780	620	420	260	180

Model Answer

A population pyramid shows the age and sex structure as back-to-back horizontal bars, one sex on each side of a central axis.

Step 1: Draw the central axis. Draw a vertical axis for the age groups, the youngest at the bottom and the oldest at the top.

Step 2: Draw the bars. For each age group draw the male bar to the left and the female bar to the right, each scaled to its population.

Step 3: Label the sides and axes. Mark the two sexes, label the axes and the age groups, as in Figure 3.12.

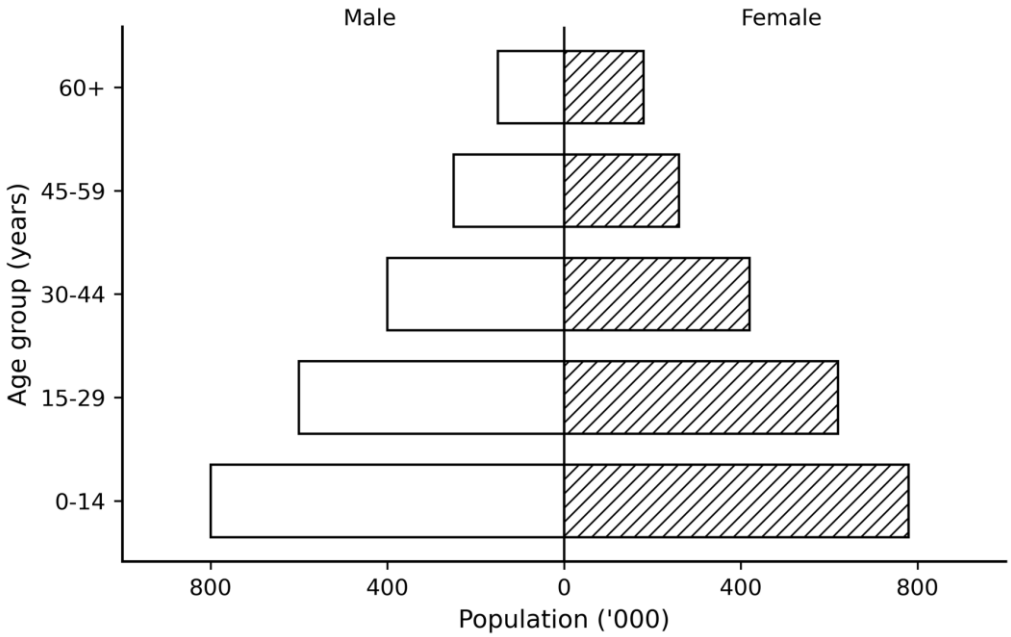


Figure 3.12: *Population pyramid (absolute numbers)*

Interpretation. The wide base and narrow top show a youthful, fast-growing population with high birth rates, the structure typical of Tanzania.

Question 47

To compare this district with a larger one, the same data are turned into percentages. The table shows the percentage of the population in each age-sex group. Draw a percentage population pyramid.

Age group (years)	0-14	15-29	30-44	45-59	60+
Male (%)	26	20	13	8	5
Female (%)	25	20	14	8	6

Model Answer

When two populations of different sizes are compared, each age-sex group is first turned into a percentage of the total population.

Step 1: Convert each figure to a percentage. Divide each group by the total population and multiply by 100:

$$\text{Percentage} = \frac{\text{group population}}{\text{total population}} \times 100$$

Step 2: Draw the pyramid from the percentages. Plot the male and female percentages as back-to-back bars, exactly as for the absolute pyramid.

Step 3: Label the axis in per cent. Label the horizontal axis as a percentage and mark the two sexes, as in Figure 3.13.

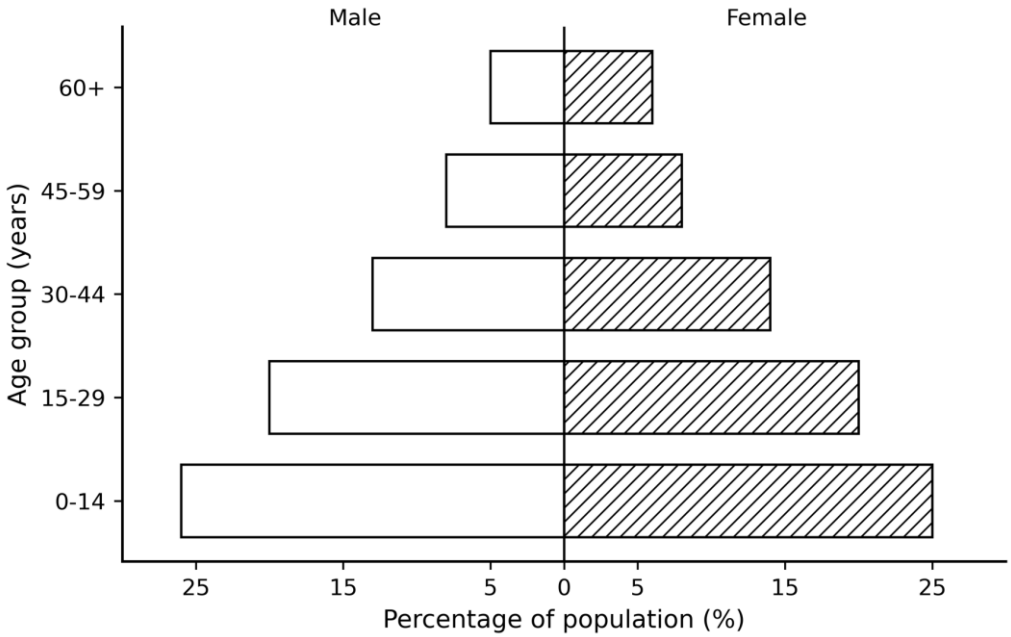


Figure 3.13: *Population pyramid (percentages)*

Interpretation. Because the bars now show shares rather than numbers, this pyramid can be compared fairly with the pyramid of a larger or smaller population.

Question 48

The table shows the yields of three crops over five years. Draw a multiple line graph.

Year	2019	2020	2021	2022	2023
Maize ('00 kg/ha)	20	22	25	24	28
Rice ('00 kg/ha)	15	16	18	17	20
Wheat ('00 kg/ha)	10	11	12	13	15

Model Answer

A multiple line graph plots each crop as its own line on shared axes, so their trends can be compared.

Step 1: Set up the axes. Put the years on the horizontal axis and yield on the vertical, with one scale covering the largest value.

Step 2: Plot each crop. Plot and join the points for maize, rice and wheat in turn.

Step 3: Distinguish the lines and add a key. Draw each crop's line in a different style and add a key, as in Figure 3.14.

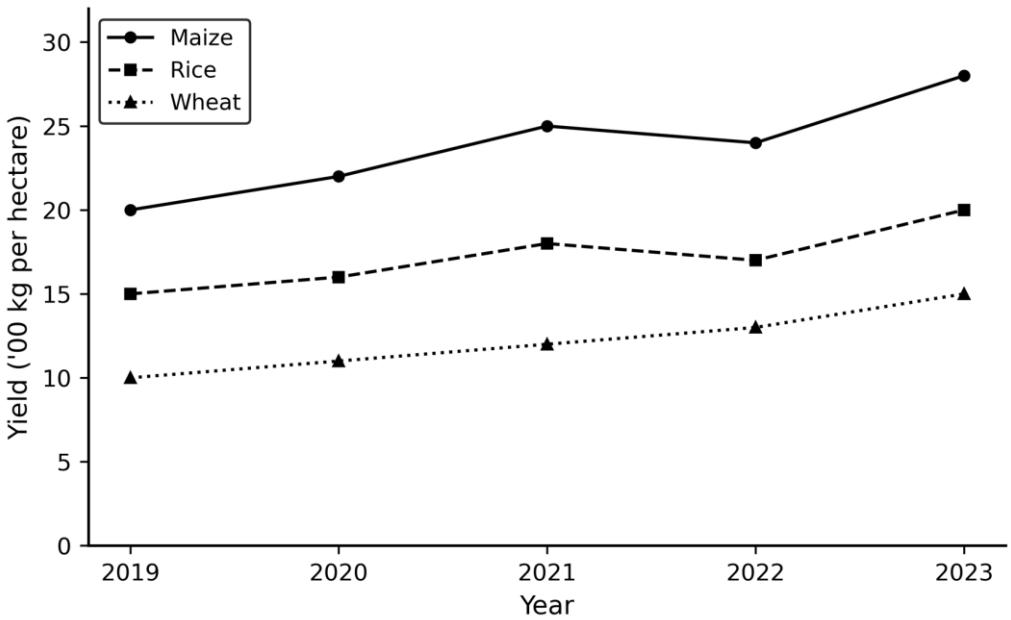


Figure 3.14: *Multiple line graph of crop yields*

Interpretation. All three crops show rising yields over the five years, with maize highest throughout, so farming productivity improved across the board.

Question 49

The table shows the land use of a district in hectares. Draw a simple divided circle to present the data.

Land use	Farmland	Forest	Grassland	Settlement
Area (ha)	200	120	50	30

Model Answer

A divided circle shows each part as a sector whose angle is its share of the whole circle of 360 degrees.

Step 1: Find the total. Add the four areas, because every sector is a fraction of this total: 200 + 120 + 50 + 30 = 400 ha.

Step 2: Convert each area to a sector angle. Each angle is the area's share of the total multiplied by 360 degrees:

$$\text{Sector angle} = \frac{\text{area of the part}}{\text{total area}} \times 360°$$

Step 3: Work out and check the angles. Apply the formula to each land use and confirm the angles total 360 degrees.

Land use	Area (ha)	Working	Angle
Farmland	200	(200/400) × 360°	180°
Forest	120	(120/400) × 360°	108°
Grassland	50	(50/400) × 360°	45°
Settlement	30	(30/400) × 360°	27°
Total	**400**		**360°**

Step 4: Draw the circle. Draw a circle, mark a radius at the top, and measure each angle in turn from the largest, labelling each sector and adding a key, as in Figure 3.15.

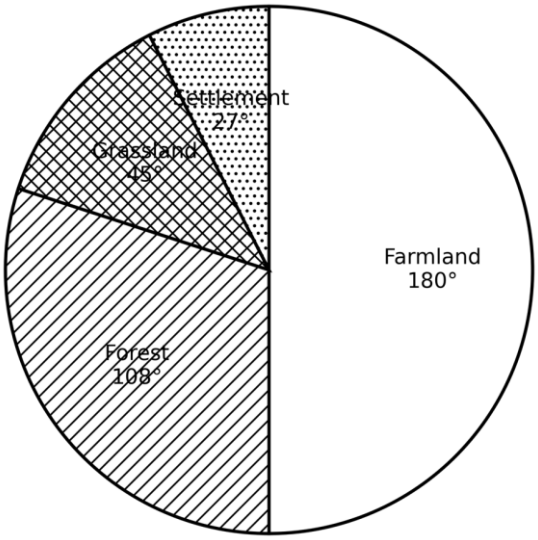


Figure 3.15: *Simple divided circle of district land use*

Interpretation. Farmland dominates the district at 180 degrees, half the whole circle, so the land is used mainly for farming.

Question 50

The table shows the water use of a town by sector, in thousands of cubic metres. Draw a simple divided circle.

Sector	Agriculture	Domestic	Industry	Other
Water ('000 m³)	250	100	70	30

Model Answer

As before, each sector's angle is its share of 360 degrees.

Step 1: Find the total. Add the four figures: 250 + 100 + 70 + 30 = 450 thousand cubic metres.

Step 2: Convert each to a sector angle. Multiply each share by 360 degrees:

$$\text{Sector angle} = \frac{\text{sector use}}{\text{total use}} \times 360°$$

Step 3: Work out and check the angles. Confirm the angles total 360 degrees.

Sector	Water	Working	Angle
Agriculture	250	(250/450) × 360°	200°
Domestic	100	(100/450) × 360°	80°
Industry	70	(70/450) × 360°	56°
Other	30	(30/450) × 360°	24°
Total	**450**		**360°**

Step 4: Draw the circle. Draw the circle and measure each angle from the largest, labelling and keying it, as in Figure 3.16.

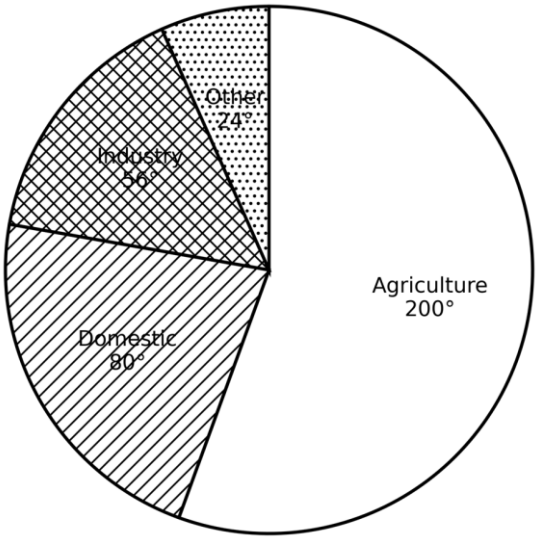


Figure 3.16: *Simple divided circle of town water use*

Interpretation. Agriculture takes 200 degrees, well over half, so it is by far the largest water user in the town.

Question 51

The table shows crop production (in thousand tonnes) in two regions of different size. Draw proportional divided circles to compare them.

Crop	Region A	Region B
Maize	200	500
Rice	120	250
Beans	80	150
Total	**400**	**900**

Model Answer

Proportional divided circles make each circle's area proportional to its total, so the radius is proportional to the square root of the total; each circle is then divided into its crops.

Step 1: Find the radii. Because area depends on the square of the radius, take the square root of each total:

$$\text{radius} \propto \sqrt{\text{total}}$$

Step 2: Compute the two radii. The square roots set the sizes:

$$\sqrt{400} = 20, \quad \sqrt{900} = 30$$

Step 3: Divide each circle and draw. Draw Region A with radius 20 and Region B with radius 30 (to a chosen scale), and divide each by the sector-angle method into maize, rice and beans, as in Figure 3.17.

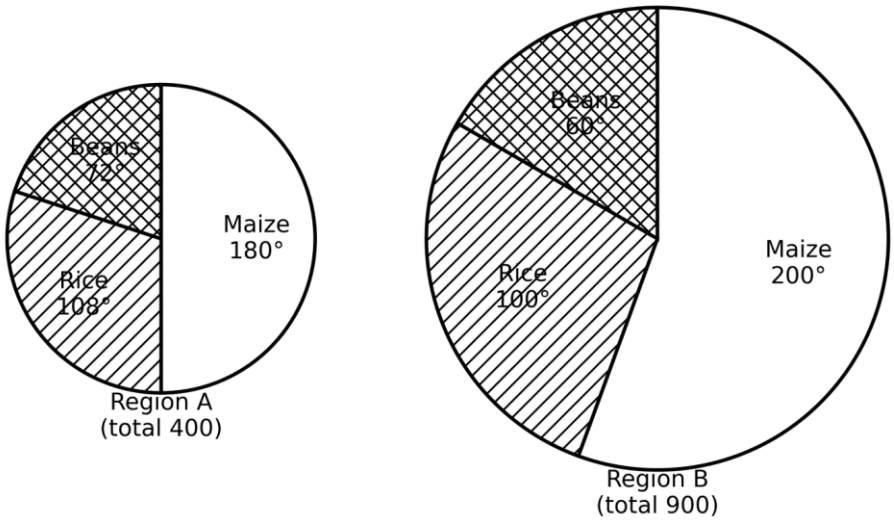


Figure 3.17: *Proportional divided circles for two regions*

Interpretation. Region B's circle is larger, showing its greater total output, and maize is the leading crop in both regions.

Question 52

The table shows coffee-belt production (in thousand tonnes) in two years. Draw proportional divided circles.

Crop	Year 1	Year 2
Coffee	100	300
Tea	80	200
Other	45	125
Total	**225**	**625**

Model Answer

Again the radius of each circle is the square root of its total, and each circle is divided into its parts.

Step 1: Take the square roots of the totals. The radii are set by the square roots:

$$\sqrt{225} = 15, \quad \sqrt{625} = 25$$

Step 2: Divide and draw. Draw the two circles with radii 15 and 25 and divide each into coffee, tea and other by the sector-angle method, as in Figure 3.18.

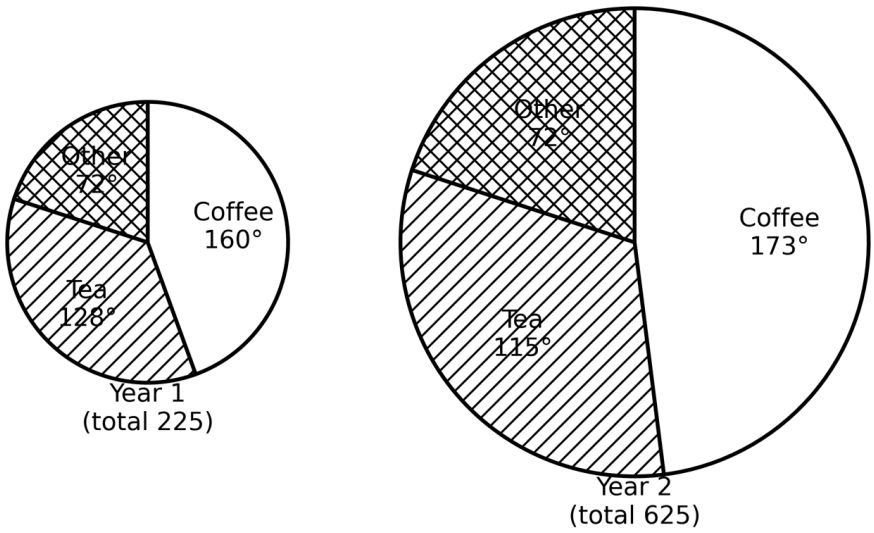


Figure 3.18: *Proportional divided circles for two years*

Interpretation. The larger second circle shows that production grew strongly, and coffee remained the leading crop in both years.

Question 53

The table shows a household's monthly budget as percentages. Draw a divided semicircle to present it.

Item	Food	Rent	Transport	Other
Share (%)	40	25	20	15

Model Answer

A divided semicircle spreads the parts over 180 degrees instead of 360, so each angle is the part's share of 180 degrees.

Step 1: State the angle rule. Each item's angle is its percentage of the half-circle:

$$\text{angle} = \frac{\text{item share}}{\text{total}} \times 180°$$

Step 2: Work out and check the angles. Confirm the angles total 180 degrees.

Item	Share (%)	Working	Angle
Food	40	(40/100) × 180°	72°
Rent	25	(25/100) × 180°	45°
Transport	20	(20/100) × 180°	36°
Other	15	(15/100) × 180°	27°
Total	**100**		**180°**

Step 3: Draw the semicircle. Draw a base line and a semicircle on it, then measure each angle from one end, as in Figure 3.19.

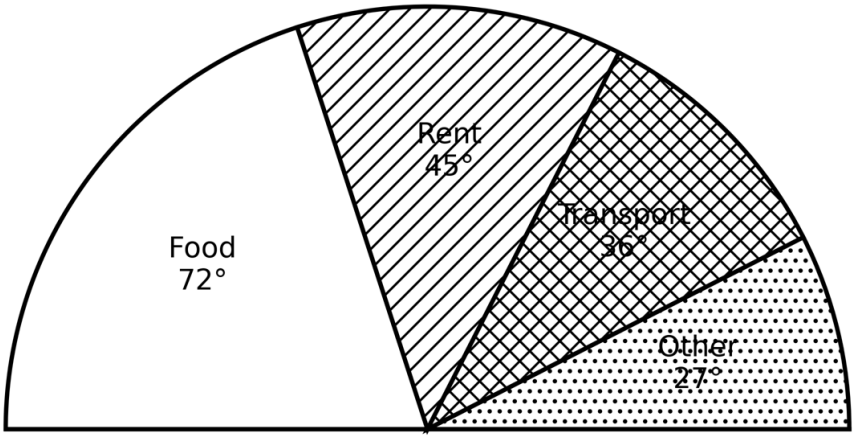


Figure 3.19: *Divided semicircle of a household budget*

Interpretation. Food takes the largest angle, 72 degrees or two-fifths of the half-circle, so it is the household's biggest expense.

Question 54

The table shows the composition of a country's exports as percentages. Draw a simple divided rectangle.

Export	Coffee	Cotton	Tea	Sisal
Share (%)	35	25	20	20

Model Answer

A simple divided rectangle shows a whole as one bar divided along its length in proportion to each part.

Step 1: Set the length by the percentages. Draw a rectangle of a convenient length to stand for 100 per cent, so each part's segment length is its percentage of that length.

Step 2: Mark the segments. Along the bar mark segments of 35, 25, 20 and 20 units for coffee, cotton, tea and sisal.

Step 3: Shade and label. Shade each segment differently and label it with its export and share, as in Figure 3.20.

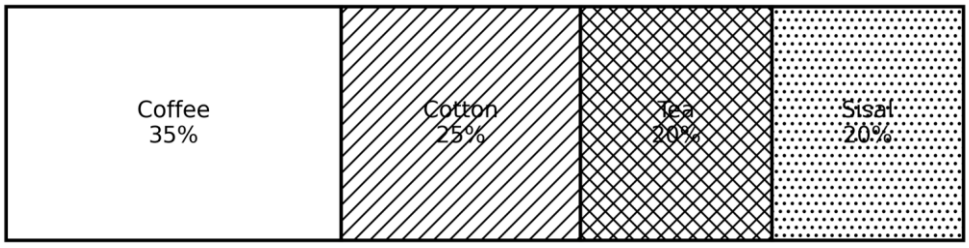


Figure 3.20: *Simple divided rectangle of exports*

Interpretation. Coffee is the largest export at 35 per cent, and the rectangle shows the whole composition in one clear strip.

Question 55

The table shows crop production (in thousand tonnes) in three regions. Draw a compound divided rectangle.

Region	Maize	Rice	Beans
Mbeya	40	20	10
Iringa	35	15	12
Njombe	50	10	8

Model Answer

A compound divided rectangle draws one bar per region, each divided into its crops, so the regions are compared side by side.

Step 1: Convert each region to percentages. For each region turn the crops into percentages of that region's total, so every bar has the same height of 100 per cent.

Step 2: Draw and divide the bars. Draw a bar of equal width for each region and divide it into maize, rice and beans in proportion.

Step 3: Shade and key. Shade each crop consistently across the bars and add a key, as in Figure 3.21.

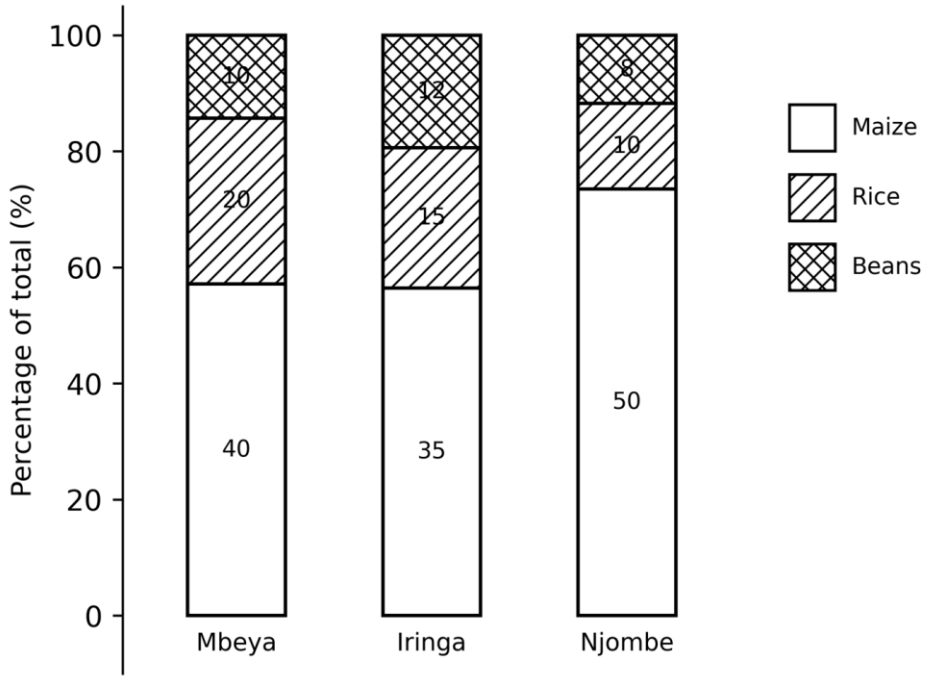


Figure 3.21: *Compound divided rectangle of crop production*

Interpretation. Maize takes the largest share in every region, so the three regions share a maize-based farming pattern despite their different totals.

Question 56

The table shows the land use of three villages as areas in hectares. Draw a compound divided rectangle.

Village	Crops	Grazing	Forest
Choma	50	30	20
Mkuza	60	25	15
Ilula	45	35	20

Model Answer

As before, each village becomes a bar of equal height divided into its land uses.

Step 1: Convert each village to percentages. Turn each village's areas into percentages of its own total.

Step 2: Draw and divide the bars. Draw an equal-width bar for each village, divided into crops, grazing and forest.

Step 3: Shade and key. Shade each land use consistently and add a key, as in Figure 3.22.

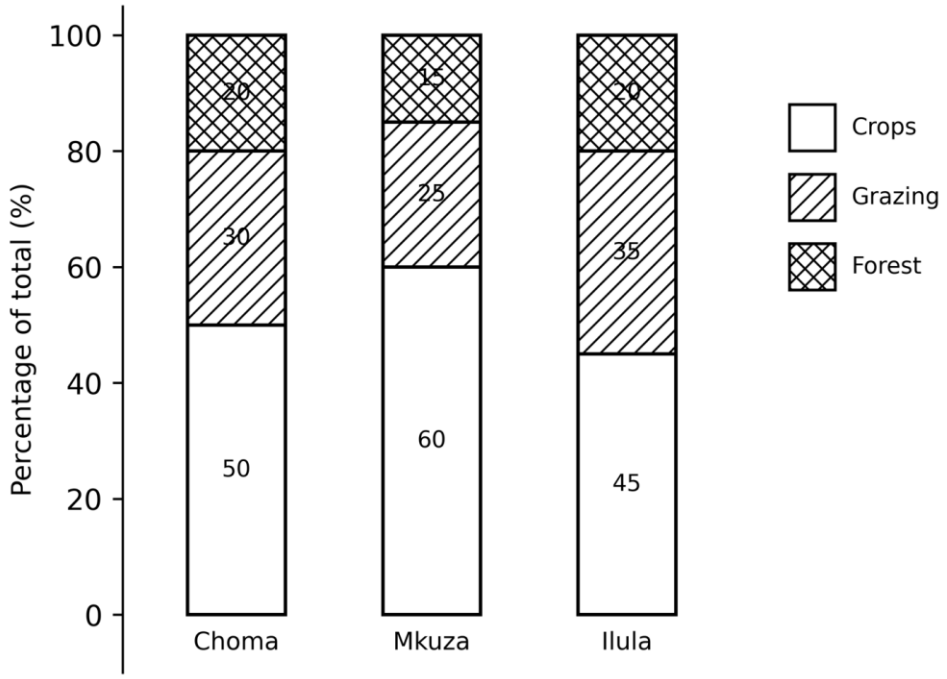


Figure 3.22: *Compound divided rectangle of village land use*

Interpretation. Crops take the largest share in all three villages, and Mkuza devotes the most of its land to crops.

Question 57

The table shows the number of cattle in four districts. Present the data using repeated symbols.

District	Bariadi	Maswa	Meatu	Itilima
Cattle	5 000	3 000	4 000	2 000

Model Answer

Repeated symbols show a quantity as a row of identical symbols, each standing for a fixed unit value.

Step 1: Choose a unit value and a symbol. Let one symbol stand for 1 000 cattle, a value that divides the data neatly.

Step 2: Find the number of symbols. The number of symbols for each district is its total divided by the unit value:

$$\text{number of symbols} = \frac{\text{cattle}}{\text{unit value}}$$

Step 3: Draw the rows. Draw 5, 3, 4 and 2 symbols for the four districts, using part of a symbol for any remainder, and add a key, as in Figure 3.23.

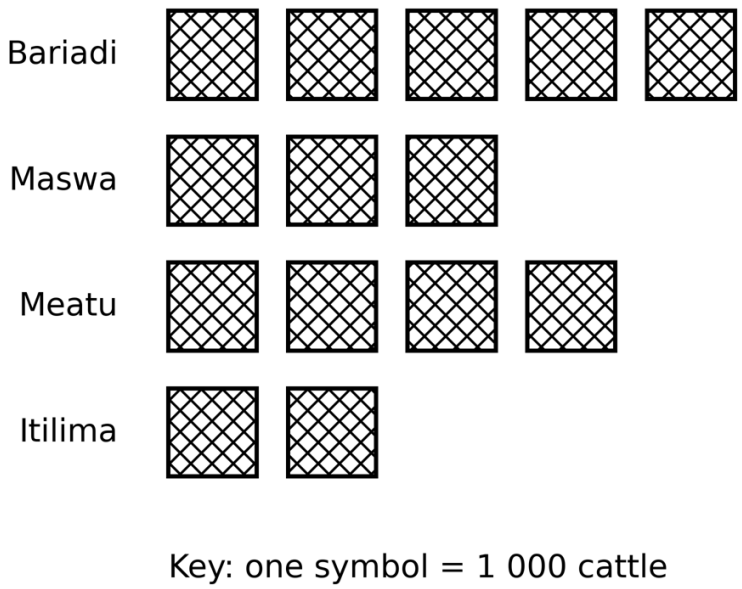


Figure 3.23: *Repeated symbols of cattle numbers*

Interpretation. Bariadi has the most cattle at five symbols; the method is quick and clear to read, though only as exact as the unit value allows.

Question 58

The table shows the population of three towns. Present the data using proportional squares.

Town	Town A	Town B	Town C
Population	400	900	1 600

Model Answer

A proportional square shows a value by a square whose area is proportional to it, so the side is proportional to the square root of the value.

Step 1: State the rule. Because a square's area depends on the square of its side, take the square root of each value:

$$\text{side} \propto \sqrt{\text{value}}$$

Step 2: Compute the sides. The square roots give the sides:

$$\sqrt{400} = 20, \quad \sqrt{900} = 30, \quad \sqrt{1600} = 40$$

Step 3: Draw the squares. Draw squares of side 20, 30 and 40 units to a chosen scale, labelling each, as in Figure 3.24.

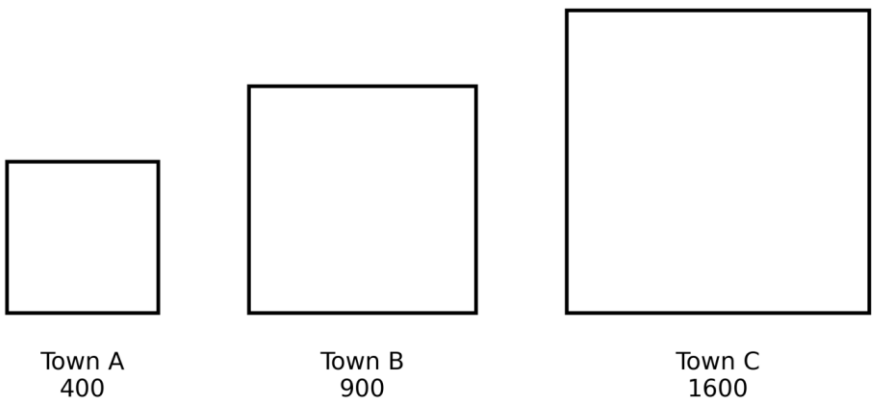


Figure 3.24: *Proportional squares of town population*

Interpretation. Town C is clearly the largest, and the squares compare the towns at a glance, though exact values are hard to read from area alone.

Question 59

The table shows three quantities that differ greatly in size. Present them using proportional cubes.

Item	First	Second	Third
Quantity	1 000	8 000	27 000

Model Answer

A proportional cube (or sphere) shows a value by a solid whose volume is proportional to it, so the side of a cube, or the radius of a sphere, is proportional to the cube root of the value.

Step 1: State the rule. Because a cube's volume depends on the cube of its side, take the cube root of each value:

$$\text{side} \propto \sqrt[3]{\text{value}}$$

Step 2: Compute the sides. The cube roots give the sides:

$$\sqrt[3]{1000} = 10, \quad \sqrt[3]{8000} = 20, \quad \sqrt[3]{27000} = 30$$

Step 3: Draw the cubes. Draw cubes of side 10, 20 and 30 units (a sphere would use the same cube-root value as its radius), as in Figure 3.25.

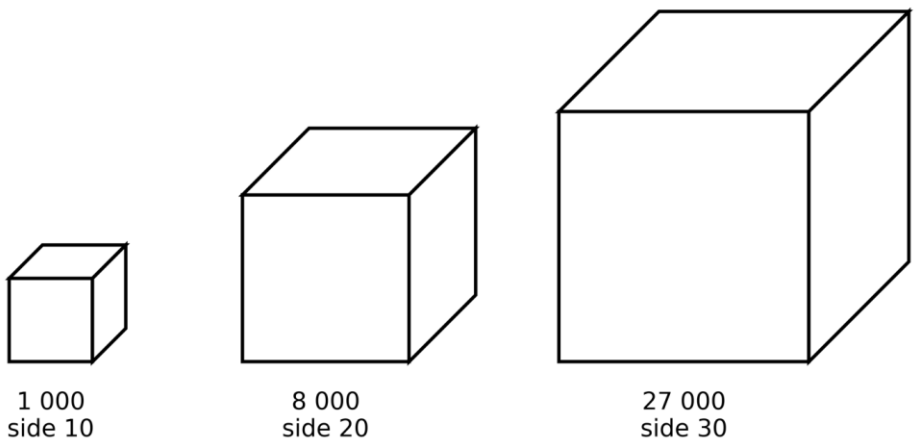


Figure 3.25: *Proportional cubes of three quantities*

Interpretation. The cubes fit very large differences into a small space, but because volume is judged by eye even less accurately than area, the method suits display more than precise reading.

Question 60

The table shows the number of days the wind blew from each direction at a station in one month. Draw a wind rose.

Direction	N	NE	E	SE	S	SW	W	NW
Days	5	8	12	10	6	4	3	2

Model Answer

A wind rose shows how often the wind blows from each direction as arms radiating from a centre, each arm's length being its frequency, with calm days shown in the central circle.

Step 1: Draw the compass arms. From a centre draw the eight compass directions, N at the top.

Step 2: Scale each arm to its frequency. Draw each arm outward to a length proportional to the number of days from that direction.

Step 3: Show the calms and add a scale. Mark the calm days in the central circle and add a scale of days, as in Figure 3.26.

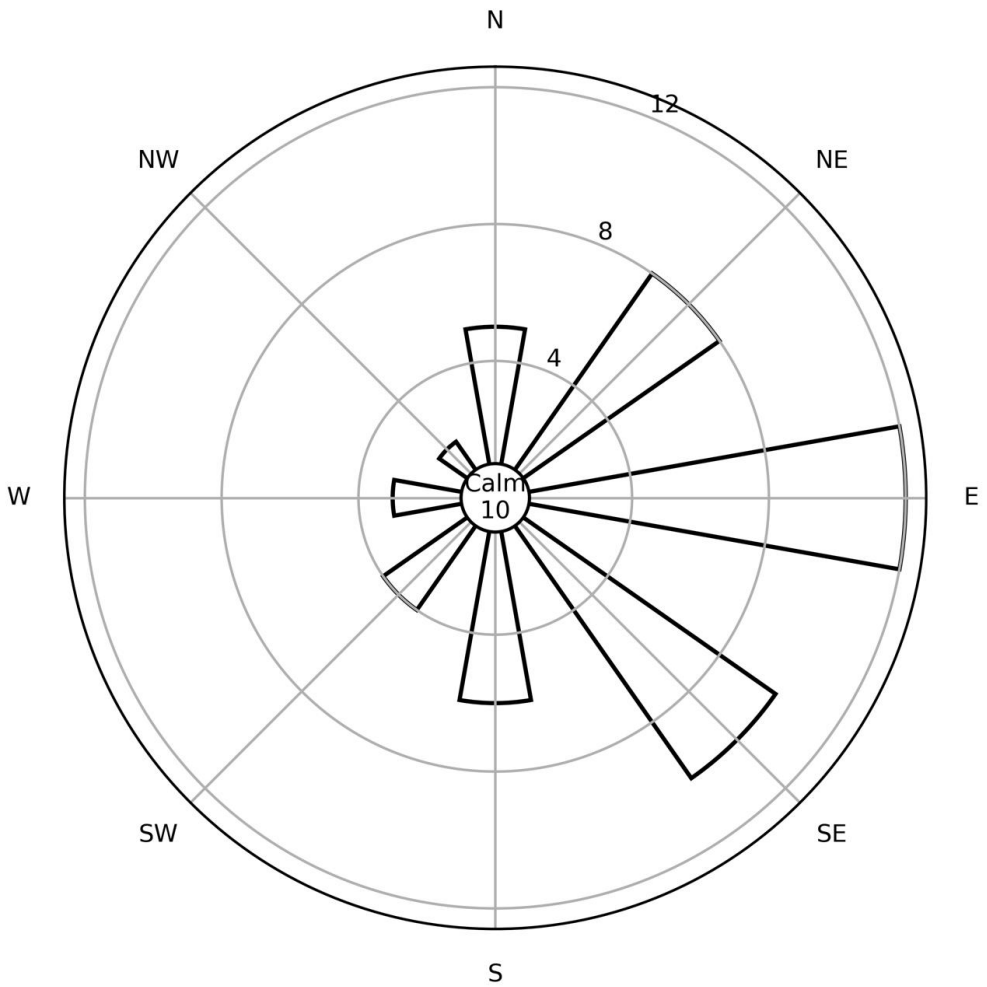


Figure 3.26: *Simple wind rose*

Interpretation. The longest arms point east and south-east, so the prevailing wind at the station blows from the east and south-east.

Question 61

The table shows the number of days of light, moderate and strong wind from each direction. Draw a compound wind rose.

Direction	N	NE	E	SE	S	SW	W	NW
Light	3	4	6	5	3	2	2	1
Moderate	1	3	4	3	2	1	1	1
Strong	1	1	2	2	1	1	0	0

Model Answer

A compound wind rose adds wind speed by dividing each arm into segments for light, moderate and strong winds.

Step 1: Draw and scale the arms. Draw the eight arms and, along each, mark the total number of days as before.

Step 2: Divide each arm by speed. Split each arm into light, moderate and strong segments from the centre outward, in proportion to their days.

Step 3: Shade and key the speeds. Shade each speed class differently and add a key, as in Figure 3.27.

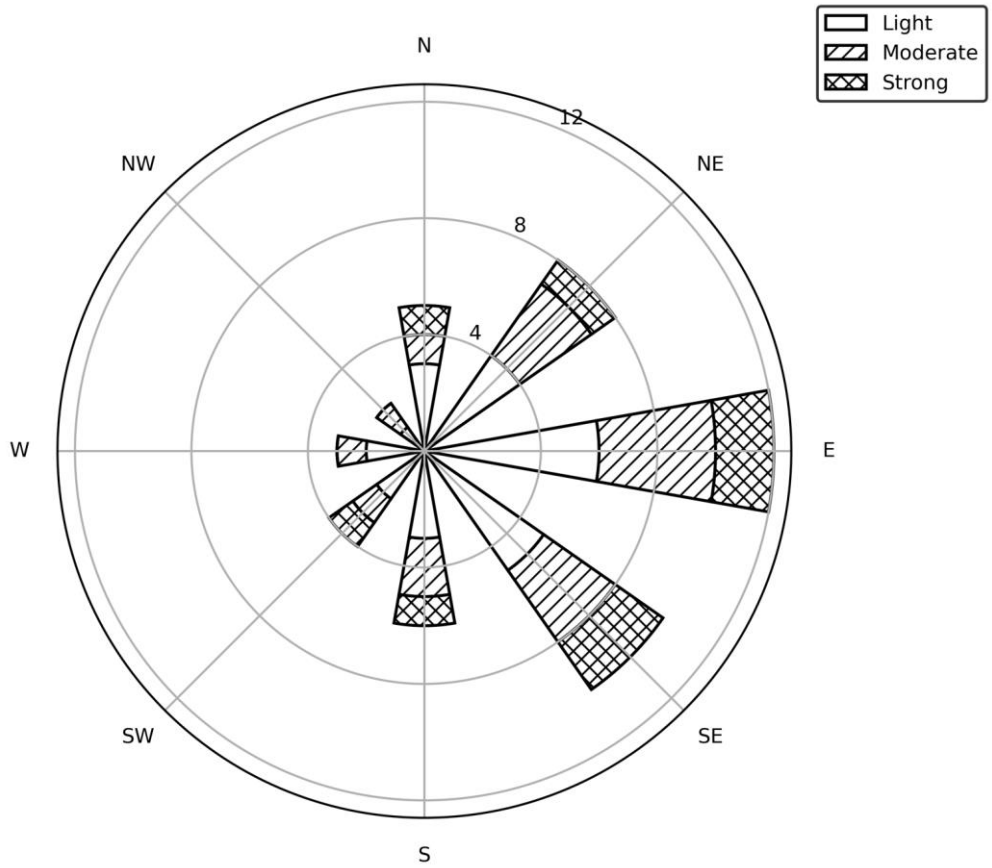


Figure 3.27: *Compound wind rose*

Interpretation. The east and south-east arms are both the longest and carry the most strong-wind days, so those directions bring both the most frequent and the strongest winds, which matters for siting wind pumps or drying racks.

Question 62

When a quantity varies from place to place, a statistical map shows the pattern better than a graph. Outline the main methods of mapping geographical data.

Model Answer

Geographical quantities are mapped in four main ways, each suited to a different kind of pattern.

1) **Dot map:** dots of a fixed value are placed where the feature occurs, so their spacing shows distribution and density.
2) **Isoline (isopleth) map:** lines join places of equal value, showing a continuous surface such as temperature or rainfall.
3) **Choropleth (shading) map:** each area is shaded by its density, darker where the value is higher.
4) **Flow-line (desire-line) map:** lines whose width shows the volume of movement are drawn between places.

So the method follows the data: dots and shading for how a quantity is distributed, isolines for a continuous surface, and flow lines for movement between places.

Question 63

The table shows the population of four areas of a district. Present the data using a dot map.

Area	Kimo	Sato	Ndoro	Bwawa
Population	4 000	2 000	3 000	1 500

Model Answer

A dot map shows distribution by placing dots of a fixed value where the feature occurs, so a denser cluster means a higher figure.

Step 1: Choose a dot value. Let one dot stand for 500 people, small enough to show the pattern but not so small that the dots crowd.

Step 2: Find the number of dots. The number of dots for each area is its population divided by the dot value:

$$\text{number of dots} = \frac{\text{population}}{\text{dot value}}$$

Step 3: Place the dots and key the map. Draw 8, 4, 6 and 3 dots spread evenly within the four areas, and add a key, as in Figure 3.28.

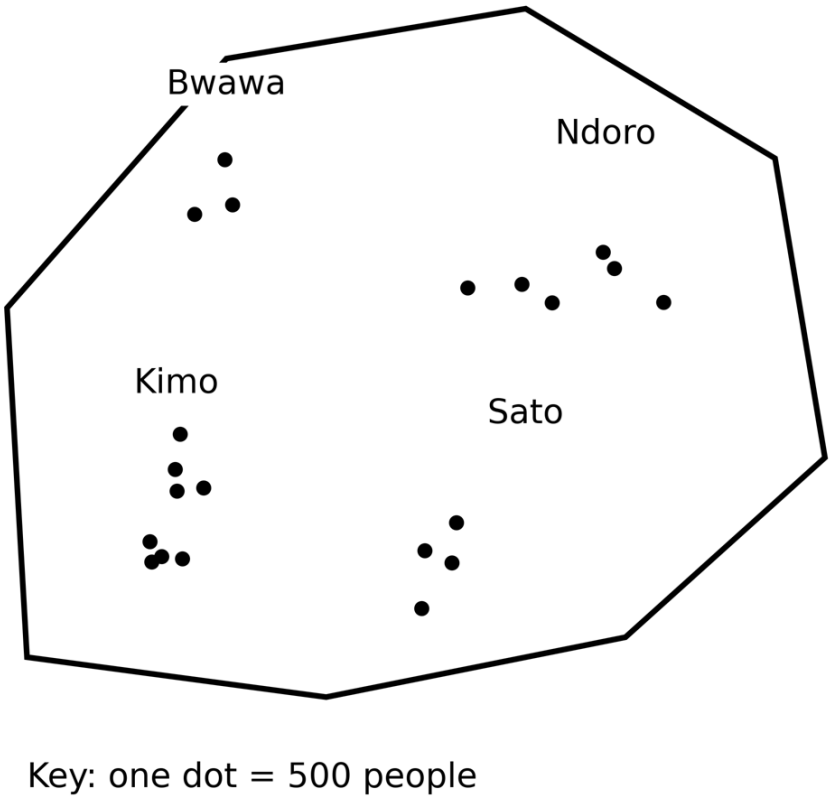


Figure 3.28: *Dot map of district population*

Interpretation. The dots cluster most thickly in Kimo, showing it is the most populous area, while Bwawa is the most thinly peopled.

Question 64

The table shows the maize production of four areas in tonnes. Present the data using a dot map.

Area	North	East	Hill	Lake
Maize (tonnes)	6 000	3 000	5 000	7 000

Model Answer

The method is the same: choose a dot value, work out the dots, and place them.

Step 1: Choose a dot value. Let one dot stand for 1 000 tonnes, which divides the data neatly.

Step 2: Find the number of dots. Divide each area's output by the dot value: 6, 3, 5 and 7 dots for the four areas.

Step 3: Place the dots and key the map. Spread the dots within each area and add a key, as in Figure 3.29.

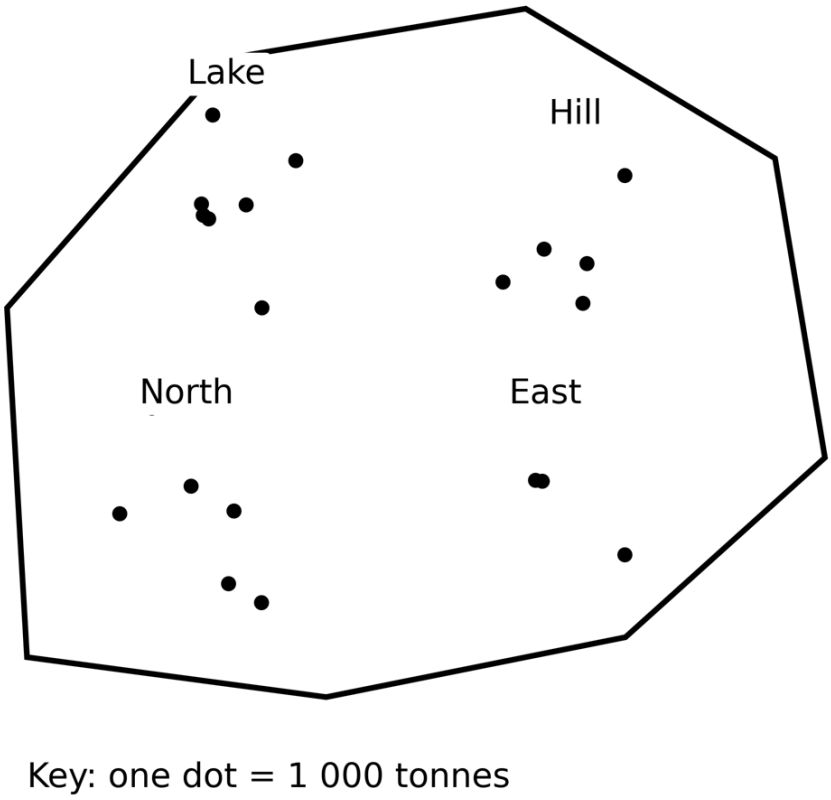


Figure 3.29: *Dot map of maize production*

Interpretation. The Lake area carries the densest dots and so the greatest output, while the East is the least productive.

Question 65

The table shows the temperature recorded at six stations. Present the data as an isoline map.

Station	P	Q	R	S	T	U
Temperature (°C)	21	19	18	20	17	18

Model Answer

An isoline (isopleth) map joins places of equal value with smooth lines, showing a continuous surface; values between stations are found by interpolation.

Step 1: Plot the station values. Mark each station on the map and write its temperature beside it.

Step 2: Interpolate between stations. Estimate where a round value falls between two stations in proportion to the distance; for example, the 20 degree line crosses halfway between a 21 degree and a 19 degree station.

Step 3: Join equal values. Draw a smooth line (isotherm) through all the points that share the same value, for 22, 20, 18 and 16 degrees, as in Figure 3.30.

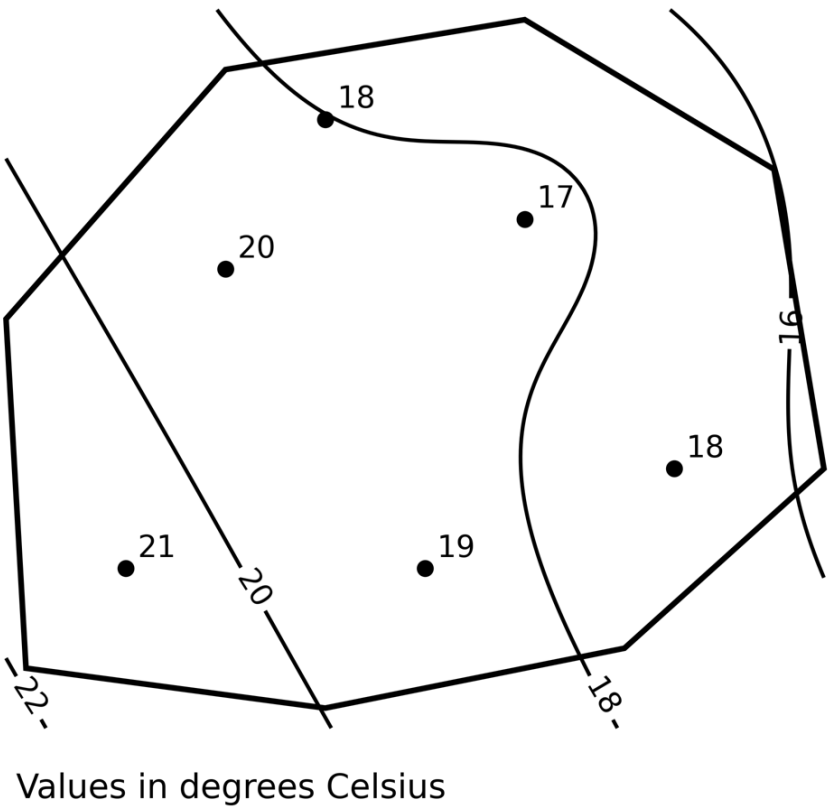


Figure 3.30: *Isoline map of temperature (isotherms)*

Interpretation. The isotherms show temperature falling from the warmer south-west towards the cooler north-east, a gradient that a table of six figures alone could not reveal.

Question 66

The table shows the annual rainfall recorded at five stations. Present the data as an isoline map.

Station	V	W	X	Y	Z
Rainfall (mm)	760	1 150	1 400	830	1 180

Model Answer

The lines joining places of equal rainfall are called isohyets, drawn in the same way as isotherms.

Step 1: Plot the station values. Mark each station and write its rainfall beside it.

Step 2: Interpolate and join. Estimate where each round value (700, 900, 1100, 1300 mm) falls between stations and join equal values with smooth isohyets.

Step 3: Label the isohyets. Label each line with its value and add a key, as in Figure 3.31.

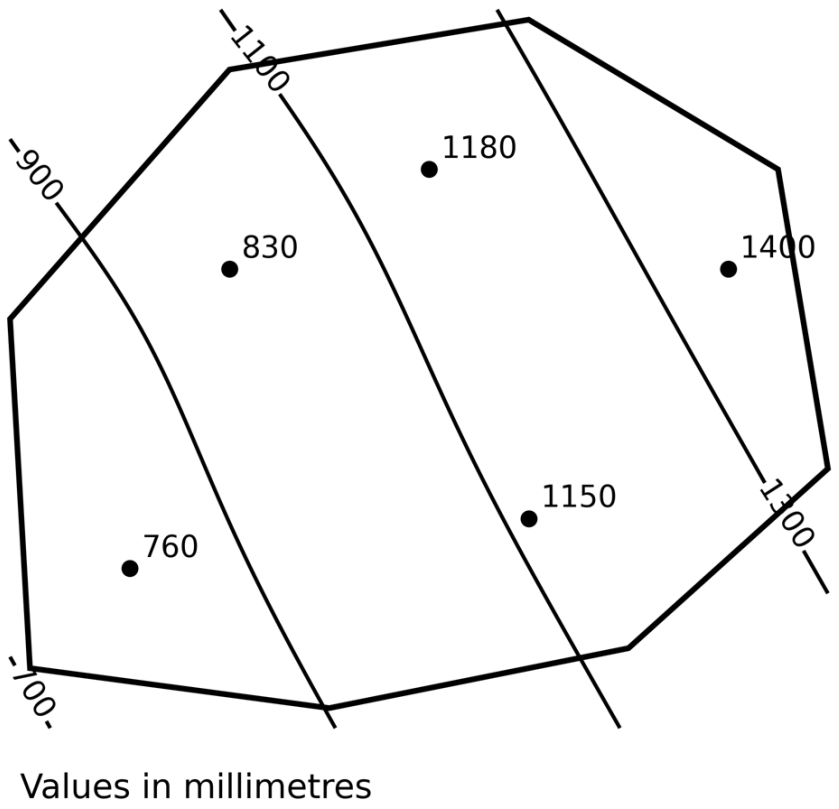


Figure 3.31: *Isoline map of rainfall (isohyets)*

Interpretation. The isohyets crowd where rainfall changes quickly and spread where it changes slowly, showing the wetter and drier parts of the area at a glance.

Question 67

The table shows the population, area and resulting density of four regions. Present the density as a choropleth map.

Region	Population	Area (km²)
A	3 500	100
B	9 000	100
C	16 000	100
D	24 000	100

Model Answer

A choropleth map shades each area by its density, denser shading for higher values, so the pattern of concentration stands out.

Step 1: Work out each density. Density is the population divided by the area:

$$\text{density} = \frac{\text{population}}{\text{area}}$$

Region	Population	Area (km²)	Density (per km²)
A	3 500	100	35
B	9 000	100	90
C	16 000	100	160
D	24 000	100	240

Step 2: Group the densities into classes. Sort the densities into classes such as 0 to 50, 50 to 100, 100 to 200 and over 200 persons per square kilometre.

Step 3: Shade and key the map. Shade each region by its class, light for the lowest and densest for the highest, and add a key, as in Figure 3.32.

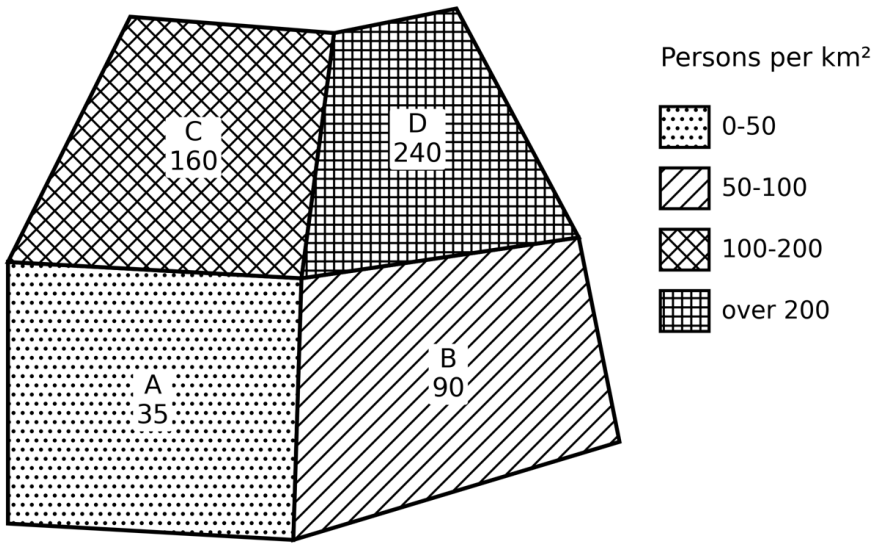


Figure 3.32: *Choropleth map of population density*

Interpretation. The shading darkens from region A to region D, showing at a glance that people are concentrated in region D and thinly spread in region A.

Question 68

The table shows the tonnes of goods carried from Morogoro to four towns. Present the data as a flow-line map.

Destination	Dodoma	Tanga	Dar es Salaam	Iringa
Goods (tonnes)	300	200	450	150

Model Answer

A flow-line (desire-line) map shows movement between places as lines whose width is proportional to the volume carried.

Step 1: Choose a width scale. Choose a scale for the line width, for example 1 mm = 100 tonnes, so that every flow can be drawn to the same rule.

Step 2: Draw each flow line. From Morogoro draw a line to each town, its width set by the tonnes carried divided by the scale.

Step 3: Label and add the scale. Label each destination and show the width scale, as in Figure 3.33.

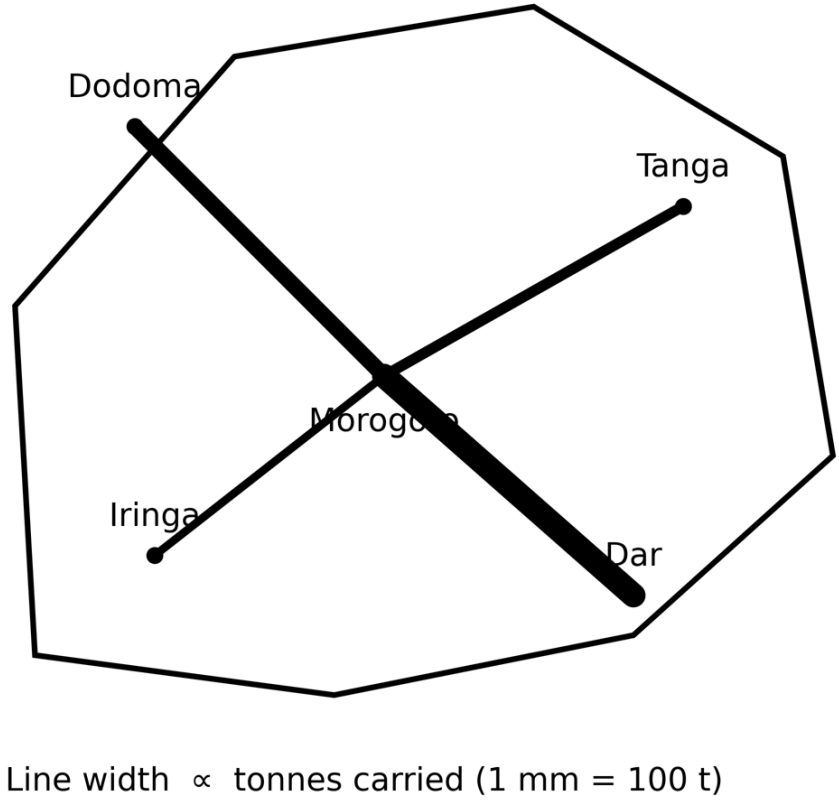


Figure 3.33: *Flow-line map of goods movement*

Interpretation. The widest line runs to Dar es Salaam, carrying 450 tonnes, so it is the main destination of goods from Morogoro, while Iringa receives the least.

Question 69

A student is asked to judge the dot map as a method. Give the merits and demerits of dot maps.

Model Answer

The dot map is simple and vivid but only approximate, so it has clear strengths and weaknesses.

Merits: it shows distribution and density at a glance, is simple to draw, and represents absolute quantities well, so uneven spread is easy to see.

Demerits: the placing of dots within an area is often guessed, exact totals are hard to recover by counting, and a badly chosen dot value either crowds the map or leaves it almost empty.

So the dot map is best for showing a pattern of distribution quickly, but not for reading precise values from the map.

Question 70

Compare the isoline and choropleth methods by giving the merits and demerits of each.

Model Answer

The two methods show different things and so have different strengths and weaknesses.

Isoline map: it shows a continuous surface and its gradients clearly, but it needs many well-spread data points, and interpolation assumes the value changes evenly between them.

Choropleth map: it shows the pattern of density at a glance, but it treats each area as uniform and creates false sharp jumps at the boundaries between areas.

So the isoline suits a smoothly changing quantity such as temperature, while the choropleth suits a density that is reported area by area, and each must be read with its weakness in mind.

Question 71

A finished graph or a computed average is not the end of a study; it must be read for meaning. Explain what is meant by the interpretation of geographical results.

Model Answer

Interpretation is the stage at which analysed figures and diagrams are turned into geographical meaning, saying what the results show and why.

Reading the result: stating plainly what the number or diagram shows, such as a trend over time, a concentration in one place, or a difference between areas.

Explaining the result: linking that pattern to geographical causes and back to the question the study set out to answer.

So interpreting a rising rainfall graph for the southern highlands means not merely noting the rise but explaining it and saying what it means for farming there.

Question 72

Interpreting a result is done in a set order, not at random. Outline the steps a geographer follows when interpreting a statistical result.

Model Answer

Interpretation moves through four ordered steps, from what the data show to what they mean.

1) **Describe:** state the pattern the figure or diagram shows, such as the highest and lowest values or the general trend.
2) **Compare:** set the result against an average, another place, or another period, so its size has meaning.
3) **Explain:** give the geographical reasons for the pattern, such as relief, distance from the coast or human activity.
4) **Conclude:** relate the finding back to the research question or hypothesis.

So interpretation carries the geographer from describing the data, through comparison and explanation, to a sound conclusion.

Question 73

From a set of measured results a geographer often wants to make a broader statement. Explain what generalisation means in handling geographical data.

Model Answer

Generalisation is drawing a broader statement from particular results, moving from the sample actually measured to a claim about the wider whole it represents.

From sample to statement: a result found for the stations, farms or people studied is extended to the area or population they stand for.

The caution it needs: the statement holds only as far as the sample truly represents the whole, so over-reaching from a small or biased sample must be avoided.

So finding that thirty stations show falling rainfall may support a general statement about the region, but only if those stations fairly represent it.

False Confidence Alert
A generalisation is only as good as its sample. Declaring that "Tanzania is getting drier" from a handful of stations in one region stretches the data further than it can bear.

Question 74

Modern geographical data are rarely handled by hand alone. Explain how computers help in managing and analysing geographical data.

Model Answer

Computers store, process, analyse and present large data sets far faster and more accurately than working by hand.

Spreadsheets: a spreadsheet such as Microsoft Excel stores, sorts and totals data and draws graphs and charts quickly and without arithmetic slips.

Statistical software: a package such as SPSS computes averages, measures of dispersion and statistical tests, and handles data sets far too large to work through by hand.

So computers take over the slow, error-prone processing and analysis of large geographical data sets, freeing the geographer to concentrate on interpreting the results.

Question 75

The last stages of a study, namely presentation, interpretation and conclusion, depend on one another. Explain how these three stages are linked.

Model Answer

The three closing stages form a chain in which each depends on the one before it.

Presentation feeds interpretation: a clear graph, table or map makes the pattern in the data visible, so that it can be read correctly.

Interpretation feeds the conclusion: the meaning drawn from the presented data becomes the basis of the conclusion and of any recommendation made.

So a weak presentation hides the pattern, a careless interpretation misreads it, and either fault is carried straight through to a mistaken conclusion, which is why the three stages must each be done well and in turn.

REAL QUESTIONS

Question 76

A team plans to study why maize yields differ from ward to ward in Kongwa district. Before collecting anything, they must decide what kinds of data to gather and where to get them. Advise them.

Model Answer

The team needs both kinds of geographical data, drawn from both kinds of source.

Locational and descriptive data: the position and boundary of each ward (locational, fixed by map or GPS) together with each ward's yield, rainfall, soil type and use of inputs (descriptive).

Primary and secondary sources: primary data collected in the field by measuring plots and interviewing farmers, and secondary data taken from district yield records and meteorological rainfall figures.

So the study combines mapped ward positions with measured and recorded attributes, drawing on both fieldwork and existing records to explain the differences in yield.

Question 77

In the same Kongwa study the team also records what farmers say about why their yields are falling. Explain how this non-numeric information is analysed.

Model Answer

Because the farmers' answers are words, not numbers, they are handled by qualitative analysis rather than by calculation.

Grouping by theme: the responses are read and sorted into recurring themes, such as poor rains, tired soil or costly inputs.

Weighing and interpreting: the number of farmers raising each theme is noted, and the themes are interpreted for their meaning rather than averaged.

So the opinions are turned into a set of explained themes that sit beside the measured yields, giving the reasons behind the numbers.

Question 78

A student researching water shortage in Singida returns with raw field data and must carry it all the way to a conclusion. Set out the stages of handling the data from collection to interpretation.

Model Answer

Sound handling of data moves through an ordered chain, each stage feeding the next.

1) **Collect:** gather the field measurements, questionnaires and records.
2) **Process:** edit, code, classify and tabulate the raw data so that it is clean and orderly.
3) **Analyse:** summarise it with measures of central tendency and dispersion and with graphs.
4) **Present and interpret:** display the results clearly, read their meaning, and draw a conclusion that answers the research question.

So the Singida data pass from raw notes, through processing and analysis, to a presented, interpreted result; a fault at any stage carries through to the conclusion.

Question 79

The table shows the number of passengers, in thousands, carried by the TAZARA railway over six years. Calculate the mean annual number of passengers.

Year	2016	2017	2018	2019	2020	2021
Passengers ('000)	520	480	610	450	540	448

Model Answer

The mean shares the total of the six years equally among them.

The mean of the series is the sum of the yearly figures divided by their number:

$$\bar{x} = \frac{\sum x}{n}$$

Sum the six years:

$$\sum x = 520 + 480 + 610 + 450 + 540 + 448 = 3048$$

There are n = 6 years, so divide the total by six:

$$\bar{x} = \frac{3048}{6} = 508$$

TAZARA carried a mean of about 508 thousand passengers a year, the single figure that represents the line's six-year traffic.

Question 80

The Geography scores of fifty-eight students at School Y are grouped below. Using the assumed-mean method, calculate the mean score.

Score	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100
Students (f)	8	12	20	10	8

Model Answer

The assumed-mean method keeps the arithmetic light by measuring how far each midpoint lies from a chosen value.

The mean is the assumed mean plus the average of the frequency-weighted deviations:

$$\bar{x} = A + \frac{\sum fd}{\sum f}$$

Take A = 50, the midpoint of the middle class; then d = x - 50.

Class	Midpoint x	Frequency f	d = x − 50	f d
0 - 20	10	8	−40	−320
20 - 40	30	12	−20	−240
40 - 60	50	20	0	0
60 - 80	70	10	20	200
80 - 100	90	8	40	320
Total		**58**		**−40**

Divide the total of the deviation-products by the total frequency and add it to the assumed mean:

$$\bar{x} = 50 + \frac{-40}{58} = 50 - 0.69 = 49.31$$

The mean score at School Y is about 49.31 marks, so the class sat a little below the middle of the 40 to 60 band.

Question 81

The table shows the coffee bought by a cooperative, in tonnes, grouped by member holding. Using the assumed-mean method, find the mean amount per holding.

Coffee (tonnes)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50
Holdings (f)	7	13	20	6	4

Model Answer

Again a central midpoint is assumed and the small deviations are averaged.

The grouped mean by the assumed-mean method is:

$$\bar{x} = A + \frac{\sum fd}{\sum f}$$

Take A = 25; then d = x - 25.

Class	Midpoint x	Frequency f	d = x − 25	f d
0 - 10	5	7	−20	−140
10 - 20	15	13	−10	−130
20 - 30	25	20	0	0
30 - 40	35	6	10	60
40 - 50	45	4	20	80
Total		**50**		**−130**

Divide and add to the assumed mean:

$$\bar{x} = 25 + \frac{-130}{50} = 25 - 2.6 = 22.4$$

The mean holding delivered about 22.4 tonnes of coffee, a little below the middle class, showing most members are small growers.

Question 82

The following are the Geography scores of forty students at a secondary school in Tanzania. Prepare a frequency distribution with the lowest class 60 to 64, then calculate the mean, the median and the mode, and describe the nature of the data.

66, 87, 79, 74, 84, 72, 81, 78, 68, 74, 80, 71, 91, 62, 77, 66, 87, 72, 80, 77, 76, 83, 75, 71, 83, 67, 94, 64, 82, 78, 77, 67, 76, 82, 78, 88, 66, 79, 64 and 71.

Model Answer

We first tally the scores into classes of width five, then apply the grouped formulae.

Build the frequency distribution. Tally the forty scores into seven classes, carrying the midpoint, the product and the cumulative frequency for the later steps.

Class	Midpoint x	f	f x	Cumulative f
60 - 64	62	3	186	3
65 - 69	67	6	402	9
70 - 74	72	7	504	16
75 - 79	77	11	847	27
80 - 84	82	8	656	35
85 - 89	87	3	261	38
90 - 94	92	2	184	40
Total		**40**	**3040**	

Mean. Divide the total of the products by the total frequency:

$$\bar{x} = \frac{3\,040}{40} = 76$$

Median. Half the total is 20; the 20th score lies in the 75 to 79 class, with $L = 74.5$, $cf = 16$, $f = 11$ and $i = 5$:

$$\text{Median} = 74.5 + \frac{20 - 16}{11} \times 5 = 76.32$$

Mode. The modal class is 75 to 79, with $\Delta_1 = 11 - 7 = 4$ and $\Delta_2 = 11 - 8 = 3$:

$$\text{Mode} = 74.5 + \frac{4}{4 + 3} \times 5 = 77.36$$

The mean is 76, the median 76.32 and the mode 77.36, all close together in the 75 to 79 class, so the marks form a nearly symmetrical distribution that clusters around the upper-seventies.

Question 83

A teacher reports the mean mark of a class as 45 but a colleague, seeing that a few pupils scored very high, doubts the mean is typical. The marks are 20, 22, 25, 25, 28, 30, 90 and 95. Find the mean, the median and the mode, and judge which best represents the class.

Model Answer

With two very high marks pulling the mean up, we must compare all three averages before trusting one.

Mean. Add the eight marks and divide by eight:

$$\bar{x} = \frac{335}{8} = 41.9$$

Median. Ordered, the middle two marks are 25 and 28, so the median is their average:

$$\frac{25 + 28}{2} = 26.5$$

Mode. The mark 25 occurs most often, so the mode is 25.

The mean, 41.9, is dragged upward by the two marks of 90 and 95 and represents nobody in the group, while the median, 26.5, sits among the marks most pupils actually scored. So for this skewed set the median, not the mean, best represents the class.

False Confidence Alert
A mean is not automatically the fairest average. When a few extreme values are present, quoting the mean alone (here 41.9) gives a figure no pupil is near; the median must be checked against it.

Question 84

Explain, with the help of a diagram, how the mean, the median and the mode are related in a symmetrical distribution and in skewed distributions.

Model Answer

The three averages coincide when a distribution is symmetrical but separate as it becomes skewed, and the order in which they separate reveals the direction of the skew.

Symmetrical distribution: the curve is balanced, so the mean, median and mode fall at the same central point.

Positive (right) skew: a tail of high values pulls the mean to the right of the median, which lies to the right of the mode, so mode is less than median is less than mean.

Negative (left) skew: a tail of low values pulls the mean to the left, so mean is less than median is less than mode.

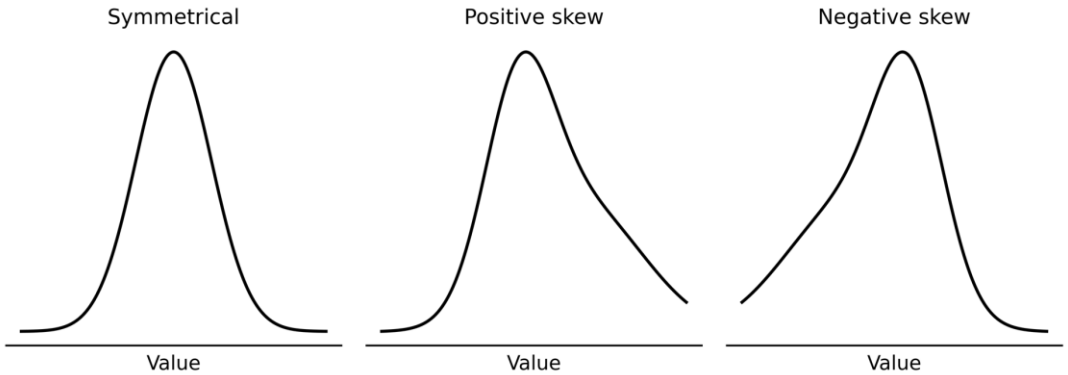


Figure 3.34: *Relationship of mean, median and mode in symmetrical and skewed distributions*

So comparing the three averages, as in the School examples above, tells a geographer at once whether a set of marks or yields is balanced or lop-sided.

Question 85

The Geography Paper Two scores of eight candidates were 30, 35, 42, 50, 32, 49, 39 and 33. Calculate the standard deviation of the scores.

Model Answer

The standard deviation measures how far, on average, the candidates' scores lie from their mean.

For ungrouped data:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

Find the mean:

$$\bar{x} = \frac{310}{8} = 38.75$$

Square the deviations and add them:

Score x	Deviation (x − 38.75)	Squared deviation
30	−8.75	76.56
35	−3.75	14.06
42	3.25	10.56
50	11.25	126.56
32	−6.75	45.56
49	10.25	105.06
39	0.25	0.06
33	−5.75	33.06
Total		**411.48**

Divide by the number of scores, then take the root:

$$s = \sqrt{\frac{411.48}{8}} = \sqrt{51.44} = 7.17$$

The standard deviation is about 7.17 marks, so the candidates' scores lie on average about 7 marks from the mean of 38.75, a moderate spread.

Question 86

Natural-gas output, in million cubic feet, was recorded at two Tanzanian sites over five days: Site P gave 20, 22, 18, 21 and 19; Site Q gave 10, 30, 12, 28 and 20. Find the standard deviation at each site and say which is the more reliable producer.

Model Answer

Both sites average the same daily output, so only their standard deviations can tell us which is steadier.

Find each mean:

$$x_P = \frac{100}{5} = 20, \quad x_Q = \frac{100}{5} = 20$$

Square deviations and total (Site P):

Site P (x)	20	22	18	21	19	**Total**
$(x - 20)^2$	0	4	4	1	1	**10**

Square deviations and total (Site Q):

Site Q (x)	10	30	12	28	20	**Total**
$(x - 20)^2$	100	100	64	64	0	**328**

Take each standard deviation:

$$s_P = \sqrt{\frac{10}{5}} = 1.41, \quad s_Q = \sqrt{\frac{328}{5}} = 8.10$$

Both sites average 20, but Site P's standard deviation (1.41) is far smaller than Site Q's (8.10), so Site P is the steadier and more reliable producer, and the developer should treat Site Q's output as unpredictable.

Question 87

For a Geography Paper Two set with highest mark 50 and lowest 30, and for a Paper One set with highest 90 and lowest 10, calculate and compare the coefficient of range.

Model Answer

The coefficient of range is a relative measure, so it compares the spread of the two papers fairly despite their different marks.

The coefficient of range divides the range by the sum of the largest and smallest marks:

$$\text{Coefficient of range} = \frac{L - S}{L + S}$$

Paper Two: With L = 50 and S = 30:

$$\frac{50 - 30}{50 + 30} = \frac{20}{80} = 0.25$$

Paper One: With L = 90 and S = 10:

$$\frac{90 - 10}{90 + 10} = \frac{80}{100} = 0.80$$

Paper One's coefficient (0.80) is far higher than Paper Two's (0.25), so the marks on Paper One are relatively far more spread out, pointing to a paper that separated the candidates much more sharply.

Question 88

The scores of thirty-four students at Jangwani Girls Secondary School are grouped below. Calculate the mean deviation.

Score	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50
Students (f)	4	8	10	8	4

Model Answer

The mean deviation is the average distance of the marks from their mean, weighted by frequency.

The grouped mean deviation is:

$$MD = \frac{\sum f|x - \bar{x}|}{\sum f}$$

Find the mean and the weighted absolute deviations:

$$\bar{x} = \frac{850}{34} = 25$$

Class	Midpoint x	f	f x	$\lvert x - 25\rvert$	f $\lvert x - 25\rvert$
0 - 10	5	4	20	20	80
10 - 20	15	8	120	10	80
20 - 30	25	10	250	0	0
30 - 40	35	8	280	10	80
40 - 50	45	4	180	20	80
Total		**34**	**850**		**320**

Divide the total of the last column by the total frequency:

$$MD = \frac{320}{34} = 9.41$$

The mean deviation is about 9.41 marks, so the Jangwani scores lie on average 9.41 marks from the mean of 25.

Question 89

Two classes each averaged 60 in a test. Class A scored 58, 60, 62, 59 and 61; Class B scored 40, 80, 55, 65 and 60. Find the mean and standard deviation of each and say which class is more consistent.

Model Answer

Equal means hide the difference, so we compute each standard deviation to compare consistency.

Confirm the means:

$$x_A = \frac{300}{5} = 60, \quad x_B = \frac{300}{5} = 60$$

Squared deviations (Class A):

Class A (x)	58	60	62	59	61	**Total**
$(x - 60)^2$	4	0	4	1	1	**10**

Squared deviations (Class B):

Class B (x)	40	80	55	65	60	**Total**
$(x - 60)^2$	400	400	25	25	0	**850**

Take each standard deviation:

$$s_A = \sqrt{\frac{10}{5}} = 1.41, \quad s_B = \sqrt{\frac{850}{5}} = 13.04$$

Both classes average 60, but Class A's standard deviation (1.41) is far smaller than Class B's (13.04), so Class A is far more consistent while Class B mixes very weak and very strong pupils.

Question 90

The table shows Dodoma region's beef and chicken output over six years. Present the two together on a combined line-and-bar graph and interpret them.

Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Beef ('000 head)	40	44	46	50	54	60
Chicken ('000)	80	90	88	100	110	120

Model Answer

Because beef and chicken are measured on very different scales, one is shown as bars and the other as a line, each on its own vertical axis.

Step 1: Set up the two axes. Put the years on the horizontal axis, beef on the left axis for the bars, and chicken on the right axis for the line.

Step 2: Draw the bars, then the line. Draw a bar for each year's beef against the left axis, then plot the chicken line against the right axis, as in Figure 3.36.

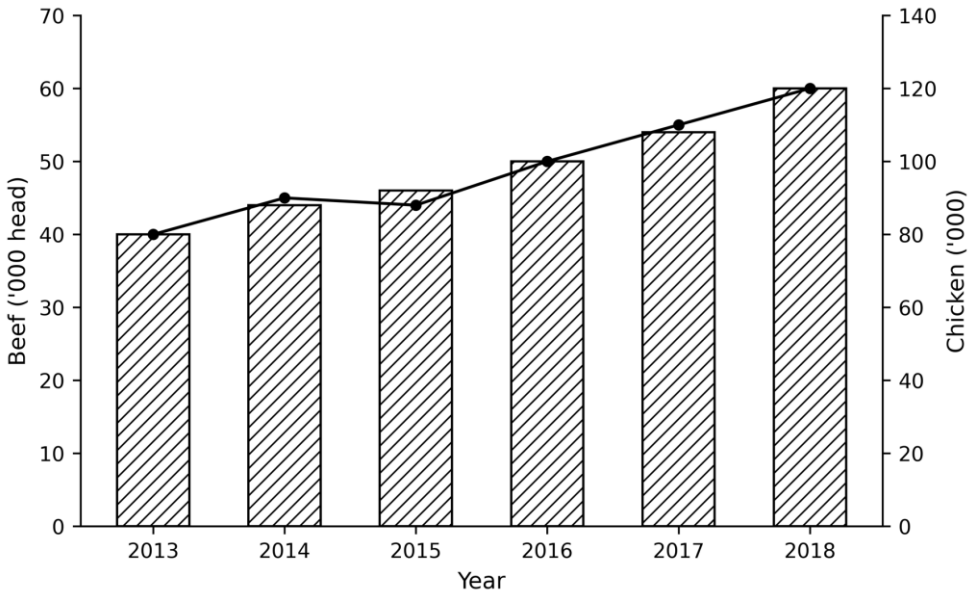


Figure 3.36: *Combined line-and-bar graph of Dodoma livestock*

Interpretation. Both beef and chicken rose steadily over the six years, so the region's livestock sector grew across the board, with beef climbing by half and chicken by a similar share.

Question 91

The table shows a country's rice, maize and wheat production over three years. Draw a compound bar graph and comment on the trend.

Year	2019	2020	2021
Rice ('000 t)	30	34	38
Maize ('000 t)	50	55	60
Wheat ('000 t)	10	12	15

Model Answer

A compound bar stacks the three crops in one bar per year, showing both each year's total and its make-up.

Step 1: Set up the axes. Put the years on the horizontal axis and production on the vertical, scaled to the largest total.

Step 2: Stack the crops. For each year draw one bar and stack rice, maize and wheat, shading each differently, as in Figure 3.37.

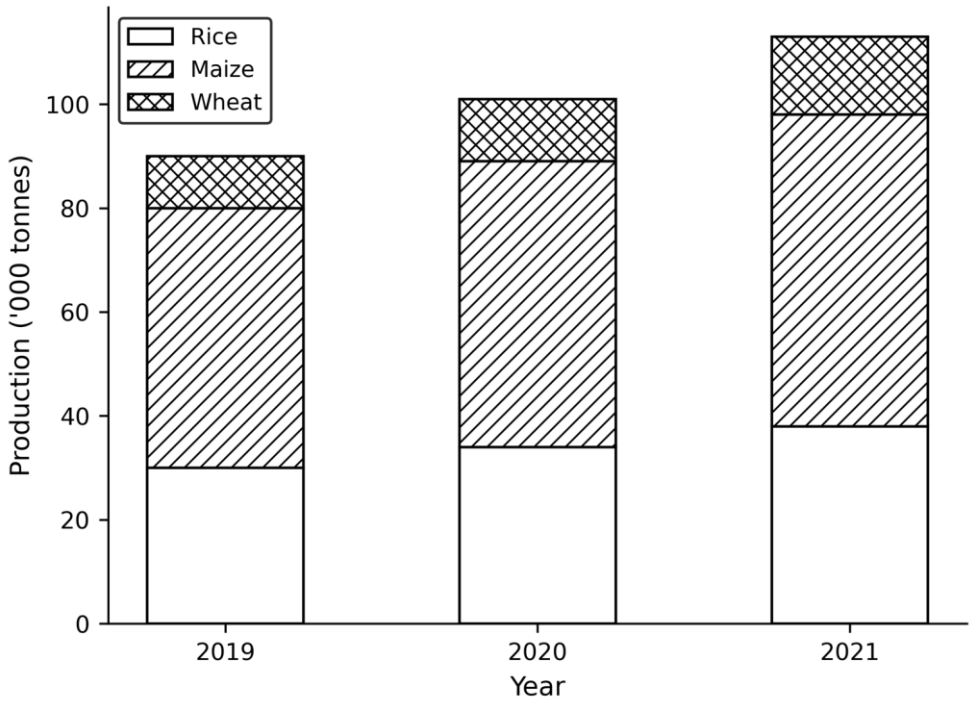


Figure 3.37: *Compound bar graph of cash-crop production*

Interpretation. Every crop and every year's total rose, so overall output grew; maize remained the leading crop throughout while wheat, though smallest, grew fastest in proportion.

Question 92

The table shows Tanzania's fish production, in mega tonnes, over six years. Show how each year departs from the six-year mean on a divergent graph.

Year	2011	2012	2013	2014	2015	2016
Fish (mega tonnes)	38	42	35	48	52	45

Model Answer

A divergent graph is drawn about the mean, so years above it rise as a surplus and years below it fall as a deficit.

Step 1: Find the mean and the deviations. The six years total 260, so the mean is about 43.3; subtract it from each year to get the departures.

Step 2: Draw the divergent graph. Rule a base line for the mean and draw each year's departure above or below it, with a line joining the points, as in Figure 3.35.

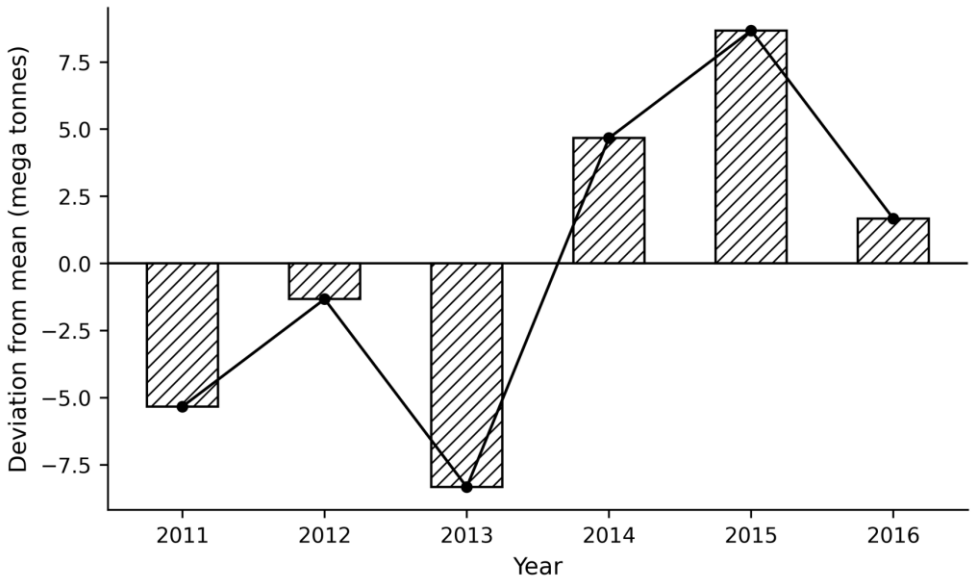


Figure 3.35: *Divergent line-and-bar graph of fish production*

Interpretation. The early years and 2013 fell below the mean while 2014 and 2015 rose well above it, so production was uneven but climbed to a peak in 2015 before easing.

Question 93

A school registry shows form-five registrations by subject combination over four years. Present them on a percentage cumulative bar graph and give its strengths and weaknesses.

Combination	2017	2018	2019	2020
HGE	258	285	243	267
CBG	292	310	285	295
EGM	180	200	190	210

Model Answer

Because the combinations differ in size each year, turning each into a percentage of that year's total lets the shares be compared on bars that all reach 100 per cent.

Step 1: Convert each year to percentages. For each year express HGE, CBG and EGM as percentages of that year's total registrations.

Step 2: Stack the percentages. Draw a bar for each year and stack the three combinations to 100 per cent, shading each, as in Figure 3.38.

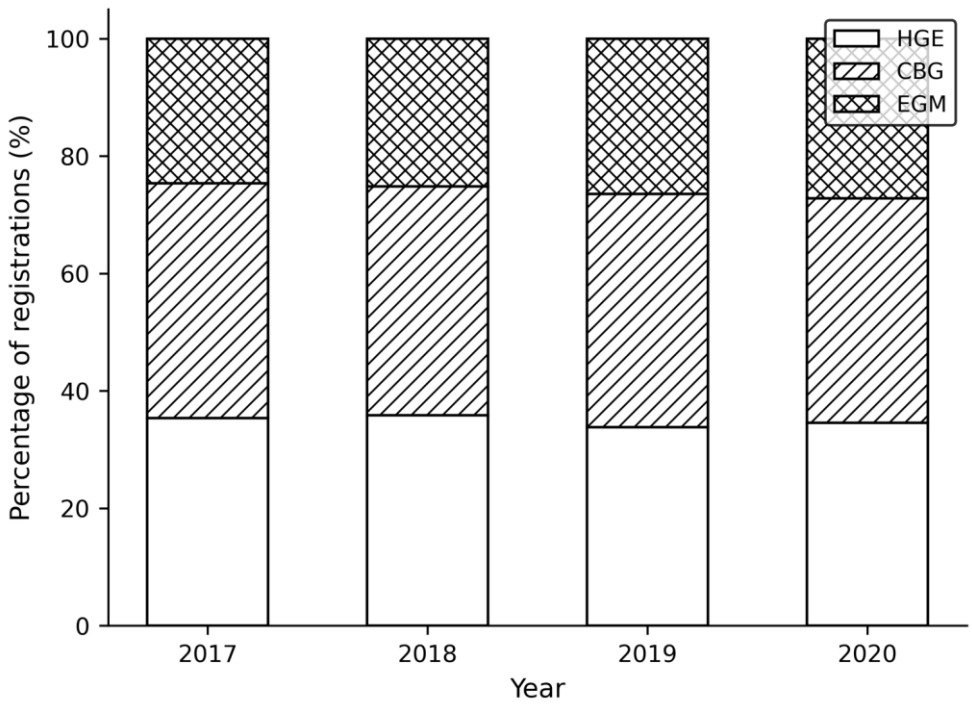


Figure 3.38: *Percentage cumulative bar graph of registrations*

Strengths: it shows the changing share of each combination clearly, allows fair comparison between years of different size, and keeps every bar the same height.

Weaknesses: it hides the actual numbers behind the percentages, and small changes in a share are hard to read exactly from the bar.

Interpretation. CBG kept the largest share throughout while EGM stayed the smallest, so the pattern of choice among combinations changed little over the four years.

Question 94

The table shows the monthly rainfall at Malampaka weather station in 2022. Present it on a polar chart, and give four strengths and three weaknesses of the method.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	14	121	140	220	51	25	25	40	100	102	250	300

Model Answer

A polar chart wraps the twelve months around a circle and plots each month's rainfall as a distance from the centre, so the yearly rhythm shows as a closed loop.

Step 1: Set out the months and scale. Space the twelve months evenly around the circle and mark a radial scale of rainfall from the centre outward.

Step 2: Plot and join. Plot each month's rainfall along its radius and join the points into a closed curve, as in Figure 3.39.

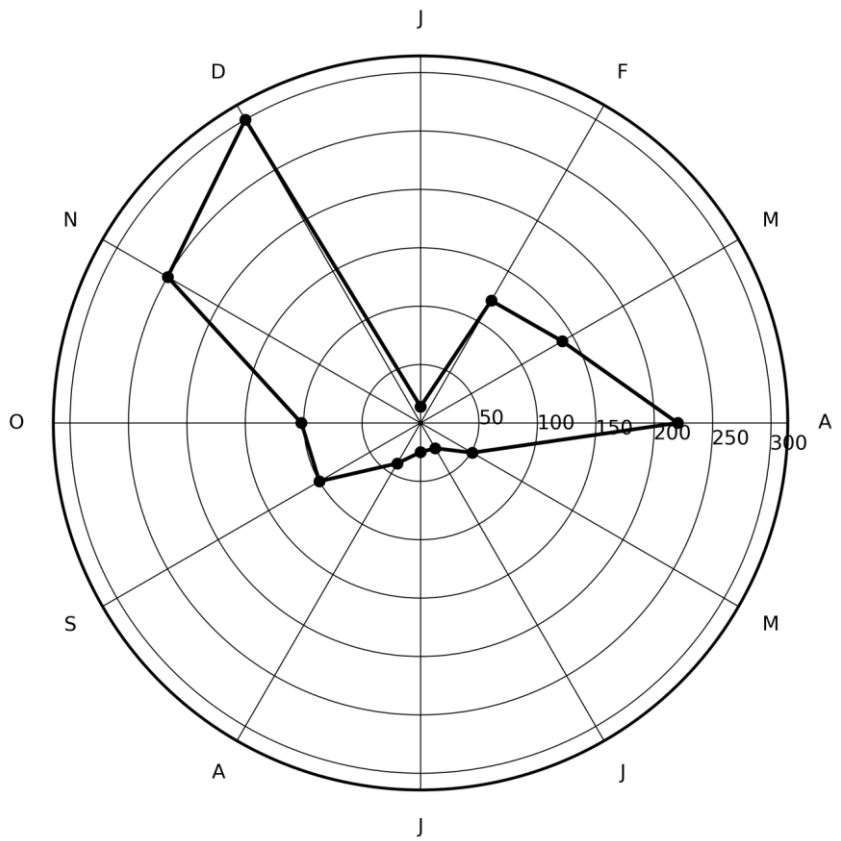


Figure 3.39: *Polar chart of monthly rainfall at Malampaka*

Strengths: (i) it shows the yearly cycle at a glance, (ii) reveals the wet and dry seasons by the loop's shape, (iii) compares all twelve months on one figure, and (iv) needs little space.

Weaknesses: (i) exact values are hard to read from the radius, (ii) the eye can misjudge distances near the centre, and (iii) it suits cyclic data only.

Interpretation. The loop reaches farthest in November and December and in April, and shrinks to the centre from June to August, so Malampaka has a marked wet season around the end of the year and a dry mid-year.

Question 95

A district's population is recorded every two years, as below. Choose the most suitable graph, construct it, and justify your choice.

Year	2012	2014	2016	2018	2020	2022
Population (millions)	1.2	1.4	1.6	1.9	2.2	2.6

Model Answer

Because the data are a single quantity changing continuously over time, a simple line graph is the fitting choice.

Step 1: Justify the choice. A line graph joins the points to show a trend over time better than bars, which suit separate categories; the population changes smoothly, so a line is right.

Step 2: Construct the graph. Put years on the horizontal axis and population on the vertical, plot each point and join with straight lines, as in Figure 3.41.

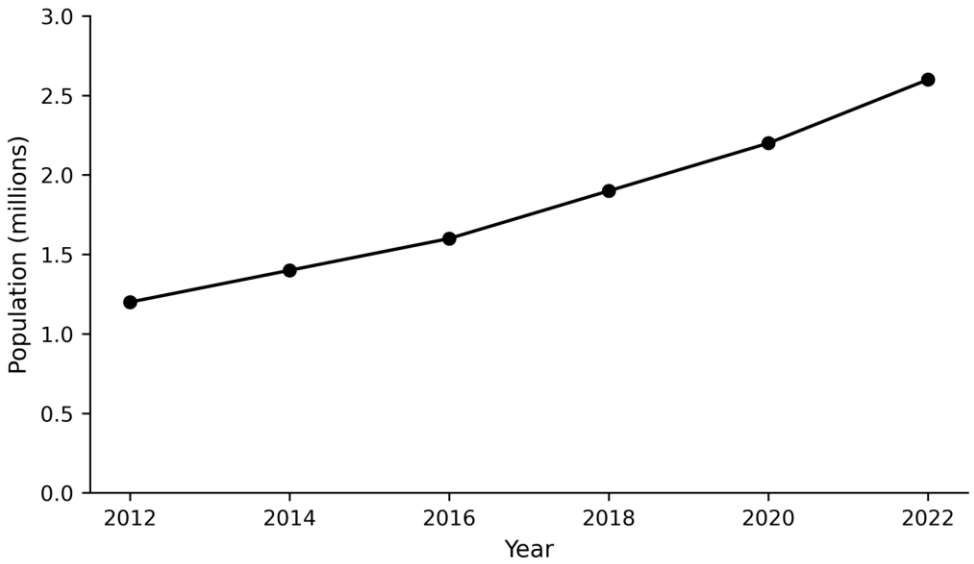


Figure 3.41: *Simple line graph of district population*

Interpretation. The line rises throughout and steepens after 2016, so the district's population grew steadily and then faster, more than doubling over the decade.

Question 96

The table shows the monthly rainfall and temperature at a station. Draw a climate graph and describe the climate.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	160	150	130	80	30	15	10	15	35	85	140	170
Temp (°C)	27	27	26	25	23	21	21	22	24	26	27	27

Model Answer

A climate graph is a combined line-and-bar graph in which rainfall is shown as bars and temperature as a line, on two axes.

Step 1: Set up the two axes. Put months on the horizontal axis, rainfall on the left axis and temperature on the right.

Step 2: Draw the bars and the line. Draw the rainfall bars and plot the temperature line, as in Figure 3.40.

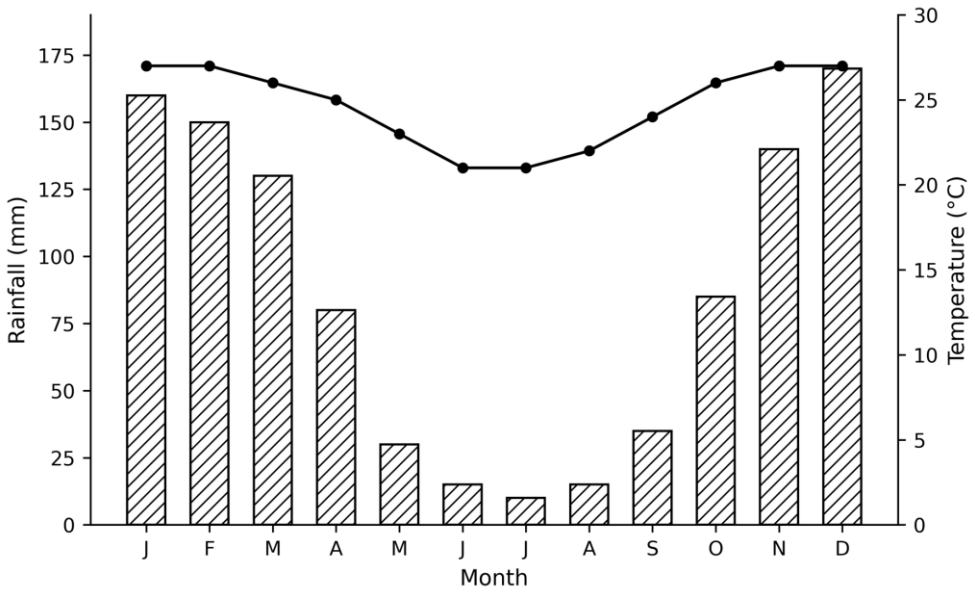


Figure 3.40: *Climate graph of a station*

Interpretation. Rainfall is heavy from November to April and very low from June to August, while temperature stays high and changes little, so the station has a hot tropical climate with a clear wet and dry season.

Question 97

The table shows the land use of five East African countries as percentages of total area. Present the data on a compound divided rectangle and interpret it.

Country	Agric	Recreation	Forest	Industry
Tanzania	60	20	15	5
Kenya	35	25	40	0
Uganda	25	28	35	12
Rwanda	26	42	23	9
Burundi	45	20	35	0

Model Answer

A compound divided rectangle draws one bar of equal height for each country, divided into its land uses, so the five can be compared side by side.

Step 1: Set the bars to 100 per cent. Because the figures are already percentages, each country's bar is drawn to the same height of 100 per cent.

Step 2: Divide and shade the bars. Divide each bar into agriculture, recreation, forest and industry in proportion, shading each land use consistently, as in Figure 3.42.

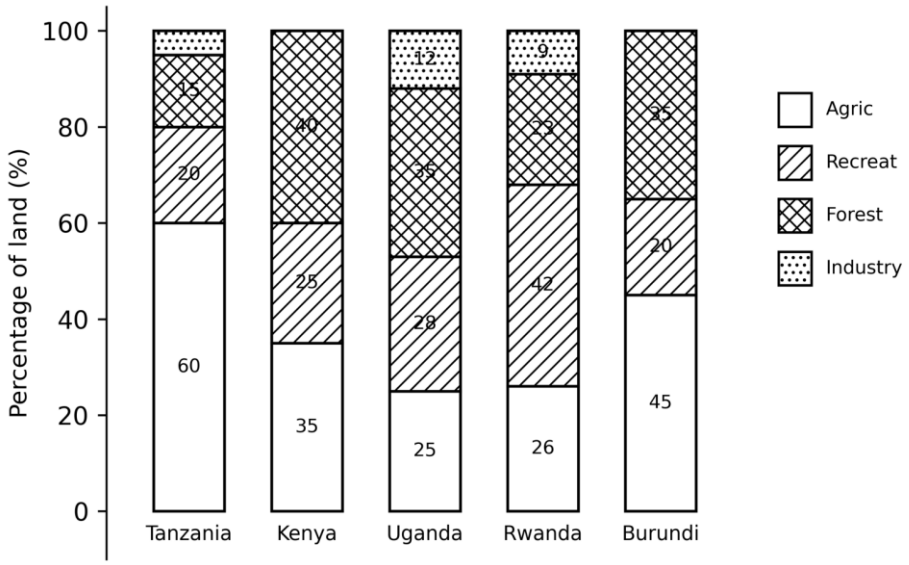


Figure 3.42: *Compound divided rectangle of East African land use*

Interpretation. Agriculture takes the largest share in Tanzania and Burundi, forest dominates in Kenya, and recreation is greatest in Rwanda, so the rectangle shows at a glance how differently the five countries use their land.

Question 98

The table shows a region's cash-crop production in tonnes. Present it on a simple divided circle and comment on it.

Crop	Cotton	Coffee	Tea	Sisal
Production (tonnes)	120	90	60	30

Model Answer

Each crop is shown as a sector whose angle is its share of the whole circle of 360 degrees.

Step 1: Find the total and the angles. The total is 300 tonnes, and each angle is the crop's share multiplied by 360 degrees:

$$\text{Sector angle} = \frac{\text{crop}}{\text{total}} \times 360°$$

Step 2: Work out and check the angles. Confirm the four angles total 360 degrees.

Crop	Tonnes	Working	Angle
Cotton	120	(120/300) × 360°	144°
Coffee	90	(90/300) × 360°	108°
Tea	60	(60/300) × 360°	72°
Sisal	30	(30/300) × 360°	36°
Total	**300**		**360°**

Step 3: Draw the circle. Draw the circle and measure each angle from the largest, labelling and keying it, as in Figure 3.43.

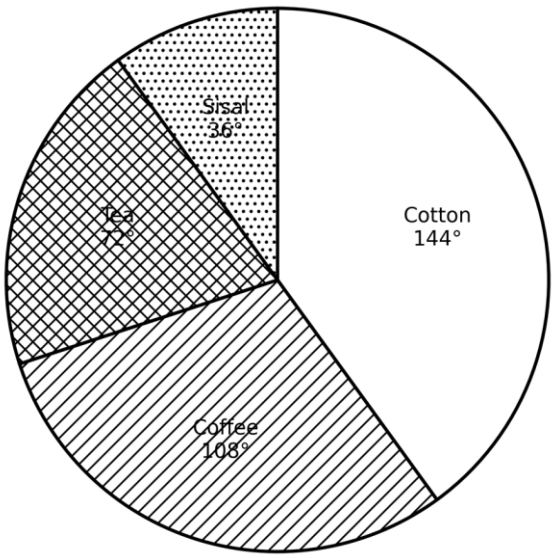


Figure 3.43: *Simple divided circle of cash-crop production*

Interpretation. Cotton takes the largest sector at 144 degrees while sisal takes the smallest, so cotton is the region's leading cash crop.

Question 99

The table shows forest plantations, in hectares, established in three areas in two years. Present the two years as proportional divided circles, and name three other diagrams that could show the same data.

Area	2014	2017
Morogoro	180	320
Ruvu	120	200
Geita	100	130
Total	**400**	**650**

Model Answer

Proportional divided circles make each circle's area proportional to its total, so the radius is the square root of the total, and each circle is then divided into its areas.

Step 1: Find the radii. Take the square root of each year's total:

$$\sqrt{400} = 20, \quad \sqrt{650} = 25.5$$

Step 2: Divide and draw. Draw the 2014 circle with radius 20 and the 2017 circle with radius 25.5, dividing each into Morogoro, Ruvu and Geita by the sector-angle method, as in Figure 3.44.

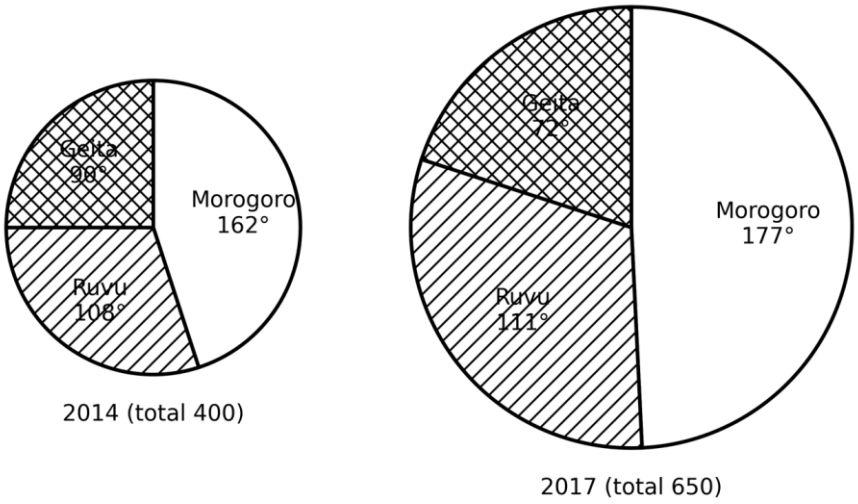


Figure 3.44: *Proportional divided circles of forest plantations*

The same data could also be shown as a compound divided rectangle, a compound bar graph, or a divided semicircle for each year.

False Confidence Alert
A common error is to make the radius, not the area, proportional to the total, drawing the 2017 circle 650/400 times as wide. Because area grows as the square of the radius, that would exaggerate the larger year; the radius must be the square root of the total.

Question 100

The table shows the number of days the wind blew from each direction at a station in one month. Draw a wind rose and state the prevailing wind.

Direction	N	NE	E	SE	S	SW	W	NW
Days	4	6	10	14	9	5	3	2

Model Answer

A wind rose shows each direction as an arm radiating from a centre, its length being the number of days the wind came from that direction, with calms in the central circle.

Step 1: Draw and scale the arms. Draw the eight compass arms and scale each to its number of days.

Step 2: Show the calms. Mark the calm days in the central circle and add a scale, as in Figure 3.45.

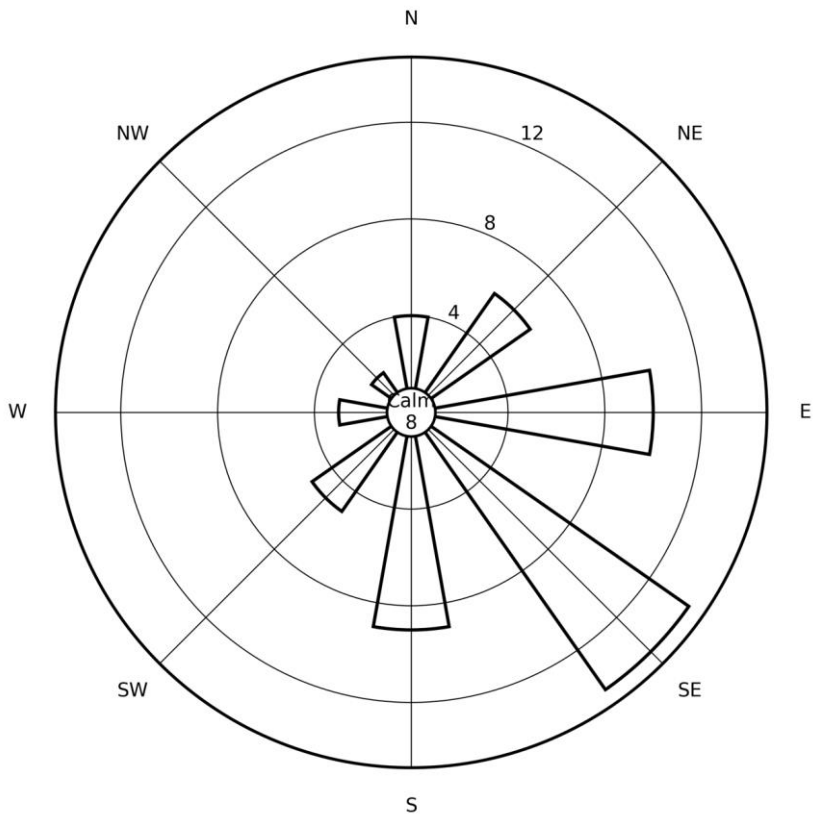


Figure 3.45*: Wind rose of a station*

Interpretation. The longest arm points south-east, followed by east, so the prevailing wind at the station blows from the south-east.

Question 101

The table shows the number of tractors in three countries. Present the data using repeated symbols.

Country	Ghana	Sudan	Kenya
Tractors	40	60	50

Model Answer

Repeated symbols show each figure as a row of identical symbols, each standing for a fixed unit value.

Step 1: Choose a unit value. Let one symbol stand for 10 tractors, so the data divide neatly.

Step 2: Find the number of symbols. The number of symbols is each figure divided by the unit value: 4, 6 and 5 symbols for the three countries.

Step 3: Draw and key the rows. Draw the rows of symbols, one country per row, and add a key, as in Figure 3.46.

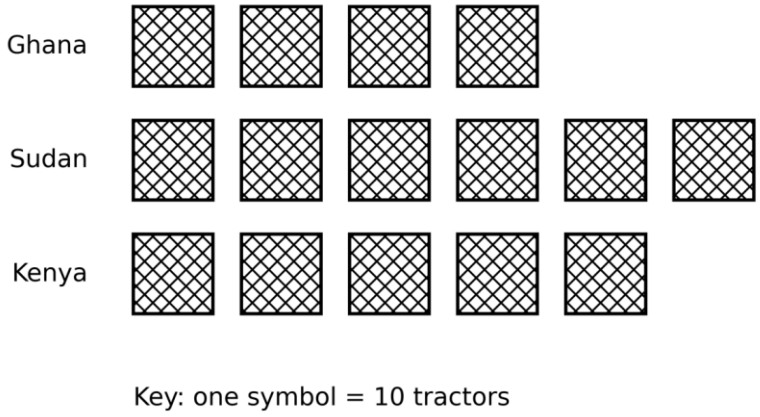


Figure 3.46: *Repeated symbols of tractor numbers*

Interpretation. Sudan has the most tractors at six symbols and Ghana the fewest, and the rows compare the three at a glance.

Question 102

A council's yearly budget is split among education, health, roads and other services. Choose a suitable diagram, construct it, and justify your choice.

Service	Education	Health	Roads	Other
Budget (billion sh)	140	90	70	60

Model Answer

Because the four services are parts of one whole budget, a divided circle, which shows shares of a total, is the fitting diagram.

Justify and find the angles. A divided circle shows how a single total is shared better than separate bars; the total is 360 billion, so each angle is the service's share times 360 degrees:

$$\text{Sector angle} = \frac{\text{service}}{\text{total}} \times 360°$$

Work out the angles and draw. Education 140, health 90, roads 70 and other 60 degrees (summing to 360), then draw and label the circle, as in Figure 3.47.

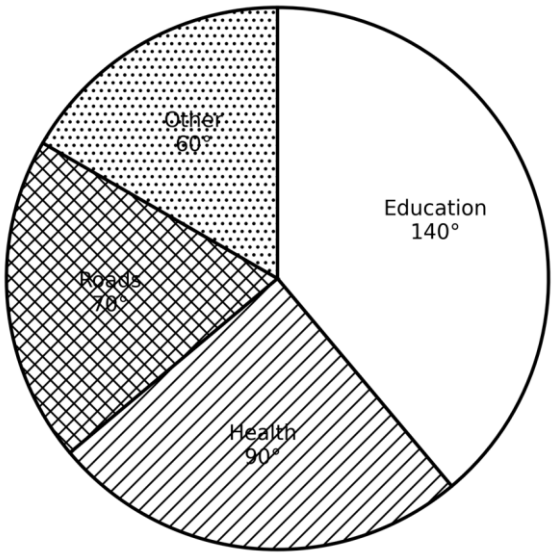


Figure 3.47: *Divided circle of the council budget*

Interpretation. Education takes the largest sector at 140 degrees, well over a third of the budget, so it is the council's leading area of spending.

Question 103

The table shows cashew-nut production, in tonnes, in five coastal regions. Draw a dot map on a sketch map of the coast to show it, and give five merits and demerits of dot maps.

Region	Dar es Salaam	Tanga	Lindi	Pwani	Mtwara
Cashew nuts (tonnes)	828	1 833	2 644	2 346	3 240

Model Answer

A dot map places dots of a fixed value where the crop is grown, so a denser cluster shows a greater output.

Step 1: Choose a dot value. Let one dot stand for 300 tonnes, a value that keeps the dots readable.

Step 2: Find the number of dots. Divide each region's output by the dot value:

$$\text{number of dots} = \frac{\text{production}}{\text{dot value}}$$

Step 3: Place the dots on the sketch map. Draw about 3, 6, 9, 8 and 11 dots in Dar es Salaam, Tanga, Lindi, Pwani and Mtwara, spread within each region, with a key, as in Figure 3.48.

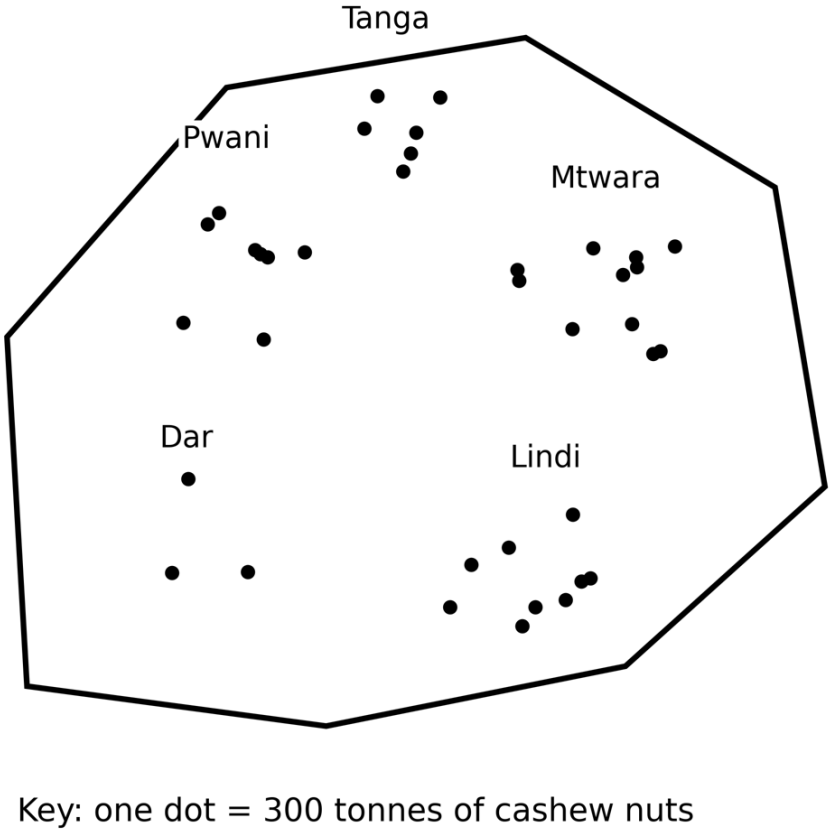


Figure 3.48: *Dot map of cashew-nut production in coastal regions*

Merits: (i) it shows distribution and density at a glance, (ii) is simple to draw, (iii) represents absolute quantities well, (iv) allows regions to be compared, and (v) needs no shading.

Demerits: (i) the placing of dots is often guessed, (ii) exact totals are hard to count back, (iii) a poor dot value crowds or empties the map, (iv) dots may overlap where output is high, and (v) boundaries between regions can be lost.

Interpretation. The dots cluster most thickly in Mtwara and Lindi, showing they are the leading cashew regions, while Dar es Salaam grows the least.

Question 104

The table shows the daily number of vehicles moving from Mwanza to Dar es Salaam along the route through Tabora, Dodoma and Morogoro. Draw a flow-line map and comment on it.

Section of route	Mwanza to Tabora	Tabora to Dodoma	Dodoma to Morogoro	Morogoro to Dar
Vehicles per day	350	300	260	220

Model Answer

A flow-line map draws the route as lines whose width is proportional to the number of vehicles using each section.

Step 1: Choose a width scale. Choose a scale for the width, for example $1\ \text{mm} = 50$ vehicles, to be used for every section.

Step 2: Draw the flow lines. Along the route draw each section as a band whose width matches its traffic, narrowing as the flow falls, as in Figure 3.49.

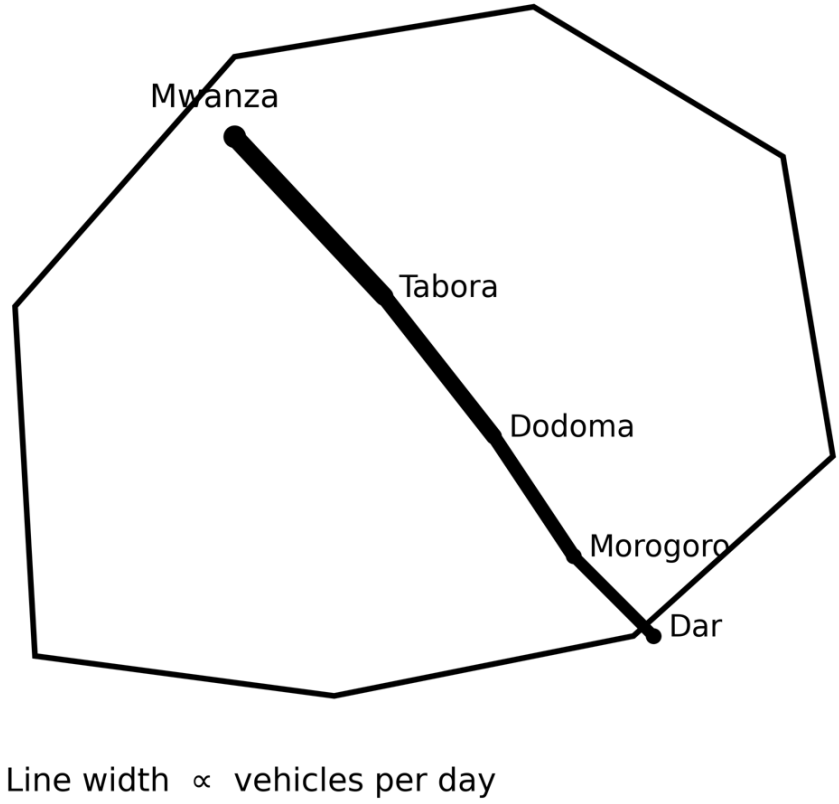


Figure 3.49: *Flow-line map of vehicle movement*

Interpretation. The band is widest between Mwanza and Tabora and narrows steadily towards Dar es Salaam, so traffic is heaviest at the northern end of the route and thins as vehicles turn off along the way.

Question 105

The table shows the population density of four regions. Present it on a choropleth map and read the pattern.

Region	Lindi	Mbeya	Mwanza	Dar es Salaam
Density (per km²)	22	75	180	3100

Model Answer

A choropleth map shades each region by its density, denser shading for higher values.

Step 1: Group the densities into classes. Sort the four densities into classes such as under 50, 50 to 100, 100 to 500 and over 500 persons per square kilometre.

Step 2: Shade and key the map. Shade each region by its class, light for the lowest and densest for the highest, with a key, as in Figure 3.50.

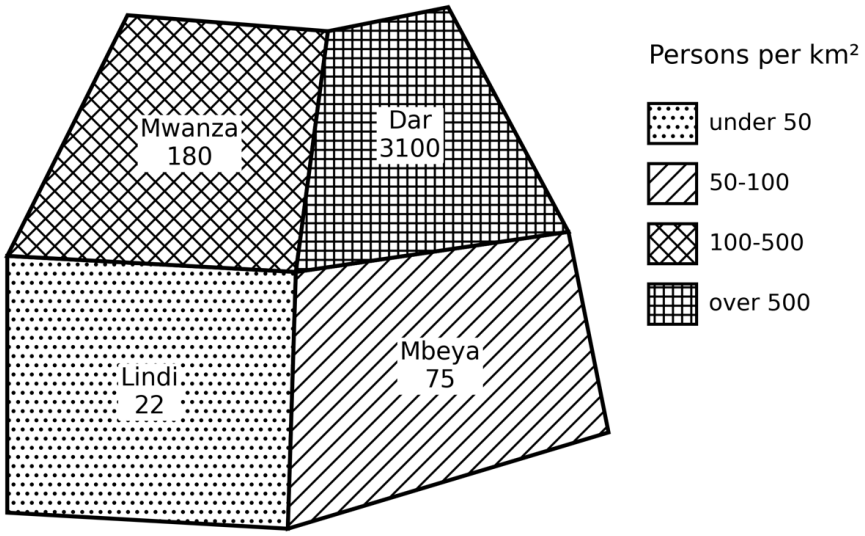


Figure 3.50: *Choropleth map of regional population density*

Interpretation. Dar es Salaam falls in the highest class and stands out at once, while Lindi is the most thinly peopled, so the map shows how sharply population is concentrated in the city.

False Confidence Alert

Choropleth shading suggests each region is evenly peopled, which it is not: Dar es Salaam's density is packed into the city, so the flat shading of the whole region overstates how crowded its rural edges are.

Question 106

The table shows the temperature recorded at six stations. Present it as an isoline map and interpret it.

Station	P	Q	R	S	T	U
Temperature (°C)	22	20	19	21	18	19

Model Answer

An isoline map joins places of equal temperature with smooth lines, the values between stations found by interpolation.

Step 1: Plot the station values. Mark each station and write its temperature beside it.

Step 2: Interpolate and join. Estimate where each round value falls between stations and join equal values into isotherms for 22, 20 and 18 degrees, as in Figure 3.51.

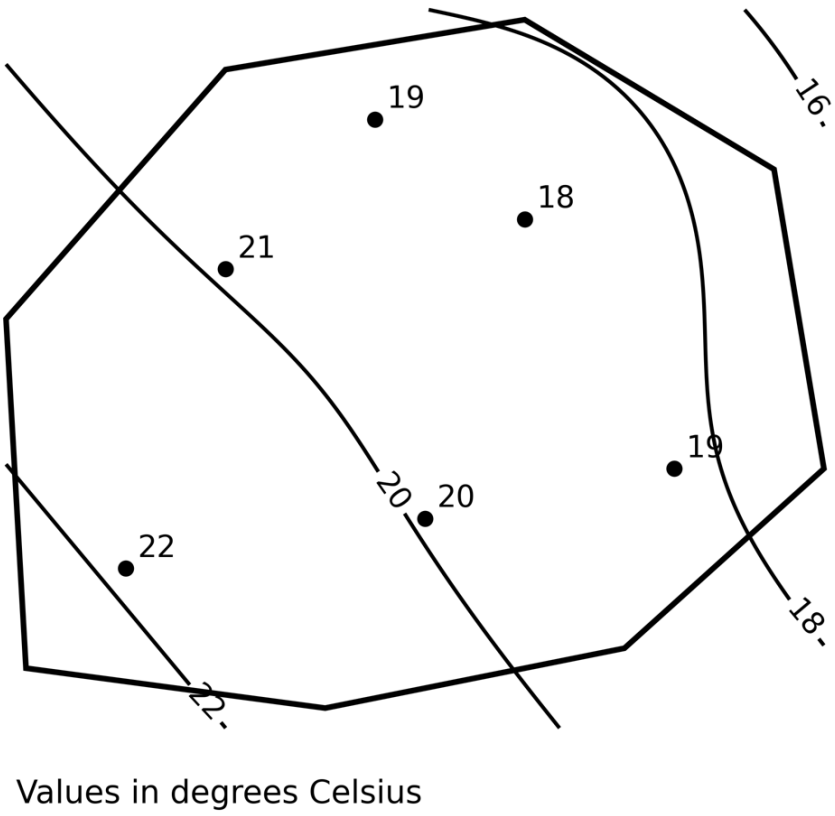


Figure 3.51: *Isoline map of temperature*

Interpretation. The isotherms show temperature falling from the warm south-west, where station P reads 22 degrees, towards the cooler north-east, where T reads 18, a gradient the six figures alone could not reveal.

Question 107

A student wonders why so much of practical geography is given over to statistics. Identify the main roles of statistics in geography.

Model Answer

Statistics turns raw geographical figures into understanding, and it does so in several ways.

1) **Summarising:** it reduces large amounts of data to a few representative measures, such as an average and a spread.
2) **Comparing:** it lets places, times and groups be compared on the same footing.
3) **Revealing patterns:** it brings out trends, concentrations and relationships that raw figures hide.
4) **Supporting decisions:** it gives planners a firm basis for siting services and sharing resources.
5) **Testing ideas:** it allows a hypothesis about the world to be checked against the evidence.

So statistics is not an end in itself but the tool by which a geographer draws reliable meaning from measured data.

Question 108

The table shows a region's rainfall and maize yield over five years. Interpret the results and state the relationship between them.

Year	2017	2018	2019	2020	2021
Rainfall (mm)	800	650	900	700	850
Yield (tonnes/ha)	2.0	1.4	2.4	1.6	2.2

Model Answer

Interpretation means reading what the two rows show and how they move together.

1) **Describe:** both rainfall and yield rose and fell together: the wettest year, 2019, gave the highest yield, and the driest, 2018, the lowest.
2) **State the relationship:** the yield rises and falls with the rainfall, so there is a positive relationship between rainfall and maize yield in the region.

So the figures show that maize yield in this region depends closely on the rains, which a planner would read as a warning that a dry year threatens the harvest.

Question 109

A report on a district sets a table of its rising population beside a graph of its food production, which is rising more slowly. Explain how the two are interpreted together to reach a single conclusion.

Model Answer

A sound conclusion comes from reading the two presentations together, not each on its own.

Read each in turn: note from the table that population is climbing steeply, and from the graph that food production is rising, but more gently.

Compare the rates: set the two trends side by side and see that population is outrunning food.

So the two together lead to one conclusion, that the district faces a widening food gap, which a table or a graph read alone would not have made plain, and which points to the need to raise food output or ease population growth.

HOT QUESTIONS

Question 110

Some students hurry past processing to reach the graphs. Assess the claim that data processing is the least important stage of a geographical study.

Model Answer

Processing looks dull beside analysis and presentation, yet it is the stage on which the trustworthiness of all the others rests, so the claim is mistaken.

The case against the claim: analysis carried out on unprocessed data multiplies every error it contains, so a single unedited or miscoded figure distorts the mean, the spread and every graph that follows.

The qualification: processing alone proves nothing, since clean data still have to be analysed and interpreted; it is necessary but not sufficient.

So processing is not the least important stage but the quiet foundation of a sound study, and skipping it dooms the analysis built upon it.

Question 111

A student insists that only numbers count in geography, so qualitative analysis is second-rate. To what extent is this true?

Model Answer

Quantitative analysis is powerful but partial, and qualitative analysis answers questions that numbers cannot, so the claim is only partly true.

The strength of numbers: quantitative analysis measures, compares and tests, giving precise and repeatable results such as averages, spreads and correlations.

The limit of numbers: it cannot capture why people farm as they do, how they perceive a risk, or the meaning behind a choice, which qualitative analysis of interviews and observation supplies.

The balance: the strongest studies use both, letting the numbers show what happens and the words show why.

So numbers are essential but not sufficient; qualitative analysis is a partner to them, not a second-rate substitute.

Question 112

"The mean is the proper average; the median and mode are only rough substitutes." Assess this claim.

Model Answer

No average is best in every case, so the claim is false; the shape of the data decides which average represents it fairly.

When the mean is best: for roughly symmetrical data the mean is ideal because it uses every value and feeds into further statistics.

When the median is best: for skewed or open-ended data, such as incomes or farm sizes, the median resists the pull of extreme values that would distort the mean.

When the mode is best: for the most typical category, such as the commonest house type, the mode is the only average that answers the question.

So the mean is not inherently superior; the median and mode are the proper averages whenever the data are skewed, open-ended or categorical.

False Confidence Alert
Reaching automatically for the mean is a common error. For a village where most earn little and a few earn a great deal, the mean income describes nobody, and the median must be preferred.

Question 113

Under what conditions should a geographer prefer the median to the mean?

Model Answer

The median is preferred whenever extreme values or open-ended classes would drag the mean away from the typical value.

1) **Skewed data:** where a few very large values (large farms, high incomes) inflate the mean, the median stays among the bulk of the data.
2) **Open-ended classes:** where a class such as "over 100" has no midpoint, the mean cannot be found but the median can.
3) **Ordinal data:** where values are ranked rather than measured, the middle rank is meaningful while an average is not.

So whenever extremes, an open class or mere ranking would mislead, the median is the safer and fairer average.

Question 114

The monthly incomes of a market's traders gave a mean of 85, a median of 60 and a mode of 50 thousand shillings. Without seeing the raw data, judge the shape of the distribution and which average to report.

Model Answer

The three averages fall in the order mean greater than median greater than mode, which is the signature of a positively skewed distribution.

1) **Reading the gap:** the mean, 85, sits well above the median, 60, and the mode, 50, so a few very high incomes are pulling the mean upward.
2) **Judging the shape:** this order of the averages means the distribution has a long tail of high incomes to the right, a positive skew.
3) **Choosing the average:** because the mean is inflated by the few rich traders, the median of 60 best represents a typical trader.

So the incomes are positively skewed, and the officer should report the median of 60, not the mean of 85, as the typical trader's earnings.

Question 115

Explain how the skewness of a distribution guides a geographer's reading of it.

Model Answer

Skewness reveals where the bulk of the data lies and warns which average can be trusted.

Positive skew: most values are low with a few high ones, so the mean overstates the typical value and the median should be quoted.

Negative skew: most values are high with a few low ones, so the mean understates the typical value.

The practical warning: a marked skew tells the geographer to look for the cause of the long tail, such as a few very large farms or very dry years.

So reading the skew is not a technicality but a guide to choosing the right average and to asking what produced the tail.

Question 116

"The range is the least useful measure of dispersion." Substantiate this on statistical grounds.

Model Answer

The range is quick to find but crude, because it rests on only two of the values, so the claim is well founded.

The case for the claim: it uses only the highest and lowest values and ignores all those between, one freak reading can double it, and it says nothing about how the data cluster.

The qualification: it is still useful as a fast first check of spread and in simple quality control, where only the extremes matter.

So the range is the least reliable measure because it wastes most of the data, even though it remains a handy rough guide.

Question 117

Compare the standard deviation and the mean deviation, and say which a geographer should generally prefer.

Model Answer

Both measure the average spread about the mean, but the standard deviation is generally preferred for its mathematical usefulness.

The mean deviation: it is simple to explain and uses the plain distances from the mean, but its use of absolute values makes it awkward in further calculation.

The standard deviation: it squares the deviations, so it feeds naturally into other statistics and weights large departures more heavily, which is often what matters.

The trade-off: that same squaring makes the standard deviation more sensitive to extreme values than the mean deviation.

So the standard deviation is generally preferred because it fits the wider body of statistics, while the mean deviation keeps the advantage of being easier to grasp.

Question 118

Two rain-gauges record the same mean annual total, but gauge A has a standard deviation of 40 mm and gauge B one of 120 mm. Which station's rainfall is the more dependable, and why does the mean alone not tell you?

Model Answer

Gauge A's rainfall is the more dependable, because although the two averages match, A's rainfall varies far less about that average.

Why the mean is silent: both gauges share the same mean, so on the average alone the two sites look identical.

What the spread reveals: A's small standard deviation shows its yearly totals cluster close to the mean, while B's large one shows wild swings from year to year.

The practical meaning: a farmer near A can plan on a fairly steady rainfall, while one near B faces alternating drought and flood.

So the standard deviation, not the mean, decides dependability here, which is why a spread must always be reported beside an average.

Question 119

Given a set of data, how does a geographer decide which graph will present it best?

Model Answer

The choice of graph follows the structure of the data and the message to be carried, not habit.

1) **Trends over time:** a line graph, which joins points to show change.
2) **Comparison of categories:** a bar graph, whose separate bars compare sizes.
3) **Parts of a whole, or two variables:** a compound bar for composition over time, a divergent graph for departures from a norm, and a combined line-and-bar for two related variables.

So the geographer matches the graph to what the data are and to the point to be made, choosing deliberately rather than by routine.

Question 120

A population pyramid's shape tells a demographic story. Explain what the expansive, stationary and constrictive shapes reveal.

Model Answer

The outline of a population pyramid summarises a population's growth and its likely future at a glance.

Expansive: a wide base tapering fast to a narrow top shows a youthful, fast-growing population with high birth rates, the shape typical of Tanzania.

Stationary: nearly straight sides show a stable population with low birth and death rates and slow growth.

Constrictive: a narrow base below a broader middle shows falling birth rates and an ageing population that may soon shrink.

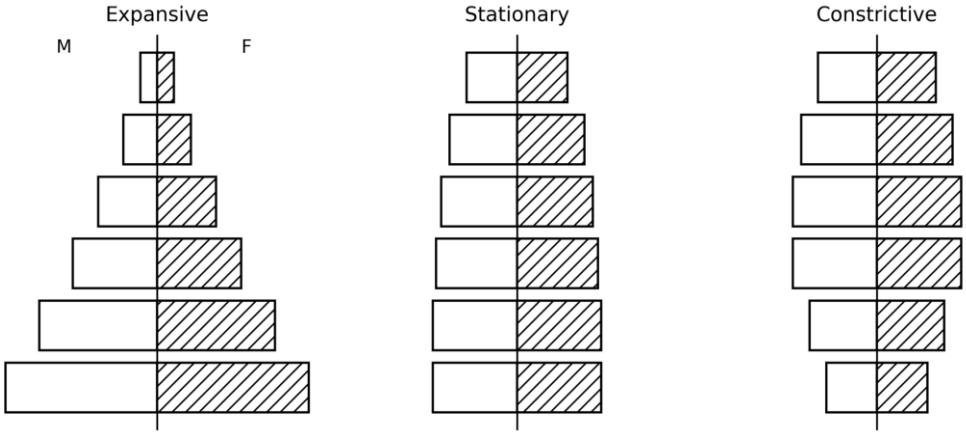


Figure 3.52: *The three types of population pyramid*

So a glance at the pyramid's shape tells the geographer whether a population is booming, steady or ageing, and therefore what schools, jobs or care it will need.

Question 121

Assess the value of graphs as a way of presenting geographical data.

Model Answer

Graphs make patterns visible at a glance, but they can also mislead, so their value depends on honest construction.

The strengths: they show trends, comparisons and relationships far more quickly than a table, and reach readers who would not study columns of figures.

The limits: exact values are lost, a stretched or broken scale can exaggerate a change, and a graph of the wrong type distorts the data.

The safeguard: a graph is most trustworthy when the table behind it is available and its scale is fair.

So graphs are valuable for revealing pattern, provided they are drawn with honest scales and read alongside the figures they summarise.

Question 122

When should a geographer choose a divided rectangle rather than a divided circle for showing composition?

Model Answer

Both show the parts of a whole, but the divided rectangle is preferred when several wholes must be compared or exact shares read.

The divided circle: suits a single whole, where the eye reads shares easily as sectors of a familiar circle.

The divided rectangle: lines several wholes up as bars of equal height, so shares can be compared across them and read off a percentage scale.

The deciding factor: one whole favours the circle, several wholes or a need for exact percentages favour the rectangle.

So the divided rectangle is the better choice for comparing the composition of several places or for reading precise shares, and the circle for a single striking whole.

Question 123

Proportional squares, cubes and spheres can misrepresent data. Explain how, and how the risk is reduced.

Model Answer

Because the eye judges area and volume poorly, proportional symbols can mislead unless they are used with care.

The problem: a value four times larger is shown by a square only twice as wide, yet looks far larger to the eye, and a cube or sphere misleads even more strongly.

The cause: the symbol scales by the square or cube root of the value, but the reader perceives the whole area or volume, which grows much faster.

The remedy: label each symbol with its value, keep them for display rather than precise reading, and prefer squares to cubes where accuracy matters.

So proportional symbols compress large differences neatly but must be labelled and read with caution, since the eye cannot measure area or volume reliably.

False Confidence Alert
The temptation is to make the symbol's width proportional to the value; that is wrong, because it makes the area grow as the square of the value and hugely exaggerates the larger figure. The side must scale by the square root.

Question 124

A compound wind rose for a site shows the most, and the strongest, winds coming from the south-east. Explain how this reading is reached and why it matters for planning.

Model Answer

The south-east arm is both the longest and the most heavily shaded, so it carries both the greatest frequency and the greatest strength of wind.

Reading the rose: the length of each arm gives how often the wind blows from that direction, and the shaded segments give how strong those winds are.

The conclusion drawn: the long, heavily-shaded south-east arm shows a prevailing wind from the south-east that is often strong.

Why it matters: this guides the siting of wind pumps and drying racks, the orientation of buildings and shelter belts, and the timing of spraying.

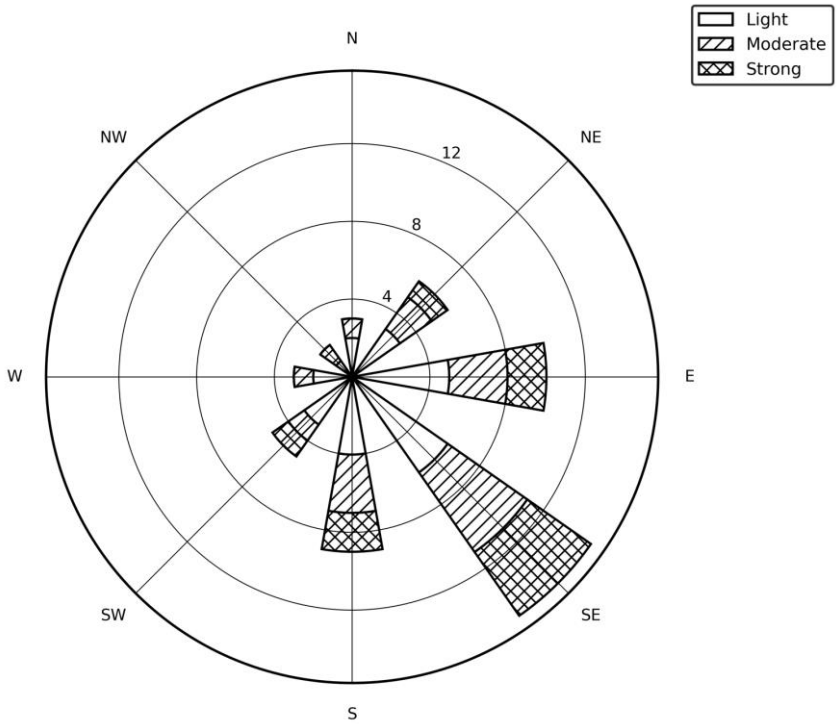


Figure 3.53: *Compound wind rose showing wind direction and strength*

So the wind rose does more than describe the weather; it tells a planner where the wind's power lies and how to build and farm with it.

Question 125

How does a geographer decide among a dot map, a choropleth and an isoline map for a given set of data?

Model Answer

The choice follows the kind of quantity being mapped and the way it varies across space.

A dot map: suits an absolute quantity of counted things, such as cattle or people, whose distribution is to be shown.

A choropleth: suits a density or rate reported area by area, such as persons per square kilometre.

An isoline map: suits a continuous surface, such as temperature or rainfall, that changes smoothly from place to place.

So the geographer maps counted things with dots, area densities with shading, and continuous surfaces with isolines, matching the method to the data.

Question 126

Assess the reliability of statistical maps as a basis for planning decisions.

Model Answer

Statistical maps reveal spatial patterns clearly, but each simplifies reality, so they must be read with their methods in mind.

The strength: they show at a glance where a quantity is concentrated or sparse, which a table cannot.

The weaknesses: dot placement is often guessed, a choropleth implies each area is uniform, an isoline assumes an even gradient, and all depend on the class boundaries chosen.

The safeguard: a map still guides a decision well if the planner knows how it was made and does not read more into it than the method allows.

So statistical maps are reliable guides only when their simplifications are understood; used blindly, they can mislead a plan.

Question 127

A ministry wants a map showing where cholera is concentrated across a region's districts, so as to target clinics. Recommend a mapping method and justify it against the alternatives.

Model Answer

A choropleth map of cases per unit of population fits the purpose best, because it shows the intensity of the disease district by district.

Why a choropleth: shading each district by its rate of cases shows at once where the disease is worst, which is exactly what targeting clinics needs.

Why not a dot map: dots would show the count of cases but crowd in populous districts and hide the rate, so a busy district might look worst simply for being large.

Why not an isoline: disease does not vary as a smooth surface across space, so isolines would impose a pattern that is not real.

So a choropleth of the case rate is the right choice, provided the class boundaries and the population base are chosen with care.

Question 128

Explain how the interpretation of results carries a study from testing a hypothesis to building a theory.

Model Answer

Interpretation is the bridge from a single tested idea to a general explanation of how the world works.

The hypothesis: a study begins with a testable statement, such as that yields rise with rainfall.

The test: the data are analysed and the hypothesis is confirmed or rejected on the evidence.

The theory: when the same result is confirmed across many places and studies, the interpreted findings harden into a general theory.

So interpretation turns a confirmed hypothesis into a contribution to theory, which is how geographical knowledge grows beyond the single study.

Question 129

Trace what happens to a study's conclusion when its data are processed incorrectly at the very start.

Model Answer

An error made in processing does not stay put; it travels unseen through every later stage to a false conclusion.

The entry: a miscoded or unedited figure enters the clean data as if it were correct.

The spread: it shifts the average, distorts the graph and misleads the interpretation, all of which look perfectly orderly.

The outcome: the study ends in a confident but wrong conclusion, and any decision built on it is misdirected.

So a small processing error becomes a large mistake at the end, which is why editing and checking the raw data is not a formality but a safeguard.

False Confidence Alert
A polished result is not a proof of a correct one. A single wrong figure carried from processing produces a neat graph and a firm conclusion that are both, quietly, false.

Question 130

The table shows the percentage of households with piped water in five villages of a ward. Take this raw data through analysis, presentation and interpretation to a conclusion the ward officer can act on.

Village	Kito	Mlima	Bonde	Juu	Chini
Piped water (%)	20	35	25	60	10

Model Answer

A capstone study runs the data through each stage, and here the average alone would hide the very inequality the officer must act on.

Step 1: Analyse. Find the mean access across the five villages:

$$\bar{x} = \frac{20 + 35 + 25 + 60 + 10}{5} = \frac{150}{5} = 30$$

Step 2: Present. Draw a bar graph of the five villages against their access, marking the mean, as in Figure 3.54.

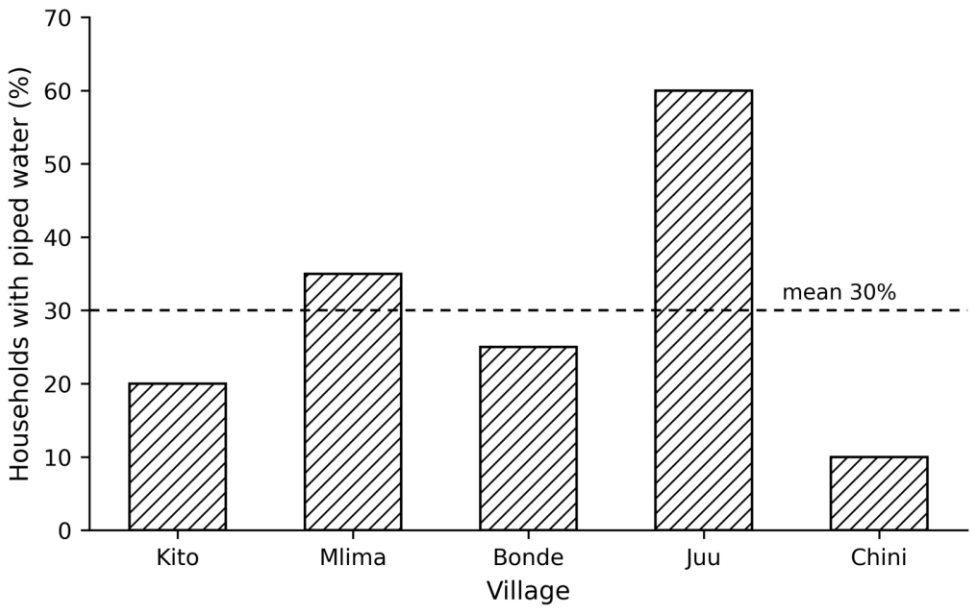


Figure 3.54: *Households with piped water in five villages*

Interpret: the ward averages 30 per cent access, but the bars range from 60 per cent in Juu down to only 10 per cent in Chini, so the mean hides a wide gap.

Conclude and act: the officer should not spread effort evenly on the strength of the average, but direct new supply first to Chini and the other villages below the mean.

So carried through to the end, the data point past their own average to a clear action, which is the purpose of analysing, presenting and interpreting geographical information.

Chapter 4

TECHNIQUES OF PHOTOGRAPH INTERPRETATION

Every day we look at pictures without asking what they can tell us. A photograph, however, is more than a picture; it is a store of geographical information waiting to be read, and this chapter turns that reading into a skill. It opens with the basic ideas, showing how a photograph differs from an image and how satellites and remote sensing gather pictures of the Earth from far above. It then separates photographs into ground and aerial types, and within the aerial group it distinguishes the vertical view from the oblique. Because a vertical photograph is taken to a known scale, the chapter shows how that scale is calculated from the camera and the aircraft. The largest part is interpretation itself: dividing a photograph into parts, working through the keys of tone, shape, texture, pattern, size, site, association and shadow, and using them to read climate, farming, settlement, relief and drainage from the evidence in the frame. Photograph interpretation is examined directly in the geography paper, so each question that follows is built to train both the knowing and the answering.

BINDER QUESTIONS

Question 1

A student looks at an X-ray of a broken arm and a holiday snapshot and calls both photographs. Explain why this is not correct, showing how a photograph is related to an image.

Model Answer

A photograph is a special kind of image, so every photograph is an image, but not every image is a photograph.

Image: any pictorial representation of an object, however it is produced, so X-ray plates, radar pictures and infrared displays are all images.

Photograph: the particular image formed when a camera records the visible light reflected from an object, so it is only one member of the image family.

The one-way link: because the camera is just one of many recording devices, its product sits inside the wider group of images, which is why the snapshot is both a picture and an image while the X-ray is an image but not a photograph.

So a visitor's snapshot of Mount Kilimanjaro is a photograph and an image, whereas an infrared satellite scene of the same mountain is an image but not a photograph.

Question 2

The same stretch of the Rufiji floodplain can be recorded as an X-ray-type image, a radar picture, an infrared scene or an ordinary photograph. Account for this by explaining how images are grouped by wavelength.

Model Answer

Images are grouped by the part of the electromagnetic spectrum, that is the wavelength, which the sensor records.

1) **X-ray images:** record very short wavelengths that pass through soft material, so they are used to look inside bodies and objects rather than across a landscape.
2) **Infrared images:** record heat and near-infrared energy, so they show differences in temperature and in plant health over the floodplain.
3) **Radar images:** record long microwave wavelengths that the sensor sends out and receives back, so they work through cloud and at night.
4) **Photographs:** record the visible light we see, giving the familiar true-colour picture of the floodplain.

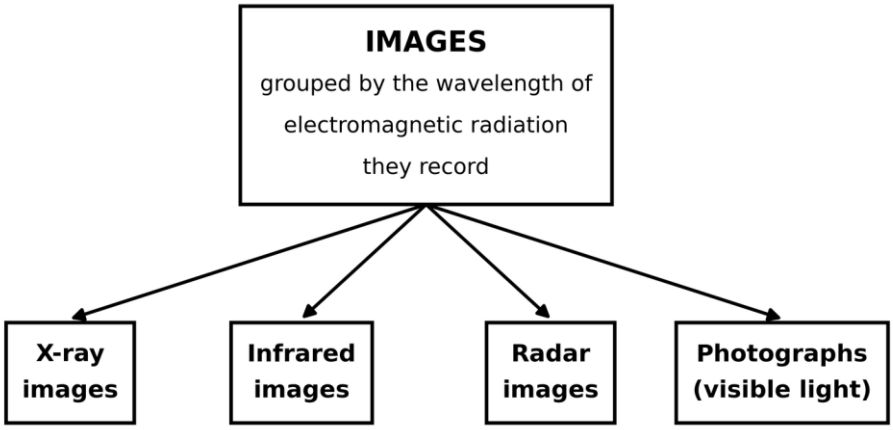


Figure 4.1: *Images grouped by the wavelength of radiation they record.*

So the one floodplain near Utete yields several different images because each sensor listens to a different wavelength.

Question 3

A drone flown over Dodoma carries both a camera and a thermal scanner. Using this, explain the statement that all cameras are sensors but not all sensors are cameras.

Model Answer

A sensor is any device that records radiation from a distance, and a camera is only the type of sensor that records visible light.

Because the camera detects and stores radiation coming from the ground, it is by definition a sensor, so every camera is a sensor. The thermal scanner on the same drone also detects radiation, but it records heat rather than visible light, so it is a sensor that is not a camera. The word sensor is therefore the wide term and camera is the narrow one inside it.

So over Dodoma the drone carries two sensors, yet only one of them, the visible-light camera, produces what we would call a photograph.

Question 4

People often say the satellite takes the picture. Examine why it is more correct to say the satellite carries the instrument that takes the picture.

Model Answer

A satellite is a platform, that is a carrier that holds sensors steady in space, and it is the sensor, not the satellite body, that records the image.

A platform, not a sensor: the satellite is a manufactured carrier, rather like a vehicle, whose job is to hold the instruments in a fixed position and supply them with power.

The sensor does the work: the recording is done by the camera or scanner mounted on the satellite, which measures the radiation coming from the Earth.

Support role: the satellite also keeps the sensor in the right orbit and sends the recorded data back to receiving stations on the ground.

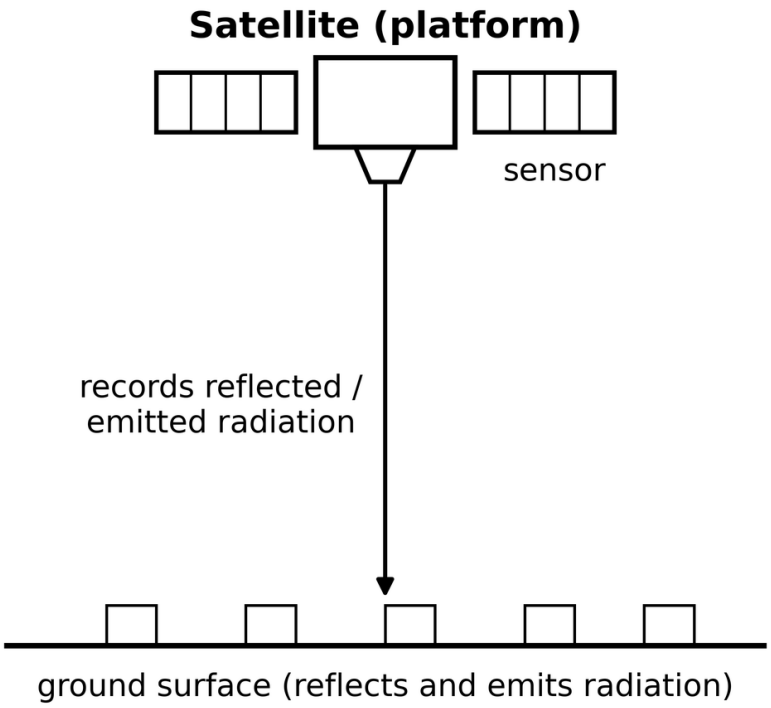


Figure 4.2: *A satellite is a platform that carries and supports the sensor.*

So when an image of the Tanzanian coast is captured, the satellite provides the position and power while the mounted sensor actually forms the picture.

Question 5

On a satellite image of the Kilombero Valley, open water, forest, bare soil and a town can each be told apart. Explain why, using the idea of a reflection signature.

Model Answer

Every surface reflects and emits radiation in its own characteristic way, and this unique pattern is called its signature.

Because water, leaves, soil and concrete are made of different materials, each returns a different mixture and strength of radiation to the sensor. Water reflects little and appears dark, healthy forest reflects strongly in the infrared, bare soil and a town return their own distinct values. The sensor records these differences as different tones and colours, so features that look nothing alike on the ground also record differently on the image.

So the sensor separates the Kilombero wetland, the surrounding forest and the town of Ifakara because each carries its own reflection signature.

Question 6

A weather satellite above the Equator seems to hang still over Tanzania while an imaging satellite sweeps past twice a day. Account for this by describing the three orbits that satellites use.

Model Answer

Satellites are placed in different orbits according to the job they do, and the three main orbits are the sun-synchronous, the geostationary and the low Earth orbit.

1) **Sun-synchronous orbit:** a fairly low, near-polar orbit at about 500 to 900 km that crosses each area at the same local time, so it is used by Earth-observation and mapping satellites.

2) **Geostationary orbit:** a very high orbit of about 36 000 km above the Equator in which the satellite keeps pace with the Earth's spin, so it appears to hang still and is used for weather watching and communication.

3) **Low Earth orbit:** the lowest orbits, used for detailed observation and some surveillance because the satellite is close to the surface.

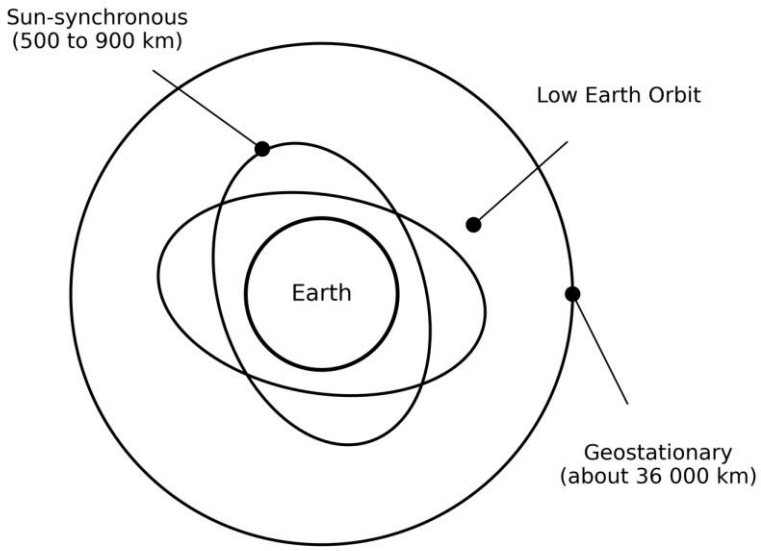


Figure 4.3: *The three satellite orbits.*

So the forecasting satellite over Tanzania holds its place in a geostationary orbit, while the mapping satellite passes overhead in a lower sun-synchronous orbit.

Question 7

A geographer maps the health of the miombo woodland near Tabora without ever setting foot in it. Explain the principle of remote sensing that makes this possible.

Model Answer

Remote sensing is the gathering of information about an object by a recording device that is not in physical contact with it.

Because the woodland reflects and emits radiation, a sensor on an aircraft or satellite can measure that radiation from a distance and turn it into an image. The geographer then reads plant health, gaps and clearings straight from the image, so the study is done without walking through the trees. The saving in time, cost and access is what makes the method so useful over large or difficult country.

So the condition of the miombo around Tabora is judged from above, which is far quicker than a ground survey of the same area.

Question 8

From the weather forecast on the radio to the map on a phone in Mwanza, satellite images touch daily life. Examine the main uses of satellite images.

Model Answer

Satellite images serve many everyday and professional needs, from forecasting weather to guiding travel.

1) **Weather and climate:** they show cloud, rainfall and storms, which supports the forecasts heard on radio and television.

2) **Disaster warning:** they help detect and monitor floods, wildfires and volcanic activity so that people can be warned in time.
3) **Planning and mapping:** they supply up-to-date information for land-use planning and for updating existing maps.
4) **Communication and navigation:** they carry telephone, radio and television signals and provide the positioning that guides travel and tracking.

So a traveller finding the way to Mwanza and a planner updating a district map both depend, often without knowing it, on satellite images.

Question 9

To study the whole Selous region at once a geographer chooses a satellite image, but to inspect a single village she prefers an aerial photograph. Distinguish aerial photographs from satellite images.

Model Answer

Aerial photographs and satellite images differ chiefly in the height they are taken from, the area they cover and the detail they show.

Aspect	Aerial photograph	Satellite image
Taken from	an aircraft, at hundreds to a few thousand metres	a satellite, at hundreds to thousands of km
Area covered	a small area at a time	a very large area, about 185 by 185 km
Radiation used	mainly visible light	visible and invisible, such as infrared and radar
Detail and scale	fine detail, larger scale	less detail, smaller scale
Repeat cover	occasional, by a special flight	regular, often every few days

So the wide sweep of the Selous suits a satellite image, while a close look at one village in the same region is better served by an aerial photograph.

False Confidence Alert
A satellite image is not automatically clearer than an aerial photograph. Because it is taken from much farther away it usually shows a smaller scale and less ground detail, so for close inspection of a single village the aerial photograph is the better choice.

Question 10

A photograph taken from a hilltop, one from an aeroplane and one from a satellite all show the town of Iringa. Classify photographs into their three main groups.

Model Answer

Photographs are grouped, according to where the camera is placed, into ground, aerial and satellite-image photographs.

1) **Ground (terrestrial) photographs:** taken by a camera held at or near ground level, giving a sideways or slightly downward view, like the hilltop shot of Iringa.

2) **Aerial photographs:** taken from above by a sensor on a kite, aircraft, helicopter or drone, giving a view looking down on the town.

3) **Satellite-image photographs:** taken from far out in space by a sensor on a satellite, giving the widest and highest view of all.

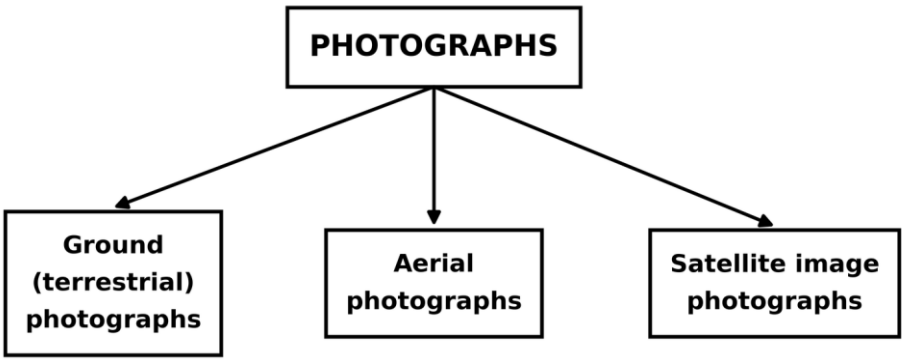


Figure 4.4: *The three main groups of photographs.*

So the same town of Iringa can be recorded in three ways, and naming the group is the first step in reading any photograph.

Question 11

Standing on the shore of Lake Victoria, a student takes pictures looking out across the water. Explain what makes these ground photographs.

Model Answer

A ground or terrestrial photograph is one taken by a camera held at ground level, looking horizontally or obliquely at the scene.

Because the camera is on the ground rather than above it, the view is taken from the side, so the student sees the fronts and sides of boats and buildings rather than their tops. This viewpoint is the everyday one we all use, and it is the defining feature of a ground photograph, whether the camera looks straight ahead or is tilted a little downward.

So the pictures taken along the Lake Victoria shore are ground photographs because the camera records the scene from ground level and from the side.

Question 12

A photograph taken with the camera held level in Kariakoo market shows the fronts of the stalls but not their roofs. Account for the features of a ground horizontal photograph.

Model Answer

A ground horizontal photograph is taken with the camera axis held level, so it shows the front and side of objects and is the commonest type.

1) **Level axis:** the camera looks straight ahead, so the line of sight is parallel to the ground.

2) **Side and front view:** objects are seen from the side, which is why the stall fronts show but their roofs do not.

3) **Limited depth:** nearer objects hide those behind them, so the photograph shows little of the ground plan of the market.

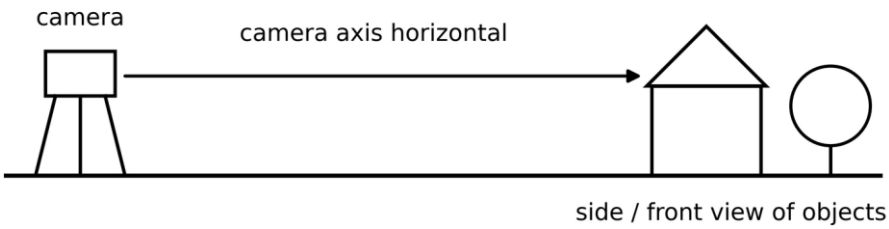


Figure 4.5: *A ground horizontal photograph: the camera axis is level.*

So the level camera in Kariakoo captures the faces of the stalls clearly but cannot reveal how they are laid out from above.

Question 13

A close photograph of a single sisal plant near Morogoro shows the plant huge in front while a lorry behind it looks tiny. Explain the characteristics of a ground close-up photograph.

Model Answer

A ground close-up photograph is taken very near the object, so the object fills the foreground and the scale falls away sharply toward the back.

1) **Large foreground object:** because the camera is close, the chosen object appears very large and detailed in front.
2) **Rapid change of scale:** things only a little farther away look far smaller, which is why the lorry behind the plant seems tiny.
3) **No top view:** the object is still seen from the side, so its top is not shown.

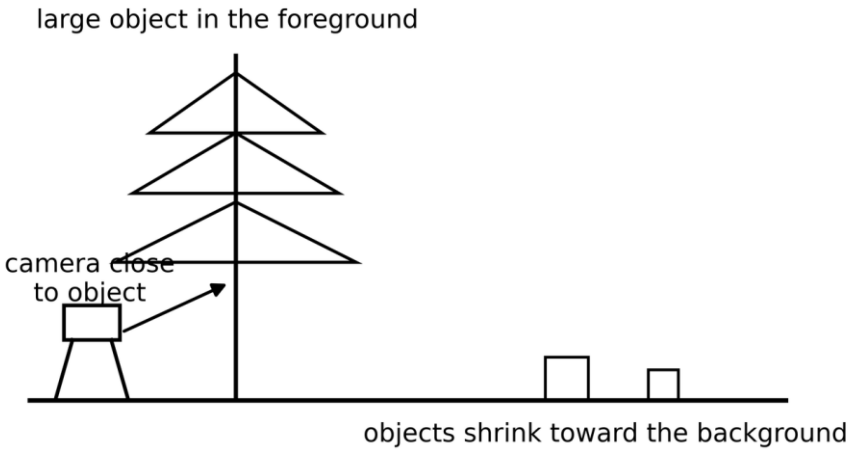


Figure 4.6: *A ground close-up photograph: a large foreground and a rapidly shrinking background.*

So the close shot near Morogoro shows every detail of the sisal leaves but badly exaggerates their size against the lorry behind.

Question 14

From the roof of a tall building in Dodoma a photograph is taken looking down and across the city at an angle. Examine the characteristics of a ground oblique photograph.

Model Answer

A ground oblique photograph is taken from raised ground with the camera tilted downward at an angle, usually between thirty and sixty degrees, so it shows both the top and the side of objects.

1) **Raised viewpoint and tilt:** the camera looks down from a hill, roof or high ground, so it captures more than a level shot can.
2) **Top and side together:** because of the tilt, roofs as well as walls are seen, which helps show the layout of the city.
3) **Fore, middle and background:** the scene divides into a clear foreground, middle ground and background, with a small strip of horizon at the top.

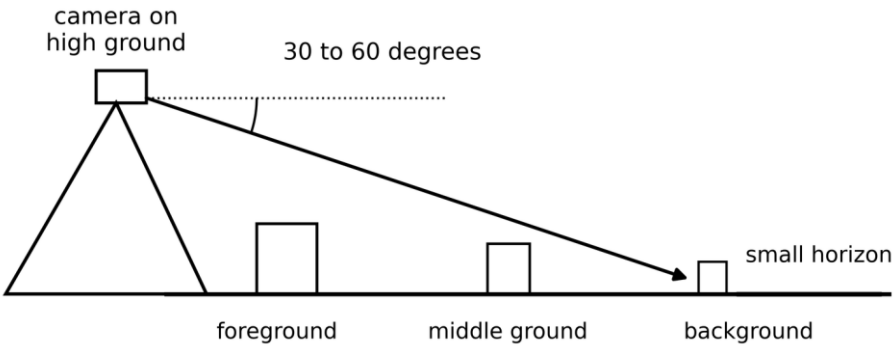


Figure 4.7: *A ground oblique photograph taken from high ground.*

So the tilted shot from the Dodoma rooftop reveals both the roofs and the street pattern that a level photograph would hide.

Question 15

During a flood on the Rufiji, a ground oblique photograph from a nearby hill gave information that instruments on the ground could not. Explain the advantages of ground oblique photographs.

Model Answer

Ground oblique photographs are valuable because they give a wide, timely view that shows both the top and the side of a scene.

1) **Timely landscape data:** they can be taken quickly at the moment of an event, such as the height and spread of a flood.
2) **They supplement other data:** they capture things instruments miss, such as the extent of floodwater or a locust swarm.
3) **They aid field sketching:** the clear fore, middle and background make it easy to draw a sketch of the area.
4) **Clearer relief:** the tilt shows slopes and high ground better than a level photograph does.

So a single oblique photograph from a hill above the Rufiji recorded the reach of the flood far faster than gauges spread along the river.

Question 16

A surveyor refuses to make an accurate map from a ground oblique photograph of a Kigoma hillside. Account for the disadvantages of ground oblique photographs.

Model Answer

Ground oblique photographs have real weaknesses, chiefly that their scale is not uniform, which limits their use in measurement and mapping.

1) **Changing scale:** the scale decreases from the foreground to the background, so distances measured on the photograph are unreliable.

2) **Scale hard to fix:** unless the true size of some object is already known, the scale cannot be worked out at all.
3) **Not for large-area mapping:** because of the distortion, the photograph cannot be used to produce an accurate map.
4) **Restricted horizon:** only a small strip of horizon shows, so distant parts are cramped and unclear.

So the surveyor on the Kigoma hillside is right to reject the oblique photograph for exact mapping, even though it remains useful for a quick sketch of the slope.

False Confidence Alert
An oblique photograph is not useless just because it cannot be mapped from. It still helps field sketching and records an event quickly, so its weakness is in measurement, not in observation.

Question 17

A geographer needs a picture that looks down on the whole of a sisal estate near Korogwe at once. Explain what an aerial photograph is and the platforms used to take one.

Model Answer

An aerial photograph is a picture of the ground taken from above by a sensor mounted on a flying platform.

Taken from above: the camera looks down on the land, so it records the tops of features and their true plan.

Carried by platforms: the sensor is flown on a kite, an aircraft, a helicopter or a drone, depending on the height and detail needed.

Purpose: this overhead view is used for making maps, planning land use and following boundaries and routes.

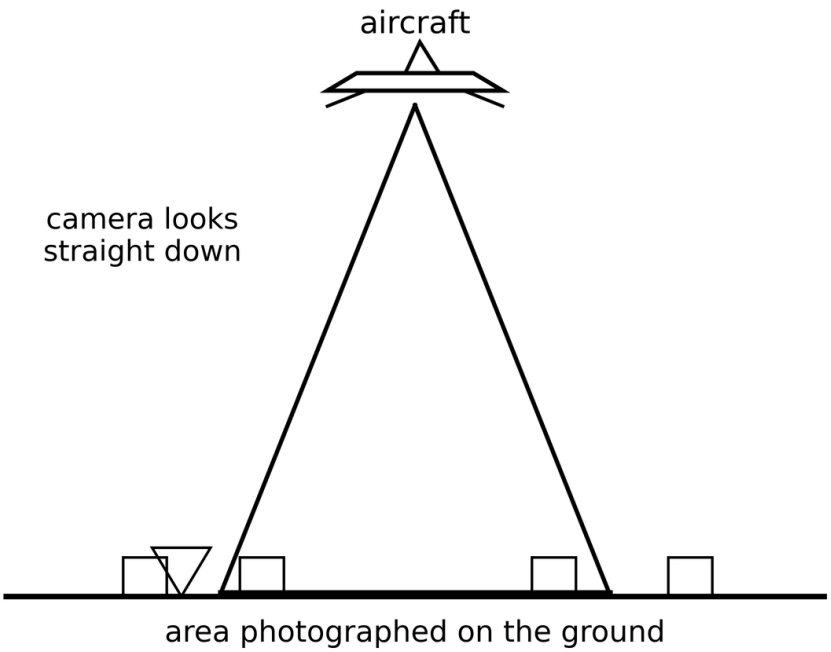


Figure 4.8: *An aerial photograph is taken by a camera looking down from a flying platform.*

So the whole sisal estate near Korogwe can be seen in one overhead view that no ground photograph could give.

Question 18

Two aerial photographs of Arusha differ in the tilt of the camera, the width of ground they cover and the film used. Explain the criteria by which aerial photographs are classified.

Model Answer

Aerial photographs are classified on three bases: the direction of the camera axis, the angular coverage and the type of emulsion or film.

1) **Camera axis:** whether the axis points straight down or is tilted, which separates vertical from oblique photographs.
2) **Angular coverage:** the width of ground the lens takes in, from narrow to wide angle.
3) **Emulsion or film:** the kind of film used to record the image, such as black-and-white, colour or infrared.

So describing an Arusha photograph fully means stating its axis, its angular coverage and its film, not just calling it aerial.

Question 19

A forester near Mufindi wants a photograph on which healthy and stressed trees look clearly different. Account for the emulsion types used in aerial photography.

Model Answer

The emulsion is the light-sensitive film on which the photograph is recorded, and four types are commonly used.

1) **Panchromatic black-and-white:** records the visible range as shades of grey, and is the cheapest and commonest.
2) **Colour:** records the scene in natural colours, which makes features easier to recognise.
3) **Infrared black-and-white:** records near-infrared energy, which shows plant vigour and moisture.
4) **False-colour composite:** displays infrared as bright red, so that healthy vegetation stands out strongly.

So the forester at Mufindi would choose an infrared or false-colour film, on which vigorous trees separate clearly from stressed ones.

Question 20

On a photograph taken with the camera pointing straight down over Dodoma, the streets show only their rooftops and the centre looks sharpest. Examine the characteristics of a vertical aerial photograph.

Model Answer

A vertical aerial photograph is taken with the camera axis pointing straight down, so it shows the top view of the ground at a fairly even scale.

1) **Top view only:** because the axis is vertical, roofs and plan shapes show rather than the sides of buildings.
2) **The principal point:** the exact centre of the photograph, lying directly below the camera, where the view is truest.
3) **Scale largest at the centre:** the scale is greatest at the principal point and falls off a little toward the edges.

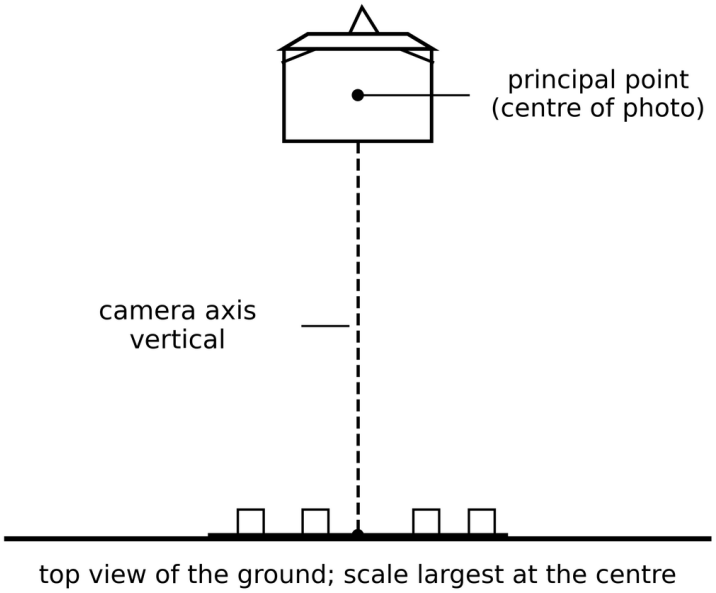


Figure 4.9: *A vertical aerial photograph and its principal point.*

So the straight-down photograph of Dodoma gives a near-plan of the streets, sharpest at its principal point.

Question 21

Two tilted photographs of the Uluguru foothills differ in one thing: on one the distant skyline appears, on the other it does not. Distinguish a low oblique from a high oblique aerial photograph.

Model Answer

Both are taken with the camera tilted, and the single test that separates them is whether the horizon shows.

Low oblique: the camera is tilted only a little, so the photograph does not show the horizon.

High oblique: the camera is tilted more steeply, so the distant horizon does appear across the top.

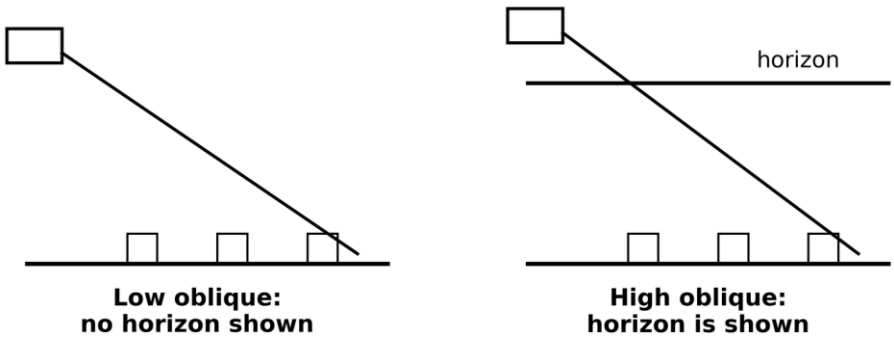


Figure 4.10: *Low oblique (no horizon) and high oblique (horizon shown).*

So the photograph of the Uluguru foothills that shows the skyline is the high oblique, and the one without it is the low oblique.

Question 22

A wildlife officer counting animals over a wide plain in the Serengeti prefers an oblique photograph to a vertical one. Explain the merits of oblique aerial photographs.

Model Answer

Oblique aerial photographs are valued because they give a wide, natural view that covers a large area and shows relief well.

1) **Wide panoramic view:** the tilt lets a single photograph take in a large stretch of country.
2) **Larger area than ground photographs:** they cover far more than any picture taken from the ground.
3) **Clear relief:** slopes, hills and valleys stand out because they are seen from the side as well as above.
4) **Useful for counting and searching:** they suit wildlife census, finding sites and following moving objects such as vehicles and herds.

So the officer over the Serengeti gains from the oblique a sweeping view of the herds that a narrow vertical frame would miss.

Question 23

A candidate is asked why a vertical photograph and an oblique photograph of the same Iringa farm look so different. Distinguish vertical from oblique aerial photographs.

Model Answer

Vertical and oblique aerial photographs differ mainly in the tilt of the camera and in what and how much they show.

Camera axis: the vertical photograph has a straight-down axis, while the oblique has a tilted one.

View given: the vertical shows the top of features, while the oblique shows both top and side.

Horizon: the vertical never shows the horizon, while a high oblique does.

Scale: the vertical has a fairly even scale, while the oblique scale falls off from foreground to background.

Area covered: the oblique takes in more ground, while the vertical covers a smaller, more uniform area.

So the vertical view of the Iringa farm reads like a plan, whereas the oblique looks more like the scene as a person would see it from a hill.

Question 24

A district officer argues that a vertical aerial photograph tells him more about a remote part of Lindi than the topographical map does. Account for the advantages of vertical aerial photographs over maps.

Model Answer

Vertical aerial photographs have real advantages over maps because they show the ground as it actually is and can reach difficult places.

1) **Reach inaccessible areas:** they record dense forest, swampland and remote interiors that are hard to survey on foot.
2) **Show real detail:** every visible feature is recorded, not only those a cartographer chose to draw.
3) **Raw material for planning:** they supply up-to-date information for land use, settlement layout and disaster management.
4) **Support prediction:** repeated photographs show change over time, which helps forecast future conditions.

So for a little-mapped part of Lindi the photograph carries fuller and fresher information than the printed map.

Question 25

The same officer is warned not to rely on vertical aerial photographs alone. Examine the limitations of vertical aerial photographs.

Model Answer

Vertical aerial photographs also have limitations of cost, weather and competition from free data.

1) **Costly to obtain:** commissioning an aircraft and camera is expensive compared with using existing sources.
2) **Weather barriers:** heavy rain, cloud, fog and mist delay or prevent good photography.
3) **No ready explanation:** a photograph shows what is there but does not name features or give heights as a map does.
4) **Free alternatives:** online imagery and mapping tools now meet many needs, reducing demand for new flights.

So the Lindi officer is right to treat the photograph as one source among several rather than a complete answer on its own.

Question 26

In an examination a student meets the terms photo mosaic, camera station and principal point and cannot define them. Explain these three terms as used in photograph interpretation.

Model Answer

These are basic terms of aerial photography that describe how photographs are joined and where they are centred.

Photo mosaic: a set of overlapping aerial photographs fitted together to show a larger area as one continuous picture.

Camera station: the exact point in the air, above the ground, from which a photograph is taken.

Principal point: the centre of a vertical photograph, lying directly below the camera station.

So a strip of photographs of the Rufiji delta can be joined into a mosaic, each frame having its own camera station above and its own principal point at the centre.

Question 27

A student is puzzled that pairs of overlapping photographs of a Mbeya hillside can be made to look solid and three-dimensional. Explain the terms stereoscope and stereoscopy.

Model Answer

Stereoscopy is the viewing of two overlapping photographs so that the land appears three-dimensional, and the stereoscope is the instrument that makes this possible.

Stereoscopy: the technique of looking at two photographs of the same ground taken from slightly different points, so the brain sees depth and relief.

Stereoscope: a simple instrument of lenses through which the overlapping pair is viewed, so hills and valleys stand up from the flat prints.

So a candidate studying the Mbeya hillside would place the overlapping pair under a stereoscope to judge the steepness of the slopes.

False Confidence Alert
A stereoscope does not take photographs and is not a camera. It is only a viewing instrument, used after the flight to see two overlapping photographs in three dimensions.

Question 28

Before measuring anything on a vertical photograph of a Tabora farm, a geographer insists on knowing its scale. Explain why the scale of a vertical photograph must be determined.

Model Answer

The scale must be known because it is the bridge between distances on the photograph and real distances on the ground.

1) **To measure real distances:** only with the scale can a length on the photograph be turned into metres or kilometres on the ground.
2) **To find real areas:** field and plot sizes can be worked out once the scale is known.
3) **To compare with maps:** a known scale lets the photograph be matched to a map of the area.

So without the scale the photograph of the Tabora farm is only a picture, but with it the picture becomes a measuring tool.

Question 29

A survey camera of focal length 152 mm is flown above a level plain near Singida. Explain how the scale of the vertical photograph it produces is related to the camera and the aircraft.

Model Answer

The scale of a vertical photograph is the ratio of the camera focal length to the flying height above the ground.

Step 1: Write the relationship. $S = \frac{f}{H}$ where f is the focal length and H is the flying height above the ground.

Step 2: Read the geometry. The photograph is small and the ground is large, so the same ratio $\frac{f}{H}$ also equals the photo length divided by the ground length.

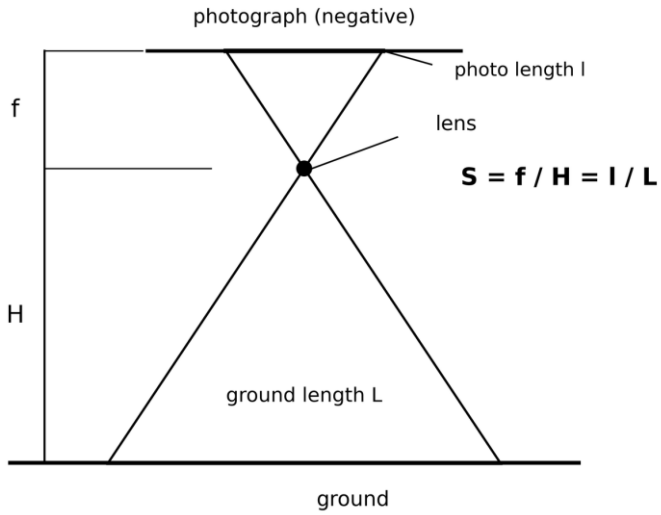


Figure 4.11: *The scale of a vertical photograph: S = f / H.*

Interpretation. So the scale of the Singida photograph is fixed by two things only, the focal length of the camera and the height from which it was flown.

Question 30

A camera of focal length 152 mm is flown at a height of 3 800 m above a level plain near Shinyanga. Calculate the scale of the vertical photograph produced.

Model Answer

The scale follows directly from the focal length and the flying height once both are in the same unit.

Step 1: State the formula. $S = \frac{f}{H}$.

Step 2: Put both in metres. $f = 152\ mm = 0.152\ m$ and $H = 3\ 800\ m$.

$$S = \frac{0.152}{3\ 800} = \frac{1}{25\ 000}$$

Scale = 1:25 000.

Interpretation. So the Shinyanga photograph is at 1:25 000, meaning one unit on the print stands for 25 000 of the same units on the ground.

False Confidence Alert
A greater flying height gives a smaller scale, not a larger one, because H is in the denominator. Flying twice as high would halve the scale and show half the detail.

Question 31

A vertical photograph taken over Morogoro is at a scale of 1:25 000, and the aircraft flew at 3 300 m above the ground. Calculate the focal length of the camera used.

Model Answer

Rearranging the scale relationship gives the focal length from the scale and the flying height.

Start from $S = \frac{f}{H}$, so $f = S \times H$.

Substitute the values. $S = \frac{1}{25\ 000}$ and $H = 3\ 300\ m$.

$$f = \frac{1}{25\ 000} \times 3\ 300\ m = 0.132\ m$$

Focal length = 0.132 m = 132 mm.

Interpretation. So the camera used over Morogoro had a focal length of 132 mm, one of the two lengths commonly used in Tanzania.

Question 32

A photograph is taken over the hilly country near Mbeya, where the land stands well above sea level. Explain how the scale formula is adjusted when the mean ground elevation is known.

Model Answer

When the ground stands above sea level, the flying height is measured from sea level and the mean ground elevation is subtracted.

Step 1: Use the adjusted formula. $S = \frac{f}{H - h}$ where h is the mean elevation of the land above sea level.

Step 2: Keep the units the same. Both f and the height difference H - h must be in the same unit before dividing.

Interpretation. So over the Mbeya highlands the true scale uses the height of the aircraft above the land, which is the sea-level height minus the height of the land itself.

Question 33

An aircraft flies at a height above mean sea level over land near Iringa whose mean elevation is 500 m, using a 152 mm camera, and the photograph comes out at 1:20 000. Calculate the flying height of the aircraft above sea level.

Model Answer

The adjusted scale formula gives the height of the aircraft above the ground, to which the ground elevation is then added.

Start from $S = \frac{f}{H - h}$, so $H - h = \frac{f}{S}$.

Substitute. $f = 0.152$ m, $S = \frac{1}{20\,000}$ and $h = 500$ m.

$$H - h = 0.152 \times 20\,000 = 3\,040 \text{ m}$$

$$H = 3\,040 + 500 = 3\,540 \text{ m}$$

Flying height above sea level = 3 540 m.

Interpretation. So the aircraft over Iringa flew at 3 540 m above sea level, which is 3 040 m above the land it photographed.

Question 34

Two landmarks near Mwanza lie 50 mm apart on a vertical photograph of scale 1:20 000, and 20 mm apart on a map of the same ground. Calculate the scale of that map.

Model Answer

The map scale comes from the ratio of the two measured distances multiplied by the photograph scale.

Step 1: State the formula. $MS = \frac{MD \times PS}{PD}$ where MD is the map distance, PD the photo distance and PS the photo scale.

Step 2: Substitute. $MD = 20$ mm, $PD = 50$ mm and $PS = \frac{1}{20\,000}$.

$$MS = \frac{20}{50} \times \frac{1}{20\,000} = \frac{1}{50\,000}$$

Map scale = 1:50 000.

Interpretation. So the Mwanza map is at 1:50 000, a smaller scale than the photograph, which is why the same ground looks shorter on it.

Question 35

An aircraft flies at 19 000 feet above sea level over land of mean elevation 100 feet near an airfield, using a camera of focal length 6 inches. Calculate the scale of the vertical photograph.

Model Answer

With the data in feet and inches, the height above the ground is found first and then converted so that it shares the unit of the focal length.

Step 1: Use $S = \frac{f}{H - h}$ and find the height above the land. $H - h = 19\,000 - 100 = 18\,900$ ft.

Step 2: Convert to inches to match the focal length. $18\,900 \text{ ft} \times 12 = 226\,800$ in.

$$S = \frac{6}{226\,800} = \frac{1}{37\,800}$$

Scale = 1:37 800.

Interpretation. So the photograph is at 1:37 800, and the answer only comes out right because the height was turned into the same unit, inches, as the focal length.

Question 36

A student writes the scale of a photograph once as 1:25 000 and once as one over twenty-five thousand, and asks whether a photograph can be enlarged. Explain the representative fraction and the ideas of enlargement and reduction.

Model Answer

The representative fraction is the scale written as a ratio or fraction, and a photograph can be enlarged or reduced by changing that fraction.

Representative fraction: the scale expressed as one unit on the photograph to so many of the same units on the ground, such as 1:25 000.

Enlargement: printing the photograph bigger, which makes the fraction larger, for example from 1:25 000 to 1:10 000, showing more detail over less ground.

Reduction: printing it smaller, which makes the fraction smaller, for example from 1:25 000 to 1:50 000, showing more ground in less detail.

So the two ways the student wrote the scale mean the same thing, and the same photograph can be enlarged or reduced to suit the task.

Question 37

On a vertical photograph of Moshi the water tower near the edge appears to lean outward, away from the centre. Account for image displacement, also called parallax, on a vertical photograph.

Model Answer

Image or relief displacement is the outward shift of the top of a tall object away from the principal point, and it grows toward the edges of the photograph.

Cause: because the camera looks straight down only at the centre, tall objects away from the centre are seen slightly from the side, so their tops lean outward.

Grows with distance from centre: the displacement is nil at the principal point and increases toward the edges.

Grows with height: taller objects, such as a water tower, are displaced more than low ones.

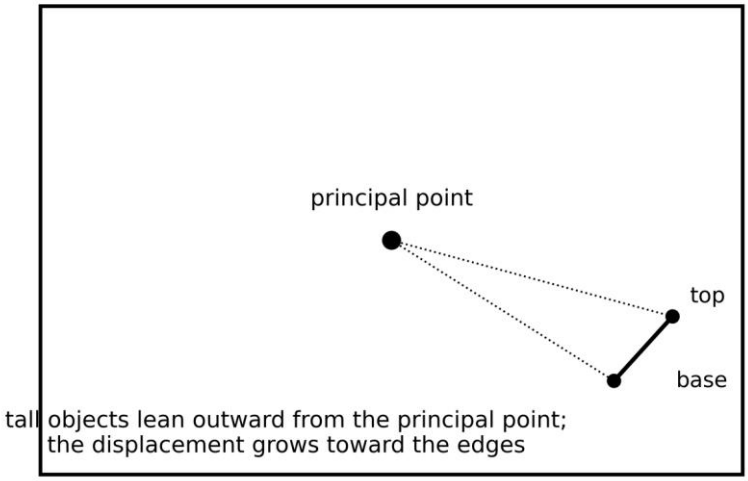


Figure 4.12: *Relief (image) displacement increases away from the principal point.*

So the leaning water tower near the edge of the Moshi photograph is not really tilted; it is displaced because it is both tall and far from the centre.

Question 38

A candidate is told to describe where a bridge lies on a photograph of the Kilombero Valley but does not know how to divide the view. Explain how a photograph is divided into foreground, middle ground and background.

Model Answer

A photograph is divided by depth into three parts, the foreground, the middle ground and the background, according to distance from the camera.

Foreground: the part nearest the camera, where features appear large and clear.

Middle ground: the central band, where features are of moderate size.

Background: the part farthest away, where features look small and the horizon may appear.

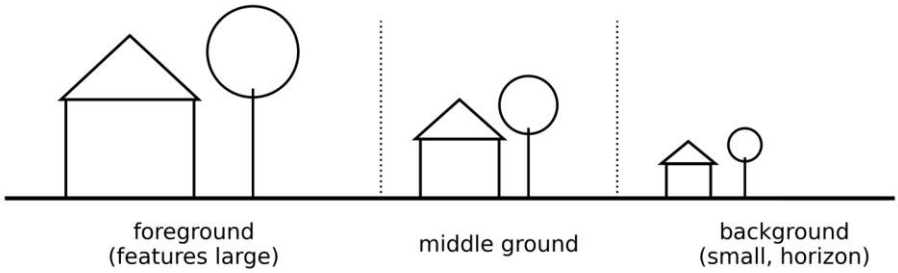


Figure 4.13: *A photograph divided by depth into foreground, middle ground and background.*

So the bridge on the Kilombero photograph is located by saying whether it lies in the foreground, the middle ground or the background.

Question 39

To pinpoint a single building on a crowded photograph of Mwanza, a teacher lays a grid over it. Explain how the vertical division and the nine-part grid are used to locate a feature.

Model Answer

Besides the depth division, a photograph is divided from side to side into left, centre and right, and the two divisions together give a nine-part grid.

Vertical division: the view is split into a left, a centre and a right part.

The nine-part grid: combining left, centre and right with foreground, middle and background gives nine cells, such as left foreground or centre background.

Precise location: a feature is then placed in one named cell, which removes any doubt about where it lies.

background left	background centre	background right
middle left	middle centre	middle right
foreground left	foreground centre	foreground right

Figure 4.14: *The nine-part grid for locating a feature.*

So the building in Mwanza can be fixed exactly by saying, for example, that it lies in the centre foreground of the photograph.

Question 40

A student describing a photograph of Tanga writes that the harbour is in the north. Account for the rule that words like north, south, top and bottom are not used in photograph interpretation.

Model Answer

Direction words such as north and east, and position words such as top and bottom, are avoided because a photograph carries no fixed orientation.

No built-in direction: unlike a map, a photograph has no north arrow, so the true compass direction is unknown.

Position is relative: what looks like the top is simply the background, and what looks like the bottom is the foreground.

Correct language: features are placed by left, centre or right and by foreground, middle or background, always relative to other objects.

So the harbour at Tanga should be described by its position in the frame, not as lying to the north.

False Confidence Alert
You cannot assume that north is at the top of a photograph as it usually is on a map. A photograph has no fixed orientation, so calling a feature northern or top is a guess that loses marks.

Question 41

Given an oblique photograph of a Singida hillside to interpret, a student does not know where to begin. Explain the steps followed in interpreting a ground or oblique photograph.

Model Answer

Interpreting a photograph follows an orderly set of steps, from identifying its parts to explaining how its features formed.

1) **Identify the parts:** note the foreground, middle ground and background and the important features in each.
2) **Read the caption and fix the viewpoint:** use any caption and the way features shrink to work out where the camera stood.
3) **Trace the main features:** lay tracing paper over the photograph and draw the chief features as a simple sketch.
4) **Describe and explain:** write short descriptions of the features, then explain the processes that formed any landforms shown.

So the Singida photograph is worked through step by step, which turns a confusing picture into an ordered description.

Question 42

An examiner says a good interpreter moves from what is seen to what it means. Explain the three processes of photograph interpretation.

Model Answer

Photograph interpretation moves through three linked processes: observation, analysis and judgement.

1) **Observation:** finding the typical patterns and characteristics in the photograph using the basic keys.
2) **Analysis:** studying those characteristics closely to work out what each one means.

3) **Judgement:** suggesting, from experience and knowledge, the features or activities that the evidence points to.

So reading a photograph of a Dodoma farm moves from noticing the field pattern, through working out what it means, to judging that the land is under crop cultivation.

Question 43

Two photographs of the same Iringa scene differ greatly in how much can be read from them. Examine the factors that affect the quality of a photograph.

Model Answer

The quality of a photograph, and so how much can be read from it, depends on the camera, the photographer, the ground and the conditions.

1) **The camera:** the focal length, film and filters decide how sharp and detailed the image is.
2) **The photographer:** skill in choosing distance, height and angle affects how clearly features show.
3) **The ground:** level land photographs more evenly, while steep slopes distort the view.
4) **The weather:** a clear day free of cloud, fog and harsh sun gives the best result.
5) **The time taken:** photographs taken at extreme times, such as deep night or blazing noon, lose detail.

So the clearer Iringa photograph is the one taken with a good camera, on level ground, on a bright calm day.

Question 44

Faced with a photograph of unfamiliar country near Babati, an interpreter relies on a set of visual keys. Explain the basic keys used to interpret a vertical aerial photograph.

Model Answer

Interpreters read a photograph through a set of keys, each of which gives a clue to what a feature is.

1) **Tone or colour:** the darkness or brightness of a feature, as water and forest are dark while sand and roads are bright.
2) **Shape:** the outline of a feature, as rivers and roads are long and curved while pitches are oval.
3) **Size:** the measured extent of a feature when the scale is known.
4) **Texture:** the roughness or smoothness, as forest is rough while water and grass are smooth.
5) **Pattern:** the arrangement, as planned areas are regular while natural forest is irregular.
6) **Site:** the position, as a line across a river is likely a bridge.
7) **Association:** nearby features, as a chimney suggests an industry.
8) **Shadow:** the shape and length of shadows, which show height and time.
9) **Background information:** maps and written accounts used when the keys alone cannot decide.

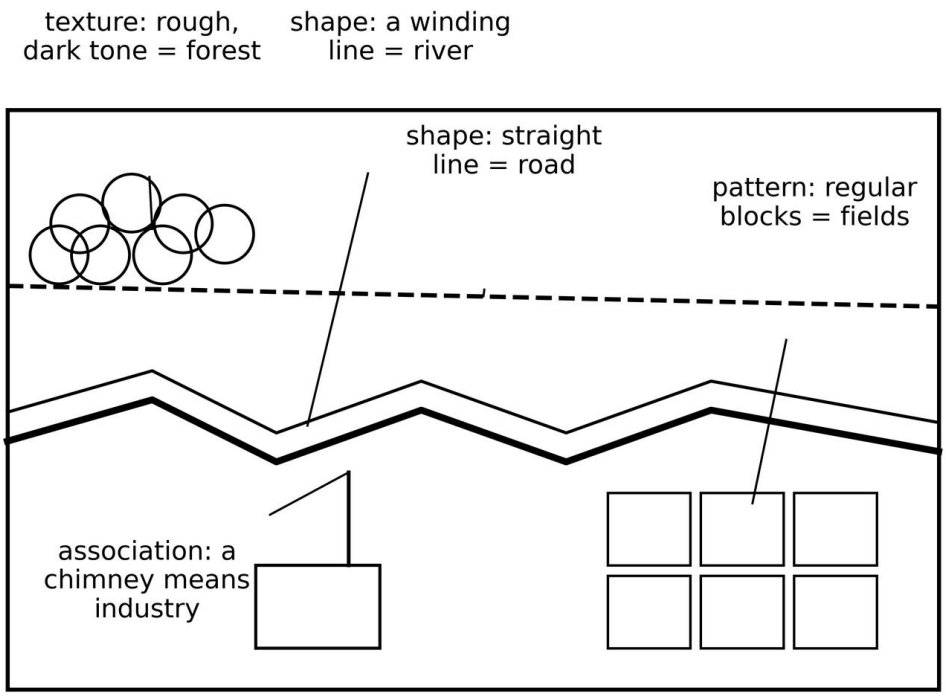


Figure 4.15: *The interpretation keys read from a landscape.*

So even unfamiliar country near Babati can be read by working patiently through tone, shape, texture, pattern and the other keys.

Question 45

On a photograph of the coast near Bagamoyo, the sea appears dark while the beach appears bright. Account for the use of tone or colour as a key of interpretation.

Model Answer

Tone or colour is the key based on how dark or bright a feature appears, which depends on how much radiation it reflects.

Dark tones: features that reflect little, such as deep water, forest and wet ground, appear dark.

Bright tones: features that reflect strongly, such as beaches, bare sand and all-weather roads, appear bright.

Reading the tone: comparing dark and bright areas helps separate one surface from another.

So along the Bagamoyo coast the dark tone marks the sea while the bright tone marks the sandy beach.

Question 46

On a photograph of Dodoma a round field and a long curving line have to be named. Explain how shape and size are used as keys of interpretation.

Model Answer

Shape and size are keys that use the outline and the measured extent of a feature to identify it.

Shape: many features have a typical outline, as a river or road is a long curving line and a stadium is oval or round.

Size: when the scale is known, the true size helps confirm a feature, since a football pitch and a market have different sizes.

Using both: shape narrows the possibilities and size confirms which feature it is.

So on the Dodoma photograph the long curving line is read as a road or river by its shape, and the round mark is judged by its size to be a water tank rather than a stadium.

Question 47

A candidate must separate natural forest from a planted estate on a photograph of Mufindi. Explain how texture and pattern are used as keys of interpretation.

Model Answer

Texture and pattern are keys that use the surface roughness and the arrangement of features to identify them.

Texture: the roughness or smoothness of a surface, as forest and built-up areas are rough while water and grassland are smooth.

Pattern: the way features are arranged, as planted crops and towns are regular while natural forest is irregular.

Reading both together: a rough but regular surface suggests a plantation, while a rough and irregular one suggests natural forest.

So on the Mufindi photograph the regular rows mark the tea estate while the irregular rough patch marks the natural forest.

Question 48

On a photograph of a Moshi street the height of the buildings must be judged, and only their shadows give a clue. Account for the use of shadow as a key of interpretation.

Model Answer

Shadow is a key that gives a sense of height, shape and time by the way features cast dark outlines.

1) **Shows height:** a tall building casts a long shadow, so the length of the shadow suggests how high the feature is.
2) **Shows shape:** the outline of the shadow can reveal the form of an object seen only from above.
3) **Shows time:** the direction and length of shadows indicate the time of day the photograph was taken.

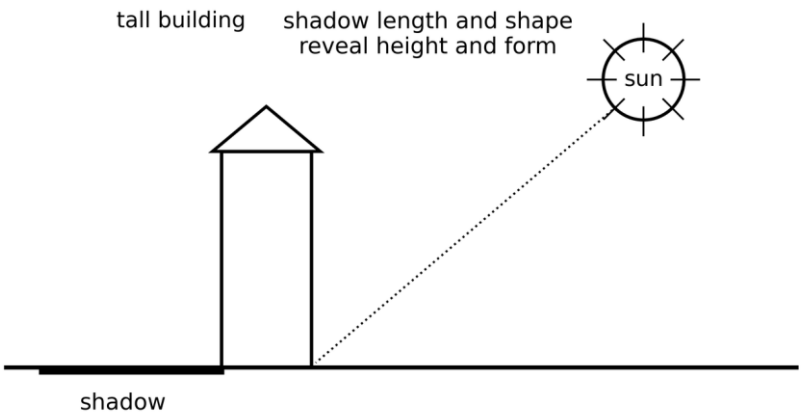


Figure 4.16: *Shadow reveals the height and shape of a feature.*

So the heights of the buildings along the Moshi street are judged from the lengths of the shadows they throw.

Question 49

On a photograph of Dodoma the shadows of the buildings fall long and to one side, and a student must say when it was taken. Explain how the time of day is read from shadows.

Model Answer

The time of day is read from the length and direction of shadows, because these change as the sun moves across the sky.

Length: shadows are longest early in the morning and late in the afternoon, and shortest around midday.

Direction: if the shadows fall to one side the photograph is of the morning, and if to the other side it is of the evening.

Midday: very short shadows show that the sun is high, so the photograph was taken near noon.

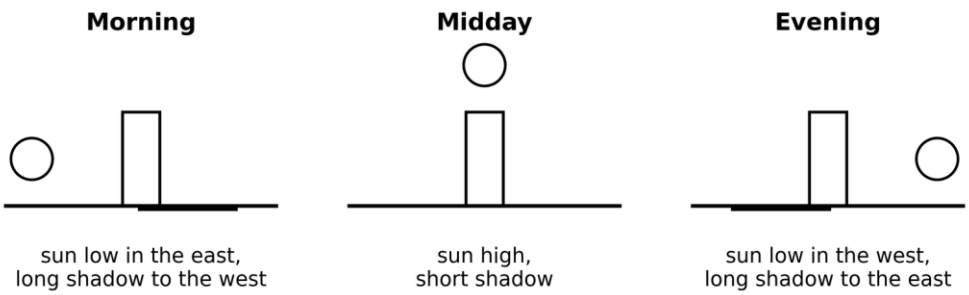


Figure 4.17: *Shadow length and direction show the time of day.*

So the long side-cast shadows on the Dodoma photograph show that it was taken in the early morning or the late afternoon, not at midday.

> **False Confidence Alert**
> A long shadow does not by itself prove morning; it could equally be late afternoon. The side to which the shadow falls, not merely its length, is what separates morning from evening.

Question 50

Two photographs of the same Kilombero farmland, taken months apart, look very different in their vegetation. Explain how the season is read from a photograph.

Model Answer

The season is read from the state of the vegetation, the sky and the activities shown.

Wet season: green luxuriant vegetation, young or flowering crops and cloud in the sky point to the rains.

Dry season: bare or leafless plants, dry grass and clear skies point to the dry months.

Activities: the work shown, such as harvesting, also helps fix the time of year.

So the greener photograph of the Kilombero farmland belongs to the wet season, while the browner one belongs to the dry season.

Question 51

A photograph taken in Tanzania shows shadows that never quite disappear even near midday. Account for how direction and hemisphere are judged from a photograph.

Model Answer

Direction and hemisphere are judged from the behaviour of shadows, because the sun is never truly overhead beyond the tropics.

Shadows point away from the sun: so the position of the sun can be worked out from the direction of the shadows.

Poleward shadows at midday: away from the Equator the midday sun is never overhead, so a short shadow still remains and points toward the pole.

Judging hemisphere: the direction in which the midday shadow points helps tell the northern from the southern hemisphere.

So the small midday shadow on the Tanzanian photograph shows that the country lies away from the point where the sun stands exactly overhead.

Question 52

On a photograph of the Serengeti an elephant in the distance looks smaller than a person in front. Explain how the size of features is estimated from a photograph.

Model Answer

Size is estimated by comparing a feature with a familiar object, but only when the two lie at the same distance from the camera.

1) **Use a familiar object:** a car, a person or a football pitch of known size gives a yardstick for measuring others.
2) **Compare like with like:** only objects at the same distance and level may be compared, because scale falls off with distance.
3) **Allow for the scale:** when the scale is known, true sizes can be worked out from measurements on the photograph.

So the elephant on the Serengeti photograph is really the larger animal, and it only looks small because it stands far behind the person.

False Confidence Alert
A larger image does not mean a larger object. Because scale decreases with distance, a person in the foreground can look bigger than an elephant in the background, so only features at the same distance may be compared.

Question 53

From the crops and plants shown on a photograph, a geographer works out the climate of the area. Explain how climatic conditions are read from a photograph.

Model Answer

Climate is read from the vegetation and crops shown, because different plants grow under different conditions of heat and rainfall.

Evidence on the photograph	Climate it suggests
Green vegetation, cloud, full rivers	wet or rainy season
Leafless plants, dry grass, low rivers	dry season
Sugarcane, cotton, sisal, cashew	tropical, generally warm
Coffee, tea and pyrethrum	cool highland climate
Millet, sorghum, cassava, scattered thorn	semi-arid, low rainfall
Dense tall forest	equatorial or mountainous, high rainfall

So a photograph showing tea gardens points to the cool highlands such as Mufindi, while one showing sisal points to the warmer, drier lowlands.

Question 54

A photograph of farmland near Kilosa shows small hand-worked plots in one place and a large machine-worked estate in another. Explain how farming activities are read from a photograph.

Model Answer

Farming is read from the size of the fields, the tools and buildings shown, and the crops grown.

1) **Subsistence crop farming:** small scattered plots, hedges, simple houses and hand tools show farming for the family.
2) **Commercial crop farming:** cash crops, machinery, processing factories and feeder roads show farming for sale.
3) **Plantation farming:** a single crop over a very large area with stores and workers' housing shows an estate.

So the small hand-worked plots near Kilosa show subsistence farming, while the large machine-worked estate shows commercial or plantation farming.

Question 55

On a photograph of the central plateau, cattle are shown grazing in three different ways. Account for how livestock keeping is read from a photograph.

Model Answer

Livestock keeping is read from the way animals are held and the structures around them.

1) **Traditional herding:** cattle grazing freely on open natural grassland, as on the semi-arid plateau.
2) **Ranching:** fenced paddocks, cattle dips, water tanks and sheds show organised beef keeping.
3) **Dairying:** high-grade cows, milking sheds and zero-grazing units show milk production.

So the free-grazing herds on the central plateau show traditional keeping, while fenced paddocks would show a ranch such as those at Ruvu or Kongwa.

Question 56

Two farms on a photograph near Njombe differ in their tools, labour and size. Explain how small-scale and large-scale production are told apart on a photograph.

Model Answer

Small-scale and large-scale production are told apart by the size of the holding, the tools and the labour shown.

Small-scale: small fields, hand hoes and family labour, usually growing food crops.

Large-scale: large fields, tractors and harvesters and hired labour, usually growing cash crops.

Reading the clues: the presence of machinery and very large fields is the clearest sign of large-scale production.

So the hand-worked food plot near Njombe shows small-scale production, while the tractor-worked estate beside it shows large-scale production.

Question 57

A single photograph of a Tanzanian district shows a market town, a forest with a sawmill and a lake with boats. Explain how a range of economic activities is read from a photograph.

Model Answer

Many economic activities can be read from the tell-tale features they leave on the ground.

Trade: towns, shops and markets show buying and selling.

Lumbering: forests with sawmills and stacked logs show timber getting.

Fishing: boats, nets drying and a water body show fishing.

Tourism and mining: wild animals, hills and historical sites suggest tourism, while quarries and pits suggest mining.

So the one district photograph reveals trade in the market town, lumbering at the sawmill and fishing on the lake, each from its own evidence.

Question 58

A photograph must be sorted into lowland and highland country, from a flat plain through a flat-topped upland to a steep peak. Explain how relief is read from a photograph.

Model Answer

Relief is read from the shape of the land and from the crops and rivers that go with each height.

Plain: low, flat land below about 500 m, often with slow meandering rivers, as on the coastal lowlands.

Plateau: high, flat-topped land with steep edges standing above the surrounding country.

Mountain: land rising steeply to a peak, over about 2 000 m, often carrying highland crops such as tea and coffee.

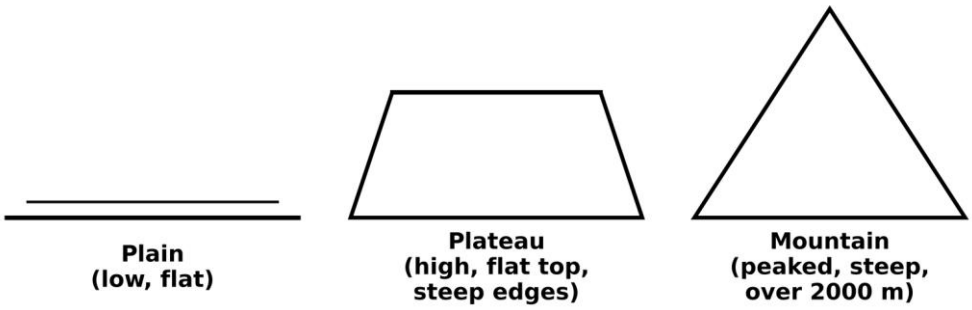


Figure 4.18: *Reading relief: plain, plateau and mountain.*

So flat land under rice suggests a plain, while steep slopes under tea suggest a mountain such as Rungwe.

Question 59

A photograph shows scattered irregular huts in one part and dense regular streets in another. Explain how rural and urban settlements are told apart on a photograph.

Model Answer

Rural and urban settlements are told apart by the density, arrangement and type of buildings.

Rural settlement: simple, semi-permanent, unevenly scattered houses, with farming or fishing nearby and few roads.

Urban settlement: permanent, densely packed buildings in a regular street pattern, with industry, storage and good communication.

Reading the clues: a regular street grid and multi-storey buildings are the clearest signs of a town.

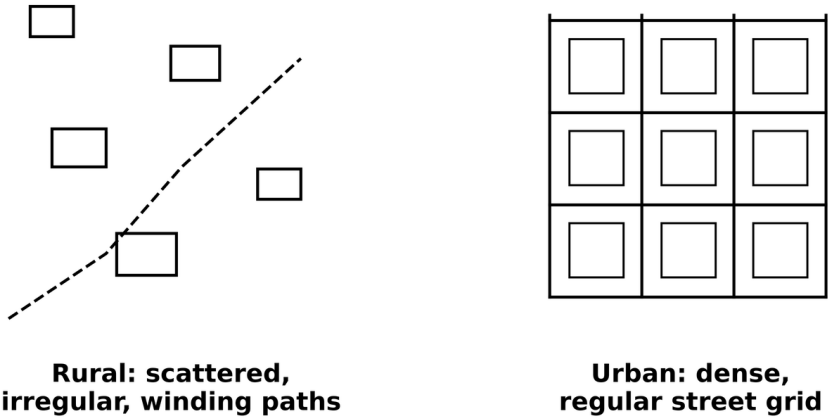


Figure 4.19: *Rural and urban settlement patterns.*

So the scattered irregular huts show a rural settlement, while the dense regular streets show an urban one such as central Mwanza.

Question 60

On a photograph of a river basin the water bodies differ in tone and the streams form clear patterns. Account for how drainage is read from a photograph.

Model Answer

Drainage is read from the tone of the water bodies and from the pattern the streams make.

Tone of water: deep water such as a lake or the sea appears dark, while shallow moving water appears brighter.

Drainage features: waterfalls and rapids suggest steep land, meanders suggest a gentle middle course, and a delta shows where a river meets a lake or sea.

Drainage patterns: streams may branch like a tree in a dendritic pattern, run in a rectangular trellis pattern, or spread out from a peak in a radial pattern.

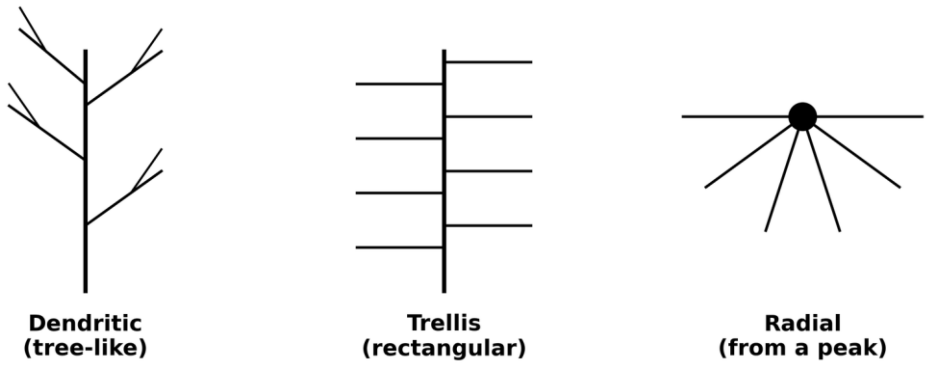


Figure 4.20: *Common drainage patterns: dendritic, trellis and radial.*

So the dark still water reads as a lake such as Victoria, while the branching streams that feed it read as a dendritic drainage pattern.

REAL QUESTIONS

Question 61

A student in Mwanza checks a map on her phone, watches a football match by satellite television and hears the day's weather forecast, all in one morning. Show how satellite technology reaches into daily life in Tanzania.

Model Answer

Satellites touch daily Tanzanian life through the positioning, communication and observation their sensors provide.

1) **Navigation:** phone maps, and the tracking of buses and lorries, depend on satellite positioning.
2) **Communication:** television, radio and telephone signals are relayed by communication satellites.
3) **Weather:** forecasts that guide farmers and Lake Victoria fishers are built from weather-satellite images.
4) **Safety and planning:** satellites help watch floods, fires and borders, and supply data for planning.

So a single morning in Mwanza quietly uses several satellites at once, for the map, the match and the forecast.

Question 62

A planning officer in Dodoma must choose a route for a new road and decide which wetlands to protect, and turns to satellite images for help. Explain how satellite images assist development planning.

Model Answer

Satellite images assist planning by supplying current, wide and repeatable information about the land.

1) **Up-to-date land use:** they show how land is being used now, which guides where new roads and buildings should go.
2) **Monitoring change:** repeated images reveal spreading towns, shrinking forests and changing wetlands.
3) **Resource mapping:** they locate water bodies, forests and farmland that must be used or protected.
4) **Environment and disaster:** they help plan for floods and erosion before development begins.

So the Dodoma officer can route the road away from the wetlands because the image shows both clearly and recently.

Question 63

To study how much the whole of Lake Rukwa has shrunk over ten years, a researcher must choose between an aerial photograph and a satellite image. Justify the better choice.

Model Answer

For a large area studied over many years the satellite image is the better choice.

1) **Wide coverage:** a satellite image takes in the entire lake in one scene, which no single aerial photograph can do.
2) **Regular repeat cover:** satellites pass over often, giving a steady record year after year.
3) **A ready archive:** past images already exist, so change over the ten years can be measured.
4) **Cost and access:** no special flight is needed, unlike commissioning aerial photography of so large an area.

So the shrinking of Lake Rukwa is best followed with satellite images, while an aerial photograph would suit only a close look at one shore.

Question 64

Study the photograph below and then answer the questions that follow.

Figure 4.21: *Photograph for Question 64*

(a) Name the type of photograph and give one reason for your answer.

(b) Describe the relief of the area shown.

(c) Identify the natural vegetation and state where on the slopes it is found.

(d) State the main economic activity, giving two pieces of evidence from the photograph.

(e) Explain why the fields on the slopes have been made into terraces.

(f) With one reason, state the season during which the photograph was taken.

Model Answer

(a) It is a ground oblique photograph, because it was taken from high ground looking across the valley, so it shows both the tops and the sides of the slopes, with distant ranges and sky along the top.

(b) The land is a deep, steep-sided valley lying between high mountain ridges, with the slopes descending to a narrow valley floor.

(c) Natural forest, dark in tone and rough in texture, covers the upper slopes and the ridge crests, above the level reached by cultivation.

(d) Farming is the main activity. The evidence is (i) the many small terraced fields of bright green crops cut into the slopes, and (ii) the scattered farmhouses with footpaths between them, worked by hand with no machinery in sight.

(e) The slopes are too steep to cultivate safely, so the land is cut into level terraces that slow the run-off of rainwater, hold the soil against erosion, and keep moisture on the fields for the crops.

(f) The wet season, because the crops and grass are lush and bright green and cumulus cloud is building over the ridges.

So the photograph shows intensive terraced farming on steep, wet highland, of the kind seen on the Matengo, Uluguru and Usambara highlands of Tanzania, where the hillsides are terraced to grow food.

False Confidence Alert
The terraces are made by people; they are not natural steps in the rock. The neat, level steps that curve to follow the shape of the slope are the mark of terrace cultivation, not of geology.

Question 65

During a locust invasion near Manyara, officers found that a single photograph taken from a nearby hill gave information their ground instruments could not. Account for the value of ground and oblique photographs.

Model Answer

Ground and oblique photographs are valued because they capture a wide scene quickly and cheaply at the moment it matters.

1) **They record an event in time:** a photograph freezes the extent of a locust swarm or a flood as it happens.
2) **They show what instruments miss:** the spread of the swarm over the land is seen at a glance, which point instruments cannot give.
3) **They show relief for sketching:** the fore, middle and background make it easy to draw a field sketch of the area.
4) **They are simple and cheap:** a single camera on a hill needs no aircraft or costly equipment.

So near Manyara one hill-top photograph recorded the reach of the locusts faster and more cheaply than any ground survey.

Question 66

Photographs taken with the camera axis pointing straight down do not look like those taken with the axis tilted toward the ground. With examples, give five criteria that separate the two.

Model Answer

Vertical and oblique aerial photographs are separated by the tilt of the axis and by what and how much they show.

1) **Camera axis:** the vertical has a straight-down axis, the oblique a tilted one.
2) **View given:** the vertical shows only the tops of features, the oblique shows top and side together.
3) **Horizon:** the vertical never shows the horizon, while a high oblique does.
4) **Scale:** the vertical keeps a fairly even scale, the oblique scale falls from foreground to background.
5) **Area covered:** the oblique takes in more ground, the vertical a smaller, more uniform area.

So a vertical photograph of Mafinga reads like a plan of the town, whereas an oblique of the same place looks like the view from a nearby hill.

Question 67

A camera carried aloft over the University of Dar es Salaam at Mlimani returns a photograph showing only the tops of the features. Explain the terms photo mosaic, stereoscope, camera station and principal point, and outline how you would interpret such a top-view photograph.

Model Answer

These are basic terms of aerial photography, and the top view is read through the interpretation keys.

1) **Photo mosaic:** overlapping aerial photographs joined together to show a larger area as one continuous picture.

2) **Stereoscope:** a viewing instrument, not a camera, through which two overlapping photographs are seen in three dimensions.

3) **Camera station:** the exact point in the air from which the photograph was taken.

4) **Principal point:** the centre of the vertical photograph, lying directly below the camera station.

To interpret the Mlimani photograph, read the tone and shape of each feature, judge sizes against the scale, note patterns and shadows, and use association, so that roads, halls of residence and playing fields can each be named.

So the top-view photograph of Mlimani is named feature by feature using the keys, once the basic terms are understood.

Question 68

A farmer near Kilombero asks a photographer to take one photograph that shows every plant across his fifty-acre farm. State the type of photograph the photographer should take and support it with four reasons.

Model Answer

The photographer should take a vertical aerial photograph, because only a straight-down view from a height can show the whole farm at once.

1) **It covers the whole farm:** taken from above, one frame takes in all fifty acres together.

2) **It shows the true plan:** the top view records the real positions and spacing of the plants.

3) **It has an even scale:** the near-uniform scale lets the plants be counted and the plots measured.

4) **Nothing is hidden:** from directly overhead, tall plants do not hide the shorter ones behind them.

So a vertical aerial photograph is the right choice for the Kilombero farmer, since a ground or oblique shot could never show every plant on the whole farm.

Question 69

Study the photograph below and then answer the questions that follow.

Figure 4.22: *Photograph for Question 69*

(a) Name the type of photograph and give at least two reasons for your answer.

(b) Identify the kind of settlement in the foreground and describe its pattern.

(c) Name at least three different land uses shown in the photograph.

(d) State the evidence that the land in the middle distance is farmland.

(e) Give one advantage of this type of photograph for studying the area.

Model Answer

(a) It is a low oblique aerial photograph. The reasons are that (i) it was taken from an aircraft, whose wing shows at the top, (ii) it shows both the tops and the sides of features, and (iii) the distant horizon appears across the top.

(b) An urban settlement, a town: the buildings are many and densely packed in regular estates and streets close together.

(c) (i) A built-up area of housing; (ii) transport, shown by the wide road curving across; (iii) farmland of green fields; and (iv) water bodies, the lakes or reservoirs on the left.

(d) The regular green fields divided by hedges, with only scattered farmhouses and no closely packed buildings, show that the land is farmland.

(e) It gives a wide, natural view that takes in the town and the surrounding country together, so the way the town relates to its farmland and its roads can be studied at a glance.

So the photograph reads as a town set among farmland and water, the kind of edge-of-city view seen around Mwanza or Arusha.

Question 70

A vertical aerial photograph of Marian Girls Secondary School was taken at a scale of 1:20 000 from an aircraft flying 3 040 m above the ground. Calculate the focal length of the camera used, in millimetres.

Model Answer

Rearranging the scale relationship gives the focal length from the scale and the flying height.

From $S = \frac{f}{H}$ it follows that $f = S \times H$.

Substitute $S = \frac{1}{20\,000}$ and $H = 3\,040$ m.

$$f = \frac{1}{20\,000} \times 3\,040 \text{ m} = 0.152 \text{ m}$$

Focal length = 0.152 m = 152 mm.

Interpretation. So the camera had a focal length of 152 mm, one of the two lengths commonly used in Tanzania.

Question 71

A camera of focal length 132 mm mounted on an aircraft flying 10 500 m above sea level produced a vertical photograph at a scale of 1:25 000. Calculate the height of the land above sea level that was photographed.

Model Answer

With the flying height measured from sea level, the scale formula gives the height of the aircraft above the land, from which the land height follows.

Use $S = \frac{f}{H - h}$, so the aircraft height above the land is $H - h = \frac{f}{S}$.

Substitute $f = 0.132$ m and $S = \frac{1}{25\,000}$.

$$H - h = 0.132 \times 25\,000 = 3\,300 \text{ m}$$

$$h = 10\,500 - 3\,300 = 7\,200 \text{ m}$$

Height of the land = 7 200 m above sea level.

Interpretation. So the land photographed lies 7 200 m above sea level, and the camera flew 3 300 m above that land.

False Confidence Alert
Here h is the height of the ground, not the flying height. The aircraft flew 3 300 m above the land, while the land itself stands 7 200 m above sea level, so the two heights must not be confused.

Question 72

On a topographical map of scale 1:40 000 two landmarks near Singida are 40 mm apart, while on a vertical photograph of the same ground they are 30 mm apart. (a) Find the scale of the photograph. (b) A second vertical photograph of scale 1:200 000 was taken with a 152 mm camera over land of mean height 500 m above sea level; calculate the flying height above sea level.

Model Answer

Part (a) transfers the scale from the map through the two measured distances; part (b) rearranges the scale formula for the flying height.

The photo scale is $PS = \frac{PD}{MD} \times MS$ where PD and MD are the photo and map distances.

$$PS = \frac{30}{40} \times \frac{1}{40\,000} = \frac{1}{53\,333}$$

(a) Photo scale = 1:53 333 (about 1:53 000).

From $S = \frac{f}{H - h}$, $H = h + \frac{f}{S}$.

$$H = 500 + 0.152 \times 200\,000 = 500 + 30\,400 = 30\,900 \text{ m}$$

(b) Flying height = 30 900 m above sea level.

Interpretation. So the photograph is at about 1:53 000, a smaller scale than the map, and the second aircraft flew 30 900 m above sea level.

Question 73

An Airbus flying from Mwanza to Dar es Salaam at 19 000 feet above sea level used a camera of focal length 6 inches and produced a photograph of scale 1:37 800. Calculate the average elevation of the land above sea level.

Model Answer

The scale formula gives the height of the aircraft above the land, and the land elevation is what remains.

From $S = \frac{f}{H - h}$, the height above the land is $H - h = f \times \frac{1}{S}$.

Keep one unit. $H - h = 6 \times 37\,800 = 226\,800 \text{ in} = 18\,900 \text{ ft}$.

$$h = 19\,000 - 18\,900 = 100 \text{ ft}$$

Average elevation = 100 ft above sea level.

Interpretation. So the land averages only 100 ft above sea level, which fits the low coastal country toward Dar es Salaam.

Question 74

A vertical aerial photograph was taken with a camera of focal length 15 cm from a height of 7 000 m above sea level over land whose mean height is 4 000 m above sea level. Calculate the scale of the photograph.

Model Answer

The scale uses the height of the aircraft above the land, which is the sea-level height less the land height.

Use $S = \frac{f}{H - h}$ with $f = 15$ cm $= 0.15$ m.

Height above the land $H - h = 7\,000 - 4\,000 = 3\,000$ m.

$$S = \frac{0.15}{3\,000} = \frac{1}{20\,000}$$

Scale = 1:20 000.

Interpretation. So the photograph is at 1:20 000, a large scale that keeps small ground detail visible.

Question 75

Two points near Tabora are 24 cm apart on a map of scale 1:200 000 and 12 cm apart on a vertical photograph of the same ground. Calculate the scale of the photograph.

Model Answer

The photo scale is transferred from the map through the ratio of the two measured distances.

Use $PS = \frac{PD}{MD} \times MS$.

$$PS = \frac{12}{24} \times \frac{1}{200\,000} = \frac{1}{400\,000}$$

Photo scale = 1:400 000.

Interpretation. So the photograph is at 1:400 000, a smaller scale than the map, which is why the same two points look closer together on it.

Question 76

A vertical photograph was taken with a 152 mm camera from 5 000 m above sea level over land of mean height 1 200 m above sea level. Find the scale of the photograph.

Model Answer

The scale uses the focal length over the height of the aircraft above the land.

Height above the land $H - h = 5\,000 - 1\,200 = 3\,800$ m, with $f = 0.152$ m.

$$S = \frac{0.152}{3\,800} = \frac{1}{25\,000}$$

Scale = 1:25 000.

Interpretation. So correcting for the 1 200 m land height gives a true scale of 1:25 000.

Question 77

A rectangular garden near Moshi measures 24.4 cm by 34.5 cm on a map of scale 1:25 000. Calculate the size the same garden would appear on a vertical photograph of scale 1:20 000.

Model Answer

First turn the map lengths into real ground lengths, then reduce those to the photograph scale.

Real ground length = map length $\times$ 25 000.

So 24.4 cm $\times$ 25 000 = 610 000 cm = 6 100 m and 34.5 cm $\times$ 25 000 = 862 500 cm = 8 625 m.

Photo length = ground length $\times \frac{1}{20\,000}$.

$$6\,100 \text{ m} \div 20\,000 = 0.305 \text{ m} = 30.5 \text{ cm}$$

$$8\,625 \text{ m} \div 20\,000 = 0.431 \text{ m} = 43.1 \text{ cm}$$

On the photograph the garden is about 30.5 cm by 43.1 cm.

Interpretation. So the garden appears larger on the photograph than on the map, because 1:20 000 is a larger scale than 1:25 000.

Question 78

Study the photograph below and then answer the questions that follow.

Figure 4.23: *Photograph for Question 78*

(a) Name the type of photograph and give one reason for your answer.

(b) Describe the course of the river shown.

(c) What does the brown colour of the water suggest?

(d) Describe the pattern of the fields and state what it tells you about land use.

(e) Name the flat landform on which the river and fields lie.

Model Answer

(a) It is a near-vertical (high) aerial photograph, because it looks almost straight down and shows the true plan of the fields at a fairly even scale.

(b) The river winds in wide, sweeping loops (meanders) across nearly level land, swinging from side to side in broad bends.

(c) The brown, muddy water shows that the river is carrying a heavy load of sediment, as a river does in flood or along its middle and lower course.

(d) The land is divided into many small fields of different tones, a regular patchwork, which shows mixed crop cultivation on the fertile land.

(e) A floodplain, the flat land built up by the river along its course.

So the scene reads as a meandering river crossing a cultivated floodplain, like the flats of the Rufiji or the Kilombero in Tanzania.

False Confidence Alert
The wide loops are meanders, a natural sign of a gently graded course; they are the river's own work, not channels dug by people.

Question 79

A geographer is handed a vertical photograph of unfamiliar country near Geita and must read its features. Give six criteria she would use to interpret it.

Model Answer

She would work through the visual keys, each of which gives a clue to a feature's identity.

1) **Tone:** the darkness or brightness, as water and forest are dark while sand and roads are bright.
2) **Shape:** the outline, as rivers and roads are long and curving while a pitch is oval.
3) **Size:** the measured extent once the scale is known, which separates a hut from a hall.
4) **Pattern:** the arrangement, as planned fields are regular while natural bush is irregular.
5) **Texture:** the roughness, as forest is rough while grass and water are smooth.
6) **Shadow:** the length and shape of shadows, which show the height of features and the time of day.

So even unfamiliar country near Geita is read by working patiently through tone, shape, size, pattern, texture and shadow.

Question 80

Study the photograph below and then answer the questions that follow.

Figure 4.24: *Photograph for Question 80*

(a) Name the land use shown in the foreground and give one reason.

(b) Using texture and pattern, distinguish the planted area from the natural woodland behind it.

(c) State whether this is small-scale or large-scale production, with a reason.

(d) State one economic use of such a tree crop.

Model Answer

(a) A plantation or orchard of tree crops, because the trees stand in straight, evenly spaced rows, a pattern that only planting by people produces.

(b) The planted area has a regular, even pattern of separate round crowns set in lines with bare strips between them; the natural woodland behind has a rough, irregular, continuous canopy with no pattern.

(c) Large-scale production, because the rows of trees cover a wide, uniform area laid out in an orderly way.

(d) The fruit or timber is harvested for sale, for example a cashew or citrus orchard or a timber plantation.

So the ordered rows read as a plantation, of the kind seen in the sisal estates near Morogoro or the citrus orchards around Muheza.

False Confidence Alert
Straight, evenly spaced rows mean a plantation, not natural forest; natural forest never grows in regular lines.

Question 81

Two photographs of the same scene near Iringa differ greatly in how much can be read from them, and a student asks what makes a photograph easy to interpret. Examine the factors that affect the quality of a photograph.

Model Answer

The quality of a photograph, and so how much can be read from it, depends on the camera, the photographer, the ground and the conditions.

1) **The camera and film:** the focal length, the film and any filters decide how sharp and detailed the image is.

2) **The photographer:** skill in choosing the distance, height and angle affects how clearly features show.

3) **The nature of the ground:** level land photographs evenly, while steep slopes distort the view.

4) **The weather:** a clear day free of cloud, mist and glare gives the best result.

5) **The time of day:** photographs taken at deep night or blazing noon lose detail.

6) **The scale:** a larger scale shows more ground detail than a small one.

So the clearer Iringa photograph is the one taken with a good camera, on level ground, on a bright calm day and at a suitable scale.

Question 82

Ngengemkeni, a new student at Mitomingi Secondary School, wants to read the climate of an area from a photograph but does not know what to look for. Give him five hints for identifying climate from a photograph.

Model Answer

Climate is read from the plants, crops and sky shown, because different climates carry different vegetation.

1) **The natural vegetation:** dense tall forest suggests heavy rain, while thorn bush and dry grass suggest a dry climate.

2) **The crops grown:** tea and coffee suggest a cool, wet highland, while sisal and cotton suggest a warm, drier lowland.

3) **The state of the vegetation:** green, leafy plants suggest the wet season, bare or brown ones the dry season.

4) **The sky:** cloud suggests a rainy period, while a clear sky suggests dry weather.

5) **The rivers:** full rivers suggest recent rain, while low or dry channels suggest drought.

So Ngengemkeni can read a cool, wet highland from a photograph of tea gardens, and a warm, dry lowland from one of sisal.

Question 83

Study the photograph below and then answer the questions that follow.

Figure 4.25: Photograph for Question 83

(a) Name the type of photograph.

(b) Name the physical feature at the centre of the photograph.

(c) With evidence, state whether the photograph was taken near midday or not.

(d) Describe how this feature is formed.

(e) What does the surrounding landscape suggest about the climate?

Model Answer

(a) A ground oblique photograph, taken from the rim of the gorge looking across and down into it.

(b) A waterfall, where the river plunges over a steep step of rock into a deep gorge.

(c) It was not taken near midday: the shadows are long and thrown to one side, and one rock face is brightly lit while the opposite face is in deep shadow, so the sun is low, in the morning or the late afternoon.

(d) The river flows over a band of hard rock lying above softer rock; the softer rock below is worn away and undercut until the hard cap breaks off, so the fall keeps retreating upstream and deepens the gorge, with a plunge pool at its foot.

(e) The bare rock, dry brown hills and sparse vegetation under a clear sky suggest a dry, semi-arid climate.

So the scene reads as a waterfall cutting back through hard rock in dry country, like the falls where the Pangani or the Rufiji crosses a band of resistant rock.

False Confidence Alert
A long shadow by itself does not fix the time as morning; it could be late afternoon. It is the low sun and the side the shadow falls on, not the length alone, that show it is not midday.

Question 84

Study the photograph below and then answer the questions that follow.

Figure 4.26: *Photograph for Question 84*

(a) Name the type of photograph and give one reason for your answer.

(b) Name the physical feature in the background.

(c) State the main economic activity and give three pieces of evidence.

(d) Describe the type of settlement shown.

(e) Suggest the time of day at which the photograph was taken, giving one reason for your answer.

Model Answer

(a) A ground oblique photograph, taken from the shore at ground level looking out across the water.

(b) A large lake, stretching to a hazy horizon with small islands upon it.

(c) Fishing. The evidence is the many wooden boats (canoes) drawn up on the shore, the people sitting with their fishing gear, and the lakeside huts of a fishing settlement.

(d) A small rural settlement, a fishing village, with simple houses and boats gathered close to the shore.

(e) The sun is high, so the photograph was taken **around the middle of the day**: the shadows of the people and the boats are short and lie close to their base, not long and thrown to one side as they would be

early or late in the day. The people keeping to the shade of the tree, and the bright, hazy light, agree with a high midday sun.

So the scene reads as a fishing village on a great lake, exactly the life of the shores of Lake Victoria at Mwanza or Musoma.

Question 85

On a photograph of farmland near Kilosa the fields are small, worked by hand, with simple houses and no machinery in sight. State whether the production is small or large scale, give three reasons, and say how the time of day could be found.

Model Answer

The scene shows small-scale production, and the time of day can be read from the shadows.

1) **Small fields:** the plots are small and irregular rather than large and regular.
2) **Hand tools only:** there is no machinery, so the work is done by hand.
3) **Family houses:** the simple, scattered houses point to family rather than estate labour.

The time of day is found from the shadows: long shadows cast to one side mean early morning or late afternoon, while short shadows mean the photograph was taken near midday.

So the Kilosa farmland is worked at a small scale, and its photograph can be timed from the length and direction of the shadows.

Question 86

A field officer in Lindi argues that, for up-to-date information, a photograph beats the topographical map. Assess the strengths of photographs over maps for field information.

Model Answer

Photographs have real strengths over maps for current field information, though a map still adds what a photograph cannot.

1) **They show the ground as it is now:** a photograph records the present state, while a map may be years out of date.
2) **They record every visible detail:** all features appear, not only those a cartographer chose to draw.
3) **They reach difficult areas:** dense forest and swamp are recorded from the air without a ground survey.
4) **They show change over time:** repeated photographs reveal growth and loss that a single map cannot.

A map, however, names features, gives heights and directions and can be measured everywhere, so the two are best used together.

So the Lindi officer is right that a photograph gives fresher and fuller field information, but the map is still needed to name and measure what the photograph shows.

HOT QUESTIONS

Question 87

In a Dodoma classroom a student insists that every image, from an X-ray to a satellite scene, is a photograph. To what extent is this true?

Model Answer

It is only partly true: every photograph is an image, but not every image is a photograph, so the statement is false as it stands.

Where the confusion starts: a photograph and an X-ray plate are both pictures, so they are loosely called the same thing.

Why it breaks down: an image is any pictorial record however it is made, while a photograph is only the image a camera forms from visible light.

The correct relation: photographs are one member of the wider family of images, so the set of photographs lies inside the set of images.

So the truth runs the other way round, which is why an infrared satellite scene of Mount Kilimanjaro is an image and yet not a photograph.

Question 88

Shown a crisp satellite image of Dar es Salaam, a geographer declares that a satellite image is always better than an aerial photograph. How far do you agree?

Model Answer

The claim is too strong: a satellite image is better for some tasks and worse for others, so it is not always better.

The case for: a satellite image covers a whole region at once and is repeated often, so for watching Lake Victoria or a spreading city it wins easily.

The case against: it is taken from far higher, so it shows a smaller scale and less fine detail than an aerial photograph.

The deciding point: the better tool depends on the size of the area and the detail needed, not on one being always superior.

So for the whole Serengeti the satellite image is better, but for one village the aerial photograph is, which is why the word always makes the claim false.

> **False Confidence Alert**
> A satellite image is not automatically clearer. Because it is taken from much farther away, for a close look at a single village an aerial photograph shows more.

Question 89

A researcher on the slopes of Kilimanjaro finds that a photograph taken from the ground tells her more than one taken from the air. When is a ground photograph a better tool than an aerial one? Examine.

Model Answer

A ground photograph is the better tool whenever the side view, the speed of capture or the low cost matters more than a view from above.

The side view: it shows the fronts and heights of buildings, cliffs and waterfalls that a vertical photograph flattens.

Speed and cost: a camera on a hill records a flood or a market at once, with no aircraft and little expense.

Fine detail: close subjects, such as a single crop or a rock face, are captured in full detail.

So for recording the height of a glacier front on Kilimanjaro or the rush of a flood on the Pangani, a ground photograph beats an aerial one, even though the aerial gives the wider plan.

Question 90

Describing the Uluguru foothills, a candidate argues that the ground oblique photograph is the best qualitative record of a landscape. Assess this claim.

Model Answer

There is real force in the claim, because the oblique view is rich and natural, but it is not the best record for every purpose.

In its favour: it shows top and side together, gives a clear foreground, middle ground and background, and reads like the human eye, so it describes a scene very well.

Against it: its scale falls away with distance, so it cannot be measured or mapped from.

The balance: for qualitative description it is very strong, but for any quantitative work the vertical photograph is better.

So as a record to describe the Uluguru foothills the oblique is hard to beat, yet the moment measurement is needed the vertical takes over.

Question 91

A survey office in Dodoma uses aerial photographs for jobs as different as mapping, counting cattle and watching floods. How do the characteristics of aerial photographs diversify their uses?

Model Answer

Each property of an aerial photograph opens a different use, so the range of characteristics gives the range of applications.

The overhead view: gives the true plan of the ground, so it is used for mapping and land-use survey.

The even scale of the vertical: allows measurement, so it is used for area and distance work.

The wide reach of the oblique: gives panorama and relief, so it is used for reconnaissance and for counting.

Repeated cover: shows change over time, so it is used for monitoring and prediction.

So one technology serves mapping, measurement, survey and monitoring, because each of its characteristics is suited to a different job.

Question 92

Photographing the Serengeti plains, a pilot wonders whether a tilted shot could ever serve better than a straight-down one. Is an oblique aerial photograph ever preferable to a vertical one? Examine.

Model Answer

Yes: although the vertical is better for mapping, the oblique is preferable whenever a wide, natural, relief-showing view matters more than an even scale.

For panorama: the oblique takes in a large sweep of country in a single frame.

For relief: slopes and hills stand out clearly because they are seen from the side as well as above.

For quick recognition: the scene looks natural, so features are easy to name at a glance.

Its limit: it cannot be mapped from, so it does not replace the vertical.

So for a first survey of the Serengeti plains or the search for a road line the oblique is preferable, while the vertical remains the choice for the map.

Question 93

Holding a vertical photograph of a remote part of Lindi, an officer says it looks so like a map that the map is no longer needed. To what extent can a vertical photograph be used in place of a topographical map?

Model Answer

Only in part: a vertical photograph can do some of a map's work but not all of it, so it supplements the map rather than replacing it.

What it can do: it gives a to-scale top view, so distances and areas can be measured and features located.

What it cannot do: it does not name features, give heights or use agreed symbols, and its scale varies with the relief.

The verdict: it is the rich raw material from which a map is made, not a finished map.

So a vertical photograph of a remote part of Lindi can stand in for a map when measuring and locating, but the map is still needed to name features and to give their heights.

False Confidence Alert
A photograph is not a map. It shows everything but explains nothing, so the names, heights and symbols must still come from a map.

Question 94

A student measuring distances on two photographs of Iringa gets different answers because the scales differ. Why does the scale of a vertical photograph matter so much, and what factors decide it?

Model Answer

Scale matters because it is the only bridge from the photograph to real distances, and it is decided chiefly by the camera and the flying height.

Why it matters: without the scale, no length or area on the photograph can be turned into a ground measurement.

Focal length: a longer focal length gives a larger scale.

Flying height: a greater height gives a smaller scale, because the height is in the denominator.

Height of the land: over high ground the scale is larger, because the aircraft is nearer the land.

So the same camera over the Iringa highlands gives a larger-scale photograph than over the coast, and the scale must be known before any measurement is trusted.

Question 95

On a vertical photograph two points are 4 cm apart, while on a 1:50 000 map of the same ground they are 1.6 cm apart, and the camera focal length is 160 mm. Find (a) the scale of the photograph and (b) the flying height above the ground.

Model Answer

The map fixes the photo scale through the two distances, and that scale then gives the flying height.

(a) Use $\mathrm{PS} = \frac{\mathrm{PD}}{\mathrm{MD}} \times \mathrm{MS}$ where PD is the photo distance and MD the map distance.

$$\mathrm{PS} = \frac{4}{1.6} \times \frac{1}{50\,000} = \frac{1}{20\,000}$$

Photo scale = 1:20 000.

(b) From $\mathrm{S} = \frac{\mathrm{f}}{\mathrm{H}}$, the flying height is $\mathrm{H} = \frac{\mathrm{f}}{\mathrm{S}}$ with $\mathrm{f} = 160\ \mathrm{mm} = 0.16\ \mathrm{m}$.

$$\mathrm{H} = 0.16 \times 20\,000 = 3\,200\ \mathrm{m}$$

Flying height = 3 200 m above the ground.

Interpretation. So combining the map with the camera shows the photograph is at 1:20 000 and was flown at 3 200 m, neither of which the photograph reveals on its own.

Question 96

A surveyor measuring a vertical photograph of the broken country near Mbeya finds that the scale at the edges is not the scale at the centre. Explain why, and how it is managed.

Model Answer

The scale varies across a vertical photograph because the ground is not all at one height and the view is truly overhead only at the centre.

Relief: higher ground is nearer the camera, so it comes out at a larger scale than lower ground.

Distance from the centre: only the principal point is seen straight down, so tall features lean outward toward the edges.

How it is managed: measurements are taken near the centre, a mean ground height is used in the scale, and rectified prints or mosaics correct the distortion.

So on a photograph of the broken country near Mbeya no single scale is exact, and the careful worker measures near the centre and allows for the mean height of the land.

Question 97

Two students interpreting a photograph of Geita argue over which clue to trust most. Which interpretation key is the most reliable, and does the answer change with the feature? Discuss.

Model Answer

No single key is most reliable for everything; the best key changes with the feature, and the surest reading comes from using several together.

Tone and shape lead first: dark, winding water reads at once as a river, so here tone and shape are strongest.

Where they fail: tone alone confuses a dark lake with a dark forest, so texture and pattern must then decide.

Association and size: a chimney beside sheds says industry, and size separates a hut from a hall.

So for water tone leads, for a plantation pattern leads, and the wise interpreter trusts no single key but weighs them together.

Question 98

Handed an unfamiliar photograph, a new Form Five student at Songea freezes, not knowing where to start. What advice would you give a beginner on interpreting a photograph?

Model Answer

The beginner should work in an orderly way, moving from the whole to the parts and from what is seen to what it means.

1) **Start with the type and parts:** name the photograph, then divide it into foreground, middle ground and background.
2) **Work through the keys:** read tone, shape, size, texture, pattern, shadow and association in turn.
3) **Reason, do not guess:** use association and any caption, and check a doubtful reading against a map.
4) **Draw it:** a quick traced sketch fixes the main features and steadies the description.

So a beginner handed a photograph of unfamiliar country near Songea should slow down, name the parts, apply the keys and sketch, rather than guess at a glance.

Question 99

Interpreting a photograph of the Rufiji swamps, a student cannot tell a dark lake from dark forest. When do the visual keys fail, and what must the interpreter fall back on?

Model Answer

The keys fail when two different features look alike, and then the interpreter must fall back on background information and, where possible, on the ground itself.

Look-alikes: a dark lake and a dark forest, or a wide road and a dry river bed, can share the same tone or shape.

The fallback: maps, written accounts and local knowledge settle what the keys leave in doubt.

Ground truth: a visit to the area, or a second overlapping photograph seen in three dimensions, confirms the reading.

So where the keys cannot separate a swamp from wet forest near the Rufiji, the map and a field check must decide.

False Confidence Alert
The keys are clues, not proof. When they point two ways, a confident guess is a wrong answer waiting to happen, so check against a map or the ground.

Question 100

As Dodoma plans new roads and moves to protect its wetlands, its planners lean heavily on photograph interpretation. How far can photograph interpretation support development planning in Tanzania?

Model Answer

Photograph interpretation supports planning greatly, giving current and wide information, though it cannot replace field checking and measurement.

What it gives: up-to-date land use, the spread of towns, the state of forests and the reach of floods, all quickly and over wide areas.

Where it reaches: remote forest, swamp and border country that a ground survey struggles to cover.

The limit: it shows what is there but not the names, heights or causes, so it must be checked on the ground.

So for siting a road or protecting a wetland near Dodoma the planner leans heavily on photographs, but confirms the key decisions in the field.

Question 101

A district officer fears that a single photograph of Kilombero, taken on one day, might mislead him about the whole area. What limits the reliability of any interpretation drawn from a photograph?

Model Answer

Even a good interpretation is limited, because a photograph is one flat, silent moment that the reader must fill in.

1) **One moment only:** it records a single instant, so a dry river or an empty market may mislead about the usual state of things.
2) **No depth or names:** heights, depths and the names of features are not given and must be inferred.
3) **Observer and quality:** poor light, a small scale or an untrained eye all weaken the reading.

So an interpretation of a Kilombero photograph is only as strong as the photograph and the reader, and any firm conclusion needs more than one source.

Question 102

A district officer has, of the same area, one vertical aerial photograph, one oblique aerial photograph and a topographical map. Advise which he should use for which task, and why.

Model Answer

Each tool has a task it does best, so the officer should match the tool to the job rather than force one to do everything.

The vertical photograph: for measuring distances and areas and for updating the map, because of its even, near-plan scale.

The oblique photograph: for a quick, natural survey of the relief and for showing the area to others, because of its wide, lifelike view.

The map: for names, heights, directions and agreed symbols, because it explains what the photographs only show.

Used together: read as a set, the three give measurement, overview and explanation at once.

So the officer measures from the vertical, surveys and presents from the oblique, and names and levels from the map, using each exactly where it is strongest.

Chapter 5

MAPS AND MAP INTERPRETATION

A topographical map is the geographer's most compressed document: a scaled, selective, symbolic model of a piece of country, folded into a single sheet. This chapter trains the complete craft of reading one. It begins with the map itself, its defining characteristics, its value, its types by function, accuracy and scale, and the supportive information on its margins that makes honest reading possible. It then works through the mathematics of the sheet: expressing and converting scale, constructing plain and graphic linear scales, measuring straight and winding distances, finding regular and irregular areas by formula, grid, strip and geometrical figures, and enlarging or reducing a map by a scale factor.

The chapter next fixes position and direction, from six figure grid references and latitude and longitude by proportion, through compass points, grid bearings, forward and back bearings and their correction, to trend, alignment, the three norths and the arithmetic of magnetic variation. Relief follows: the qualitative and quantitative methods of showing height, the rules of contours, the landforms they fingerprint, vertical intervals, gradients, cross sections, vertical exaggeration and intervisibility. Finally, the chapter turns the sheet into an argument, interpreting climate, drainage, vegetation, rocks and geomorphic processes on the physical side, and settlement, land use, economic activities, services, transport and population on the human side, before two integrated drills rehearse the whole craft on a single extract. Every worked answer shows its method inside the working.

BINDER QUESTIONS

Question 1

A Form Five student in Dodoma finds a road application on a phone and wonders why the school library still keeps drawers of printed sheets of the same city. Explain what a map really is, and account for the ideas packed into that definition.

Model Answer

A map is a scaled representation of the whole or a part of the earth's surface drawn on a flat medium such as paper, using points, lines, symbols and colours to show how selected natural and cultural features are located, arranged and related.

Scaled: the ground is far larger than the paper, so every map reduces reality by a stated ratio, and the amount of reduction rises as the coverage widens.

Selective: no map can carry everything, so the maker admits only the features that serve the purpose of the map.

Symbolic: agreed signs stand in for real objects, which is why a key must accompany the drawing.

Flat model of a curved surface: the three dimensional earth is transformed mathematically into a two dimensional sheet, so a map is a projection, and the person who makes it is a cartographer.

So the printed Dodoma sheet and the phone application are the same thing at heart, a scaled, selective, symbolic model of the city on a flat surface.

Question 2

A cartography intern at the mapping office in Dar es Salaam is told that a good map is planned long before it is drawn. Examine the cartographic principles that guide the making of a map.

Model Answer

Four principles discipline every sound map.

1) **Concept before compilation:** the maker must first settle the definition, characteristics, type and nature of the content, because a map drawn before its idea is clear ends up confused.
2) **Hierarchy with harmony:** important features such as relief, drainage, vegetation and settlements must stand out, while lesser detail is subdued so that it does not overwhelm interpretation.

3) **Simplicity from sacrifice:** a map should carry only the information its purpose demands, since every unnecessary symbol is bought at the price of clarity.
4) **Cartographic design:** colours, symbols, typography and labels are chosen to suit the purpose, the scale and the audience of the map.

A tourist sheet of Kilimanjaro obeys all four, because it promotes the peak, the routes and the huts and sacrifices everything that would distract a climber.

Question 3

Two sheets in a Mwanza bookshop look completely different, yet the geography teacher insists that every true map carries the same family marks. Justify this claim by examining the main characteristics of maps.

Model Answer

However different maps appear, they share defining characteristics.

1) **Drawn to scale:** every map states the ratio by which ground reality has been reduced to fit the sheet, and that ratio governs its size and coverage.
2) **Uses signs and symbols:** point symbols stand for features such as houses, line symbols for roads and rivers, and area symbols for swamps and forests, all defined in the key.
3) **A projection:** the curved earth is transformed mathematically onto a flat surface, so a map is a two dimensional model of reality.
4) **Generalised and selective:** information is summarised according to scale, purpose and the interest of the cartographer, so a dot may stand for houses of many different sizes.
5) **Communicative:** a trained reader can extract the meaning of an area without ever visiting it.
6) **A dated store of geographical data:** a map preserves the distribution of features as they stood at compilation, which is why a sheet of Babati printed thirty years ago shows the Babati of that time, not of today.

So the crowded topographical sheet and the simple rainfall map in that Mwanza bookshop are cousins, because both are scaled, symbolic, generalised projections that communicate stored information.

Question 4

After the 2003 landslide disaster in Hanang, Manyara, and the floods that keep returning to Morogoro, planners reached first for topographical sheets of the affected areas. Assess the value of maps in geography.

Model Answer

Maps serve geography in six main ways.

1) **Base for spatial description:** maps let the reader describe relief, climate, drainage, soils and settlement of an area and weigh their significance for human life.
2) **Revealing relationships:** because features are shown together, maps expose links such as igneous rocks with tectonic activity, or relief with drainage and settlement.
3) **Training and critical thinking:** map reading orients students to cartographic techniques and forces them to integrate geology, pedology and geomorphology when interpreting an area.
4) **Mirror of past events:** an old sheet lets the reader detect changes that have occurred over time in land cover, water and settlement.
5) **Data for analysis and research:** maps supply statistical material such as population distribution and rainfall patterns that researchers turn into evidence.
6) **Basis for planning and hazard study:** maps guide the design of engineering structures and identify dangers, which is why the Hanang landslide zone and the flood prone lowlands of Morogoro are studied first on the map.

So a map is not an ornament, because in Hanang and Morogoro it is the first instrument of both explanation and protection.

Question 5

A regional office in Songwe keeps one sheet crowded with roads, contours and villages, and another showing only dots that thicken around towns. Distinguish the two functional families of maps that these sheets represent.

Model Answer

By function and content, maps divide into topographical and statistical maps.

Topographical maps represent both natural and cultural features of a part of the earth's surface. They fix location by grid reference, bearing, latitude and longitude and place names, and they carry cultural features such as roads, railways, towns and dams, landscape such as mountains, valleys and plateaus, and drainage such as rivers and lakes. They are used for describing an area, planning the best uses of land and guiding people to their destinations.

Statistical maps, also called distribution or quantitative maps, show the spatial distribution and magnitude of one phenomenon, such as rainfall, temperature or population. Their common types are dot maps, isoline maps and choropleth maps, so they answer the question how much is where rather than what is where.

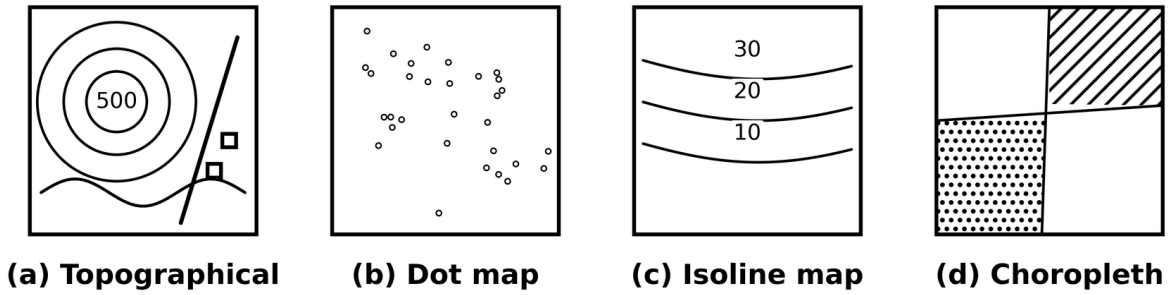


Figure 5.1: *A topographical map against the three common statistical maps*

The crowded Songwe sheet is therefore topographical, while the dotted sheet is a statistical map of population, and each serves the office in its own way.

Question 6

A history textbook sketches the old caravan route to Bagamoyo in a few free strokes, while the national mapping agency sells a precise sheet of the same coast. Differentiate the two maps by their degree of accuracy.

Model Answer

By accuracy, maps are either surveyed or sketch maps.

Surveyed maps: are built on mathematical principles and theories, because transforming the spherical earth onto a flat sheet demands projection and measured control. They carry a reliable scale, and the topographical sheets sold for the Bagamoyo coast belong here.

Sketch maps: are roughly drawn with no mathematical basis and no true scale. They serve illustration, which is why a history book can use one to show a caravan route or historical sites without claiming survey accuracy.

So the two drawings differ not in honesty but in method, because one is measured and the other merely illustrates.

Question 7

The same Iringa district can fill a wall sheet or shrink to a corner of a map of Africa. Examine how maps are classified by the size of their scale, and state the rule that connects the scale to the detail shown.

Model Answer

By scale size, maps are small, medium or large scale.

Class	Typical range	Coverage	Detail
Small scale	1:250 000 to 1:1 000 000	Very large, even a country	Little, highly generalised
Medium scale	1:50 000 to 1:125 000	Medium, a district	Moderate
Large scale	1:5 000 to 1:25 000	Small, a town or village	Great, most features shown

The governing rule is that the larger the denominator, the smaller the scale, because $1/1\,000\,000$ is a smaller fraction than $1/5\,000$. A small scale map therefore covers a wide area with little detail, whereas a large scale map covers a small area, such as a school compound, in great detail.

That is why Iringa fills a 1:10 000 town plan yet almost vanishes on a 1:1 000 000 map of Africa.

False Confidence Alert
A scale of 1:1 000 000 is not a large scale because its number looks big. The denominator is a divisor, so the bigger it grows the smaller the scale becomes and the less detail survives.

Question 8

Opening the Mpanda sheet for the first time, a candidate meets hills, a railway, brown lines and a crowded margin all at once. Classify the contents of a topographical map.

Model Answer

A topographical map carries four kinds of content.

1) **Natural contents:** all features that are not man made, such as mountains, valleys, soil types, plateaus, natural forests, rivers, lakes and oceans.
2) **Cultural contents:** all man made features, such as roads, railways, buildings, dams and planted forests, and on the Mpanda sheet the railway line is the clearest example.
3) **Relief content shown by contours:** imaginary lines joining points of the same elevation above mean sea level, drawn to define the configuration of the land.
4) **Supportive contents:** the information written close to the margin, including the title, key, scale, north direction, date, sheet number, publisher and grid, provided to help the reader interpret the map correctly.

So the candidate should sort what she sees into these four baskets before reading any further.

Question 9

Before any question is attempted, a wise candidate spends the first minute reading everything around the map rather than anything inside it. Identify the supportive contents marked (a) to (g) on the sheet in Figure 5.2, and state what each tells the user.

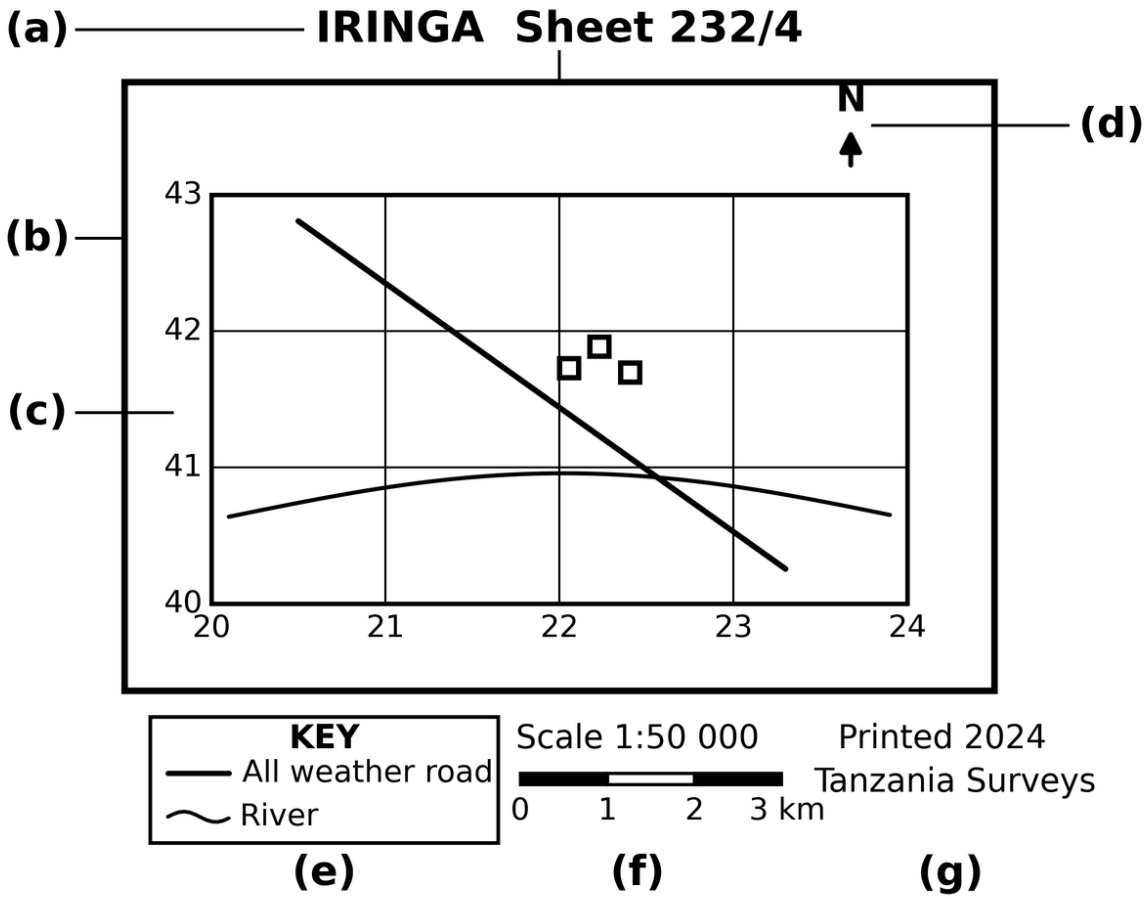


Figure 5.2

Model Answer

The seven marked items and their messages are these:

1) **(a) Title and sheet number:** the heading IRINGA names the mapped area and Sheet 232/4 places the map within its national series, answering what and where.

2) **(b) Margin or boundary:** the frame that encloses the map and marks the limit of the mapped coverage.

3) **(c) Grid reference numbers:** the eastings and northings along the edges from which grid references are read.

4) **(d) Direction indicator:** the north arrow that orients the sheet so directions and bearings can be taken.

5) **(e) Legend or key:** the dictionary of the symbols used, translating map language into ordinary language.

6) **(f) Linear scale with its statement:** the converter of map measurements into ground distances, and the bar stays true even when the sheet is photocopied.

7) **(g) Date and publisher:** Printed 2024 by Tanzania Surveys tells how current the information is and whose authority stands behind it.

Question 10

A teacher in Tabora writes on the board that a map without its margins is a letter without an address. Explain the importance of the supportive information to the map maker and to the map user.

Model Answer

Each marginal item earns its place.

Title: answers what and where, so the reader knows at once whether the sheet serves the task at hand.

Key: acts as the map dictionary, translating the conventional map language into ordinary language and preventing misreading of symbols.

Scale: lets the maker control coverage and content, and lets the user convert map measurements into ground distances and areas.

Direction indicator: fixes north, so bearings, trends and the positions of features can be determined.

Date of compilation: warns the user about change, because land cover, settlement and water keep changing, and a sheet of Dodoma taken twenty years ago differs greatly from the region today.

Sheet number: identifies the map within its series and shows how many times it has been updated.

Publisher and copyright: reveal who made the map, so the user can judge its authority and possible bias.

So the Tabora teacher is right, because without these items the finest drawing cannot be delivered to its meaning.

Question 11

Two drivers argue at Chalinze over a road map. One says the scale shrinks the road, the other says it measures the road. Define map scale and account for its uses to the map maker and to the map user, giving three points for each.

Model Answer

Map scale is the ratio between a distance measured on the map and the corresponding actual distance on the ground,

$$\text{scale} = \frac{\text{map distance}}{\text{ground distance}}$$

To the maker:

1) **Scale commands coverage:** the chosen scale decides how much ground fits on the sheet.
2) **Scale controls content:** a small scale forces generalisation while a large scale invites detail.
3) **Scale is the basis of classification:** sheets are grouped as small, medium or large scale by it.

To the user:

1) **Scale converts distance:** a measurement on the map becomes a real distance on the ground.
2) **Scale is the tool of interpretation:** it tells how the map relates to the real features it represents, so sizes are judged correctly.
3) **Scale unlocks further measurement:** areas, gradients and redrawing all begin from it.

Both drivers at Chalinze are right, because the scale both shrinks the Morogoro road onto the paper and measures it back off the paper.

Question 12

On the margin of the Uvinza sheet a candidate finds the figure 1:50 000, a sentence about centimetres and kilometres, and a divided bar. Examine the three ways of expressing a map scale and state one strength of each.

Model Answer

A scale may be expressed as a representative fraction, a statement or a linear scale.

1) **Representative fraction:** a ratio such as 1:50 000 whose numerator is always one, meaning one unit on the map stands for 50 000 of the same units on the ground. Its strength is that it is free of units, so any measuring system may be applied.
2) **Statement scale:** a written description such as one centimetre on the map represents half a kilometre on the ground. Its strength is that it is understood at once, even by a beginner.

3) **Linear scale:** a divided bar with a primary section in kilometres to the right and a secondary section in metres to the left, from which distance is read directly. Its strength is that it survives photocopying, because when the map is enlarged or reduced the bar changes with it, while a fraction or statement becomes false.

(a) Representative fraction: 1:50 000 or 1/50 000

(b) Statement scale: One centimetre represents half a kilometre

(c) Linear scale:

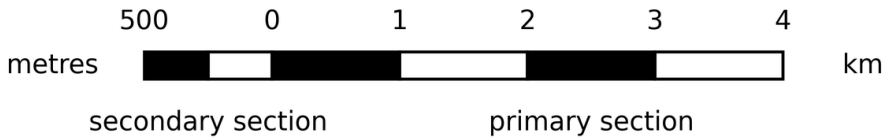


Figure 5.3: *The three expressions of one map scale*

So the three margin entries on the Uvinza sheet are one scale wearing three dresses, and the wise candidate reads distance against the bar.

Question 13

A candidate at Mafinga is handed a sheet at 1:50 000 and asked what one centimetre on it stands for on the ground. Convert this representative fraction into a statement scale, showing every step.

Model Answer

The fraction is unit free, so give it units and change them to kilometres.

Step 1: state the meaning in centimetres. Since the RF is 1:50 000, $1\text{ cm} = 50\,000\text{ cm}$ on the ground, because both sides of a ratio must carry the same unit.

Step 2: change the ground centimetres to kilometres. Using the constant $1\text{ km} = 100\,000\text{ cm}$, divide:

$$50\,000\text{ cm} = \frac{50\,000}{100\,000}\text{ km} = 0.5\text{ km}$$

Statement scale: one centimetre on the map represents half a kilometre on the ground.

Interpretation. So every centimetre the candidate measures at Mafinga is half a kilometre of real ground.

Question 14

A road survey note from Kibaha reads: one centimetre on the map represents two and a half kilometres on the ground. Express this statement as a representative fraction.

Model Answer

Bring both sides to the same unit, then write the ratio.

Step 1: convert the ground distance to centimetres. Since $1\text{ km} = 100\,000\text{ cm}$, the ground side becomes:

$$2.5\text{ km} = 2.5 \times 100\,000\text{ cm} = 250\,000\text{ cm}$$

Step 2: write map distance to ground distance in the same unit. $1\text{ cm} : 250\,000\text{ cm}$, and drop the unit because a ratio of like units is unit free.

Representative fraction: 1:250 000.

Interpretation. So the Kibaha note describes a small scale sheet of 1:250 000, suitable for a wide view but not for detail.

> **False Confidence Alert**
> A ratio written while one side is still in kilometres, such as 1:2.5, is meaningless. Both sides must first stand in the same unit, and only then may the units be dropped.

Question 15

An atlas of Africa states its scale in words as one centimetre to one hundred kilometres. Convert this wordy statement into a ratio scale.

Model Answer

Step 1: convert the ground side to centimetres. Since $1\text{ km} = 100\,000\text{ cm}$:

$$100\text{ km} = 100 \times 100\,000\text{ cm} = 10\,000\,000\text{ cm}$$

Step 2: write the ratio in like units. $1\text{ cm} : 10\,000\,000\text{ cm}$, so the scale is unit free.

Ratio scale: 1:10 000 000.

Interpretation. Such a tiny scale is why all of Tanzania occupies a hand span in the atlas while a 1:50 000 sheet needs hundreds of sheets to cover it.

Question 16

For a fieldwork display at Njombe, a class must construct a plain linear scale for a 1:50 000 sheet that will read up to 6 kilometres. Demonstrate the construction.

Model Answer

First turn the fraction into a statement, then size the baseline, then divide it.

Step 1: convert the scale. Since $1\text{ km} = 100\,000\text{ cm}$, the fraction $1{:}50\,000$ gives $1\text{ cm} = 0.5\text{ km}$.

Step 2: find the baseline length for 6 km. If $1\text{ cm} = 0.5\text{ km}$, then:

$$\text{baseline} = \frac{1\text{ cm} \times 6\text{ km}}{0.5\text{ km}} = 12\text{ cm}$$

Step 3: divide the baseline. Draw a 12 cm line. Mark six primary divisions of 2 cm, each reading 1 km, to the right of zero. Extend one further 2 cm division to the left of zero as the secondary section and divide it into five parts, each reading 200 m, because fine readings are taken there.

Step 4: label the scale. Number the primary section 0 to 6 km and the secondary section back from 0 to 1 000 m, and state the scale beneath.

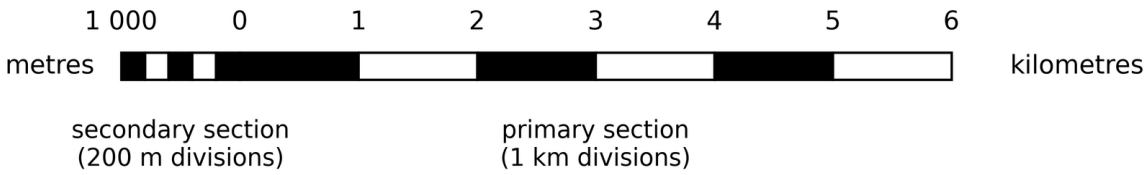


Figure 5.4: *A plain linear scale for 1:50 000 reading 6 km*

Interpretation. The finished bar reads any distance up to 6 km at Njombe directly, with no arithmetic at the moment of use.

Question 17

A practical exercise demands a graphic scale for a 1:50 000 map to read 4 kilometres, with the secondary section divided finely. Construct it, explaining the extra steps that make a scale graphic.

Model Answer

A graphic scale is a linear scale whose secondary section is subdivided geometrically.

Step 1: convert the scale. 1:50 000 means 1 cm = 0.5 km.

Step 2: find the baseline for 4 km.

$$\text{baseline} = \frac{1\ \text{cm} \times 4\ \text{km}}{0.5\ \text{km}} = 8\ \text{cm}$$

Step 3: divide the baseline. Mark three primary divisions of 2 cm for 1 km each to the right of zero, and reserve the leftmost 2 cm as the secondary section.

Step 4: subdivide the secondary geometrically. Draw oblique auxiliary lines at an equal angle of about 25 to 30 degrees from the two ends of the secondary section, mark ten equal steps along them, and join the points so that the secondary is cut into ten parts of 100 m each. This construction is what earns the name graphic scale.

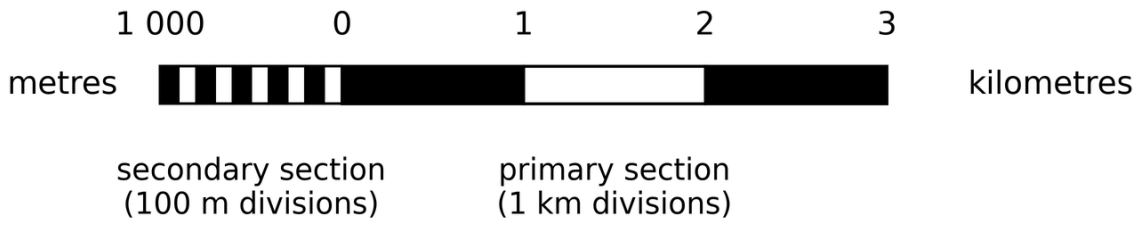


Figure 5.5: *A graphic scale for 1:50 000 reading 4 km*

Question 18

A bus leaves Morogoro for Dodoma at an average speed of 90 km/h and completes a stretch of road in 40 minutes. The same stretch measures 30 cm on a map. Determine the statement scale of the map and construct a linear scale to read 10 km.

Model Answer

Speed and time give the ground distance, and the map distance then gives the scale.

Step 1: change the time to hours. 40 min = 40/60 h = 2/3 h, because speed is stated per hour.

Step 2: find the ground distance. Distance is speed multiplied by time:

$$\text{distance} = 90\ \text{km/h} \times \frac{2}{3}\ \text{h} = 60\ \text{km}$$

Step 3: find the statement scale. Since 30 cm on the map stands for 60 km on the ground:

$$1\ \text{cm} = \frac{60\ \text{km}}{30} = 2\ \text{km}$$

Step 4: construct the scale to read 10 km. With 1 cm = 2 km, a 10 km baseline needs 5 cm. Divide it into five primary divisions of 1 cm each reading 2 km, add a secondary division to the left cut into five parts of 400 m, and label.

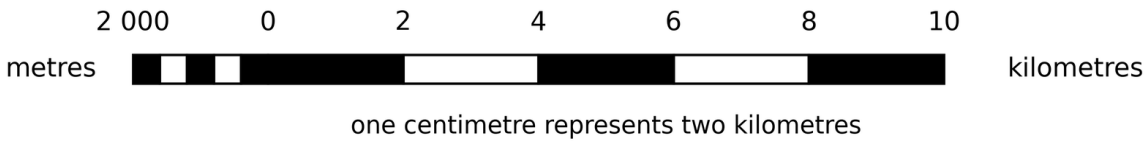


Figure 5.6: *The linear scale built from the speed of the Morogoro to Dodoma bus*

Statement scale: one centimetre represents two kilometres, that is 1:200 000.

Interpretation. So a moving bus, a clock and a ruler are enough to recover the scale of an unlabelled road map.

Question 19

A Bus Rapid Transit (Mwendokasi) vehicle in Dar es Salaam travels at 70 km/h and takes 30 minutes between Kivukoni and a suburban terminal. The route measures 7 cm on a plan. Determine the scale of the plan, and state how a linear scale reading 60 km would be sized.

Model Answer

Step 1: change the time to hours. $30 \text{ min} = 0.5 \text{ h}$.

Step 2: find the ground distance.

$$\text{distance} = 70 \text{ km/h} \times 0.5 \text{ h} = 35 \text{ km}$$

Step 3: find the scale. Since $7 \text{ cm} = 35 \text{ km}$, divide both sides by 7 so that $1 \text{ cm} = 5 \text{ km}$, which is 1:500 000.

Step 4: size the baseline for 60 km.

$$\text{baseline} = \frac{1 \text{ cm} \times 60 \text{ km}}{5 \text{ km}} = 12 \text{ cm}$$

Scale 1:500 000; the bar would be 12 cm long, divided into twelve 1 cm divisions of 5 km each, with a secondary division subdivided for finer readings.

Interpretation. So the Mwendokasi timetable itself carries enough information to scale the route plan.

Question 20

A ward officer at Kibaha needs a village sheet at twice the size of the 1:25 000 original for a land use meeting. The original grid squares are 2 cm wide and the mapped window measures 6.3 cm long by 5.5 cm wide. Show how the map is enlarged to 1:12 500, and state the redrawing procedure.

Model Answer

Enlargement multiplies every length by the scale factor, which compares the new scale with the old.

Step 1: find the scale factor.

$$\text{scale factor} = \frac{\text{new scale}}{\text{old scale}} = \frac{\frac{1}{12\,500}}{\frac{1}{25\,000}} = \frac{25\,000}{12\,500} = 2$$

Step 2: compute the new dimensions. Multiply each old length by 2: the grid side becomes $2 \text{ cm} \times 2 = 4 \text{ cm}$, the length $6.3 \text{ cm} \times 2 = 12.6 \text{ cm}$ and the width $5.5 \text{ cm} \times 2 = 11 \text{ cm}$.

Step 3: redraw. Rule the new grid of 4 cm squares, transfer the contents of each old square into its enlarged partner square by square so that shapes keep their relative positions, then restate the title, the key, the new scale and the grid numbers.

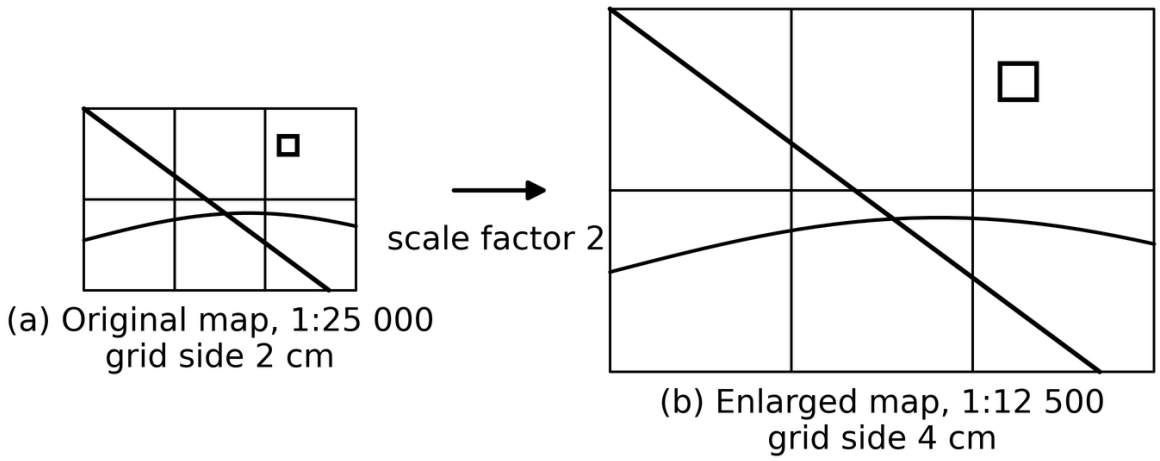


Figure 5.7: *Enlargement of a 1:25 000 map to 1:12 500 by a scale factor of 2*

New scale 1:12 500; grid side 4 cm; window 12.6 cm by 11 cm.

Interpretation. The enlarged Kibaha sheet is bigger and more readable, but no new detail appears, because enlargement magnifies the drawing, not the survey.

Question 21

To fit a display board, a teacher at Moshi must reduce a 1:50 000 sheet whose window is 14 cm long and 10 cm wide, with 2 cm grid squares, to a scale of 1:100 000. Work out the reduction.

Model Answer

Step 1: find the scale factor.

$$\text{scale factor} = \frac{\frac{1}{100\,000}}{\frac{1}{50\,000}} = \frac{50\,000}{100\,000} = \frac{1}{2}$$

Step 2: compute the new dimensions. Each length is halved: the grid side becomes $2\text{ cm} \times 1/2 = 1\text{ cm}$, the length $14\text{ cm} \times 1/2 = 7\text{ cm}$ and the width $10\text{ cm} \times 1/2 = 5\text{ cm}$.

Step 3: redraw and generalise. Rule the reduced grid, transfer the contents square by square, and simplify crowded detail, because a smaller sheet cannot carry everything the larger one did. Restate title, key and the new scale.

New scale 1:100 000; grid side 1 cm; window 7 cm by 5 cm.

Interpretation. So the display copy is half as long, a quarter the area, and deliberately simpler than the classroom original.

Question 22

A water engineer at Singida must report how far a proposed pipeline runs between an intake X and a storage tank Y, two points joined by a straight line on a 1:50 000 sheet. The dividers set between the points span 3.6 cm. Describe the procedure and complete the calculation.

Model Answer

A short straight distance is taken with a pair of dividers and read against the scale.

1) **Identify the two end points:** mark the starting point X and the ending point Y between which the measurement runs.
2) **Set the dividers:** open the pair so that one leg rests on X and the other on Y without disturbing the setting.

3) **Transfer and read:** move the dividers to the linear scale and read the ground distance directly, or read the map distance with a ruler and convert it with the statement scale.

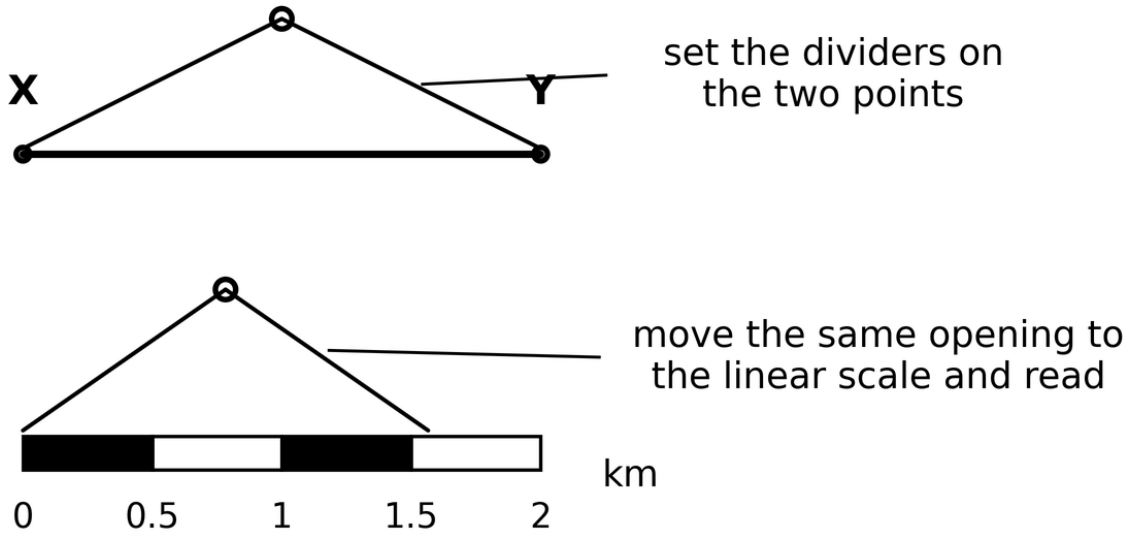


Figure 5.8: *Taking a straight distance with dividers and reading it on the linear scale*

Working: At 1:50 000, 1 cm = 0.5 km, so:

$$\text{ground distance} = 3.6 \times 0.5 \text{ km} = 1.8 \text{ km}$$

The pipeline runs 1.8 km.

Interpretation. So the Singida engineer can order 1.8 km of pipe from a single confident opening of the dividers.

Question 23

The straight murram road from a Kondoa junction to a village runs longer than any divider can span. A surveyor therefore steps the dividers, set to 2 cm, along the line and counts 6 complete intervals, and the final short segment measures 1.4 cm. The sheet is at 1:100 000. Show how the distance is obtained.

Model Answer

A long distance is stepped in equal intervals, and the leftover segment is measured separately.

Step 1: state the rule. Distance is the number of complete intervals multiplied by the interval, plus the last segment, because stepping simply adds equal lengths.

Step 2: add the map distance.

$$\text{map distance} = 6 \times 2 \text{ cm} + 1.4 \text{ cm} = 13.4 \text{ cm}$$

Step 3: convert with the statement scale. At 1:100 000, 1 cm = 1 km, so:

$$\text{ground distance} = 13.4 \times 1 \text{ km} = 13.4 \text{ km}$$

The road is 13.4 km long.

Interpretation. So stepping turns one small instrument into a measure of any length of the Kondoa road.

Question 24

A winding footpath climbs the Uluguru foothills, and no straight instrument can follow it. A piece of thread laid carefully along the path on a 1:25 000 sheet measures 7 cm when straightened. Explain the thread method and find the ground distance.

Model Answer

A thread follows every bend, then surrenders its length to the scale.

1) **Identify the end points:** fix where the measured stretch begins and ends.
2) **Lay the thread:** bend a piece of string along the feature, following each curve faithfully.
3) **Straighten and read:** shift the thread onto the linear scale for a direct ground reading, or measure it with a ruler and convert.

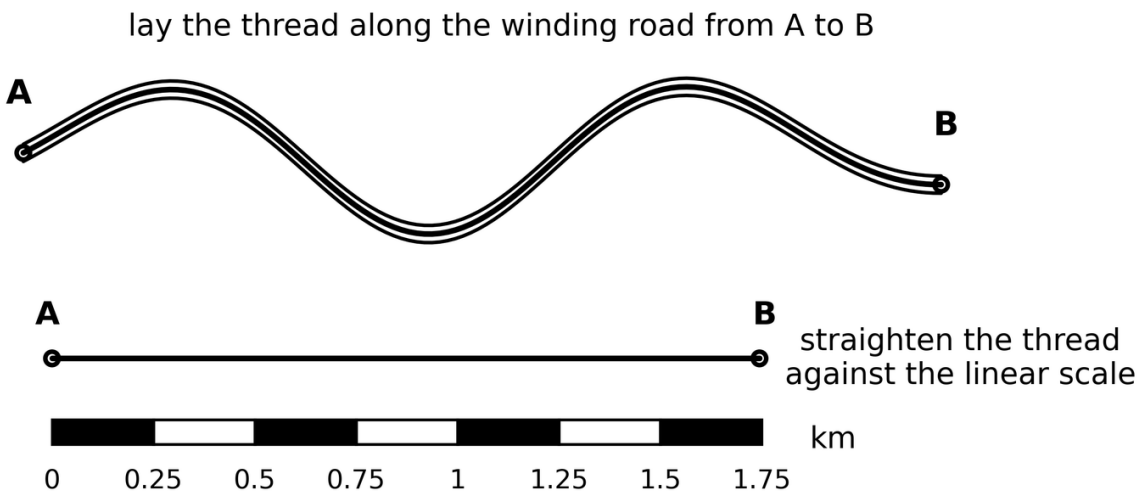


Figure 5.9: *The thread method on a winding road*

Working: At 1:25 000, 1 km = 100 000 cm gives 1 cm = 0.25 km, so:

$$\text{ground distance} = 7 \times 0.25 \text{ km} = 1.75 \text{ km}$$

The footpath measures 1.75 km.

Interpretation. So the humble thread reads the Uluguru path that defeats every ruler.

Question 25

A meandering river reach near Kilosa must be measured for a bridge report. Using the straight edge of a paper stepped along the curve on a 1:50 000 sheet, the accumulated marks give a map distance of 8.6 cm. Describe the method and complete the conversion.

Model Answer

The straight edge of a paper converts a curve into a chain of short straight steps.

1) **Divide the curve:** break the winding feature into short, nearly straight sections.
2) **Step the paper:** lay the straight edge along the first section, mark it, pivot the paper at the mark to follow the next section, and continue to the end, so the edge accumulates the whole length.
3) **Read the total:** place the marked edge on the linear scale for the ground distance, or measure it and convert.

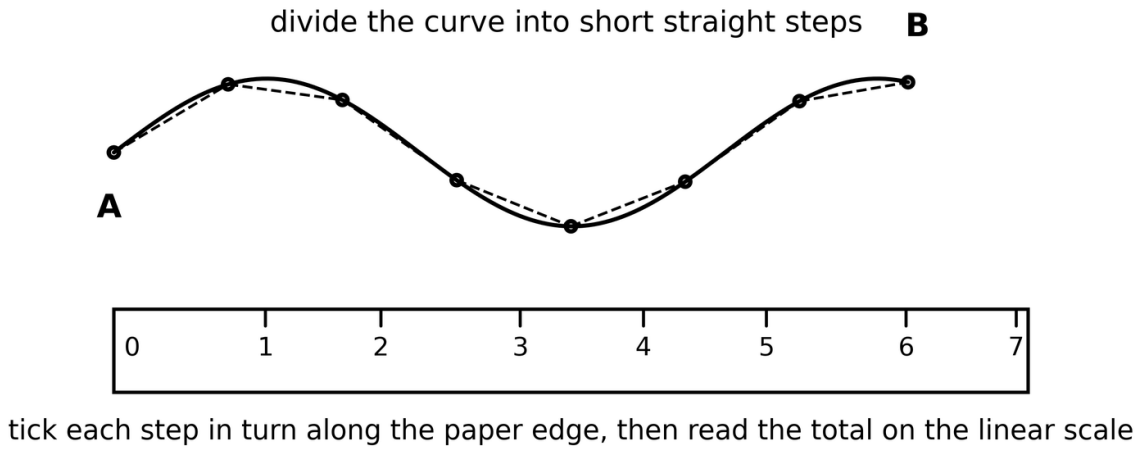


Figure 5.10: *Stepping a straight paper edge along a curved feature*

Working: At 1:50 000, 1 cm = 0.5 km, so:

$$\text{ground distance} = 8.6 \times 0.5 \text{ km} = 4.3 \text{ km}$$

The river reach measures 4.3 km.

Interpretation. So the Kilosa bridge engineers receive a length that honours every meander.

Question 26

On a 1:50 000 sheet, a sisal estate at Korogwe appears as a rectangle 4.4 cm long and 3.6 cm wide. Calculate its ground area.

Model Answer

Convert each side to ground units first, because area must be computed on the ground, not on the paper.

Step 1: convert the scale. 1:50 000 gives 1 cm = 0.5 km.

Step 2: convert the sides. Length $4.4 \times 0.5 = 2.2$ km and width $3.6 \times 0.5 = 1.8$ km.

Step 3: apply the formula for a rectangle.

$$\text{area} = \text{length} \times \text{width} = 2.2 \times 1.8 = 3.96$$

The estate covers 3.96 square kilometres.

Interpretation. So the Korogwe estate is almost 4 square kilometres of sisal, read straight off two ruler strokes.

Question 27

A triangular forest reserve near Morogoro has a base of 5 cm and a perpendicular height of 3.2 cm on a 1:50 000 sheet. Determine its ground area.

Model Answer

Step 1: convert the sides. At 1 cm = 0.5 km: base $5 \times 0.5 = 2.5$ km, height $3.2 \times 0.5 = 1.6$ km.

Step 2: apply the formula for a triangle. Half the base times the height, because a triangle is half its bounding rectangle:

$$\text{area} = \frac{1}{2} \times 2.5 \times 1.6 = 2$$

The reserve covers 2 square kilometres.

Interpretation. So the Morogoro reserve is exactly 2 square kilometres, and the halving is what distinguishes it from a rectangular estate.

Question 28

A circular centre pivot irrigation scheme at Mbarali shows a radius of 1.4 cm on a 1:50 000 sheet. Calculate the ground area it waters.

Model Answer

Step 1: convert the radius. $1.4 \times 0.5 = 0.7$ km.

Step 2: apply the formula for a circle. Taking $\pi = 22/7$:

$$\text{area} = \pi r^2 = \frac{22}{7} \times 0.7 \times 0.7 = 1.54$$

The scheme waters 1.54 square kilometres.

Interpretation. So the green circle at Mbarali, so striking from the air, is a body of about one and a half square kilometres.

Question 29

A seasonal swamp sprawls irregularly across the grid of a 1:50 000 sheet of Maswa. The grid squares are 2 cm wide, and the swamp covers 4 complete squares and 12 incomplete ones. Show how the grid method delivers its area.

Model Answer

The grid method counts complete squares fully and incomplete squares as halves.

1) **Count complete squares:** here 4 lie wholly inside the swamp.
2) **Count incomplete squares and halve them:** here 12 are cut by the boundary, and halving them balances the parts inside against the parts outside.
3) **Find the area of one square and multiply:** the grid side and the scale give each square a known ground area.

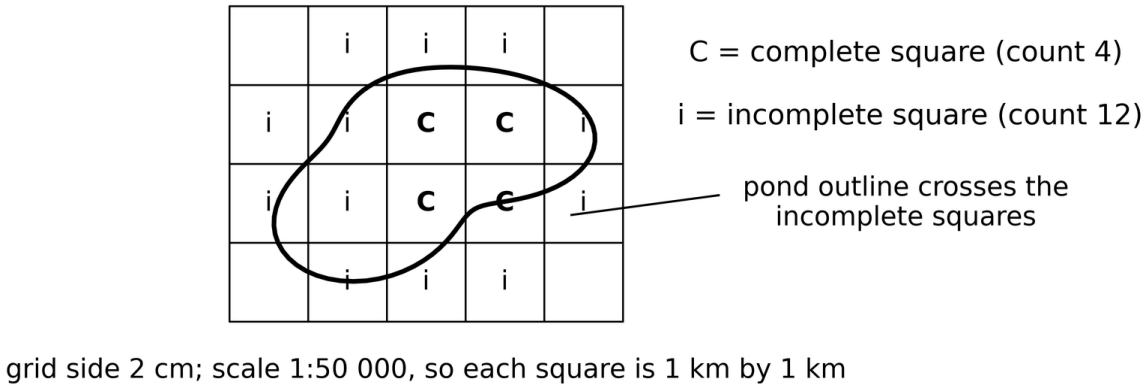


Figure 5.11: *The grid method on an irregular pond*

Working: Total squares:

$$\text{total} = 4 + \frac{12}{2} = 10 \text{ squares}$$

Area of one square: Each side is 2 cm = 1 km at 1:50 000, so one square is 1 km × 1 km = 1 km^2.

$$\text{area} = 10 \times 1 = 10$$

The swamp covers about 10 square kilometres.

Interpretation. So the Maswa swamp is estimated at 10 square kilometres, a figure honest about the raggedness of its edge.

False Confidence Alert
Counting every incomplete square as a full square inflates the area badly. The boundary squares must be divided by two, because on average only half of each lies inside the feature.

Question 30

A woodland block near Sumbawanga refuses every regular formula, so a candidate rules it into five strips of equal 1 cm width on a 1:25 000 sheet. The measured strip lengths are given below. Apply the strip method to find its area.

Strip	1	2	3	4	5
Map length (cm)	4	6	5	6	5

Model Answer

Each strip is treated as a slender rectangle, and the rectangle areas are summed.

Step 1: convert the scale. 1:25 000 gives 1 cm = 0.25 km, so every strip is 0.25 km wide.

Step 2: convert the lengths. Strips of 4, 6, 5, 6 and 5 cm become 1.0, 1.5, 1.25, 1.5 and 1.25 km.

Step 3: compute each strip area and sum. Multiplying each length by the width 0.25 km gives 0.25, 0.375, 0.3125, 0.375 and 0.3125 km^2, so:

$$\text{area} = (0.25 + 0.375 + 0.3125 + 0.375 + 0.3125)\text{km}^2 = 1.625\text{km}^2$$

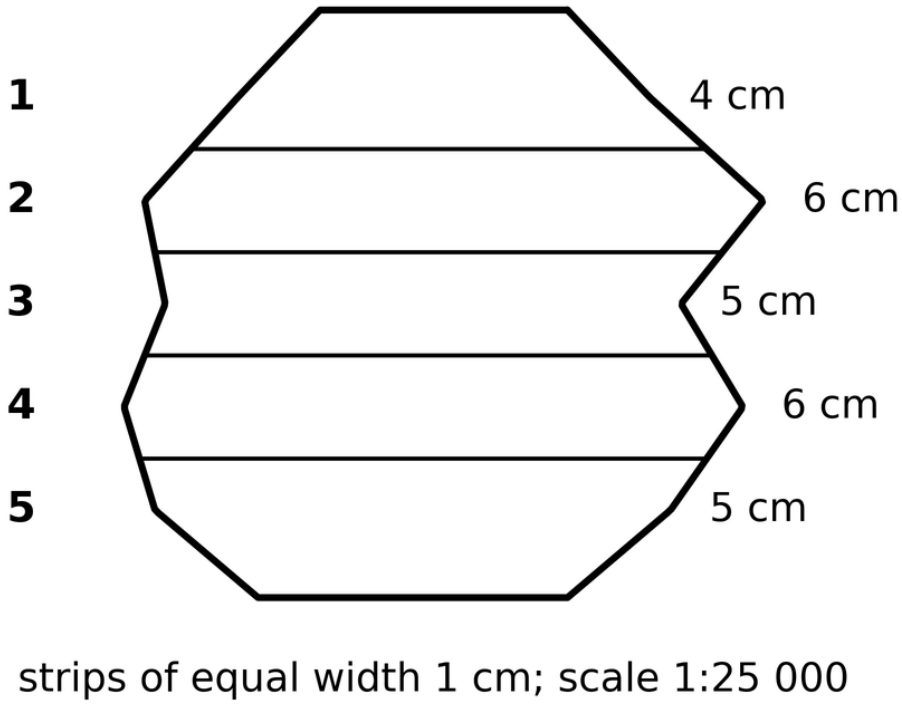


Figure 5.12: *The strip method on an irregular woodland*

The woodland covers about 1.63 square kilometres.

Interpretation. So five parallel rulings tame the Sumbawanga woodland that no single formula could hold.

Question 31

An irregular ranch block on a Kongwa sheet can be split into a rectangle A measuring 2.6 km by 1.3 km on the ground, a triangle B of base 1.3 km and height 0.95 km, and a triangle C of base 1.3 km and height 0.8 km. Use the geometrical figures method to find the total area.

Model Answer

The geometrical figures method divides an awkward shape into figures whose formulas are known, then adds the parts.

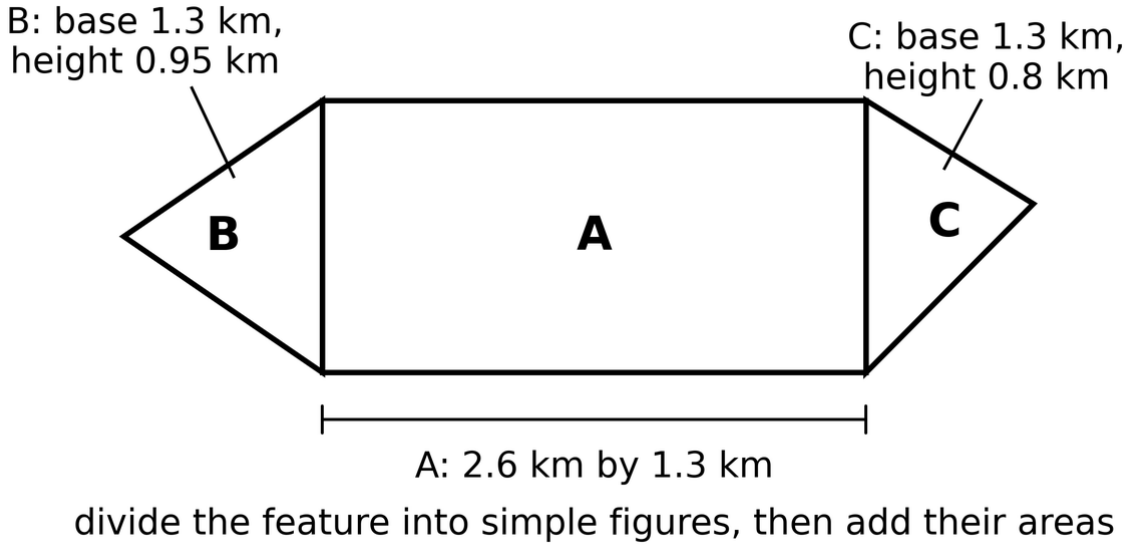


Figure 5.13: *Dividing an irregular feature into a rectangle and two triangles*

Step 1: area of the rectangle A.

$$A = 2.6 \times 1.3 = 3.38$$

Step 2: areas of the triangles B and C.

$$B = \frac{1}{2} \times 1.3 \times 0.95 = 0.6175$$

$$C = \frac{1}{2} \times 1.3 \times 0.8 = 0.52$$

Step 3: sum the parts.

$$\text{total} = (3.38 + 0.6175 + 0.52)\text{km}^2 = 4.5175\ \text{km}^2$$

The ranch covers about 4.52 square kilometres.

Interpretation. So the Kongwa block, which looked hopeless as a whole, surrenders to three familiar formulas taken one at a time.

Question 32

During a practical at Maswa, candidates must pin a borehole to within one hundred metres using nothing but the grid. With the aid of Figure 5.14, explain how a six figure grid reference is read, and state the references of the points A and P shown.

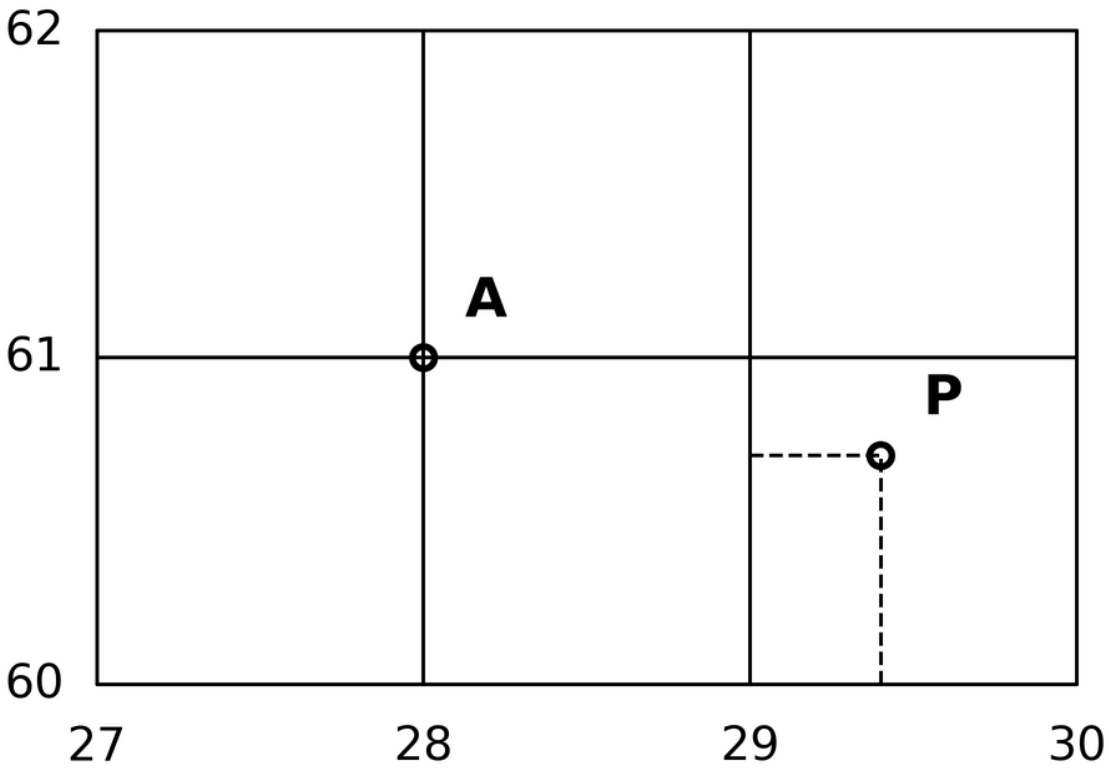


Figure 5.14

Model Answer

A six figure grid reference reads the eastings first and the northings second, each to one decimal of a square.

Read the easting: take the number of the vertical line to the left or west of the point, then estimate the tenths of the square that the point lies beyond it.

Read the northing: take the number of the horizontal line below or south of the point, then estimate its tenths northwards.

Write six digits: three digits of easting followed by three of northing, with no space or comma.

Point A sits exactly on easting 28 and northing 61, so its tenths are zero and A is **280610**. Point P lies 4 tenths past easting 29 and 7 tenths past northing 60, so P is **294607**.

False Confidence Alert
Writing the northings first reverses the point onto a different part of the sheet. Eastings always lead, so remember to walk along the corridor before climbing the stairs.

Question 33

A rescue team on the Mkomazi sheet is radioed the reference 250630 for a stranded vehicle. Show how the team converts those six digits back into a point on the map.

Model Answer

Locating from a grid reference simply reverses the reading procedure.

1) **Split the six digits:** the first three, 250, are the easting, and the last three, 630, are the northing.

2) **Find the lines:** trace vertical line 25 and horizontal line 63, because the final zeros show no tenths beyond either line.
3) **Fix the point:** the vehicle stands exactly at the intersection of easting 25 and northing 63, and had the digits been, say, 253634, the team would move 3 tenths east and 4 tenths north into the square before marking the spot.

So the six digits guide the Mkomazi team to a single crossing of two pencil lines, which is the whole genius of the grid.

Question 34

A sheet shows the meridians 30° E and 40° E ruled 14.8 cm apart, and the parallels 5° S and 10° S ruled 7.6 cm apart. Dodoma lies 8.2 cm east of the 30° E meridian and 1.8 cm south of the 5° S parallel. Determine the latitude and longitude of Dodoma by proportion.

Model Answer

Distance on the sheet is converted into angle by simple proportion between the ruled graticule lines.

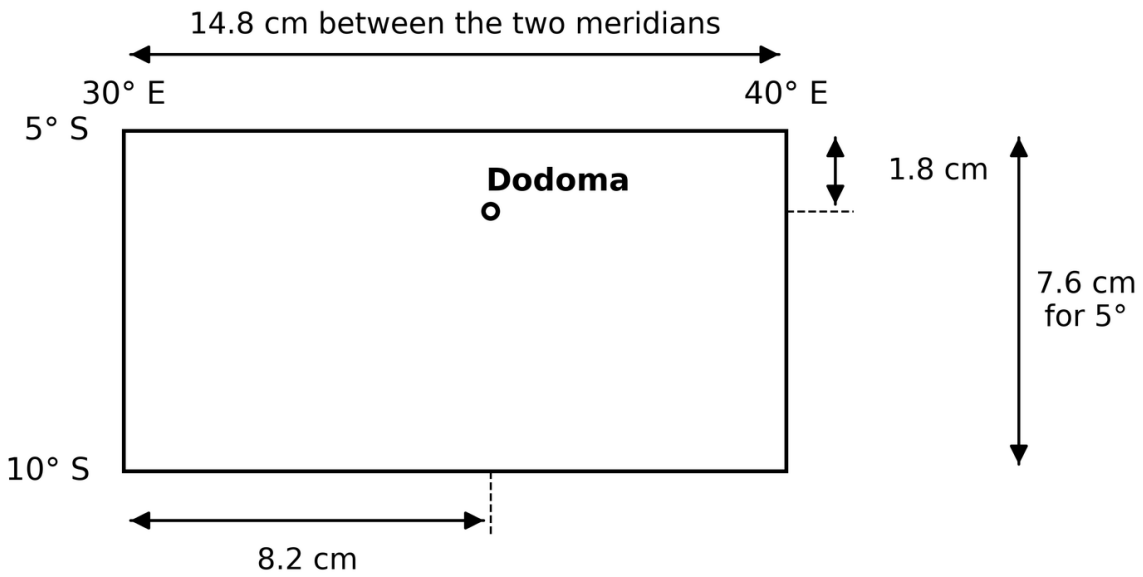


Figure 5.15: *Fixing a town between the ruled meridians and parallels*

Step 1: set the longitude proportion. A span of 14.8 cm carries 10° of longitude, so:

$$\text{angle} = \frac{8.2 \times 10°}{14.8} = 5.54°$$

Step 2: change the decimal into minutes and seconds. $0.54° \times 60 = 32.4'$, and $0.4' \times 60 = 24''$, so the angular distance is $5°32'24''$.

Step 3: add to the western meridian. Longitude $30° + 5°32'24'' = 35°32'24''$ E, because the town lies east of that line.

Step 4: repeat for latitude. A span of 7.6 cm carries 5°, so:

$$\text{angle} = \frac{1.8 \times 5°}{7.6} = 1.18°$$

Step 5: convert and add. $0.18° \times 60 = 10.8'$, and $0.8' \times 60 = 48''$, giving $1°10'48''$, so latitude $5° + 1°10'48'' = 6°10'48''$ S.

Dodoma lies at about 6°10′48″ S, 35°32′24″ E.

Interpretation. So a ruler and a proportion turn centimetres on the sheet into the global address of the capital.

Question 35

A coastal pilot approaching Mtwara names her headings NNE and ESE while the chart states 022.5° and 112.5°. Describe how direction is expressed using the cardinal and intermediate points, and relate the compass points to bearings.

Model Answer

Direction on maps is expressed through a family of compass points that grows by halving.

The four cardinal points: north, east, south and west, standing at 000°, 090°, 180° and 270°.

The eight points: adding the intermediates NE, SE, SW and NW midway between the cardinals, so NE stands at 045°.

The sixteen points: halving again to NNE, ENE, ESE, SSE, SSW, WSW, WNW and NNW, each 22.5° from its neighbours.

The link to bearings: a bearing is the same direction stated as an angle measured clockwise from north through 000° to 360°, so a reading of 045° is north east and 090° is due east.

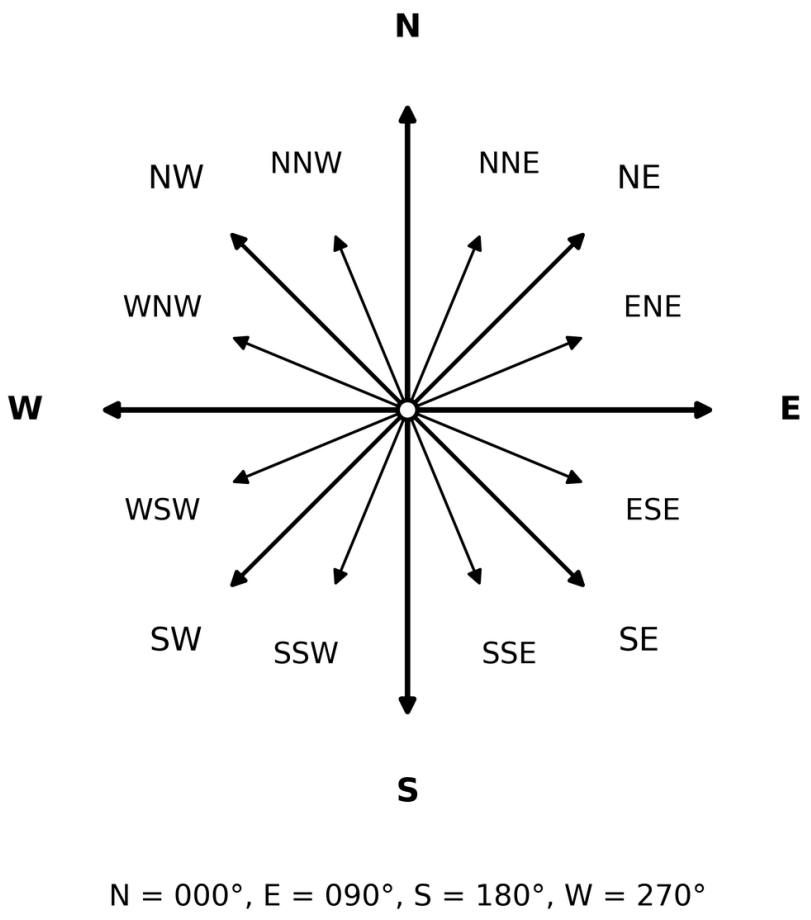


Figure 5.16: *The sixteen point compass and its bearings*

So the pilot and the chart at Mtwara speak one language in two dialects, words for the helm and degrees for the protractor.

Question 36

From a hilltop A near Mbeya a ranger sights a new fire tower B across the valley and needs its direction on the sheet. Demonstrate how a grid bearing is measured, then measure and state the grid bearing of B from A in Figure 5.17.

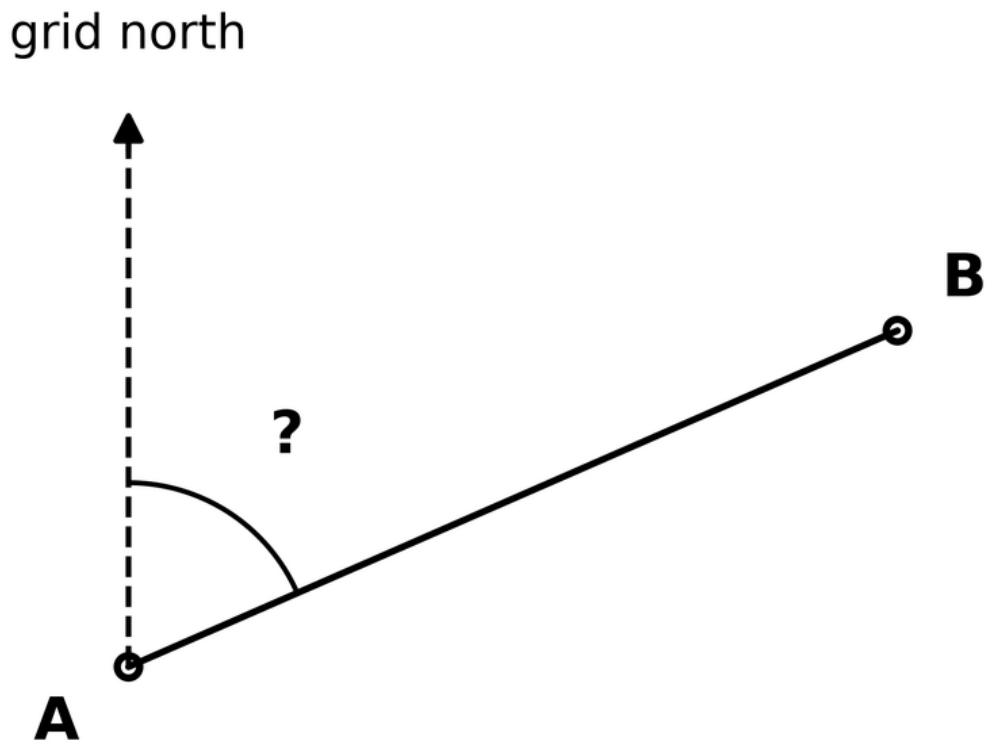


Figure 5.17

Model Answer

A grid bearing is the angle at the observing point from grid north clockwise to the line of sight.

1) **Join the points:** rule a straight pencil line from A to B.
2) **Erect grid north:** draw a line through A parallel to the vertical grid lines, because bearings on a sheet are taken from grid north.
3) **Measure clockwise:** centre the protractor at A with its zero on the north line and read the angle swept clockwise to the line AB.

In the figure the protractor sweeps **066°** from grid north to the sight line, so the tower stands on a grid bearing of 066°, which in words is east north east.

So the Mbeya ranger reports tower B at 066°, and any colleague with the same sheet can rule the same line.

Question 37

Signallers at a Monduli training camp learn that every sight line has two names, one from each end. Using Figure 5.18, explain forward and back bearing and show how one is obtained from the other.

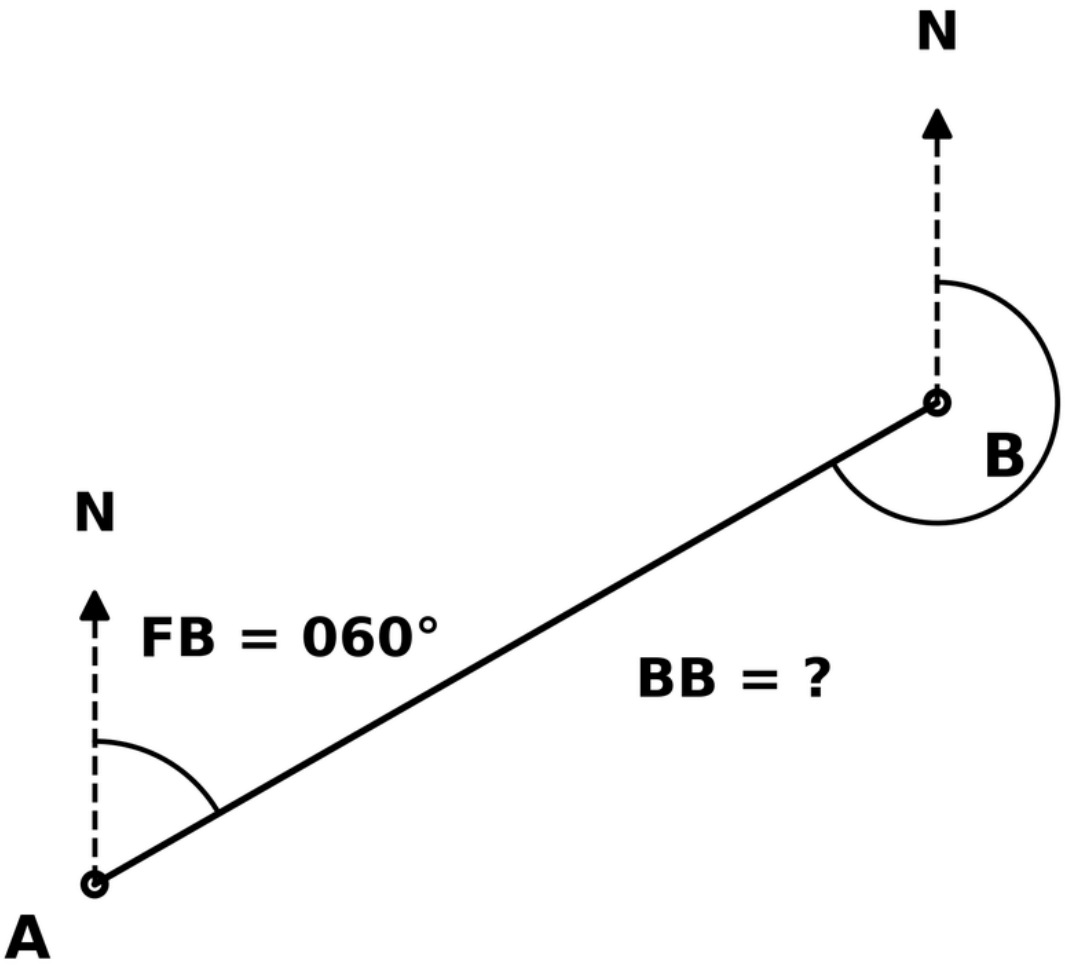


Figure 5.18

Model Answer

The forward bearing is measured from the observer to the object, and the back bearing is measured from the object to the observer along the same line.

The two are always 180° apart, so the rule is: if FB $<$ 180° then BB $=$ FB $+$ 180°, and if FB $>$ 180° then BB $=$ FB - 180°.

In the figure the forward bearing of B from A is 060°. Since 060° is less than 180°:

$$\text{BB} = 060° + 180° = 240°$$

Forward bearing 060°, back bearing 240°.

The back bearing matters because it checks the forward reading. When the two are taken in the field, their difference must be exactly 180°, and any other difference exposes an error.

False Confidence Alert
Adding 180° to every forward bearing fails when FB exceeds 180°, because a result such as 250° + 180° = 430° is no bearing at all. Past 180°, subtract instead.

Question 38

Two students at Mafinga measure the same line and return with a forward bearing of 68° and a back bearing of 250°. Detect the error in these readings and correct the discrepancy by the mean error method.

Model Answer

A correct pair differs by exactly 180°, so the surplus is split equally between the two readings.

Step 1: find the difference.

$$250° - 68° = 182°$$

Step 2: find the amount of error. The difference exceeds 180°, so a positive error of $182° - 180° = 2°$ has crept in.

Step 3: find the mean error. The two readings share the fault equally:

$$\text{mean error} = \frac{2°}{2} = 1°$$

Step 4: correct the readings. Subtract the mean error from the larger reading and add it to the smaller: $BB = 250° - 1° = 249°$ and $FB = 68° + 1° = 69°$.

Step 5: prove the correction.

$$249° - 69° = 180°$$

Corrected readings: forward bearing 069°, back bearing 249°.

Interpretation. So the Mafinga pair leave the field with readings that satisfy the 180° law, each having surrendered exactly one degree of pride.

Question 39

A candidate describing the railway near Mlimba writes only that it runs north east, and the examiner asks for the full trend. Explain trend and alignment, and complete the statement when the first measured bearing of the line is 55°.

Model Answer

Trend is the general direction of an elongated feature stated in bearings from its midpoint, and alignment is the same layout stated in compass words.

Procedure: join the two ends of the feature with a straight line, mark its middle point, erect the north line there, and measure the bearing to each end of the line.

The two angles: the second bearing lies directly opposite the first, because the feature runs through the midpoint in both directions.

Working: With the first bearing at 55°, the opposite angle is:

$$x = 55° + 180° = 235°$$

Trend 55° to 235°; alignment NE to SW; best stated as 55° NE to 235° SW.

Interpretation. So the railway near Mlimba is fully described only when the two bearings and the two compass words travel together.

Question 40

On the margin of a Tanzanian sheet three arrows lean apart, one crowned with a star, one bare, and one carrying half an arrowhead. Differentiate the three norths marked (a) to (c) in Figure 5.19.

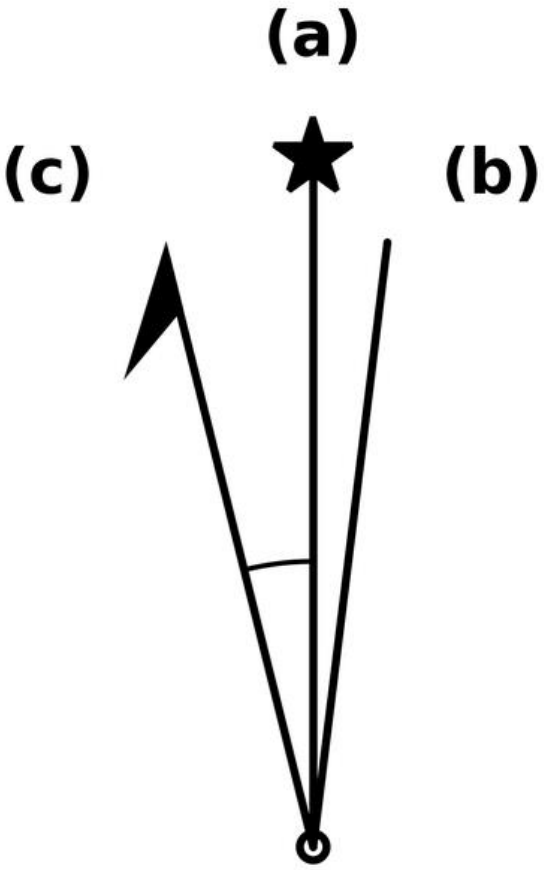


Figure 5.19

Model Answer

Maps distinguish true, magnetic and grid north.

(a) True North: the star headed line: the direction of the geographic North Pole where all meridians converge. It never changes, and angles measured from it are true bearings.

(b) Grid North: the bare line: the direction of the vertical grid lines of the sheet, parallel to the eastings of the UTM system. Angles from it are grid bearings, the ones a protractor takes on the map.

(c) Magnetic North: the half arrowhead: the direction a freely suspended compass needle points, lying in northern Canada. It migrates as the earth's magnetic field shifts, and angles from it are magnetic bearings.

Question 41

In September 2010 the magnetic variation of a survey station X near Tabora was 20°10′05″ W, and the magnetic north has been shifting eastwards at 10′ per year. Compute the magnetic variation of the station in March 2020, stating the rule you apply.

Model Answer

When magnetic north lies west of true north and shifts eastwards, the gap closes, so the total change is subtracted.

Step 1: find the elapsed time. From September 2010 to March 2020 is 9 years 6 months, which is 9.5 years.

Step 2: find the total change.

$$\mathrm{TC} = 9.5 \times 10' = 95' = 1°35'00''$$

Step 3: apply the rule. Since the shift closes the westward gap, MV = MV - TC in form, that is:

$$\text{MV} = 20°10'05'' - 1°35'00'' = 18°35'05'' \text{ W}$$

Magnetic variation in March 2020: 18°35′05″ W.

Interpretation. So station X ends the decade with its needle almost a degree and a half closer to true north than it began.

> **False Confidence Alert**
> The sign of the change follows the direction of the shift, not a fixed habit of adding. A westward variation with a westward shift would widen the gap, and only then would the total change be added.

Question 42

A coastal navigator off Mafia Island reads a magnetic bearing of 232°39′00″ to a lighthouse, and the chart states a magnetic variation of 15°26′00″ E. Determine the true bearing, and state what happens to each bearing when the variation changes.

Model Answer

When magnetic north lies east of true north, the variation is added to the magnetic bearing to give the true bearing.

Step 1: choose the rule. With an easterly variation, TB = MB + MV, whereas a westerly variation would demand TB = MB - MV.

Step 2: add the angles.

$$\text{TB} = 232°39'00'' + 15°26'00'' = 248°05'00''$$

True bearing of the lighthouse: 248°05′00″.

When the variation changes with the years, the magnetic bearing changes with it, but the true bearing remains constant, because true north itself never moves.

Interpretation. So the Mafia navigator logs 248°05′ as the permanent truth, and lets the compass reading drift around it from year to year.

Question 43

An old German era sheet of the Usambara shows slopes as fine combed strokes, while a tourist map shades its hills as if lit from one side. Identify the qualitative methods of representing relief shown at (a) to (c) in Figure 5.20, examine the limits of each, and add any other qualitative methods a sheet may use.

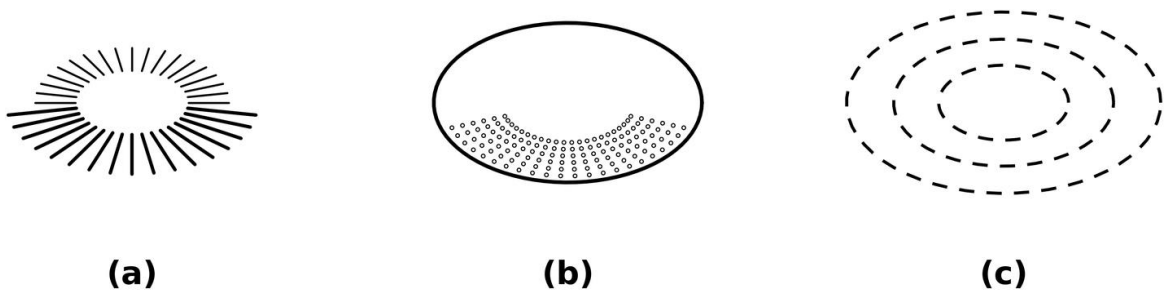


Figure 5.20

Model Answer

Qualitative methods show the shape of the land without stating heights.

(a) Hachures: short straight strokes drawn down the direction of steepest slope, growing thicker and denser as the land steepens. They picture craters and mountains vividly, but they give no actual heights, they may obscure other detail, and they consume time.

(b) Hill shading: a tint laid as if a light casts shadows, darker on steep slopes and lighter on gentle ones. It strikes the eye at once, but it can make shadowed slopes look steeper than they are.

(c) Form lines: broken, unnumbered contour like lines sketching the shape where full survey is thin; they suggest form but promise no height.

Beyond the figure: layer tinting bands elevation in colour, quick to read on atlas maps but costly and misleading where green suggests fertility; and naming simply labels a ridge or plateau in words.

So the Usambara strokes and the tourist shadows both speak the shape of the land, but neither can answer the question how high, which only quantitative methods settle.

Question 44

A candidate reading an Mbeya sheet meets numbered brown lines, a lone dot marked 512, a small triangle marked 560, and the letters BM on a wall symbol. Examine these quantitative methods of showing relief, identifying the marks (a) to (c) in Figure 5.21.

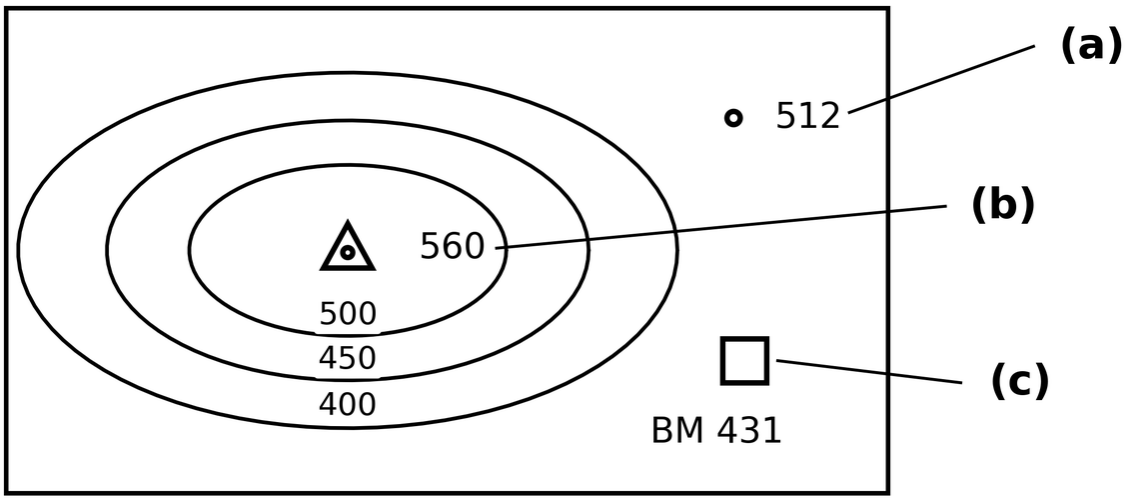


Figure 5.21

Model Answer

Quantitative methods attach measured heights above mean sea level to the map.

Contours: imaginary lines joining points of equal elevation, drawn at a fixed vertical interval. Their spacing and shapes reveal slope and landform, and they are the backbone of mathematical work such as sections and gradients.

(a) Spot heights: a dot with its exact height, such as 512, marking a surveyed point with no monument on the ground. They fill the gaps between contours, especially along roads and near summits.

(b) Trigonometrical points: a triangle with a dot and height, such as 560, marking a surveyed concrete pillar erected on a summit as a corner of the survey triangulation.

(c) Bench marks: the letters BM with a height cut on a permanent object such as a wall or bridge, serving as the reference from which levelling surveys begin.

So each symbol the candidate met is a measured promise, and together they let the Mbeya sheet be read in metres rather than impressions.

Question 45

Asked why contour lines never cross yet sometimes almost touch, a Form Six student at Babati hesitates. Examine the rules by which contour lines are drawn and read, as the panels (a) to (c) of Figure 5.22 illustrate.

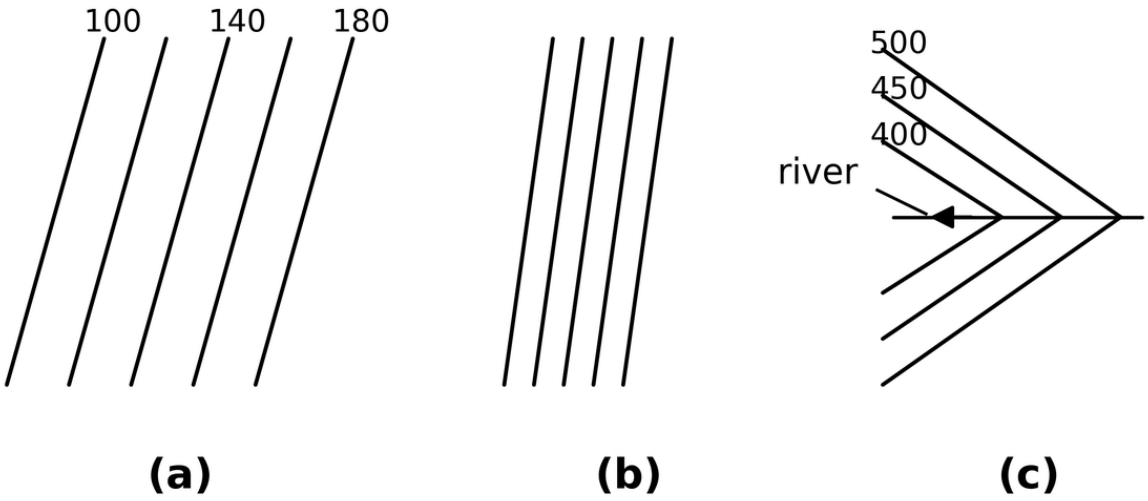


Figure 5.22

Model Answer

Contours obey firm rules, and each rule carries a meaning for the reader.

1) **Equal height:** every point on one contour stands at the same elevation above mean sea level, so a walker following it neither climbs nor descends.
2) **Fixed interval:** contours are drawn at a definite vertical interval on a sheet, such as 20 m, so their count measures height gained.
3) **Spacing shows slope:** contours far apart mean a gentle slope, and contours crowded together mean a steep one.
4) **They never cross:** one point cannot carry two heights, though at a vertical cliff contours may run so close that they appear to merge.
5) **Shape shows form:** closed rings mark a hill or a basin, a V pointing to high ground with a stream marks a valley, and a V pointing to low ground marks a spur.

So the student's puzzle dissolves, because crossing would be a contradiction of height, while near touching is simply a cliff speaking, as the rift wall above Lake Manyara shows.

Question 46

A quick sketch round in a Moshi classroom flashes six small contour patterns, and the class must name the landform of each before the next slide. Name the landform shown by each of the contour patterns (a) to (f) in Figure 5.23, and state how each is recognised.

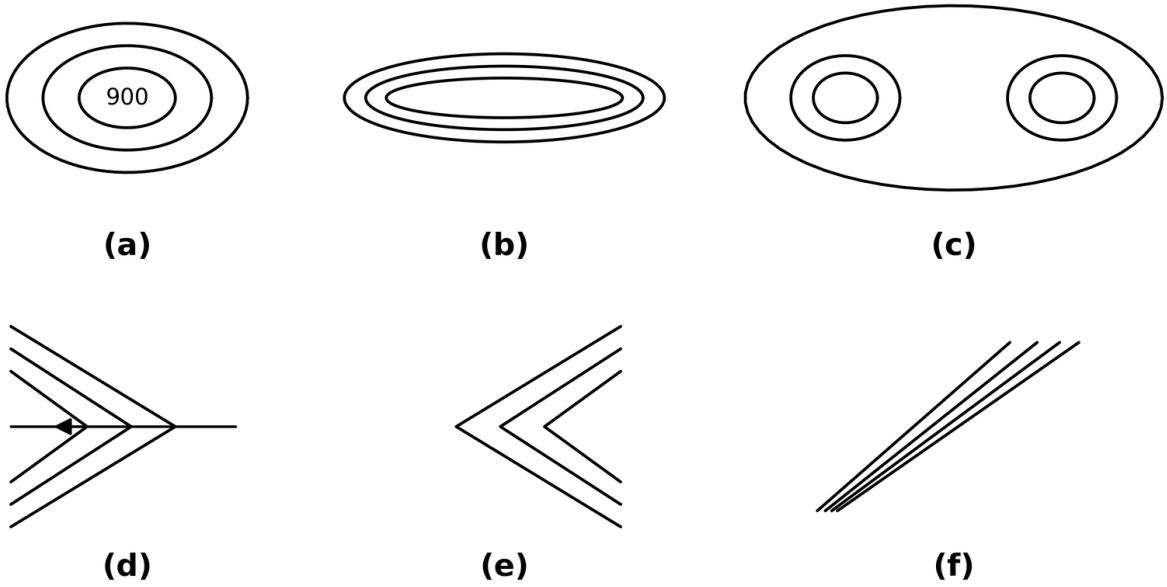


Figure 5.23

Model Answer

Each contour pattern is the fingerprint of a landform.

(a) Conical hill: closed rings rising to a small innermost ring, evenly spaced on all sides, the pattern Kilimanjaro prints on a small scale sheet.

(b) Ridge: elongated closed contours, the long crest of the Uluguru type.

(c) Saddle or col: two sets of closed rings with a low gap between them, the natural pass a road seeks.

(d) Valley: contours bent into a V pointing towards the high ground, usually holding a stream.

(e) Spur: contours bent into a V pointing towards the low ground, a shoulder projecting from a hillside.

(f) Cliff: contours so close that they nearly touch, marking an almost vertical face such as a rift wall.

Question 47

On a sheet of the Kipengere foothills, a candidate finds two labelled contours, 1 500 m and 1 000 m, separated by four silent unlabelled lines. Determine the vertical interval of the sheet.

Model Answer

The vertical interval is the height difference between labelled contours divided by the number of gaps between them.

Step 1: state the formula and its reason. With four unlabelled contours between the two labelled ones, the height difference spans $n + 1 = 5$ equal gaps, so:

$$\text{VI} = \frac{H_1 - H_2}{n + 1}$$

Step 2: substitute.

$$\text{VI} = \frac{1\,500 - 1\,000}{4 + 1} = \frac{500}{5} = 100 \text{ m}$$

The vertical interval is 100 m.

Question 48

A hiker on the Livingstone range plans a route from a stream junction at 1 000 m to a summit at 1 500 m, and the two points lie 7 cm apart on a 1:50 000 sheet. Calculate the gradient of the climb and interpret it.

Model Answer

Gradient is the vertical rise divided by the horizontal equivalent, both in the same unit.

Step 1: find the vertical rise.

$$\text{rise} = 1\,500 - 1\,000 = 500 \text{ m}$$

Step 2: find the horizontal equivalent on the ground. At 1:50 000, $1 \text{ cm} = 0.5 \text{ km}$, so $7 \text{ cm} = 3.5 \text{ km} = 3\,500 \text{ m}$, converted to metres so both terms share a unit.

Step 3: divide and simplify.

$$\text{gradient} = \frac{500}{3\,500} = \frac{1}{7}$$

Gradient 1 in 7, also written 1:7.

Interpretation. So the ground rises one metre for every seven metres the hiker walks, a stiff but honest climb.

False Confidence Alert
Leaving the horizontal distance in kilometres while the rise stands in metres inflates the slope a thousandfold. Convert both to metres before dividing.

Question 49

Asked to turn a strip of contours between two points A and B into a picture of the land, many candidates lose marks in the mechanics. Using relevant figure (s), describe the procedure for constructing a simple cross section.

Model Answer

A cross section transfers the contour crossings onto a height frame and joins them smoothly.

1) **Mark the line:** rule the line AB on the map between the two points.
2) **Transfer the crossings:** lay the straight edge of a paper along AB and tick every point where a contour crosses, writing its height at each tick, and tick a repeated contour twice because the land rises and falls.
3) **Choose the vertical scale:** pick a scale that shows the relief without wild exaggeration, such as 1 cm to 100 m.
4) **Rule the frame:** draw the horizontal base equal to AB and erect the vertical height scale at its end.
5) **Plot and join:** transfer each tick to its height in the frame, then join the points with a smooth continuous curve, never a ruler, because land does not move in straight jumps.
6) **Finish:** label A and B and state both the vertical and the horizontal scale beneath.

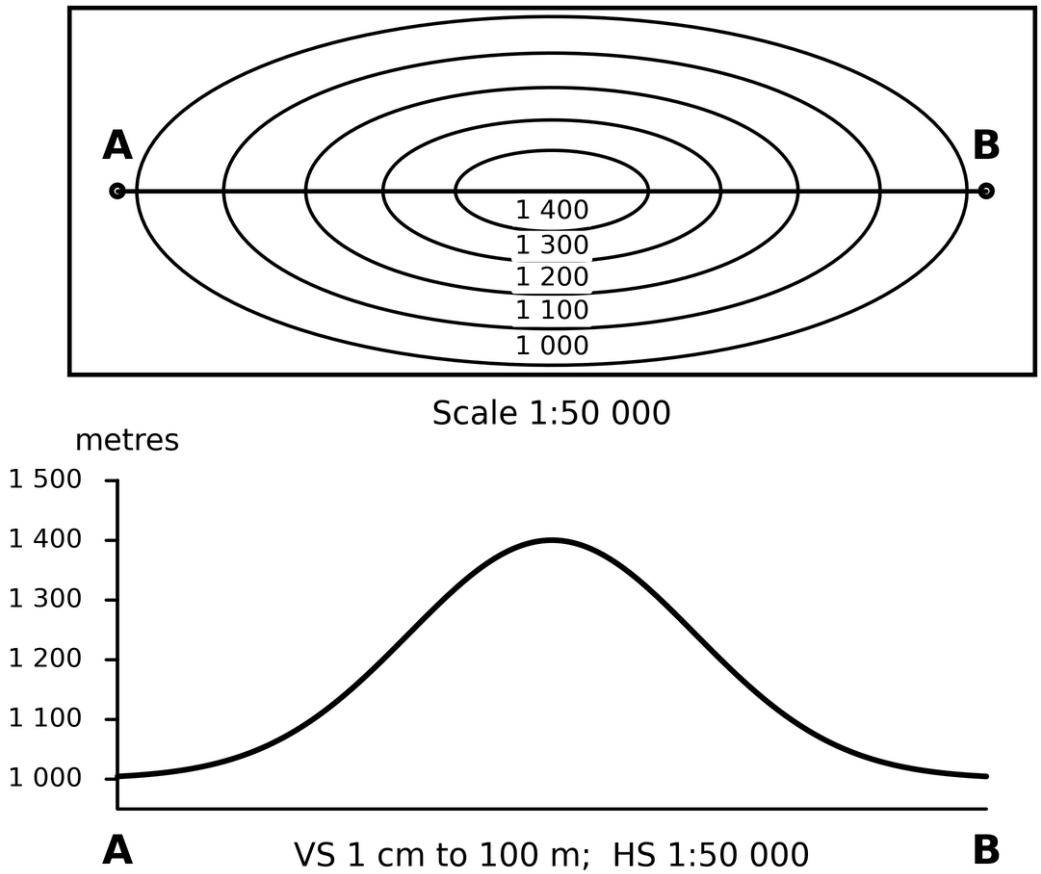


Figure 5.24: *From contour strip to plotted profile*

Question 50

A plain profile of a line across a Kilosa sheet says little until the features along it are named. With the aid of Figure 5.25, distinguish an annotated cross section from a simple one and state its value.

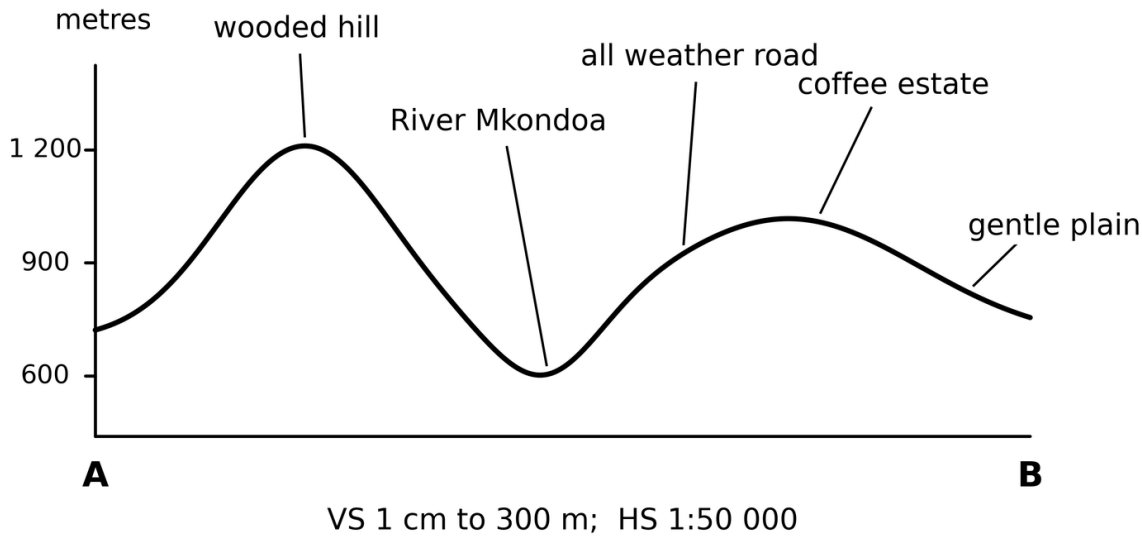


Figure 5.25

Model Answer

An annotated cross section is a simple section dressed with the information the line crosses.

The profile is constructed exactly as for a simple section, but every feature met along the line, such as a river, a road, a settlement, an estate or a forest, is marked at its true position and labelled with a vertical pointer. A sketch or transcend section, by contrast, shows only the highest and lowest points to give a rough impression.

Value one: it ties relief to human use, showing for instance that the coffee estate sits on the gentle upper slopes while the floodplain carries the river.

Value two: it supports planning, because a road engineer sees at once where the line climbs steeply and where it crosses water.

Value three: it is the natural frame for intervisibility and exaggeration questions that follow in the practical paper.

So annotation turns a bare curve above Kilosa into a small essay about how the land is lived on.

Question 51

A section drawn from a 1:50 000 sheet uses a vertical scale of 1 cm to 100 m, and the examiner asks by how much the relief has been stretched. Calculate the vertical exaggeration.

Model Answer

Vertical exaggeration compares the vertical scale of the section with the horizontal scale of the map.

Step 1: express both scales as fractions. The vertical scale 1 cm to 100 m is $1\text{ cm} : 10\,000\text{ cm} = 1{:}10\,000$, and the horizontal scale is 1:50 000.

Step 2: divide the scales.

$$\text{VE} = \frac{\text{VS}}{\text{HS}} = \frac{\frac{1}{10\,000}}{\frac{1}{50\,000}} = \frac{50\,000}{10\,000} = 5$$

Vertical exaggeration is 5.

> **False Confidence Alert**
> Vertical exaggeration has no unit. Writing 5 metres or 5 centimetres turns a ratio into a length and forfeits the mark.

Question 52

Two water tanks are proposed on hills either side of a Sao Hill forest block, and the engineers ask whether one can be seen from the other. Explain how intervisibility is tested from a map, and state with reasons whether P and Q can see each other in each of panels (a) and (b) of Figure 5.26.

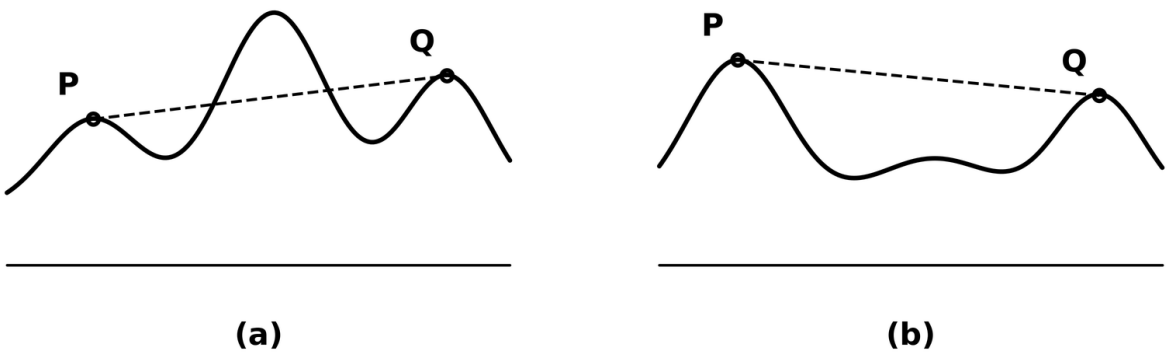


Figure 5.26

Model Answer

Two points are intervisible when no ground rises above the straight line of sight joining them.

1) **Draw the section:** construct the profile of the land along the line joining the two points.
2) **Rule the sight line:** join the two summit points on the profile with a straight line.
3) **Judge the ground:** if the profile stays below the sight line the points are intervisible, but if any ridge or spur cuts above it the view is blocked.
4) **Shortcut on the map:** rising ground between the points that stands higher than the lower point warns of blocking even before the section is drawn, whereas a valley between two summits usually leaves the view clear.

So the Sao Hill engineers need only a profile and a ruler: in panel (a) the middle ridge cuts the sight line and P and Q are not intervisible, while in panel (b) no ground reaches the line and the two points see each other.

Question 53

With help of diagram, outline a systematic way of describing relief from a topographical sheet.

Model Answer

Relief is described by altitude, by relief regions, by slopes and by named landforms, each tied to map evidence.

1) **State the altitude range:** quote the lowest and highest values on the sheet, for instance from about 600 m on the plain to above 1 600 m at the summit, and class the area highland if its average passes 1 000m.
2) **Divide into relief regions:** name the blocks the contours reveal, such as an eastern highland mass, a steep escarpment face and a western plain.
3) **Describe the slopes:** read spacing, so the crowded contours of the escarpment mean a steep face while the wide spacing westwards means a gentle plain.
4) **Name landforms with evidence:** cite the grid squares or values, such as a conical summit above 1 600 m in the north east and a river valley notching the plain.

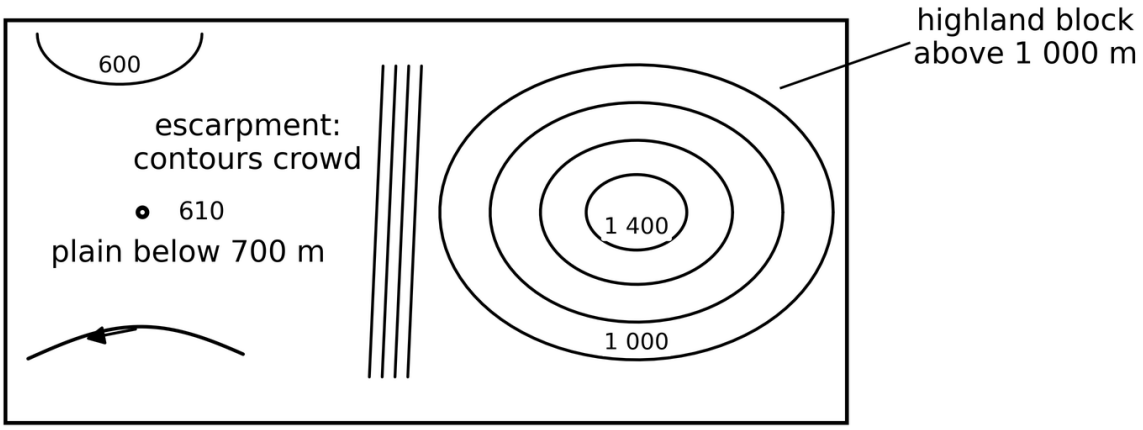


Figure 5.27: *A sheet with highland, escarpment and plain*

Question 54

Rivers on one sheet branch like a tree, on another they ladder at right angles, and on the flanks of Kilimanjaro they spill outwards like spokes. Identify the drainage patterns shown at (a) to (f) in Figure 5.28, and account for the rock or relief control behind each.

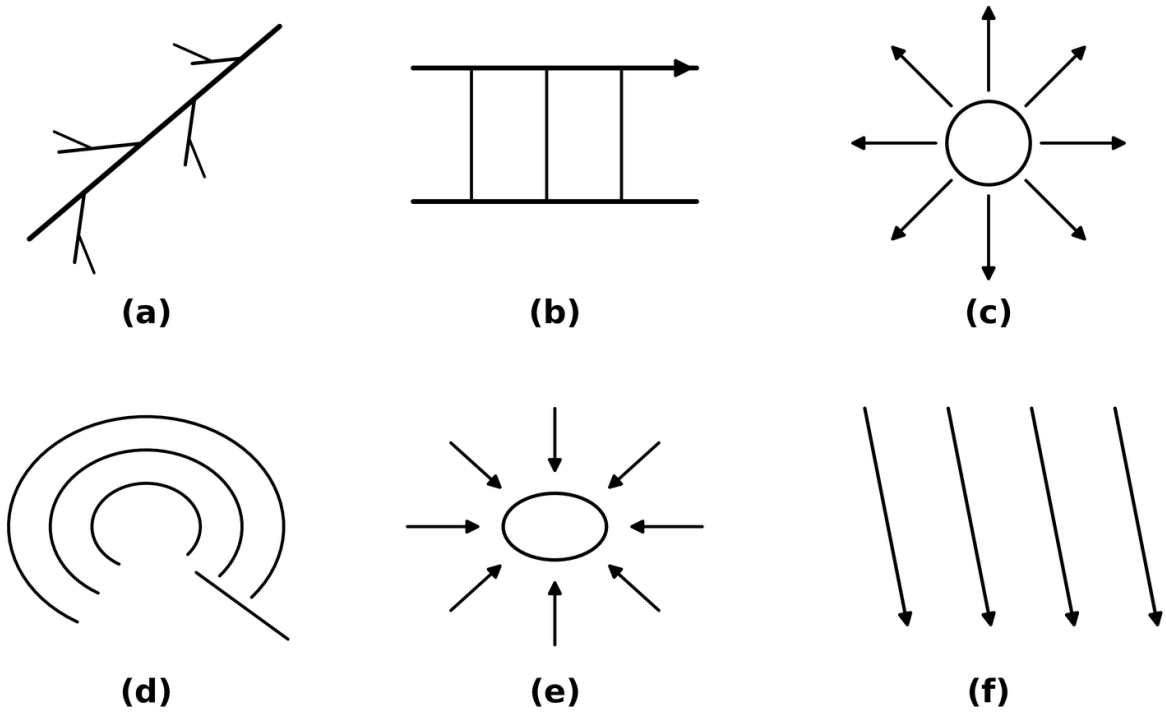


Figure 5.28

Model Answer

A drainage pattern is the plan rivers and their tributaries draw on the landscape, and each plan betrays its control.

(a) Dendritic: tributaries join the main stream at acute angles like branches of a tree. It grows on homogeneous rock such as granite or gently dipping strata, where no structure steers the water, as across much of the central plateau.

(b) Trellis: tributaries meet main streams at right angles in a lattice. It is ruled by alternating hard and soft bands in folded or scarpland country, the streams etching the weak rock.

(c) Radial: streams flow outwards down the flanks of a dome or volcanic cone, the pattern of Kilimanjaro and Meru, controlled purely by the outward gradient.

(d) Annular: streams curve in rings around a dissected dome or crater where hard and soft bands alternate concentrically.

(e) Centripetal: streams converge inwards into a basin, crater or depression, as around the Bahi depression and in parts of Kondoa, controlled by the inward slope.

(f) Parallel: streams run side by side down a uniform regional slope such as a cuesta or a newly emerged coastal plain.

Question 55

A sheet shows a nameless blue line, and the candidate must say which way the water moves without a single arrow to help. Explain the evidence used to determine the direction of river flow on a map.

Model Answer

Several silent witnesses reveal the flow.

1) **The contour V:** where contours cross a valley they bend into a V that points upstream towards the high ground, so the water flows out of the V.

2) **Tributary junctions:** a tributary meets the main stream at an acute angle that opens downstream, pointing the way the water goes.
3) **Heights along the course:** spot heights and contour values fall downstream, because water obeys gravity.
4) **Other hints:** a river leaves a lake at its lower end, grows wider downstream, and meanders more freely on the flatter lower course.

False Confidence Alert
The river does not flow the way the contour V opens. The V points upstream, so reading it as an arrow of flow reverses every river on the sheet.

Question 56

A candidate is asked to state the stage a river has reached on the mapped area. Panels (a) and (b) of Figure 5.29 show one river at two different stages. Identify the stage in each panel, the features that prove it, and the stage that lies between them.

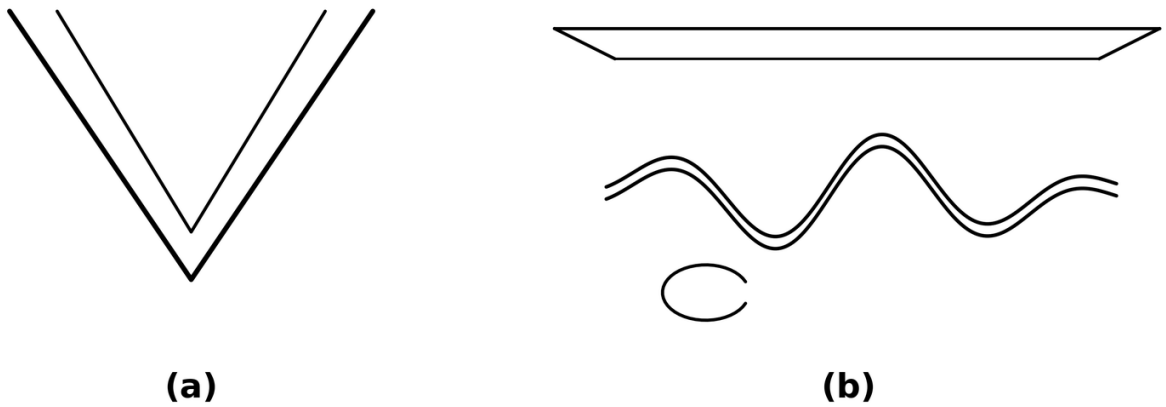


Figure 5.29

Model Answer

A river writes its age in its valley.

(a) The youthful stage: a narrow V shaped valley with contours crowding the banks, a steep gradient, rapids and waterfalls, interlocking spurs and almost no floodplain, the signature of upper courses such as the streams tumbling off the Livingstone mountains.

Between the two, the mature stage: a wider valley, gentler gradient, the first true meanders and a narrow floodplain, with tributaries fully joined.

(b) The old stage: a broad flat floodplain with widely spaced contours, sweeping meanders, ox bow lakes, braided channels and swamps, the signature of the lower Rufiji and the Kilombero valley.

So a candidate reads stage from valley shape, gradient and channel behaviour, and the Kilombero flats could never be mistaken for a mountain torrent.

Question 57

No thermometer or rain gauge is printed on a topographical sheet, yet examiners expect a climate. Account for the evidence from which climate is deduced on a map.

Model Answer

Climate is deduced from latitude, altitude, water, vegetation and crops read together.

1) **Latitude:** within about 5° of the Equator expect hot wet equatorial conditions, between 5° and 15° a tropical climate with wet and dry seasons, and between 15° and 35° increasingly dry conditions.

2) **Altitude:** temperature falls by about 6.5°C for every 1 000 m, so a station at 1 800 m is cooler than the coast by roughly 11.7°C, and high sheets carry a modified or mountain climate.
3) **Water bodies:** many perennial rivers suggest reliable rainfall, seasonal swamps and lakes suggest a marked dry season, and salt lakes, boreholes and water holes betray semi arid country.
4) **Vegetation:** forest and bamboo mean high rainfall, woodland and grassland mean moderate rainfall, and scrub, thicket and thorn bush mean little.
5) **Crops:** tea, coffee and rubber demand heavy rain, while sisal, millet and cassava tolerate drought, so the Tanga sisal belt announces its climate from the key.

So the sheet is its own weather station, because five kinds of evidence, read together, rebuild the climate that shaped them.

Question 58

Symbols for forest, scattered trees and mangrove crowd the key of a coastal sheet. Explain how vegetation is interpreted from a topographical map and what its distribution reveals.

Model Answer

Vegetation is read from symbols and names, described by position, and explained by its controls.

1) **Identify type from the key:** forest, woodland, savanna grass, bush and thicket, scrub, heath at great altitude, mangrove along tidal coasts and swamp vegetation in waterlogged basins each carry their own symbol.
2) **Describe the distribution:** state where each type lies using compass thirds, for instance thick forest on the wetter eastern slopes and scattered bush across the drier west.
3) **Explain the controls:** rainfall and altitude set the broad zones, because forest follows heavy reliable rain, scrub follows long dry seasons, heath follows the cold above 3 500 m, and mangrove follows hot silty coasts, while soils and human clearing adjust the detail.
4) **Link to climate and rock:** vegetation is itself evidence, so the mangroves of the Rufiji delta certify a hot wet coast just as thorn bush certifies semi arid Dodoma country.

So vegetation reading is a conversation, because the plants report the rain, the altitude and the soil that raised them.

Question 59

No geological column is printed on a topographical sheet, yet the rocks below can often be named. Examine the map evidence that suggests igneous, sedimentary and metamorphic rocks.

Model Answer

Rock type is inferred from landforms, drainage, water features and even the crops of an area.

Igneous country: volcanic mountains, craters and calderas, radial or annular drainage, and rich forest or tea, coffee and pyrethrum on deep volcanic soils, the signature of Kilimanjaro, Meru and Rungwe.

Sedimentary country: coral reefs and coastal plains, caves and sinking streams in limestone as at Amboni near Tanga, deltas, cliffs and depressions, salt lakes, braided and regulated channels, boreholes and water holes, with sugarcane and rice on the alluvium.

Metamorphic country: hard outcropped rock and undulating plateau surfaces with trellis drainage and thin scrubby cover, the old gneisses of the central plateau.

So rocks are named by cross examining the surface, because each family of rocks furnishes its own landforms, water and farms.

Question 60

An examiner asks which geomorphic processes have shaped the mapped area, and the only witnesses are the landforms themselves. Account for the processes that can be identified from a topographical sheet and their evidence.

Model Answer

Each internal and external process leaves a recognisable signature.

1) **Vulcanism:** cones, craters, calderas and hot springs, as on a sheet of Rungwe or Oldonyo Lengai.
2) **Faulting:** long straight escarpments, fault guided valleys and deep rift lakes, the writing of the Rift Valley walls above Lake Manyara.
3) **Folding:** parallel ridges and valleys with spurs, the grain of fold mountains.
4) **Erosion:** deep river valleys, gorges, waterfalls and dissected uplands showing material carried away.
5) **Deposition:** floodplains, deltas, levees, sand spits and swamps showing material laid down, as across the Rufiji delta.
6) **Weathering:** bare rock outcrops, tors and boulder strewn hills such as the granite tors around Mwanza.

So the sheet is a court record, because every scarp, cone, gorge and delta testifies to the process that made it.

Question 61

On one sheet the houses huddle at a crossroads, on another they string along a road, and on a third they scatter like seed. With the aid of diagram, differentiate the three settlement patterns and state how each is recognised.

Model Answer

Settlement pattern is the arrangement the dwelling symbols draw on the map.

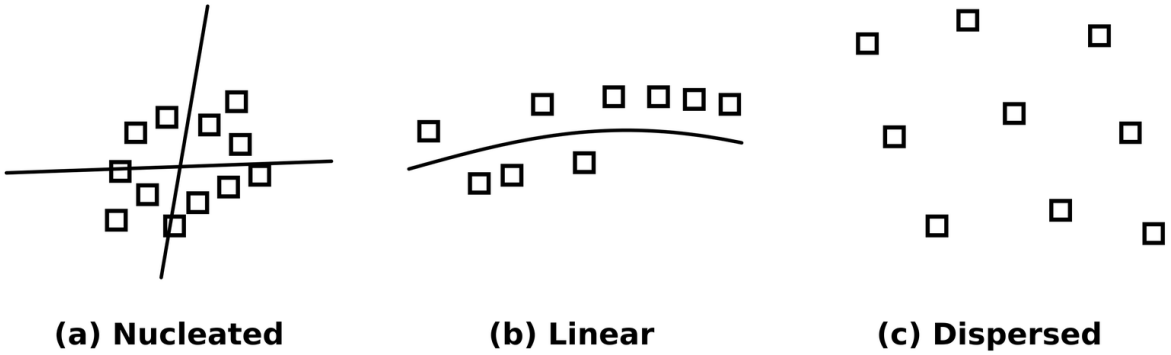


Figure 5.30: *Nucleated, linear and dispersed settlement*

Nucleated: buildings clustered closely around a nucleus such as a market, a junction, a river crossing or a water point, common in town and village centres and at borders, recognised as a dense knot of symbols.

Linear: buildings strung in a line along a road, railway, river valley or coastline, recognised as a ribbon of symbols following the route, as along the Dar es Salaam to Morogoro road.

Dispersed: homesteads scattered far apart with no clear focus, common in pastoral country such as the Maasai steppe, recognised as isolated symbols separated by open land.

So the pattern is read straight from the geometry of the dots, and each geometry hints at the life that produced it.

Question 62

Why did the village grow here and not two kilometres away? Examine the factors that influence the site and growth of settlement as they can be read from a topographical sheet.

Model Answer

Site is the ground a settlement is built on, and situation is its position relative to its surroundings, and both answer to readable factors.

1) **Relief:** flat or gently sloping land invites building, so villages avoid steep escarpment faces and crowd the level shelves.
2) **Water supply:** settlement follows rivers, lakes and boreholes, but keeps to river banks above flood level, which is a matter of situation.
3) **Soil fertility:** productive soils such as volcanic slopes carry dense farming settlement, as on the slopes of Kilimanjaro.
4) **Transport routes:** junctions, crossings and stations gather houses, because movement means trade.
5) **Defence and history:** hills and other defensible sites explain some old villages.
6) **Government policy:** planned settlement, as in the villagisation of the 1970s, places villages by decision rather than by nature.

So the map answers the opening question itself, because each cluster of symbols stands where water, level ground, soil, routes or policy put it.

Question 63

A town on a sheet is not one thing but a set of working parts. Identify the functional zones marked (a) to (f) on the town plan in Figure 5.31, giving the map evidence for each.

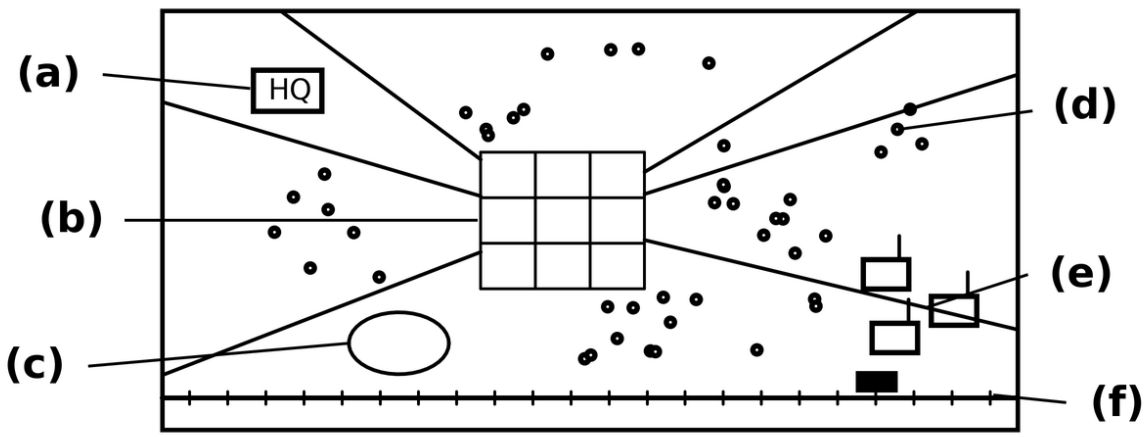


Figure 5.31

Model Answer

A town divides into functional zones that the symbols and labels reveal.

(a) The administrative zone: the HQ block in the north west, standing for the government offices, courts and police lines of a town.

(b) The central business district: the tight rectangular grid of blocks at the heart of the plan, carrying shops, offices and banks, neither residential nor industrial.

(c) The recreational zone: the stadium on the open south western ground, joined in larger towns by grounds, museums and cinemas.

(d) The residential zones: the housing dotted around the centre, densest near the business grid and thinning outwards along the roads.

(e) The industrial zone: the spacious factory plots with chimneys on the eastern leeward edge, sited so smoke blows clear of the houses.

(f) The railway with its station: the transport land along the southern edge, feeding workers and goods to every other zone.

Question 64

Land on a sheet is never idle, and the examiner may ask what it is used for. Explain how land use is interpreted from a topographical map in both urban and rural areas.

Model Answer

Land use is read from symbols, labels and the company a piece of land keeps.

Urban land uses: commercial use in the CBD grid, industrial use on spacious edge plots, residential use in the housing zones, and open space in parks, grounds and golf courses.

Rural land uses: intensive cultivation where plot and plantation symbols crowd, forestry in gazetted forest reserves, grazing on open grassland with dips and water pans, and village settlement land.

Evidence of intensity: the closeness of symbols, the size of estates and the density of routes measure how hard the land works.

Named clues: words on the sheet such as sisal estate, forest reserve or irrigation scheme settle the question directly, as the sugarcane estates do on a Kilombero sheet.

Question 65

The examiner's favourite command, describe the economic activities of the mapped area, rewards candidates who argue from symbols rather than guesswork. Account for the main economic activities and the map evidence for each.

Model Answer

Each economic activity leaves fingerprints on the sheet.

1) **Cultivation:** plot and plantation symbols, and processing marks such as a ginnery for cotton, coffee hullers, tea factories, sugar works, buying posts and maize mills.
2) **Pastoralism:** open grassland with scattered homesteads, cattle dips, water pans, boreholes, veterinary stations and quarantine camps.
3) **Manufacturing:** factory and works labels in or near towns, and large plantations implying processing plants.
4) **Trade:** markets, shops, trading centres and the converging road network that feeds them.
5) **Mining and quarrying:** quarry, mine and salt works symbols, as around Geita gold country.
6) **Logging:** saw mills and minor roads ending inside forest.
7) **Fishing:** shoreline villages, fish traps and net drying yards along lakes and the coast.
8) **Tourism:** national parks, game reserves, antiquities, hotels and camp sites, as on any Serengeti margin sheet.

So the candidate should name the activity, quote its symbol and give its grid square, because evidence is what turns a guess into a mark.

Question 66

A dispensary cross, a school S and a police post can say more about a community than a page of prose. Explain how social service activities are identified on a topographical map.

Model Answer

Social services are printed on the sheet as named institutions.

1) **Religious services:** churches, mosques and temples.
2) **Health services:** hospitals, health centres, dispensaries and clinics.
3) **Education:** schools, colleges and training centres.
4) **Administration and security:** offices marked HQ or LGHQ, courts, police posts and army camps.
5) **Recreation:** stadiums, playing grounds, cinema halls, camp sites and resorts.
6) **Water and power supply:** water tanks, taps and pipelines, power stations and transmission lines.

So a candidate reading a Tanga sheet can reconstruct the town's social life from its crosses, letters and small squares, each symbol one service.

Question 67

Roads on a sheet come in ranks, from bold double lines to fading dots, and not every district enjoys them equally. Examine how transport and communication are interpreted on a topographical map, and account for their uneven development.

Model Answer

Transport is read from the classified route symbols and their pattern.

1) **Road classes:** all weather bound surface roads in bold symbol, loose surface roads, dry weather roads and footpaths in ever lighter symbol, so the rank of a route is read from the key.
2) **Railways and airfields:** the toothed railway line with its stations, and airfield or runway symbols, as the central railway prints through Tabora.
3) **Water transport:** ports, ferries and navigable water bodies.
4) **Pattern and factors:** routes converge on towns and avoid obstacles, and their unequal development follows relief, because steep and broken country resists roads, drainage, because swamps and floodplains repel them, climate, and the weight of human activities and population that demand them.

So a sparse road net on a swampy Kigoma sheet is not neglect alone but geography, and the candidate should say which factor is at work.

Question 68

Nobody prints a census on a topographical sheet, yet candidates are asked where the people are. Explain how population distribution is deduced from a map and the factors that explain it.

Model Answer

People are counted through their works, because dwellings, services and routes stand for their makers.

Evidence of density: closely packed building symbols, many villages, dense route networks and clustered services mean dense population, while empty grids, few paths and absent services mean sparse population.

Describe by position: state where the dense and sparse belts lie using compass language and grid evidence.

Explain with physical factors: reliable water, fertile volcanic soils and gentle relief gather people, as on the Chagga slopes of Kilimanjaro, while dry, infertile or swampy country scatters them, as across the miombo of Tabora.

Explain with human factors: transport routes, towns, estates and mines concentrate labour and trade.

So the sheet is an indirect census, and the candidate reads it by moving from symbols to people to causes.

Question 69

Study the map extract in Figure 5.32, drawn at 1:50 000. A health officer cycles from the point where the road enters the sheet in the south west, at grid reference 203405, along the road to the church (Ch) at the foot of the hill. A thread laid along the road between the two points and straightened against a ruler measures 8.0 cm. (a) Calculate the ground distance of her ride. (b) Describe, with grid evidence, what the road passes on the way.

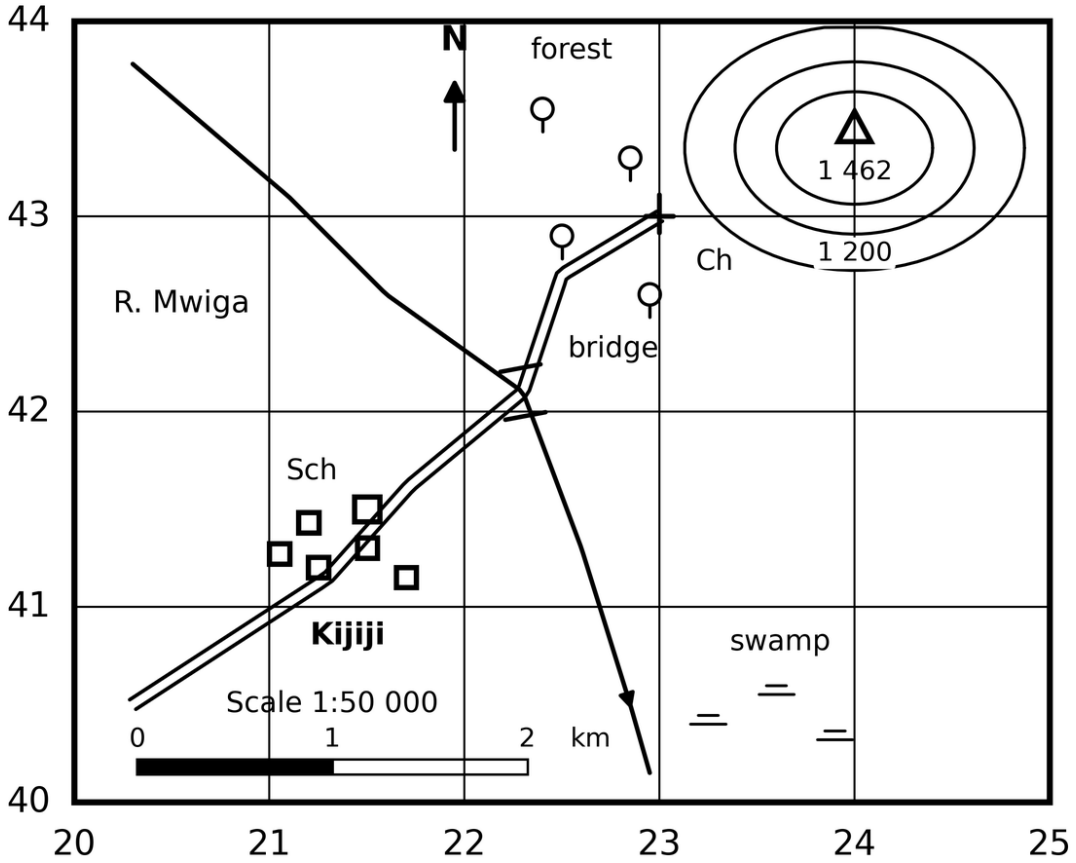


Figure 5.32: Map extract for Question 69 (scale 1:50 000)

Model Answer

(a) The thread reading converts through the statement scale.

Step 1: convert the scale. 1:50 000 gives 1 cm = 0.5 km.

Step 2: convert the thread length.

$$\text{ground distance} = 8.0 \times 0.5 \text{ km} = 4.0 \text{ km}$$

The ride is 4.0 km long.

(b) From 203405 the road runs north east, passing just south of the nucleated village of Kijiji in square 2141, with the school standing close on its western side. It crosses the River Mwiga at the bridge in square 2242, skirts the forest patch on the lower slopes in squares 2242 and 2243, and climbs to end at the church at about 230430, near the 1 200 m contour at the foot of the hill.

Question 70

Figure 5.33 shows the same district prepared for a direction exercise. (a) State the six figure grid references of the school (Sch) and the church (Ch). (b) Determine the grid bearing and the compass direction of the church from the school. (c) Name the feature at grid reference 223421 and state its use to a traveller.

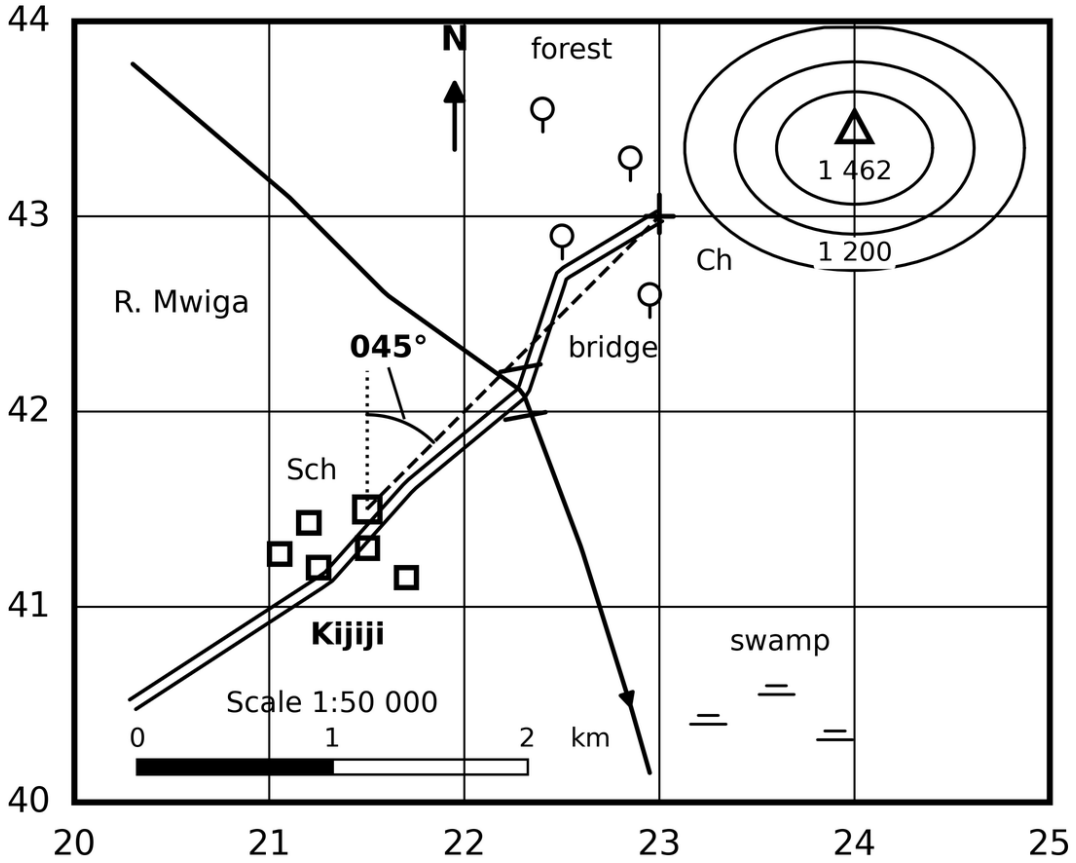


Figure 5.33: *Map extract for Question 70 (scale 1:50 000)*

Model Answer

(a) The school stands 5 tenths past easting 21 and 5 tenths past northing 41, so it is at **215415**. The church stands on easting 23 at northing 43, so it is at **230430**.

(b) Reason from the grid squares. From the school to the church the displacement is 1.5 km east and 1.5 km north, and equal eastward and northward displacement means the line runs exactly midway between north and east, so the protractor at the school reads:

$$\text{grid bearing} = 045°$$

Grid bearing 045°; compass direction north east.

(c) The feature at 223421 is the bridge where the road crosses the River Mwiga. To a traveller it is the only dry crossing of the river on this sheet, so every journey from Kijiji to the church is funnelled through it.

REAL QUESTIONS

Question 71

A candidate receives the CHEMKA extract below and one command: classify the contents of the given map, with examples. Study Figure 5.34 and answer as the examiner expects.

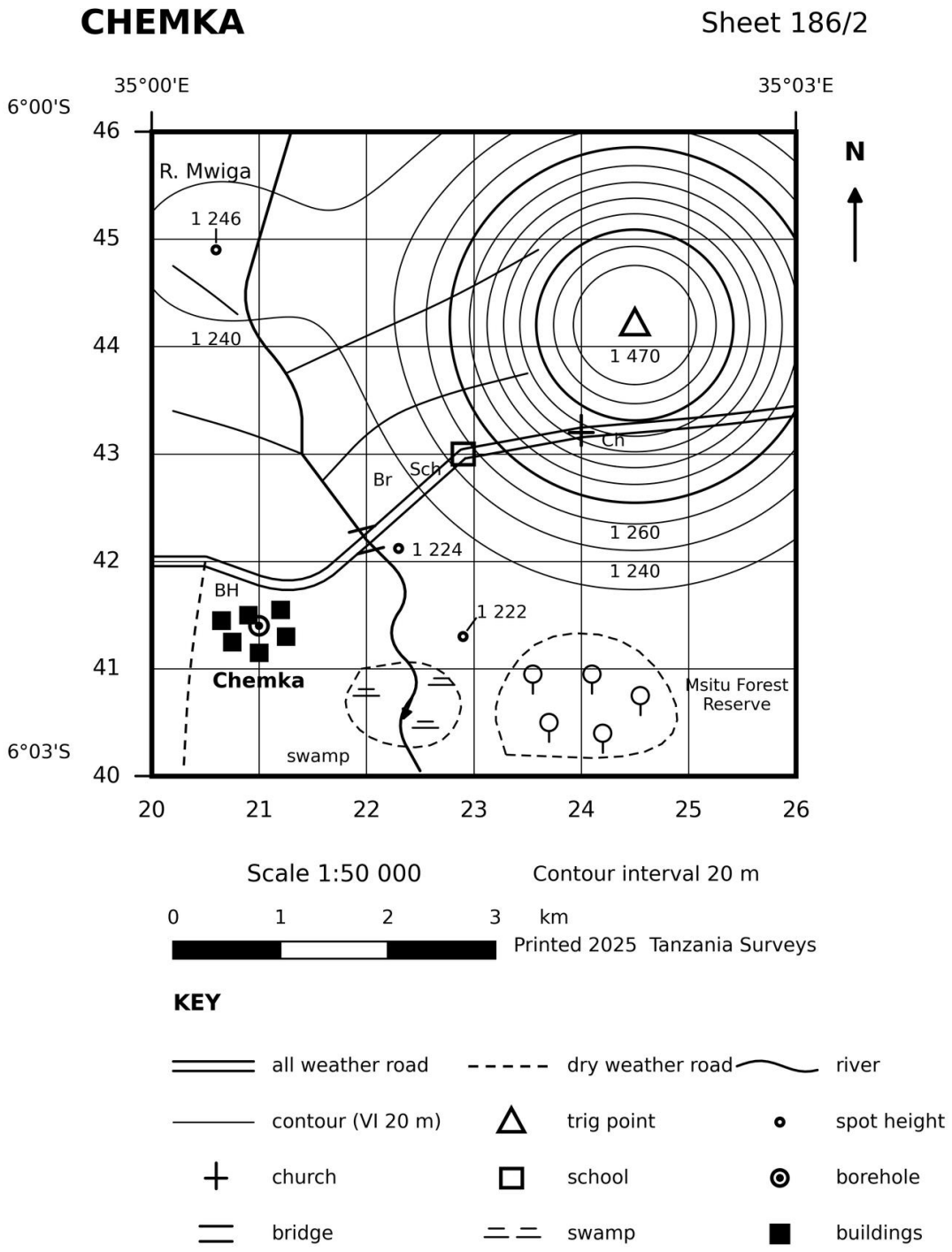


Figure 5.34: *The CHEMKA extract, Sheet 186/2*

Model Answer

The contents fall into the four standard classes, each named with map evidence.

1) Natural contents

The River Mwiga and its tributaries, the swamp on the southern floodplain, the hill mass rising above 1 400 m in the north east, and the low rise near the north west corner.

2) Cultural contents

The all weather road crossing the sheet, the dry weather road running south from the junction, the buildings of Chemka village, the school, the church, the borehole, the bridge and the Msitu Forest Reserve boundary.

3) Relief content shown by contours

Contour lines at a vertical interval of 20 m, supported by the trig point 1 470 and the spot heights 1 246, 1 224 and 1 222.

4) Supportive contents

The title CHEMKA, sheet number 186/2, the graticule values, grid numbers, scale statement with its linear scale, contour interval note, north arrow, key, and the publisher and date.

So the candidate scores by sorting what she sees into the four baskets and quoting at least one named example from the sheet for each.

Question 72

A regional planning office in Simiyu wants one map to show how population is spread across the region, and another to guide engineers laying a water pipeline through a valley. Advise the office on the right type of map for each job, with reasons.

Model Answer

The two jobs demand two different families of map.

For population distribution, a statistical map: preferably a dot map, because dots communicate the magnitude and spatial spread of one phenomenon at a glance, thickening where people concentrate and thinning where they are sparse.

For the pipeline, a large scale topographical map: because the engineers need relief, contours, gradients, rivers, existing routes and settlements together, and only a topographical sheet carries both the natural and cultural features on which the design depends.

So the office should not ask which map is best in general, because the purpose decides, a dot map for people and a topographical sheet for the pipeline.

Question 73

Before touching any calculation, an examiner awards easy marks for reading the edges of the sheet. Using Figure 5.34, identify six supportive contents of the CHEMKA extract and state what each tells the user.

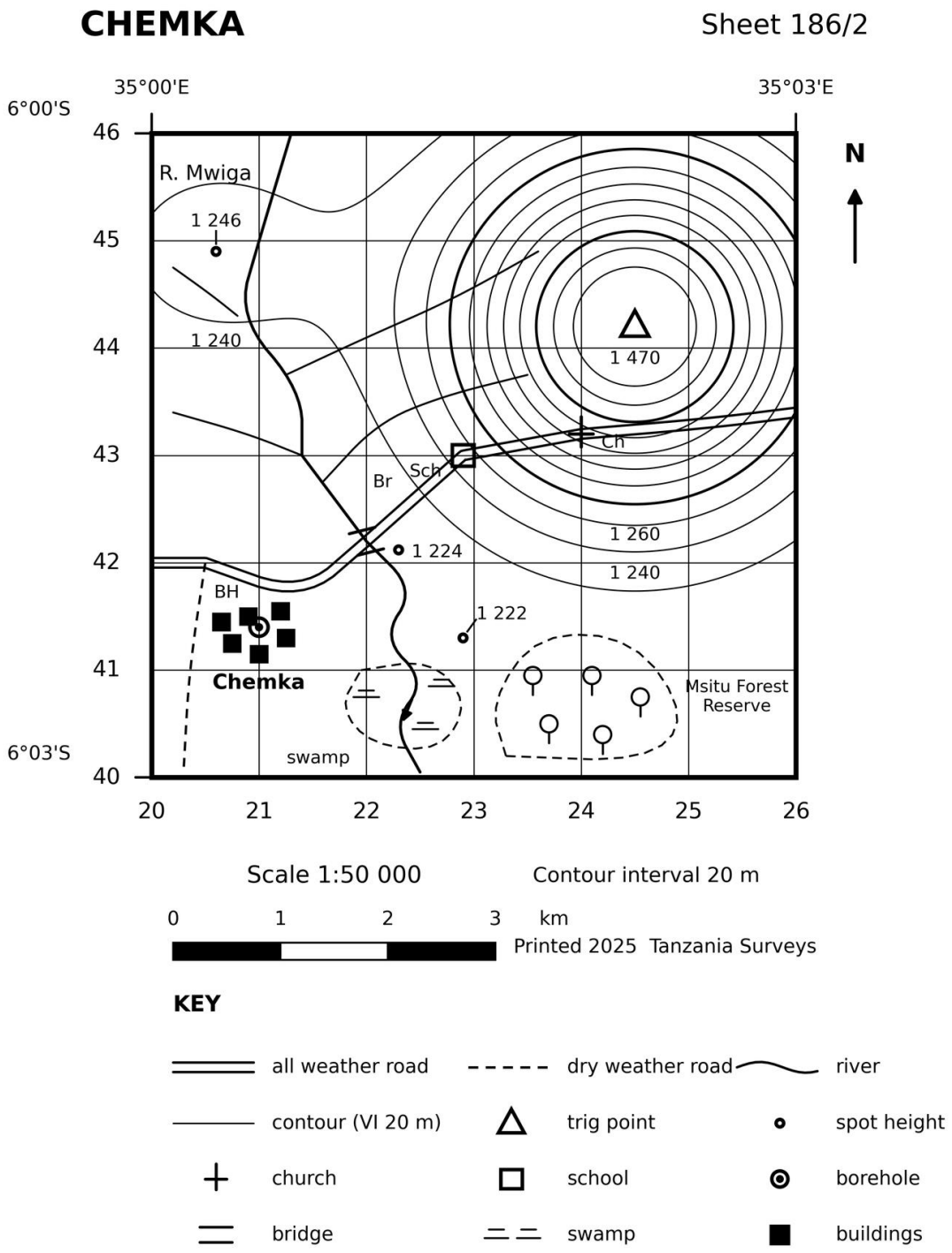


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Six marginal items and their messages are as follows.

1) **Title CHEMKA and sheet number 186/2:** they answer what and where, and they place the sheet within its national series.
2) **The graticule values:** the meridians 35°00′E and 35°03′E and the parallels 6°00′S and 6°03′S fix the extract on the globe.
3) **The grid numbers 20 to 26 and 40 to 46:** they carry the eastings and northings from which grid references are read.

4) **The scale statement, 1:50 000, with its linear scale:** it converts every map measurement into ground truth, and the bar survives any photocopying.
5) **The north arrow:** it orients the sheet so that bearings and directions can be taken.
6) **The key, the contour interval note, the publisher and the date 2025:** the key translates the symbols, the note gives the vertical interval of 20 m, and the imprint tells whose information it is and how current it is.

Question 74

On a practical paper a candidate is told only this about a sheet: it is headed CHEMKA, Sheet 186/2, and its imprint reads Printed 2025, Tanzania Surveys. Determine the type of its title, and explain what the sheet number, date and publisher each contribute.

Model Answer

The heading is a general title, and each imprint item has its own use.

Type of title: CHEMKA is a general title, because it names the mapped area only. A specific title, such as Chemka relief features, would add the purpose of the map.

Sheet number 186/2: it identifies this extract within the national 1:50 000 series, so neighbouring sheets can be found and editions can be traced.

Date of compilation: printed 2025 warns the user how current the information is, because settlement, roads and land cover keep changing, exactly as a Dodoma sheet of twenty years ago no longer shows today's city.

Publisher: Tanzania Surveys names the authority behind the map, so the user can judge its reliability and copyright.

So even without the drawing, the marginal words already declare what the map is, where it sits in the series, how fresh it is and who stands behind it.

Question 75

A candidate is asked to prepare a graphical scale of 5 km for a 1:50 000 topographical map and to show a reading of 4.7 km on it. Construct the scale and demonstrate the reading.

Model Answer

Size the baseline from the statement scale, divide it, and take 4.7 km as primary plus secondary parts.

Step 1: convert the scale. 1:50 000 gives 1 cm = 0.5 km.

Step 2: find the baseline for 5 km.

$$\text{baseline} = \frac{1\ \text{cm} \times 5\ \text{km}}{0.5\ \text{km}} = 10\ \text{cm}$$

Step 3: divide the baseline. Mark four primary divisions of 2 cm, each reading 1 km, to the right of zero, and divide the leftmost 2 cm secondary section into ten parts of 100 m each.

Step 4: show 4.7 km. Read 4 km on the primary side and add 700 m on the secondary side, so the distance runs from the 700 m mark left of zero to the 4 km mark, as the bracket in Figure 5.35 shows.

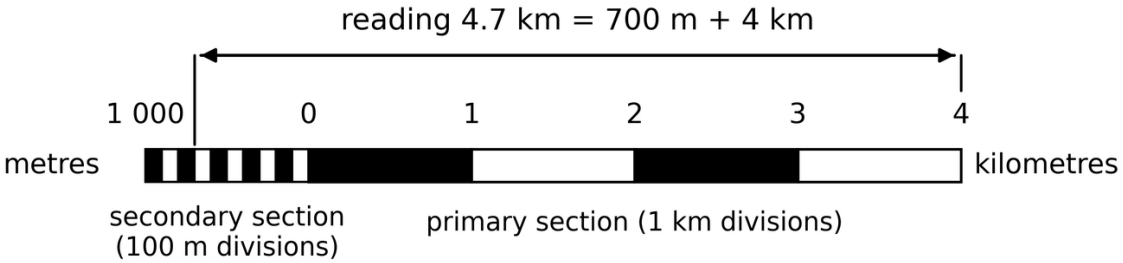


Figure 5.35: *A 5 km graphic scale for 1:50 000 showing a reading of 4.7 km*

Baseline 10 cm; reading 4.7 km = 4 km on the primary section + 700 m on the secondary section.

Question 76

A land officer at Kongwa needs the square bounded by eastings 22 and 24 and northings 42 and 44 of the CHEMKA sheet at twice its size for a site meeting. Show how the portion is redrawn at 1:25 000, and state the new dimensions.

Model Answer

Changing 1:50 000 to 1:25 000 doubles every length within the bounded part.

Step 1: find the scale factor.

$$\text{scale factor} = \frac{\frac{1}{25\,000}}{\frac{1}{50\,000}} = \frac{50\,000}{25\,000} = 2$$

Step 2: compute the new dimensions. On the sheet the two kilometre square measures 4 cm × 4 cm and each grid square 2 cm, so the redrawing measures 8 cm × 8 cm with 4 cm grid squares.

Step 3: redraw square by square. Rule the enlarged grid, then transfer the road, the river with the bridge, the school and the contours cell by cell so every feature keeps its position, and restate title, key and the new scale.

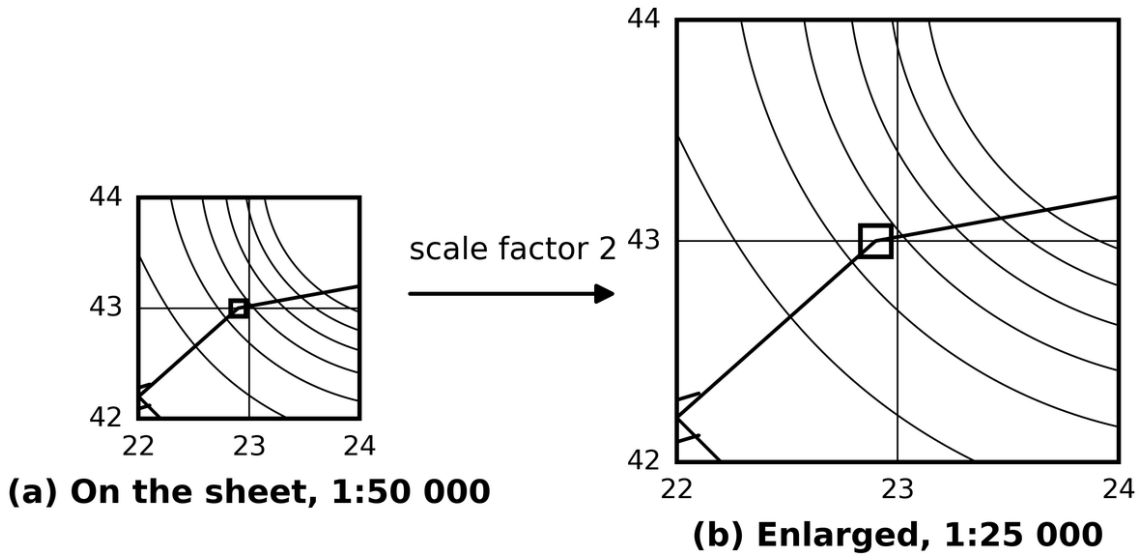


Figure 5.36: *The bounded portion of the CHEMKA sheet redrawn at 1:25 000*

New scale 1:25 000; window 8 cm by 8 cm; grid side 4 cm.

Interpretation. So the meeting copy shows the same ground twice as large but no more detailed, because enlargement magnifies the drawing, not the survey.

Question 77

The GEOGRAPHY examination once asked candidates simply to state the meaning of the scale printed on the Arusha 55/3 extract. The ZIWANI sheet carries the same scale, 1:50 000. Interpret this fraction for a user of the sheet.

Model Answer

The fraction is a unit free ratio between map distance and ground distance.

A scale of 1:50 000 means one unit of length on the map represents 50 000 of the same units on the ground. Taking centimetres, 1 cm on the sheet stands for 50 000 cm = 0.5 km of real ground, so 2 cm represent a full kilometre. Because the ratio carries no unit, an inch on the map equally represents 50 000 inches on the ground.

So the candidate who writes one centimetre represents half a kilometre has translated the fraction into working language, which is all the examiner wants before the measuring begins.

Question 78

Two sheets of the Mafinga country exist, one at 1:50 000 and an old one at 1:250 000. A student asks why the two look so different in what they show. Examine how the size of the scale influences the detail of a topographical map.

Model Answer

Scale controls coverage and detail in opposite directions.

Larger scale, more detail: at 1:50 000 one kilometre claims two centimetres of paper, so individual buildings, a borehole, a bridge and minor roads can all be drawn.

Smaller scale, more generalisation: at 1:250 000 the same kilometre shrinks to four millimetres, so villages collapse into dots, minor tracks vanish and only main rivers and roads survive.

Same ground, different questions: the large scale sheet serves site level work such as planning a school compound, whereas the small scale sheet serves regional views such as routing between districts.

So the two Mafinga sheets disagree only in sacrifice, because the smaller the scale the more the cartographer must leave out.

Question 79

With reference to the ZIWANI map sheet, justify the importance of the representative fraction (RF) scale to a map user.

Model Answer

The representative fraction is the user's conversion key.

1) **It converts measurements:** every distance and area taken from the sheet becomes ground truth only through the ratio, since 1:50 000 turns 8 cm into 4 km.
2) **It is unit free:** a reader working in centimetres and one working in inches use the same fraction without translation.
3) **It allows comparison:** the RF declares instantly whether a sheet is larger or smaller in scale than another, so the right map is chosen for the job.
4) **It warns of its own limit:** after photocopying or projection the printed fraction becomes false, which is why the sheet also carries a linear scale that shrinks and stretches with the paper.

Question 80

Study Figure 5.34. A district engineer in Chamwino District must report the length of the all weather road from the junction at 205420 to the church at 240432. A thread laid along the road between the two points and read against a ruler gives 8.0 cm. (a) Calculate the road distance in kilometres and in miles. (b) State the map distance the same stretch would occupy on a 1:100 000 sheet.

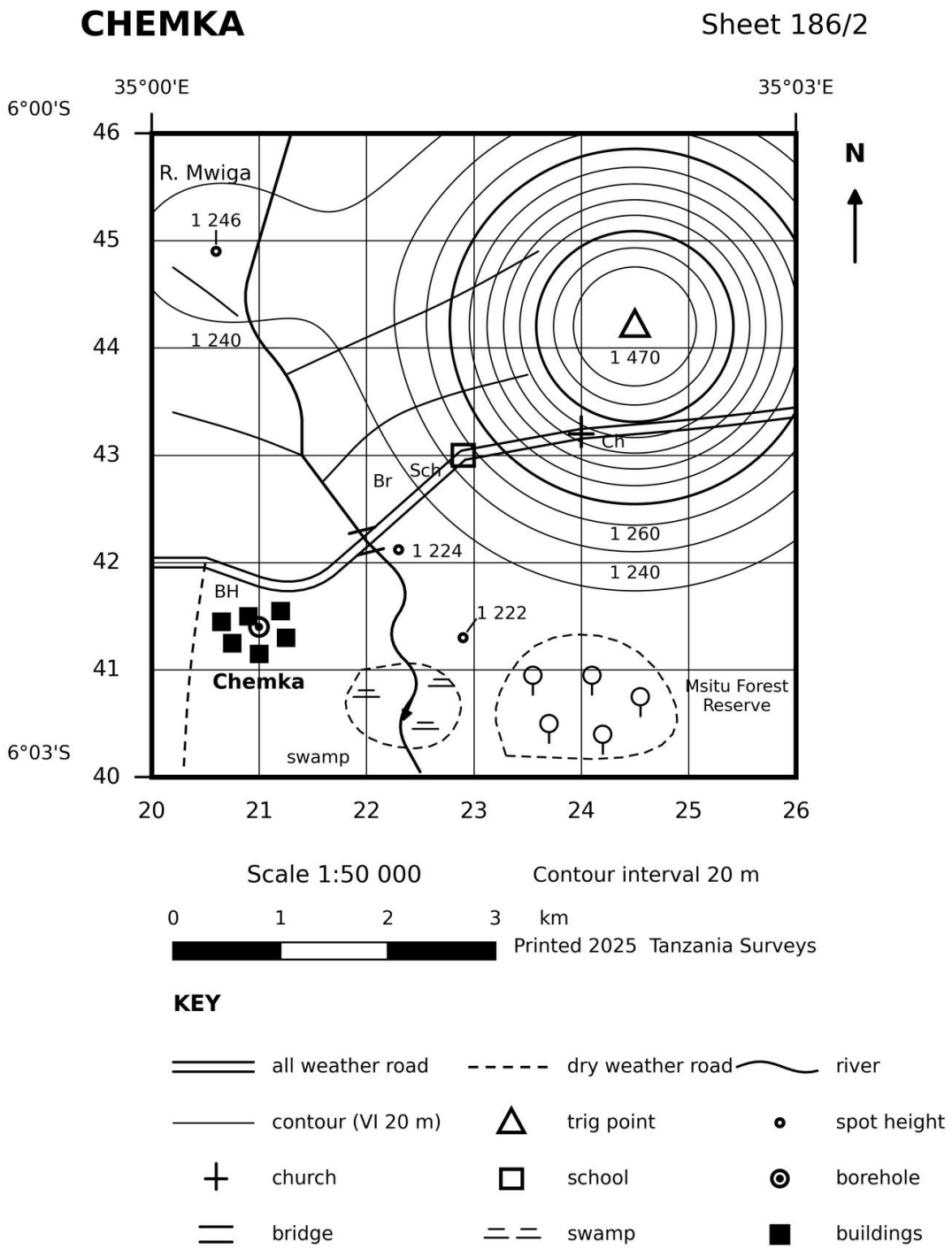


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

(a) Convert the thread reading with the statement scale, then change units.

Step 1: convert to kilometres. At 1:50 000, 1 cm = 0.5 km, so:

$$\text{ground distance} = 8.0 \times 0.5 \text{ km} = 4.0 \text{ km}$$

Step 2: convert to miles. Since 1 km = 0.621 mi:

$$4.0 \times 0.621 = 2.5 \text{ mi (to one decimal place)}$$

(b) Rescale the map distance. At 1:100 000, 1 cm = 1 km, so the same 4.0 km of road would measure only 4.0 cm on the smaller scale sheet.

Road distance 4.0 km, about 2.5 miles; on a 1:100 000 sheet it would occupy 4.0 cm.

Question 81

Using Figure 5.34, determine the length of the River Mwiga from where it enters the sheet at 213460 to the bridge at 220422, given that a thread laid along its course reads 8.4 cm.

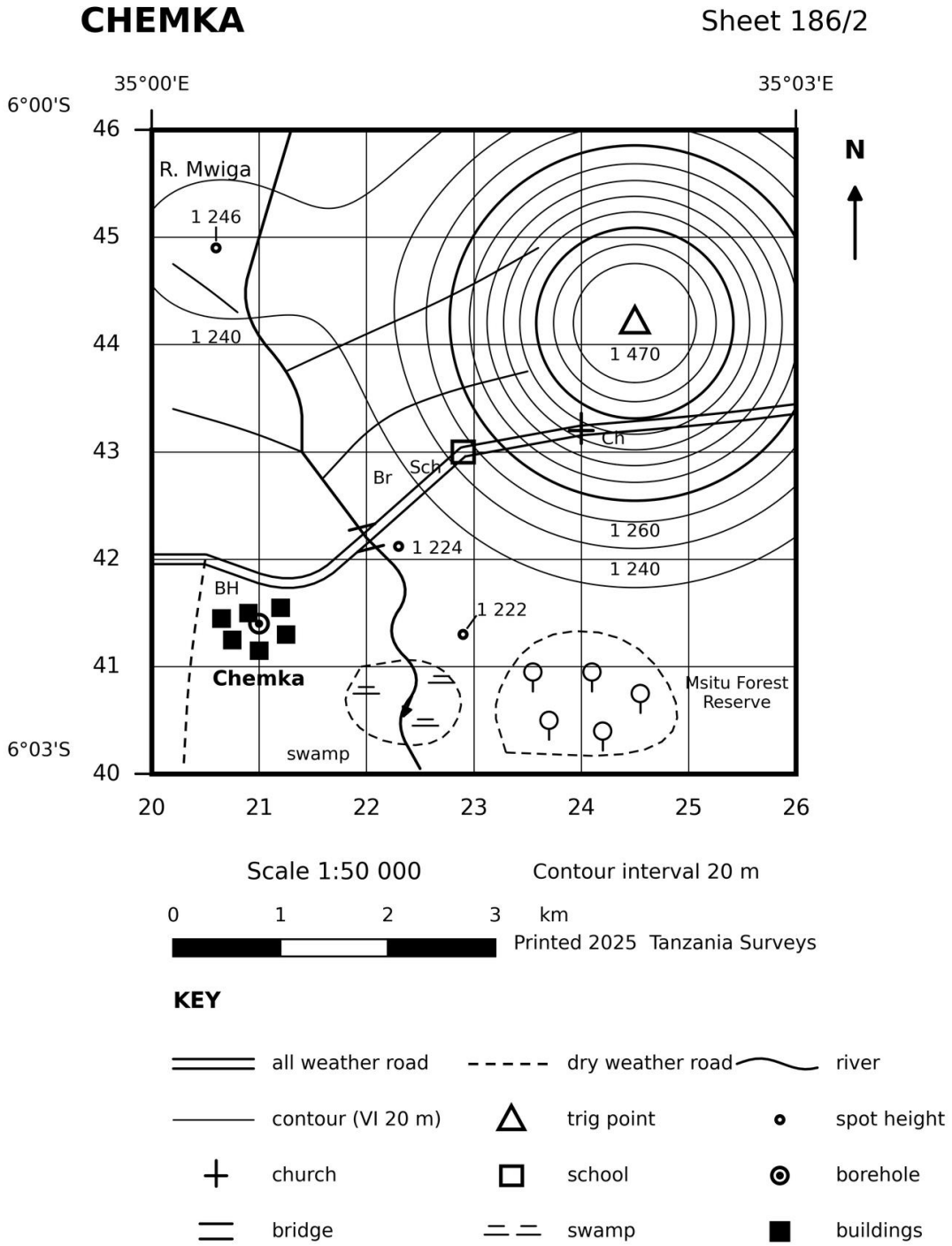


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

A winding river surrenders its length only to a thread or a stepped paper edge.

Step 1: state the method. Lay a thread along every bend from 213460 to the bridge, straighten it against a ruler, and convert with the statement scale.

Step 2: convert. At 1 cm = 0.5 km:

$$\text{river length} = 8.4 \times 0.5 \text{ km} = 4.2 \text{ km}$$

The River Mwiga runs about 4.2 km from the northern edge to the bridge.

Question 82

Using Figure 5.34, calculate the area of the Msitu Forest Reserve inside its dashed boundary by the grid square method, given that the boundary encloses no complete grid square and cuts 4 squares.

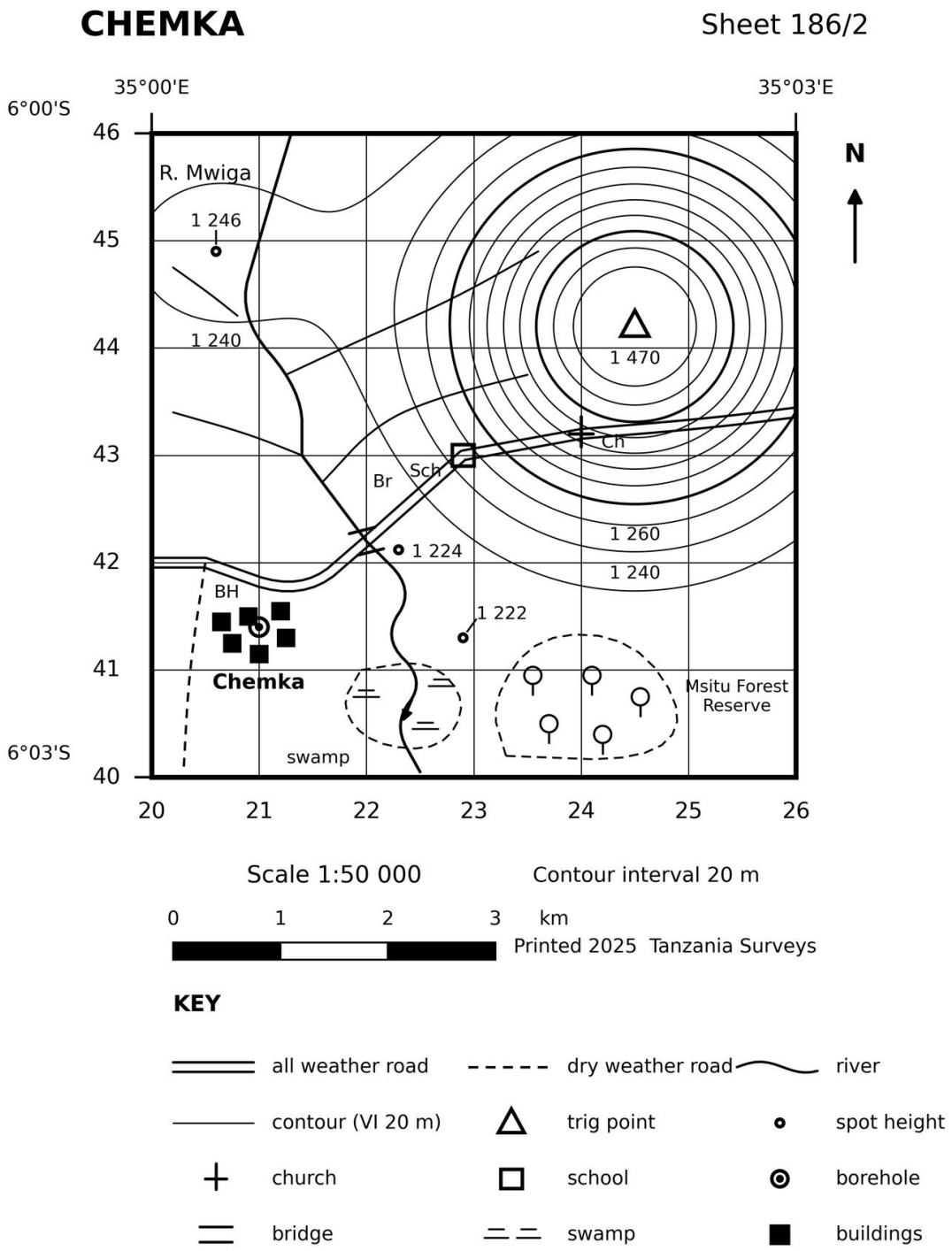


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Count complete squares fully and cut squares as halves, then convert through the square size.

Step 1: count. Complete squares $C = 0$; incomplete squares $i = 4$.

Step 2: apply the rule.

$$\text{total squares} = 0 + \frac{4}{2} = 2$$

Step 3: size one square. Each grid square is 2 cm × 2 cm at 1:50 000, which is 1 km × 1 km = 1 km^2.

$$\text{area} = 2 \times 1 \ = 2$$

The forest reserve covers about 2 square kilometres.

Question 83

The 2024 Mkomazi paper asked for the area of a tree swamp. On Figure 5.34 the swamp astride the lower River Mwiga encloses no complete grid square and cuts 2 squares. Determine its area, and state why the grid method suits such a feature.

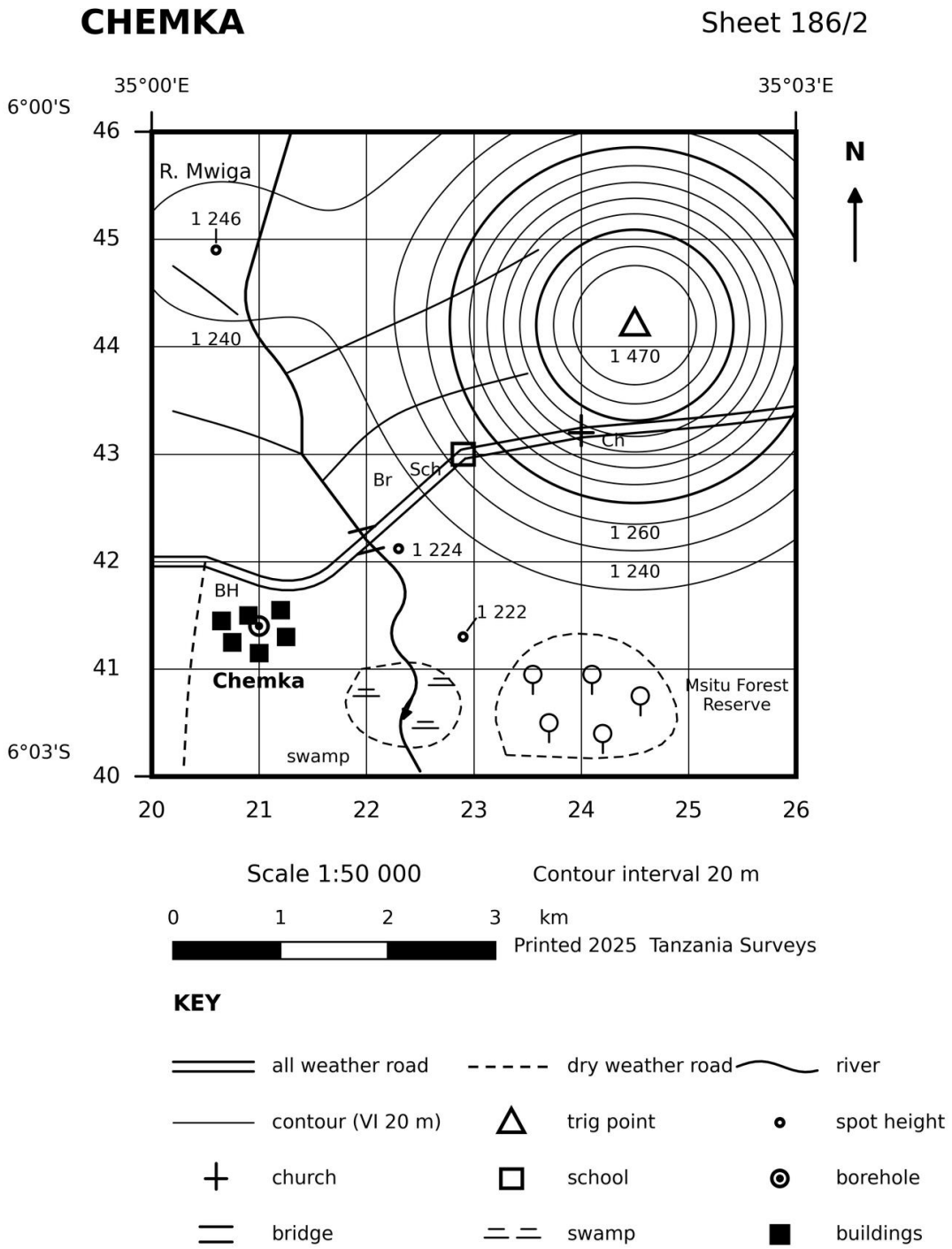


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Step 1: count and halve. $C = 0$, $i = 2$, so total squares $= 0 + 2/2 = 1$.

Step 2: convert. One grid square is $1\ km^2$ at this scale, so the swamp covers about $1\ km^2$.

Swamp area: about 1 square kilometre.

The grid method suits the swamp because its boundary obeys no formula, and counting cells with the half rule averages the ragged edge honestly, faster than strips and with no construction beyond the grid the sheet already carries.

Question 84

A GEOGRAPHY paper on the Uvinza sheet asked for the area of the district lying west of a stated easting. Apply the skill: calculate the area of the CHEMKA extract lying west of easting 21, the sheet spanning eastings 20 to 26 and northings 40 to 46.

Model Answer

The bounded part is a regular strip, so no counting is needed.

Step 1: recognise the shape. West of easting 21 lies a rectangle one grid square wide and six long, that is 1 km by 6 km.

Step 2: apply the rectangle formula.

$$\text{area} = \text{length} \times \text{width} = 6\ \text{km} \times 1\ \text{km} = 6\ \text{km}^2$$

Area west of easting 21: 6 square kilometres.

Question 85

Using Figure 5.34, determine the grid bearing and the compass direction of the bridge at 220422 from the spot height 1 222 at 229413.

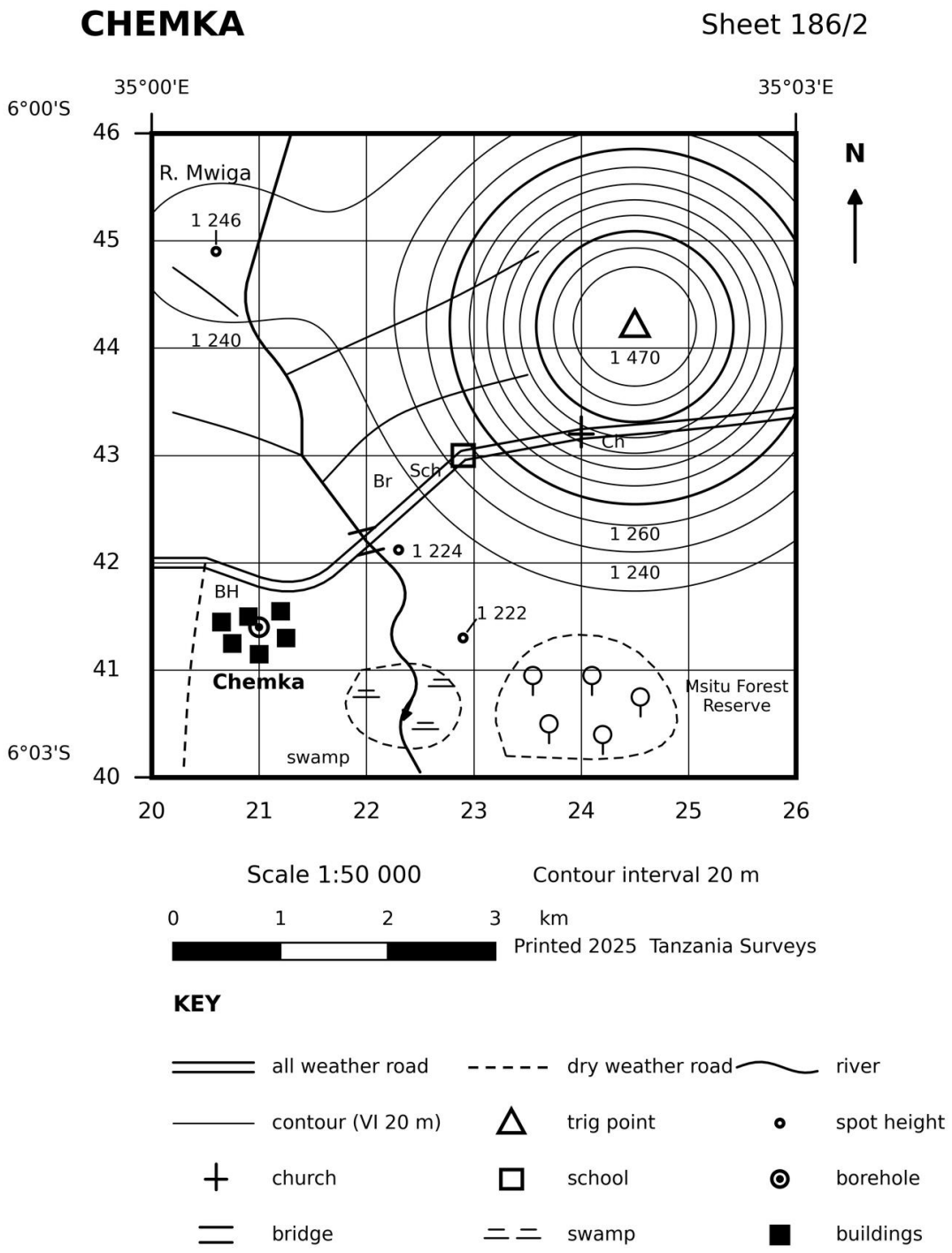


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Read the displacement from the grid references, then convert to a clockwise angle from grid north.

Step 1: find the displacement. From 229413 to 220422 the movement is 0.9 km west and 0.9 km north.

Step 2: reason the angle. Equal westward and northward displacement lies exactly midway between north (000°) and west (270°), so the protractor at the spot height reads:

$$\text{grid bearing} = 315°$$

Grid bearing 315°; compass direction north west.

Interpretation. So the bridge stands 315° from the spot height, and a protractor centred at 229413 confirms what the equal displacements already promised.

Question 86

Rural water engineers in Singida often locate new sites by bearing and distance. On Figure 5.34, a surveyor walks from the borehole at 210414 on a grid bearing of 050° for 2.5 km. Fix the point reached, state its six figure grid reference, and name the feature standing there.

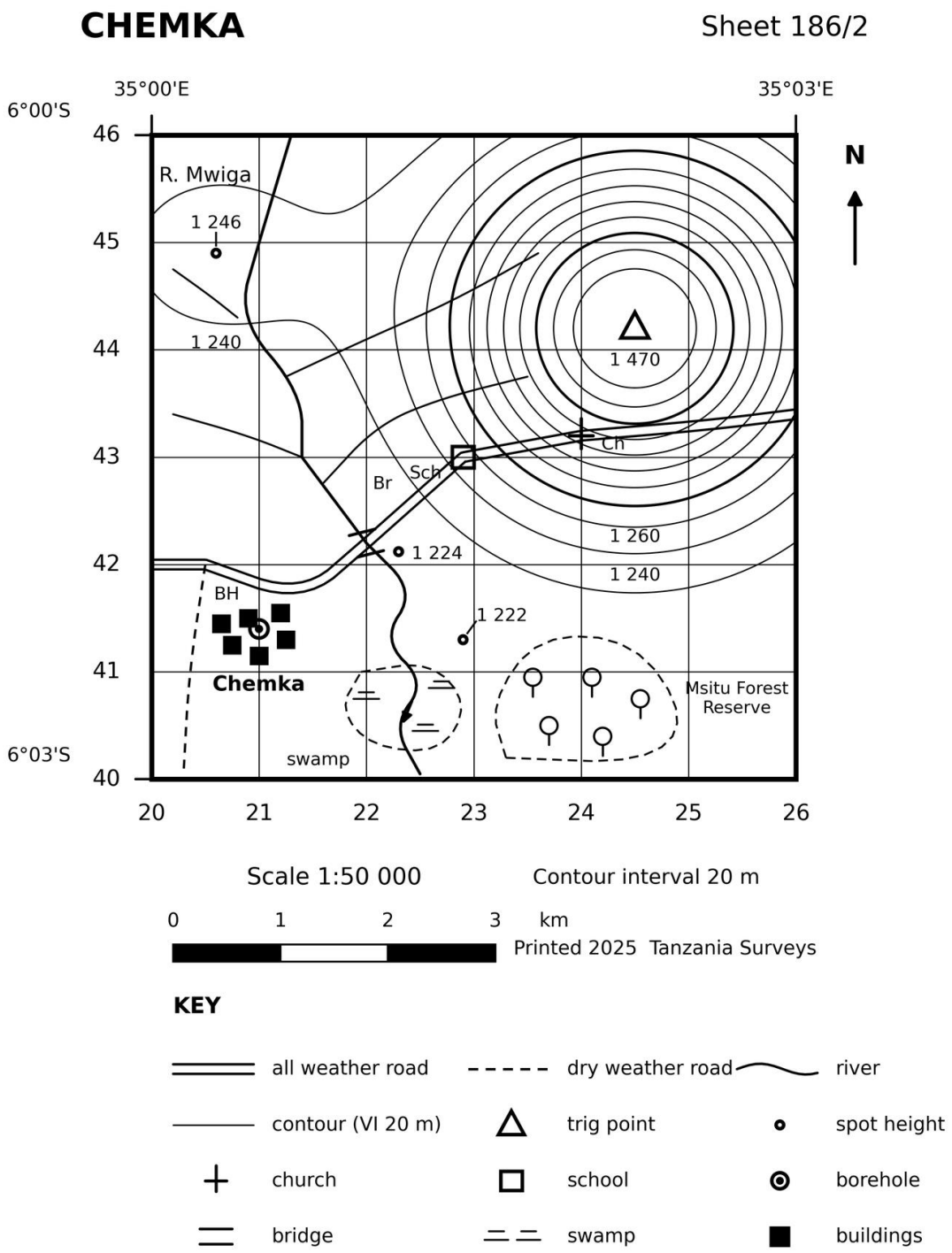


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Plot the ray, cut it at the scaled distance, and read the reference back.

1) **Draw the ray:** erect grid north at 210414 and draw a line at 050° clockwise from it.
2) **Cut the distance:** at 1:50 000 the 2.5 km walk is 5.0 cm along the ray.
3) **Read the point:** the ray ends on the school beside the all weather road, at grid reference 229430.

Point reached: 229430; the feature is the school.

Interpretation. So bearing plus distance pins a single point on the sheet, and the surveyor arrives at the school gate, not merely near it.

Question 87

Surveyors often locate features by intersecting bearings taken from two known points. On Figure 5.37, the factory chimney bears 045° from the church at grid reference 224427 and 315° from the school at grid reference 248427. Locate the chimney by intersection and state its grid reference.

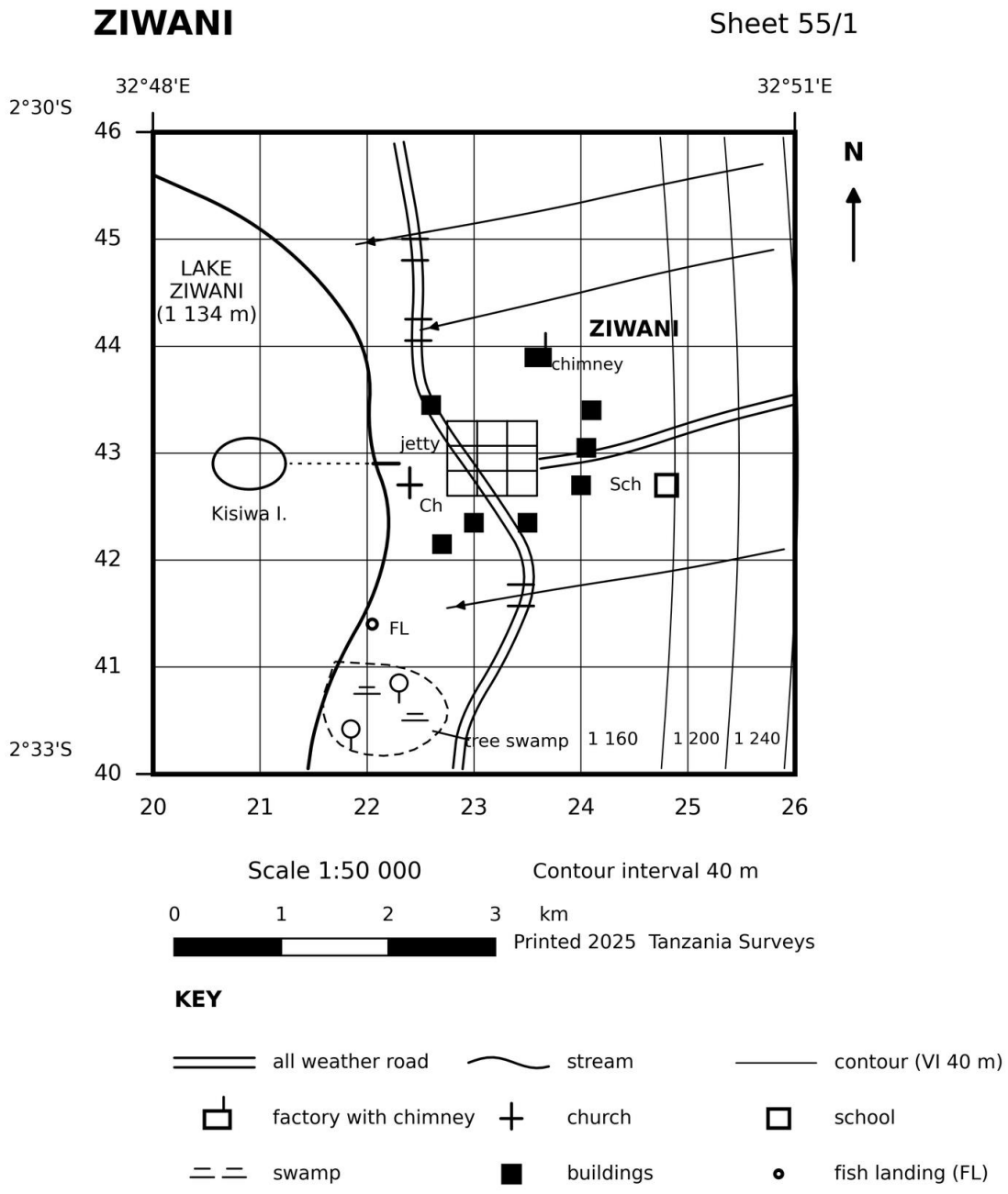


Figure 5.37: *The ZIWANI extract, Sheet 55/1 (scale 1:50 000)*

Model Answer

Two forward bearings from known points cross at the unknown point.

1) **Set the north lines:** erect grid north at the church and at the school.
2) **Draw the rays:** from the church draw 045°, and from the school draw 315°, both measured clockwise.
3) **Read the crossing:** the two rays intersect at the factory with the chimney, north of the town centre.

The chimney stands at grid reference 236439.

False Confidence Alert
Intersection uses the forward bearings exactly as observed from the two known points. Adding 180° to them belongs to resection, when the observer stands at the unknown point; mixing the two methods places the chimney on the wrong side of the town.

Question 88

A surveyor standing at the jetty at grid reference 223429 needs to locate the centre of Kisiwa Island. On Figure 5.37, determine the grid bearing and compass direction of the island from the jetty, and calculate the straight-line distance between them.

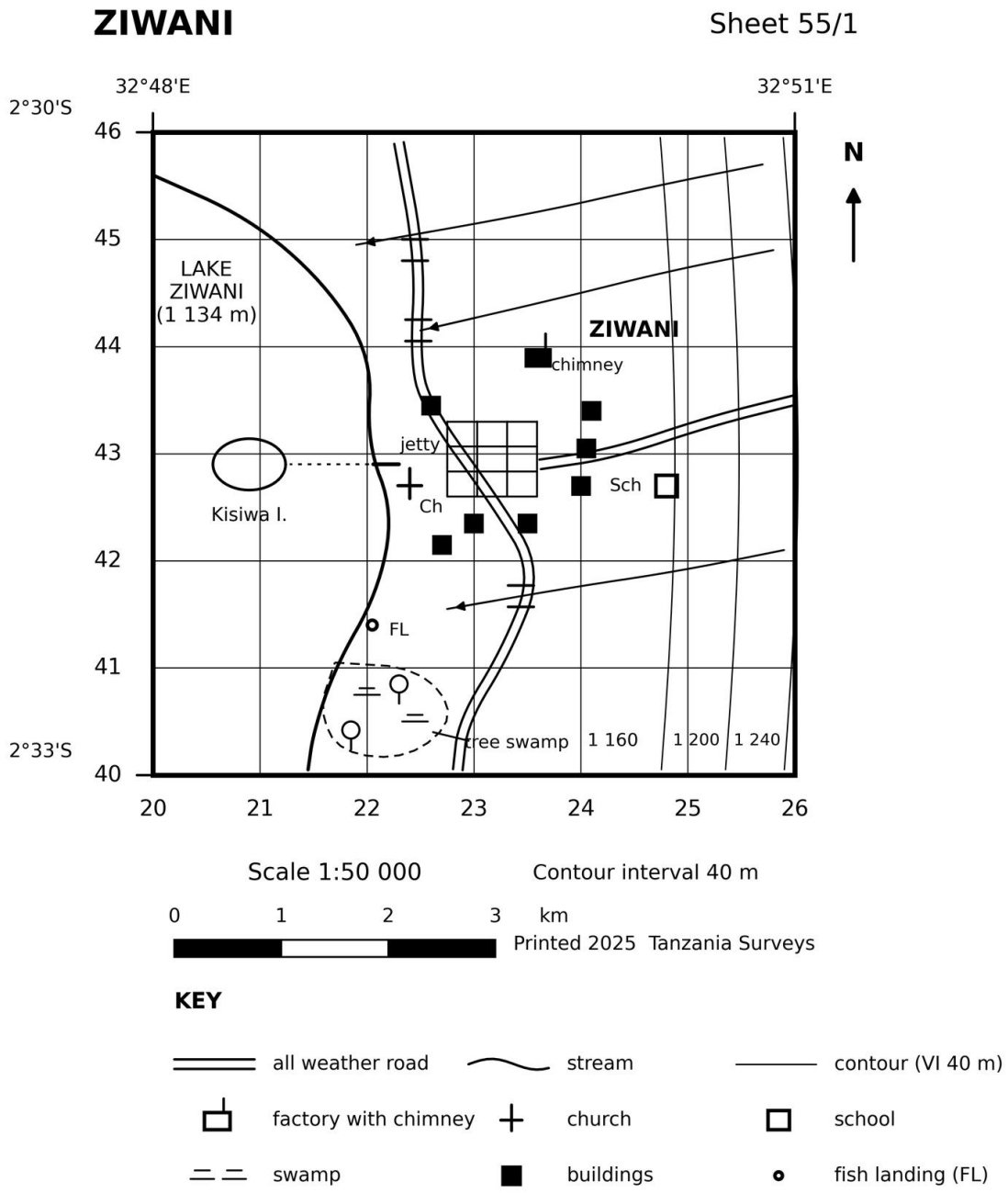


Figure 5.37: *The ZIWANI extract, Sheet 55/1 (scale 1:50 000)*

Model Answer

Step 1: read the displacement. From the jetty at 223429 to the island centre at 209429 the movement is 1.4 km due west, with no northward change.

Step 2: state the bearing. Due west measured clockwise from grid north is:

$$\text{grid bearing} = 270°$$

Step 3: convert the distance. The separation of 1.4 km measures 2.8 cm on the sheet at 1 cm = 0.5 km.

Bearing 270°, due west; distance about 1.4 km across the water.

Question 89

During a land survey, a surveyor records a forward bearing of 256° and a back bearing of 78° for the same line. Identify the error and correct the discrepancy using the mean error method.

Model Answer

A healthy pair differs by exactly 180°, so first measure the sickness.

Step 1: find the difference.

$$256° - 78° = 178°$$

Step 2: find the amount of error. The difference falls short of 180°, so the error is $178° - 180° = -2°$.

Step 3: halve it.

$$\text{mean error} = \frac{-2°}{2} = -1°$$

Step 4: correct both readings. Subtract the mean error from the larger reading and add it to the smaller, observing its sign: $FB = 256° - (-1°) = 257°$ and $BB = 78° + (-1°) = 77°$.

Step 5: prove.

$$257° - 77° = 180°$$

Corrected readings: forward bearing 257°, back bearing 077°.

Question 90

A survey conducted on Kibo Hill recorded a magnetic bearing of 120°35′25″ and a true bearing of 75°30′36″ in September 2010. At the time, magnetic north was shifting eastwards at a rate of 20′ per year. Determine the magnetic variation of Kibo Hill in May 2026.

Model Answer

First recover the 2010 variation from the two bearings, then move it through time.

Step 1: find the initial variation. The magnetic bearing exceeds the true bearing, so magnetic north lies west of true north and $MV = MB - TB$:

$$MV = 120°35'25'' - 75°30'36'' = 45°04'49'' \text{ W}$$

Step 2: find the elapsed time. September 2010 to May 2026 is 15 years 8 months = 15⅔ years.

Step 3: find the total change.

$$TC = 15⅔ \times 20' = 313'20'' = 5°13'20''$$

Step 4: apply the shift rule. An eastward shift closes a westerly gap, so the change is subtracted:

$$MV = 45°04'49'' - 5°13'20'' = 39°51'29'' \text{ W}$$

Magnetic variation of Kibo Hill in May 2026: 39°51′29″ W.

Interpretation. So by May 2026 the needle at Kibo Hill points more than five degrees closer to true north than it did in 2010, while the true bearing of the summit has never moved.

False Confidence Alert
MB greater than TB is itself the compass declaring that magnetic north lies west of true north. Assuming an easterly variation because the shift is eastward confuses the position of the needle with the direction of its drift.

Question 91

A surveyor is required to prepare an annotated cross-profile between two known points. Using Figure 5.34, describe how the profile from the borehole at grid reference 210414 to the trig point at grid reference 245442 is constructed, and present the finished annotated section.

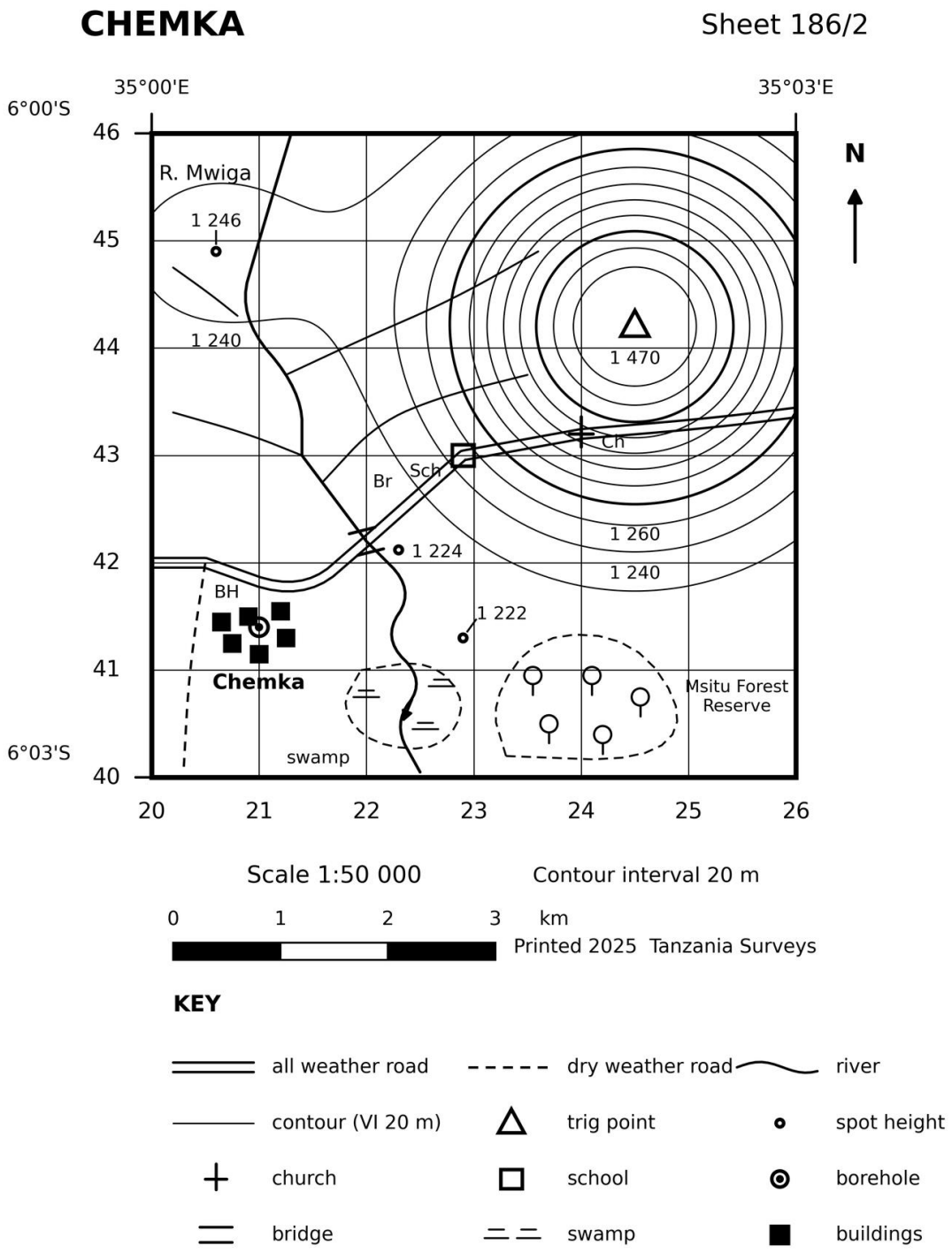


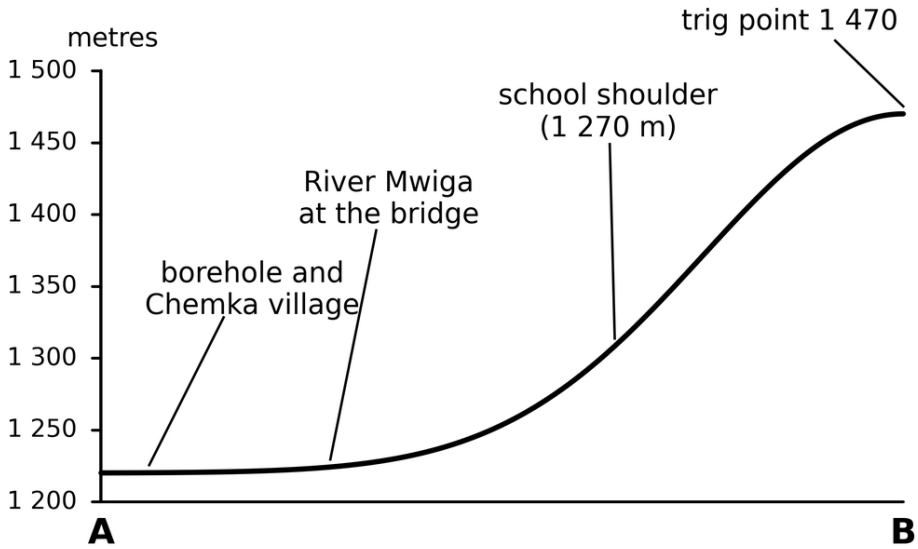
Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The section line is drawn, its contour crossings are ticked, and the ticks become a smooth annotated curve.

1) **Rule the line:** join 210414 to 245442; on the sheet the line measures 9.0 cm, which is about 4.5 km of ground.
2) **Tick the crossings:** lay a paper edge along the line and mark every contour it cuts, from the 1 240 ring near the river up through 1 260, 1 280 and each 20 m line to 1 440, writing the heights at the ticks.
3) **Choose the vertical scale:** here 1 cm to 50 m, tall enough to show the climb without caricature.

4) **Plot and annotate:** transfer the ticks to the height frame, join them with a smooth curve, and label the features the line crosses, the village and borehole, the River Mwiga at the bridge, the school shoulder at 1 270 m and the summit trig at 1 470 m.



VS 1 cm to 50 m; HS 1:50 000; A = borehole (210414), B = trig point (245442)

Figure 5.38: *The annotated cross profile from the borehole (A) to the trig point (B)*

So the profile turns the sheet's silent contours into a visible climb of 250 m across four and a half kilometres, exactly the drawing the Mpanda item rewards.

Question 92

A candidate drawing a section from a 1:50 000 sheet chooses a vertical scale of 1 cm to 50 m, as in the CHEMKA profile. Determine the vertical exaggeration of such a section.

Model Answer

Vertical exaggeration divides the vertical scale by the horizontal scale.

Step 1: express the vertical scale as a fraction. 1 cm : 50 m is 1 cm : 5 000 cm = 1:5 000.

Step 2: divide the scales.

$$\text{VE} = \frac{\text{VS}}{\text{HS}} = \frac{\frac{1}{5\,000}}{\frac{1}{50\,000}} = \frac{50\,000}{5\,000} = 10$$

Vertical exaggeration = 10.

Question 93

Using Figure 5.34, calculate the gradient from the school, which stands beside the spot value 1 270 at 229430, to the trig point 1 470 at 245442. Express the answer in the form 1 in n and interpret it.

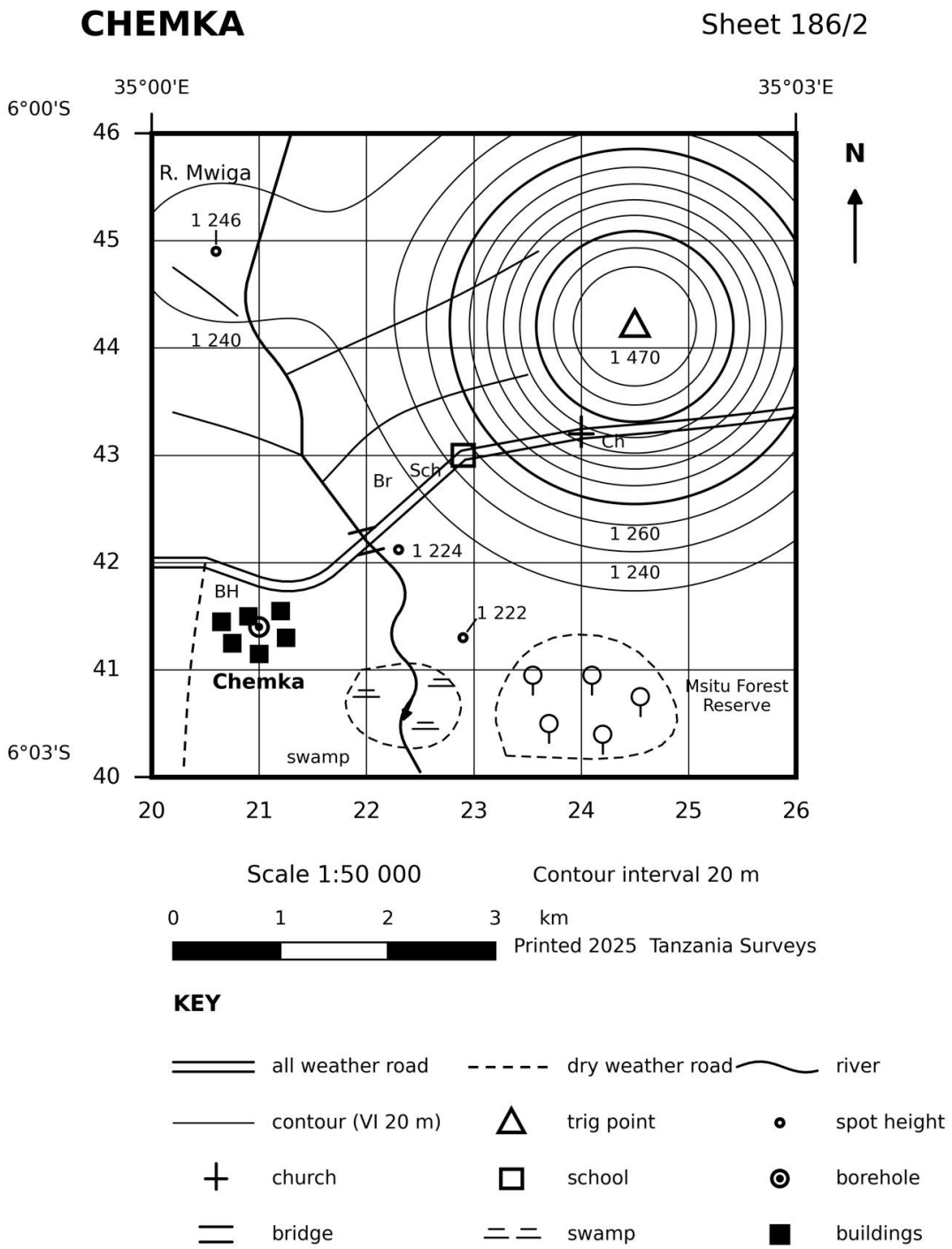


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Gradient is vertical rise over horizontal equivalent in the same unit.

Step 1: find the rise.

$$\text{rise} = 1\,470 - 1\,270 = 200 \text{ m}$$

Step 2: find the horizontal equivalent from the references. From 229430 to 245442 the displacement is 1.6 km east and 1.2 km north, so:

$$\text{HE} = \sqrt{1.6^2 + 1.2^2} = 2.0 \text{ km} = 2\,000 \text{ m}$$

Step 3: divide and simplify.

$$\text{gradient} = \frac{200}{2\,000} = \frac{1}{10}$$

Gradient 1 in 10.

Question 94

Relief on a topographic map can be represented by more than one method. Study Figure 5.34 and identify the method, other than contour lines, used to show relief on the CHEMKA extract. Describe how this method represents the nature of the land surface.

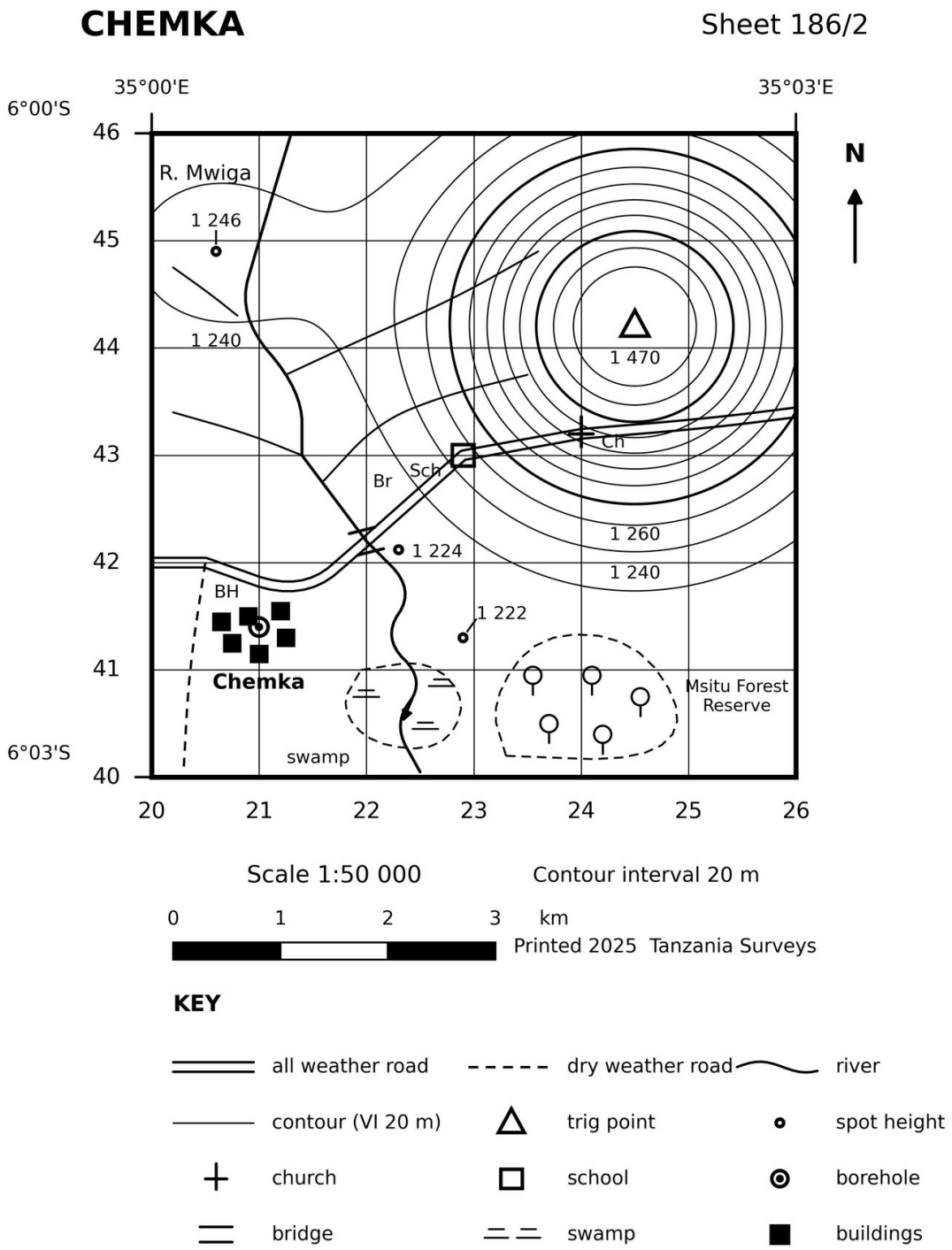


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Besides contours the sheet shows relief by surveyed point heights, namely the trigonometrical point and the spot heights.

Trigonometrical point: the triangle with the value 1 470 marks a surveyed pillar on the summit, a corner of the national triangulation, giving the exact height of the highest ground.

Spot heights: the dots valued 1 246, 1 224 and 1 222 give measured elevations on the plain, along the river and near the swamp, filling the silence between contour lines.

How they work together: the points give exact heights while the contours give shape, so the reader interpolates confidently between them, for instance placing the bridge a little above 1 220 m.

Question 95

Although contour lines are widely used to represent relief on topographic maps, they have certain limitations. State the limitations of contour lines in depicting relief.

Model Answer

Contours are the best single method, yet they fail in known ways.

1) **They step, they do not flow:** ground between two contours can hide any minor form smaller than the vertical interval, so a 15 m gully vanishes on a 20 m interval sheet.
2) **They demand skill:** an untrained reader sees curves, not hills, whereas shading or hachures speak instantly.
3) **They crowd on steep land:** on a cliff or escarpment the lines merge and become unreadable exactly where relief is most dramatic.
4) **They miss the instant of change:** a sudden bank, a quarry face or a small knoll between intervals leaves no trace.
5) **They show height, not view:** intervisibility and the felt steepness of a slope still need a drawn section.

Question 96

Study Figure 5.34 and identify two drainage patterns shown on the CHEMKA extract. For each pattern, explain one factor that has influenced its development.

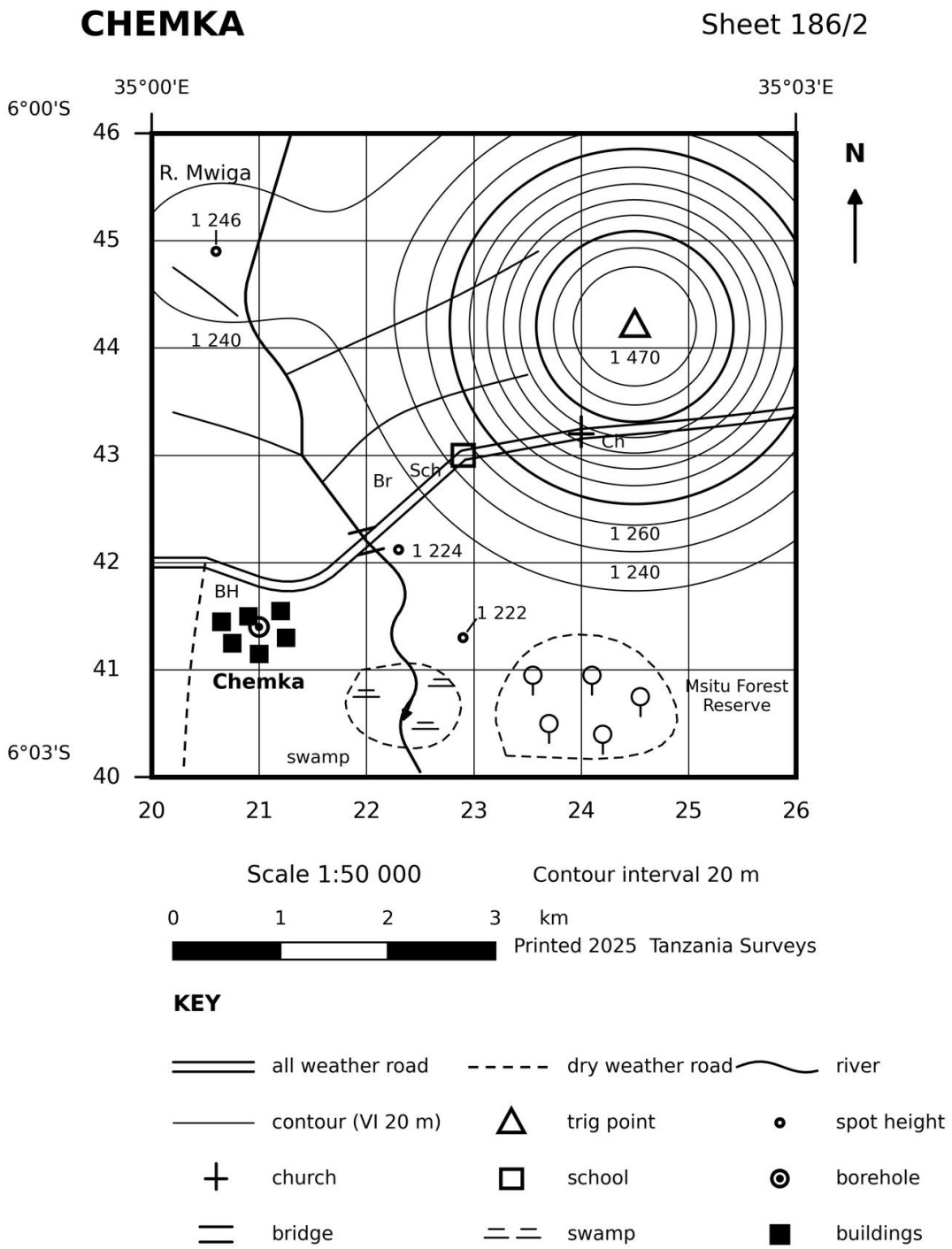


Figure 5.34: The CHEMKA extract, Sheet 186/2 (scale 1:50 000)

Model Answer

The sheet shows a radial pattern on the hill and a dendritic pattern on the plain.

Radial pattern: the tributaries rising on the north eastern hill run outwards down its flanks towards the River Mwiga. The controlling factor is gradient, because water leaves a dome in every downslope direction, as it leaves the cone of Kilimanjaro.

Dendritic pattern: on the western plain the tributaries join the main river at acute angles like branches of a tree. The controlling factor is uniform rock with a gentle regional slope, which lets streams wander freely instead of following structures.

Question 97

A GEOGRAPHY item on the Mbeya sheet asked candidates to comment on climate with map evidence. Deduce the likely climate of the CHEMKA area from Figure 5.34, citing the evidence for each deduction.

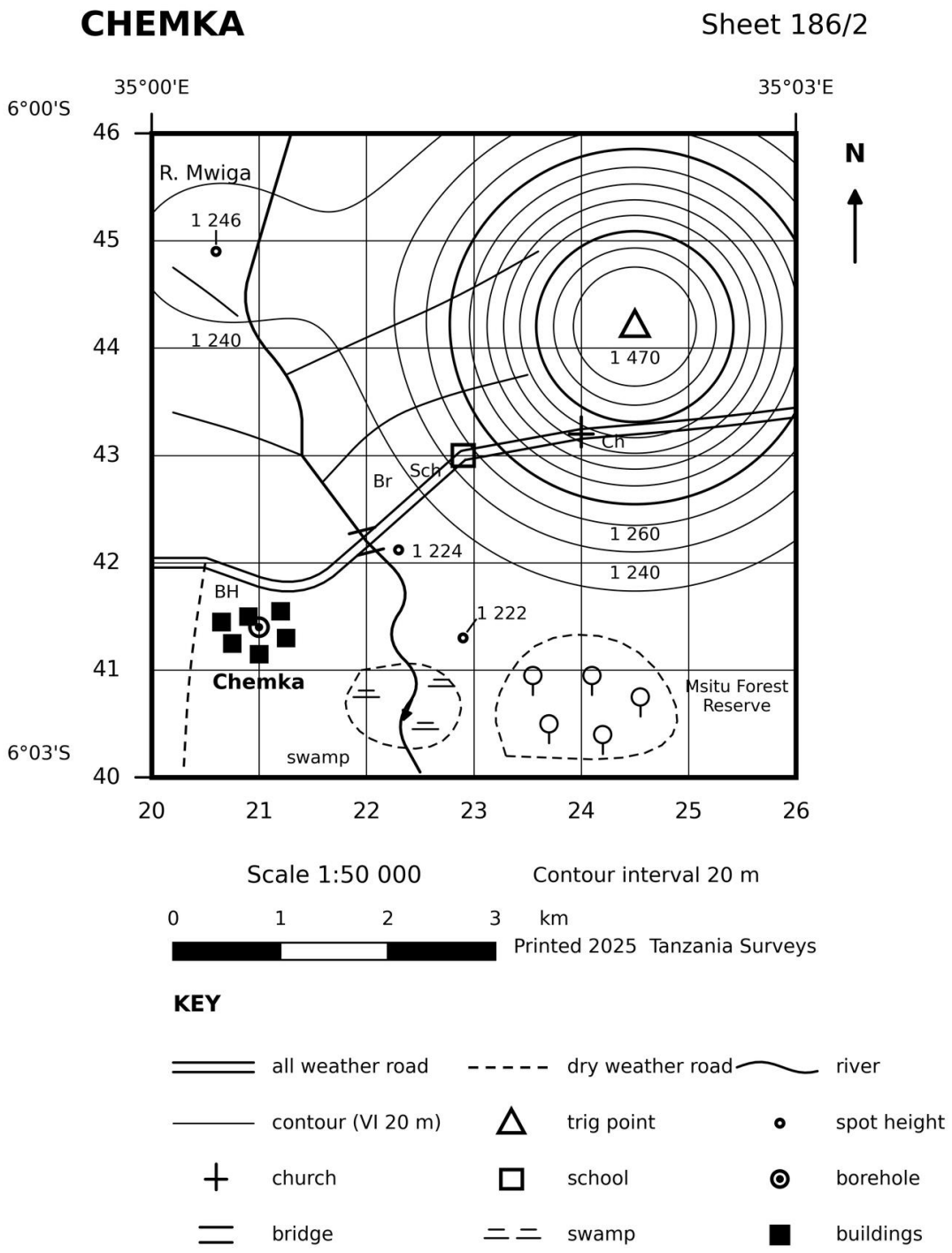


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Latitude, altitude, water features and land use together sketch the climate.

Latitude about 6°S: the graticule places the sheet in the tropics, so temperatures are warm with a wet and a dry season rather than four seasons.

Altitude 1 220 to 1 470 m: the plateau elevation cools the air by roughly 8°C against the coast, giving a mild tropical highland feel like central Dodoma country.

A perennial river but a seasonal swamp and a borehole: the Mwiga flows all year yet the village still sinks a borehole and the floodplain ponds into swamp, which together suggest moderate, seasonal rainfall with a marked dry season.

Sparse woodland outside a gazetted reserve: protected forest on the wetter hill flank and open country elsewhere point to semi arid margins rather than forest climate.

Question 98

Study Figure 5.34 and determine the stage of the River Mwiga downstream of the bridge. State the river features that support your conclusion.

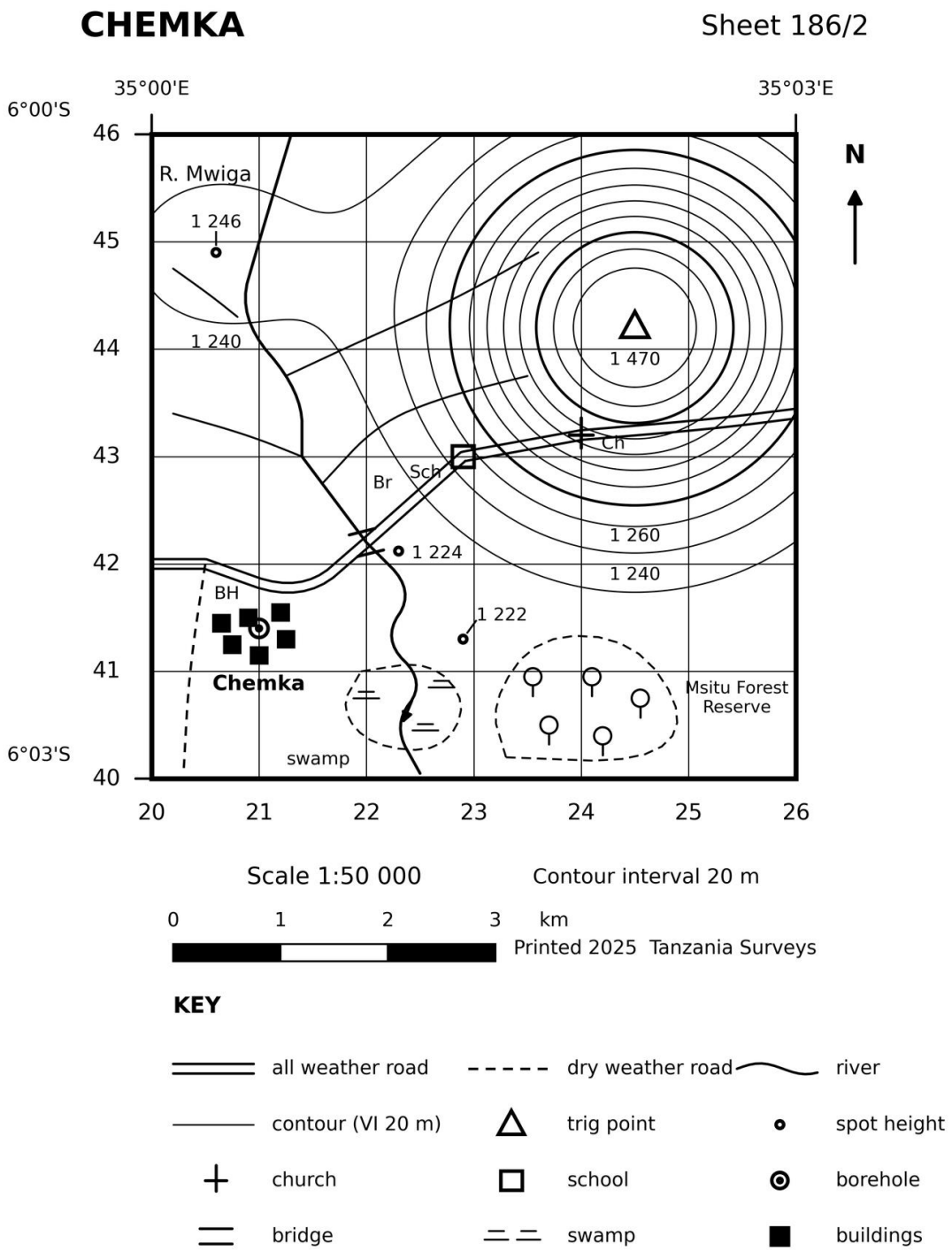


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Below the bridge the river shows a mature to early old stage.

The proving features: the channel meanders in broad loops, a swamp spreads astride the channel on a nearly level floodplain, and the contours stand far apart, giving a gentle gradient.

The stage: active meandering on a wide, waterlogged floodplain with a low gradient marks a river past its youth, in the mature stage and entering old age locally, like the Kilombero on its plain.

What is absent also testifies: no waterfalls, no gorge and no interlocking spurs survive here, so the energetic youthful stage lies upstream on the hill flank tributaries.

Question 99

Describe the vegetation of the CHEMKA extract in Figure 5.34 and account for its distribution.

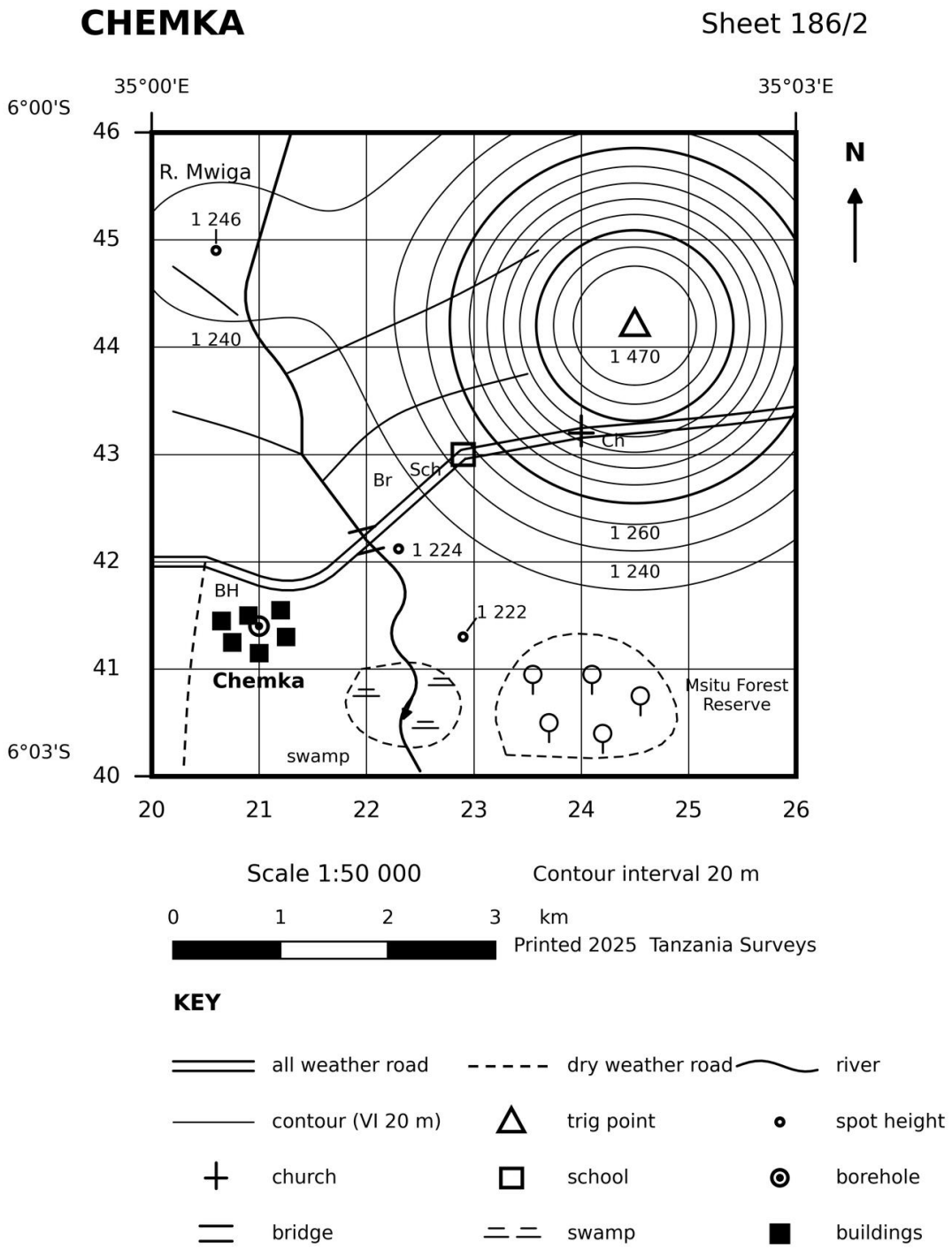


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Three vegetation belts appear, each where its water supply dictates.

1) **Gazetted forest on the south east:** the Msitu Forest Reserve carries tree cover inside a dashed boundary on the lower hill flank, protected and slightly wetter ground, as on the Mafinga plantations country.
2) **Swamp vegetation on the southern floodplain:** marsh tufts fill the waterlogged basin astride the lower Mwiga, where drainage fails rather than rain abounds.

3) **Open bush and grass elsewhere:** the wide plain and upper slopes carry no tree symbols, reading as open semi arid bushland used for settlement and grazing.

So vegetation follows water and protection, forest where the reserve holds the flank, sedges where the plain drowns, and open bush where neither applies.

Question 100

The exercise asks candidates to suggest the possible soil types of the mapped area. Infer the likely soils of the CHEMKA extract from the relief, drainage and vegetation shown in Figure 5.34.

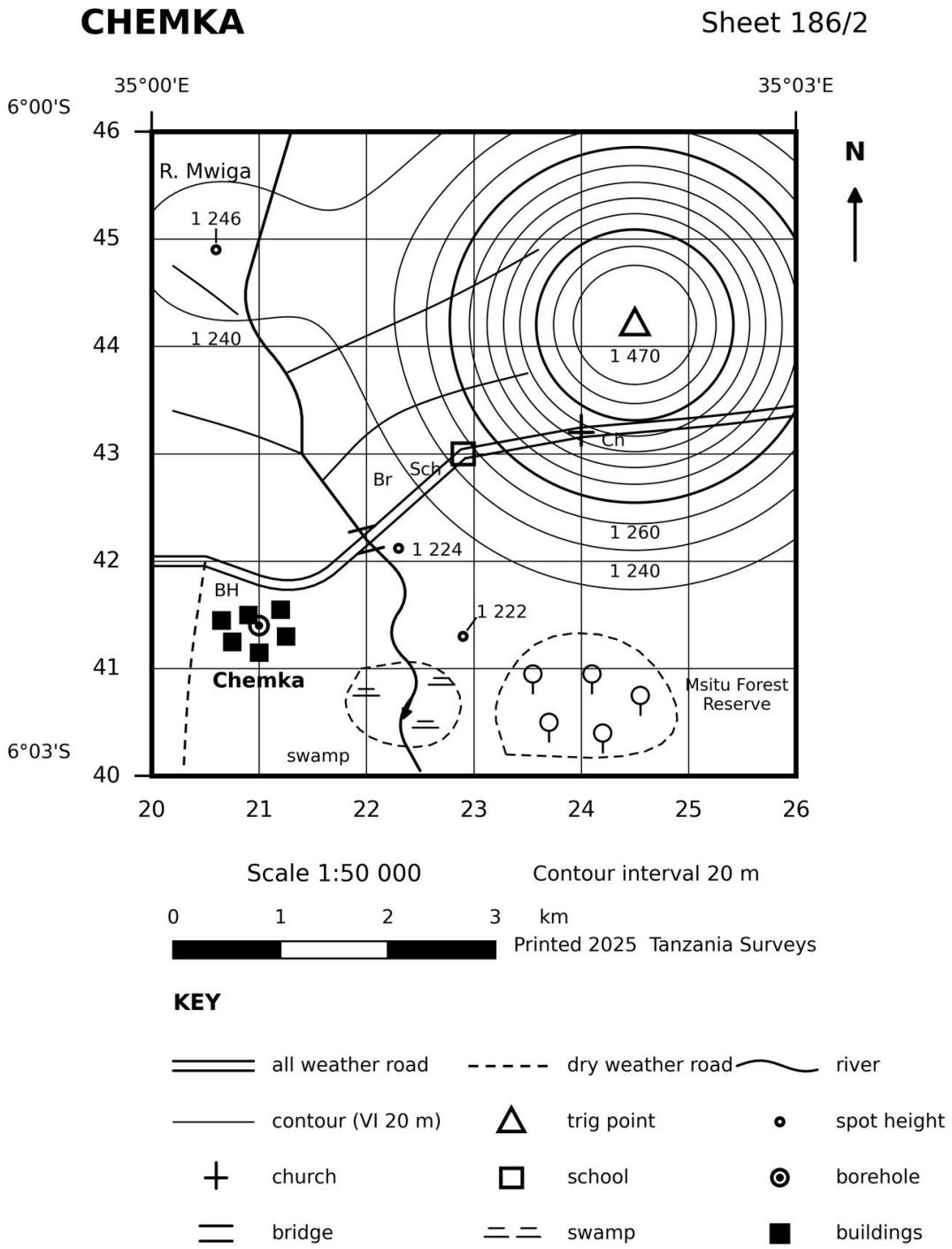


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Soils are read from the features that form and feed them.

1) **Alluvial and hydromorphic soils on the floodplain:** the meandering river and the swamp deposit silt and keep it waterlogged, promising heavy, dark, seasonally flooded soils like those of the Kilombero valley floor.
2) **Deeper, fresher soils on the hill flank:** the slope under the forest reserve sheds and renews material, and tree cover suggests soils moist and deep enough for roots.
3) **Light, drier plain soils:** the open western plain with scattered settlement and a borehole suggests well drained sandy loams of the central plateau kind, workable but thirsty.

Question 101

Using Figure 5.39, identify the settlement patterns of the MBUYU extract and account for the factors behind each.

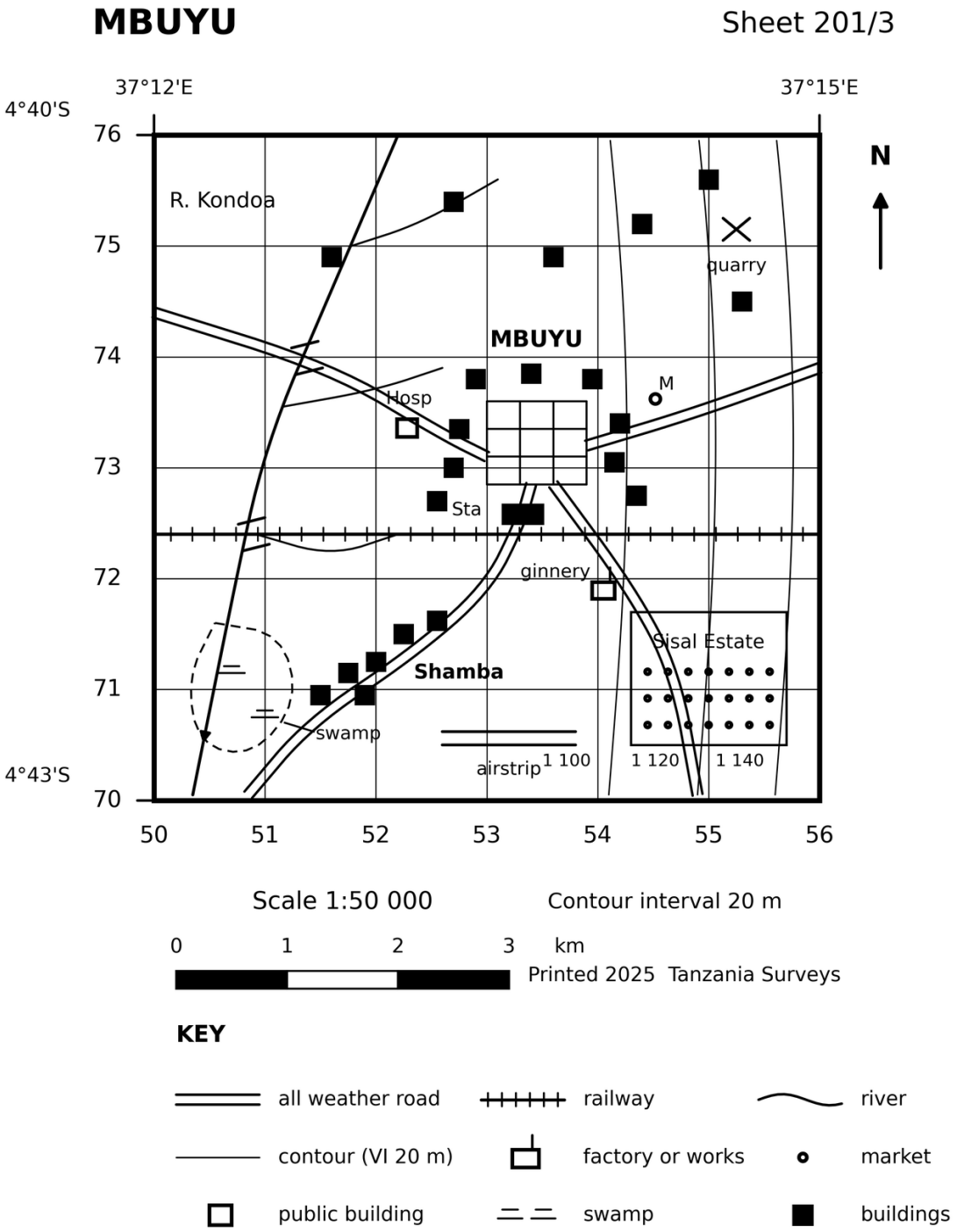


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

Three classic patterns share one sheet.

Nucleated at Mbuyu town: buildings cluster around the central business grid, the station, the market and the hospital, drawn together by the railway and the meeting of roads, exactly as railway towns like Tabora grew.

Linear at Shamba: homesteads string along both sides of the south western road, each plot fronting the route that carries its produce.

Dispersed across the north: isolated homesteads scatter over the open country between the tributaries, where families settle within their own fields.

Question 102

Describe the economic activities of the MBUYU extract in Figure 5.39, locating each by compass direction with its evidence.

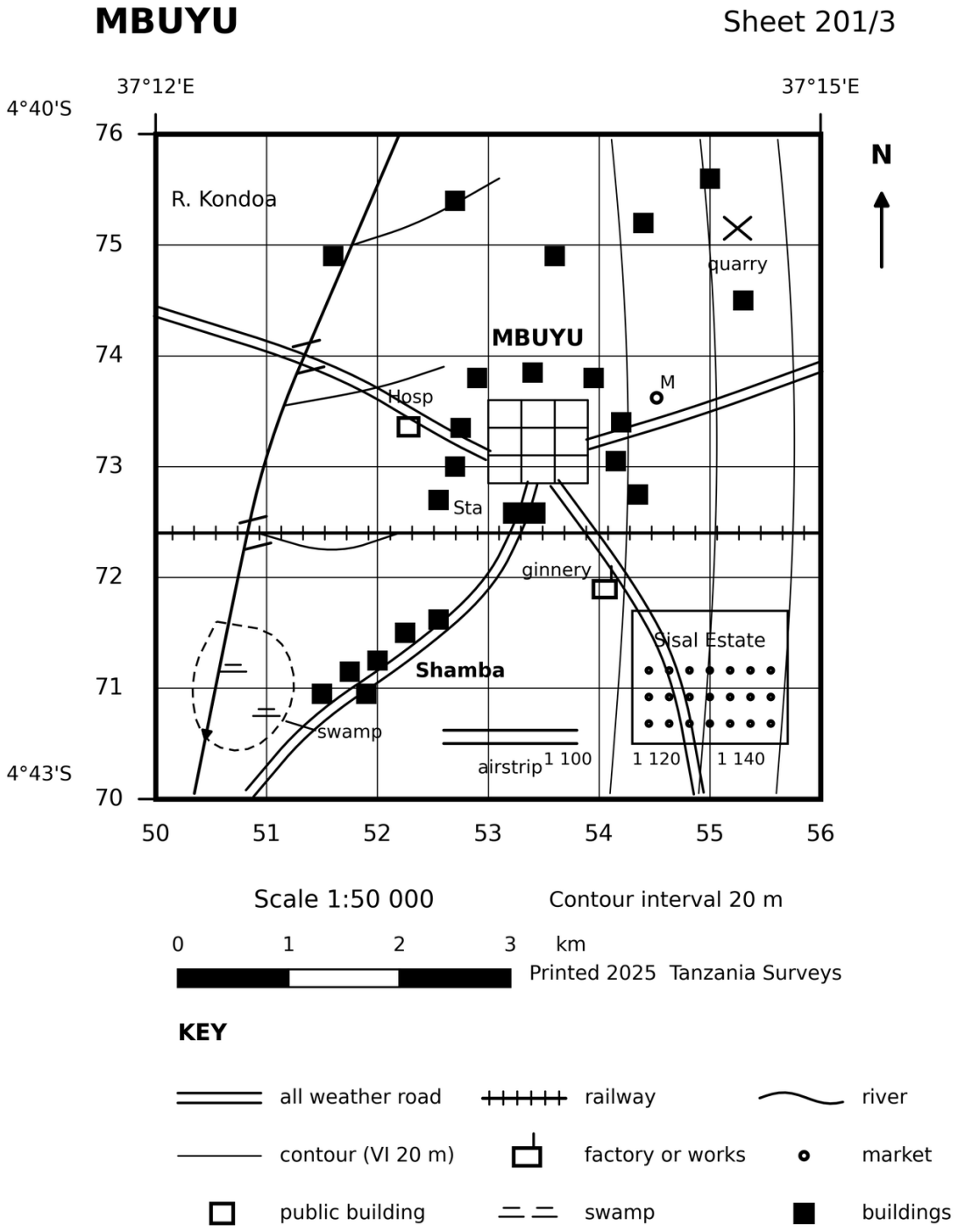


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

Each quarter of the sheet earns its living differently.

South east: sisal growing and processing: the Sisal Estate rows and the ginnery beside the road prove plantation agriculture with first stage industry, as around Korogwe.

North east: quarrying: the quarry symbol on the rising ground marks stone extraction.

Centre: trade, transport and services: the market, station, hospital and shops of Mbuyu town live on exchange and administration.

West and south west: cultivation and grazing: the riverside plain with the linear village of Shamba and scattered homesteads reads as smallholder farming country, with the swamp margin grazed in the dry season.

So the compass organises the economy, sisal SE, stone NE, trade at the centre and farming W, each claim anchored to a symbol.

Question 103

Using Figure 5.37, describe the site and situation of Ziwani town and deduce three of its functions with evidence.

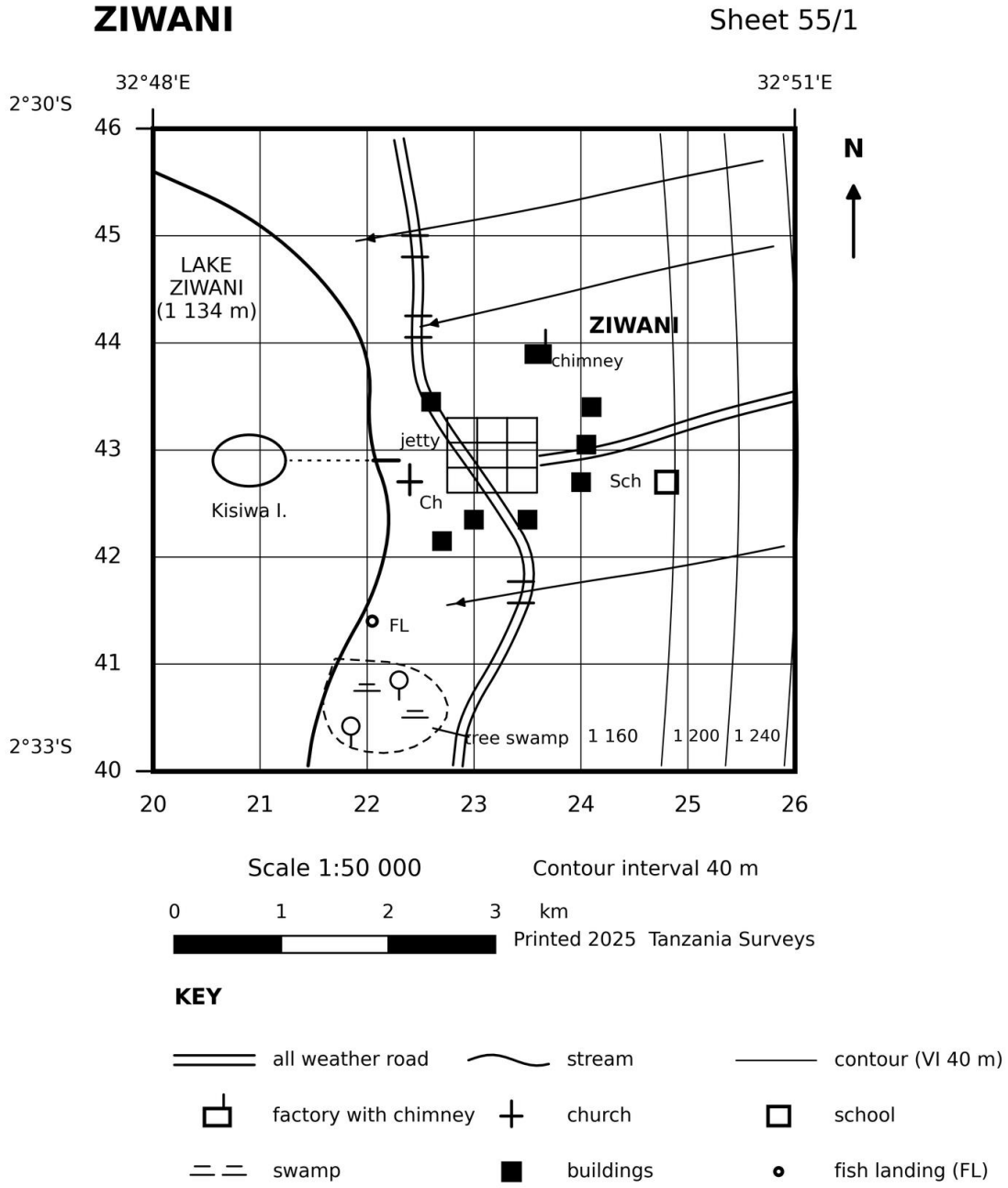


Figure 5.37: *The ZIWANI extract, Sheet 55/1 (scale 1:50 000)*

Model Answer

Site is the ground the town stands on; situation is its position in the wider country.

Site: a gently shelving lakeshore bench beside deep water, low enough for a jetty yet above the tree swamp to the south, much as Mwanza sits on its rocky shore of Lake Victoria.

Situation: between Lake Ziwani and the eastern hills, where the shore road and the inland road meet the water, so lake and land traffic exchange here.

Functions deduced: a port and fishing function from the jetty, the ferry to Kisiwa Island and the fish landing; an industrial function from the factory with its chimney; and a commercial and service function from the central business grid, the church and the school.

So the town lives where boats can land and roads can meet, and every function the candidate deduces is pinned to a drawn symbol, never to imagination.

Question 104

Using Figure 5.39, account for the difficulty of transport in the western and south western parts of the MBUYU extract.

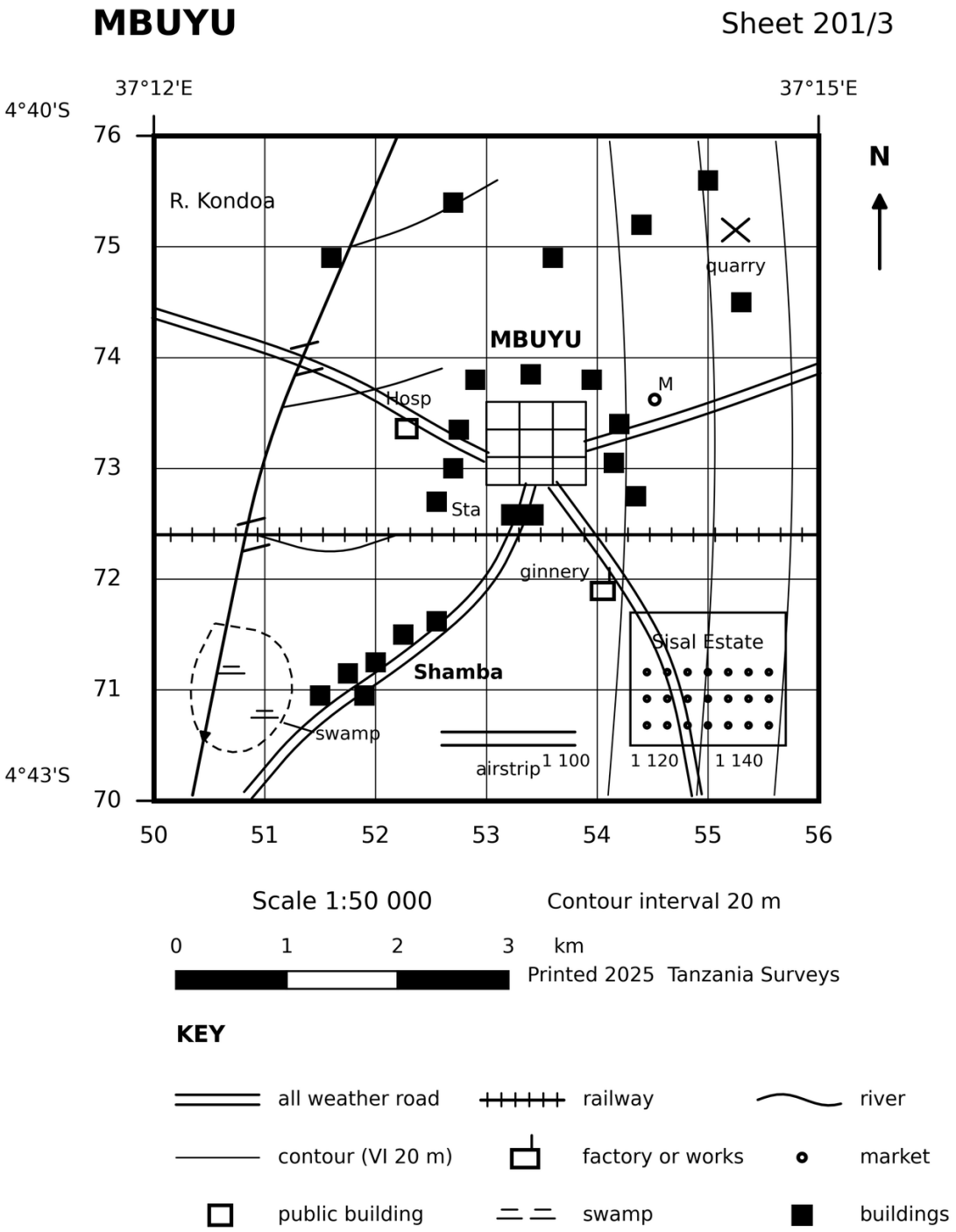


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

Water, wetland and gradient conspire against the road builder there.

The River Kondoa must be bridged: every westward route crosses the perennial river, and the sheet shows the western road and the railway forced through single crossing points.

The swamp repels routes: the wetland beside the lower river floods seasonally, so roads detour around it and the south western road swings wide of the marsh.

Dissected valley country: the tributary valleys cut the north west, multiplying small crossings and curves, whereas the even ground east of town lets the roads run straight.

So the difficulty is written in the crossings and detours themselves.

Question 105

Human activities can be inferred from evidence shown on a topographic map. State the criteria used to identify human activities from a map, and briefly illustrate each using examples from the extracts in this chapter.

Model Answer

Five criteria turn symbols into livelihoods.

1) **Named economic symbols:** a ginnery, quarry or factory chimney names its industry outright.
2) **Land use patterns:** estate rows, plot mosaics and forest reserves distinguish plantation, smallholding and conservation.
3) **Service marks:** markets, stations, jetties, schools and hospitals reveal trade, transport and administration.
4) **Settlement form:** nucleated centres suggest exchange and services, linear villages roadside marketing, dispersed homesteads farming on the spot.
5) **Supporting physique:** water bodies imply fishing, grassland grazing, and gentle well drained land cultivation, provided a cultural symbol confirms the hint.

Question 106

Study Figure 5.34 and answer: (a) state the six figure grid references of the trig point and the church; (b) calculate the road distance from the bridge at 220422 to the church, the thread reading being 4.6 cm; (c) determine the grid bearing of the trig point from the church; (d) calculate the area of the extract east of easting 25; (e) with reasons, state whether the school at 229430 and the trig point are intervisible.

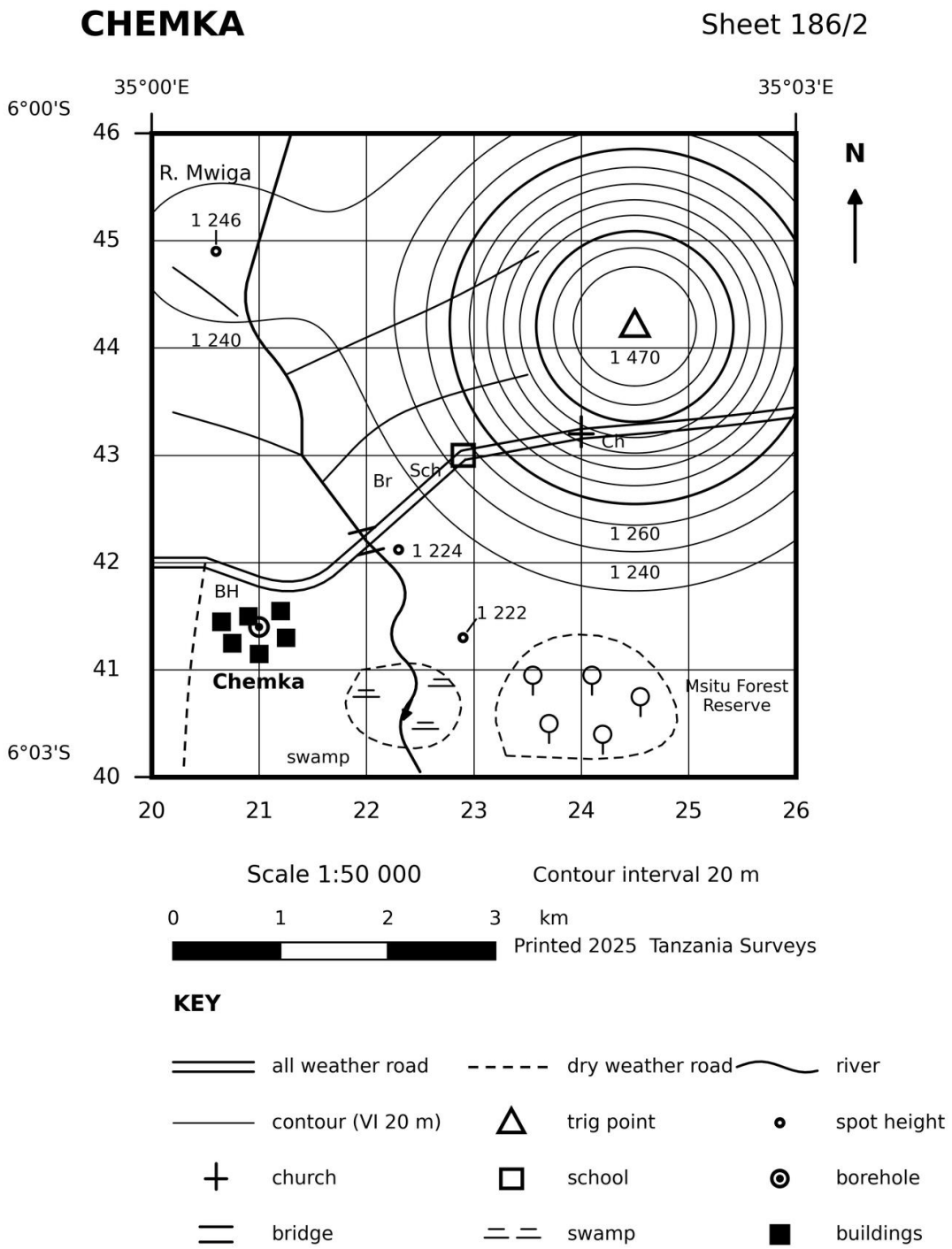


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

(a) The trig point stands at **245442** and the church at **240432**.

(b) Road distance. At 1 cm = 0.5 km:

$$\text{distance} = 4.6 \times 0.5 \text{ km} = 2.3 \text{ km}$$

(c) Bearing church to trig point. From 240432 to 245442 the displacement is 0.5 km east and 1.0 km north, and a protractor at the church reads the clockwise angle:

$$\text{grid bearing} \approx 027°$$

(d) Area east of easting 25. A regular strip one square wide and six long:

$$\text{area} = 1 \times 6 = 6 \text{ km}^2$$

(e) Intervisibility. The line from the school (1 270 m) to the trig (1 470 m) crosses the convex upper flank, where the ground at the midway point stands near 1 390 m, above the straight sight line height of about 1 370 m at that point, so the bulge blocks the view.

(a) 245442 and 240432; (b) 2.3 km; (c) about 027°; (d) 6 square kilometres; (e) not intervisible, because the convex slope rises above the sight line.

Question 107

Study Figure 5.39 and answer: (a) describe the relief of the mapped area; (b) describe its drainage; (c) identify the settlement patterns; (d) describe the land use; (e) suggest, with evidence, the likely climate.

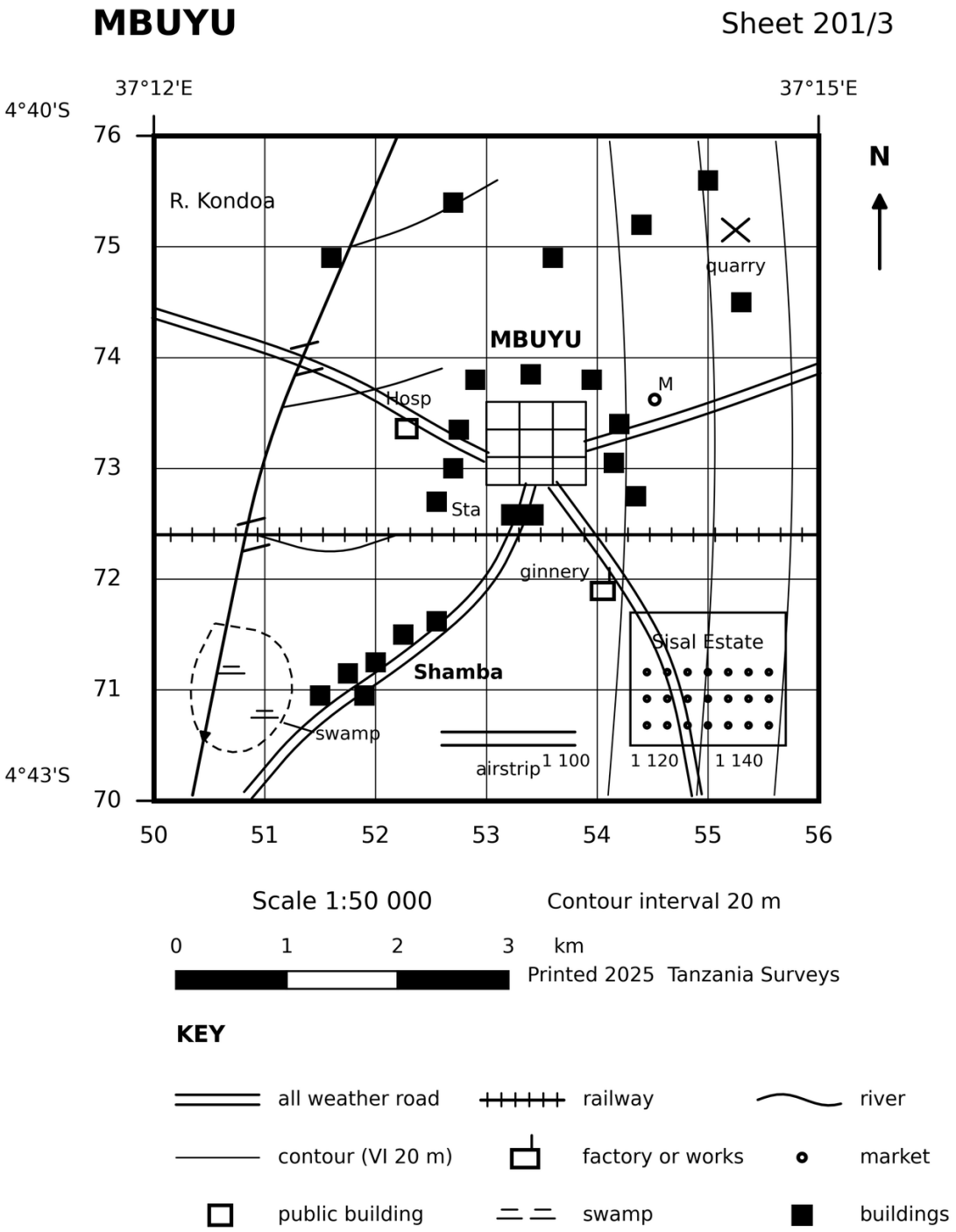


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

(a) Relief: a gently rising plain, from about 1 100 m in the west to above 1 140 m in the east, the three widely spaced contours showing an even, almost featureless slope with no steep land.

(b) Drainage: the perennial River Kondoa flows southwards along the western side, fed by short dendritic tributaries from the east, with a seasonal swamp beside its lower course; the pattern is dendritic on a uniform gentle slope.

(c) Settlement: nucleated at Mbuyu town around the station and market, linear at Shamba along the south western road, and dispersed homesteads across the north.

(d) Land use: a plantation block under sisal with its ginnery in the south east, smallholder cultivation near the river, grazing on the open plain, quarrying in the north east, and transport land under the railway and airstrip.

(e) Climate: tropical with a marked dry season, because the swamp is seasonal, sisal tolerates drought, and the plain carries no forest; the altitude near 1 100 m keeps it warm rather than hot, like the plains below Uyole.

Question 108

Study Figure 5.39 and answer: (a) convert the sheet scale into a statement scale; (b) name the settlement pattern at Shamba and give one factor for it; (c) name two economic activities with their map evidence; (d) name the drainage pattern west of the town; (e) explain the relationship between the railway and the relief.

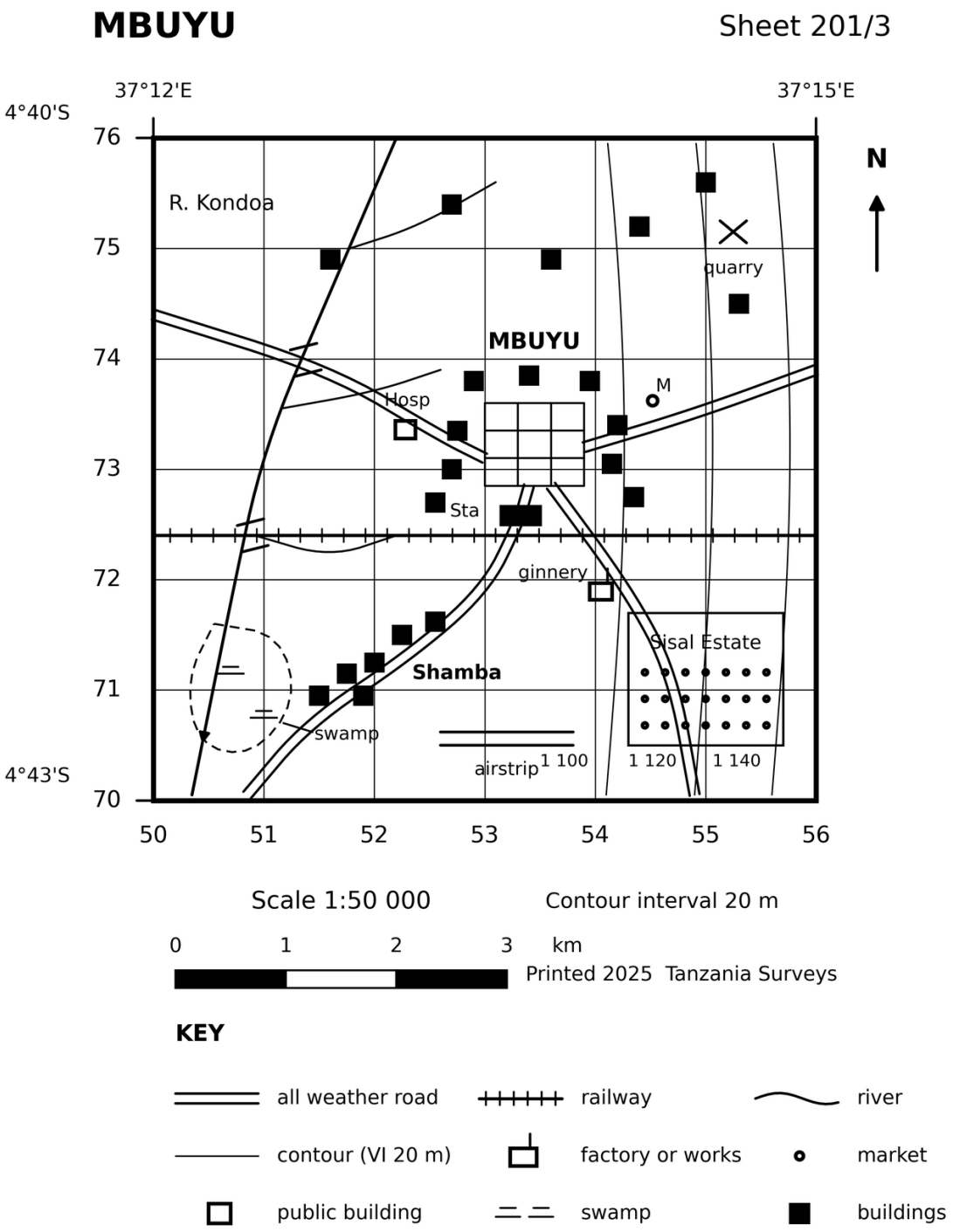


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

(a) Scale conversion. 1:50 000 means 1 cm = 50 000 cm, and since 1 km = 100 000 cm, the statement is one centimetre represents half a kilometre.

(b) Shamba: a linear settlement pattern, drawn out along the south western road because plots front the route that moves people and produce.

(c) Two activities: sisal cultivation with processing, proved by the Sisal Estate rows and the ginnery; and quarrying, proved by the quarry symbol in the north east. Trade at the town market would equally score.

(d) Drainage pattern: dendritic, the tributaries joining the River Kondoa at acute angles like branches of a tree.

(e) Railway and relief: the line runs straight across the gently sloping plain, keeping to the level ground between the river valley and the eastern rise, because railways buy flatness before distance; only at the river does it concentrate into a single bridged crossing.

Question 109

Study Figure 5.37 and answer: (a) calculate the area of the tree swamp south of Ziwani town, its boundary enclosing no complete grid square and cutting 2 squares; (b) locate two economic activities by cardinal point with evidence; (c) explain why the wetland has formed where it is, and state one use and one danger of it to the people of Ziwani.

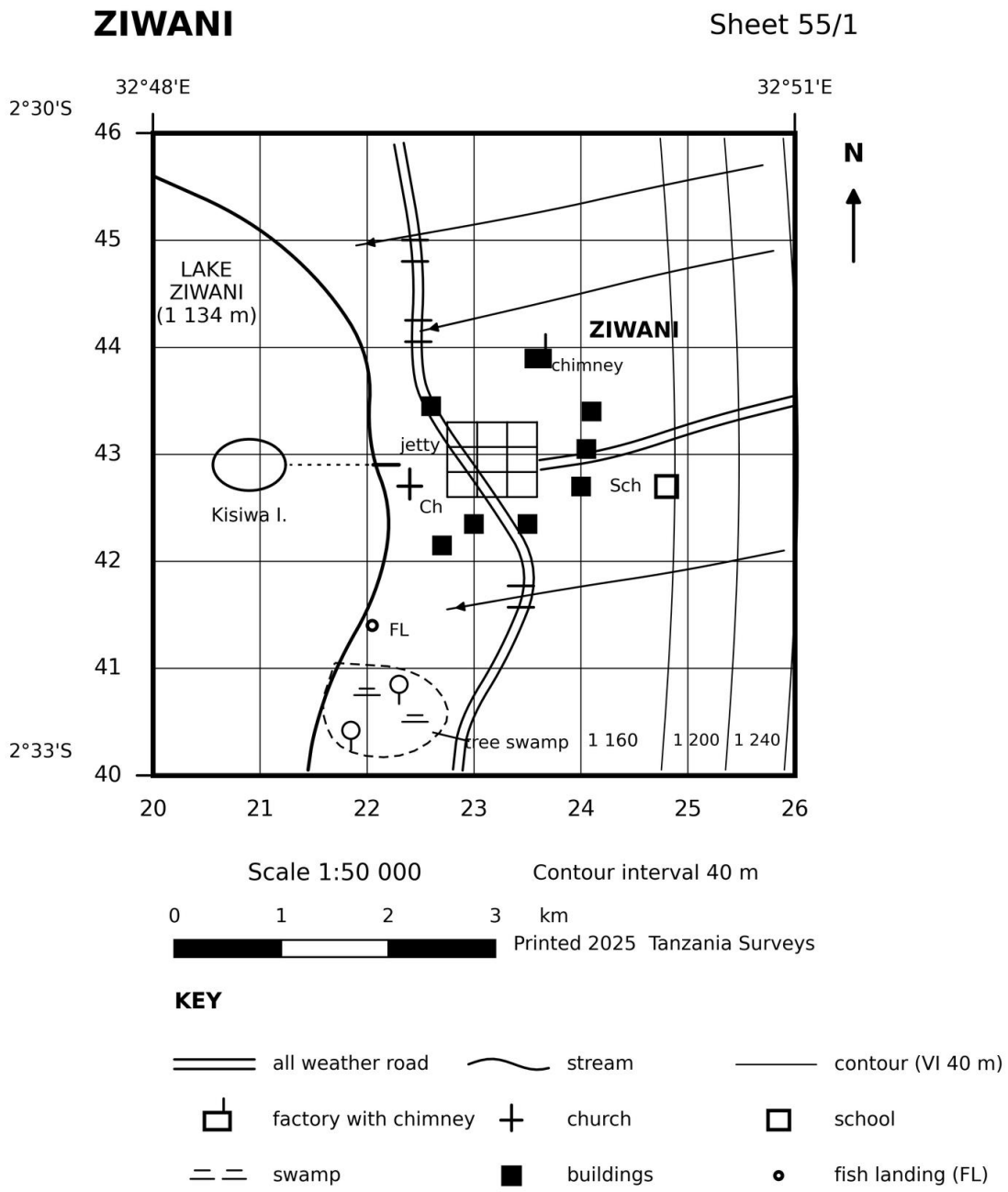


Figure 5.37: *The ZIWANI extract, Sheet 55/1 (scale 1:50 000)*

Model Answer

(a) Area by the grid method. $C = 0, i = 2$:

$$\text{area} = (0 + \frac{2}{2}) \times 1\ \text{km}^2 = 1\ \text{km}^2$$

(b) Activities by cardinal point: fishing on the south western shore, proved by the fish landing and the jetty with its ferry; and manufacturing on the northern edge of the town, proved by the factory with its chimney. Trade in the central grid would equally score.

(c) Why the wetland is there: the shore south of town is flat and low, streams from the eastern hills deliver water and silt, and the lake margin keeps the water table at the surface, so the ground stays waterlogged and carries swamp trees.

Use and danger: the swamp offers dry season grazing, reeds and rich bird and fish breeding grounds, but it also breeds mosquitoes and floods, so building south of the town is hazardous.

Question 110

Study Figure 5.34 and answer: (a) determine the latitude and longitude of the trig point at 245442 by proportion, the sheet spanning 35°00′E to 35°03′E across eastings 20 to 26 and 6°00′S to 6°03′S from northing 46 down to northing 40; (b) state the stage of the River Mwiga below the bridge with one proof; (c) describe the transport network; (d) name the second relief method on the sheet besides contours.

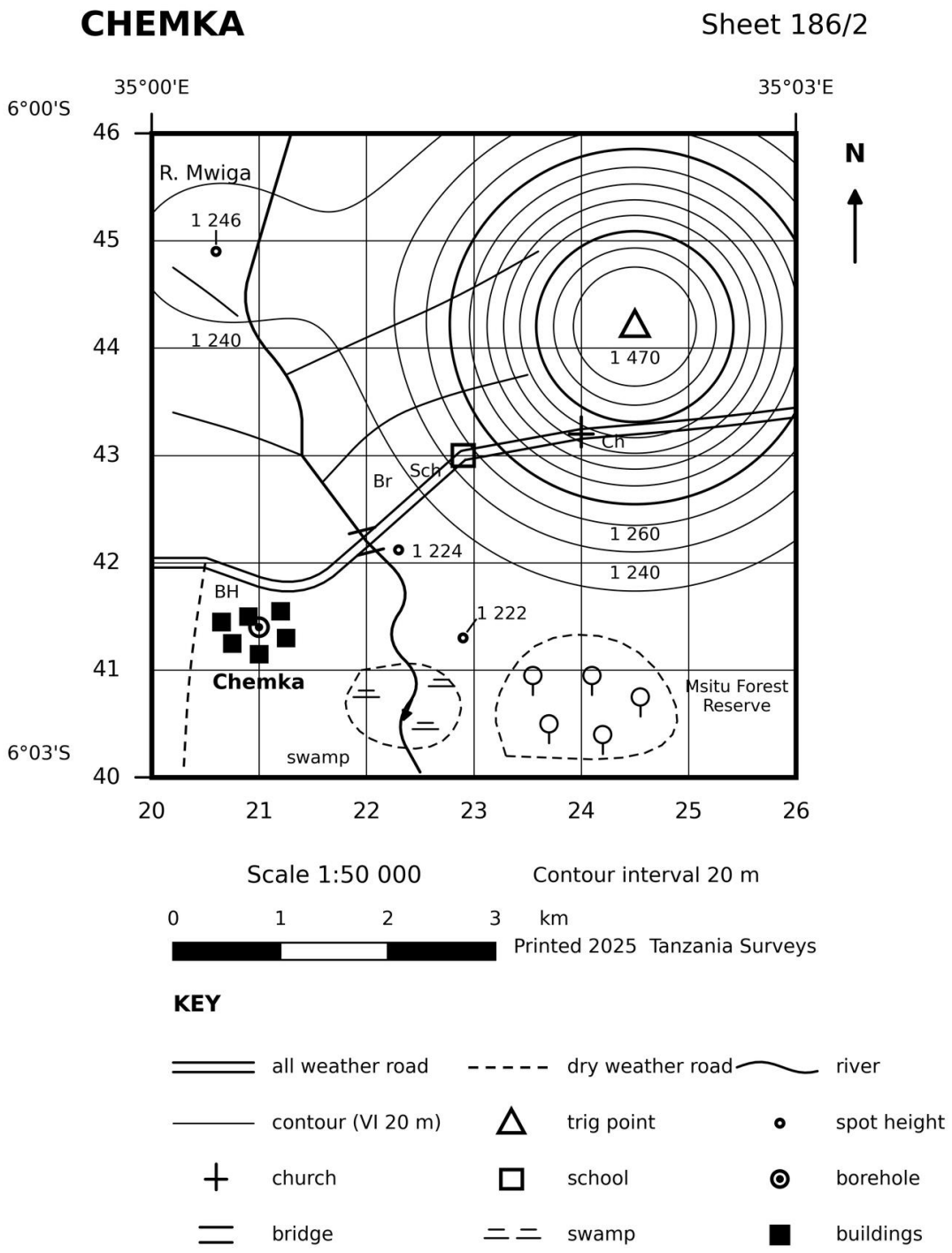


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

(a) Longitude by proportion. The trig point lies 4.5 of the 6 grid squares east of the 35°00′E meridian, and the 6 squares carry 3′ of longitude, so:

$$\text{angle} = \frac{4.5}{6} \times 3' = 2'15'',\ \text{so longitude} = 35°02'15''\ \text{E}$$

Latitude by proportion. The trig point lies 1.8 squares south of the 6°00′S parallel at northing 46:

$$\text{angle} = \frac{1.8}{6} \times 3' = 54'',\ \text{so latitude} = 6°00'54''\ \text{S}$$

(b) River stage: mature, tending to old age locally, proved by the broad meanders on the level, swampy floodplain below the bridge.

(c) Transport network: one all weather road crosses the sheet from west to east through the bridge, the school and the church, with a dry weather road branching south from the junction to serve the plain; the network is sparse and funnels through the single river crossing.

(d) Second relief method: surveyed point heights, the trig point 1 470 and the spot heights such as 1 224 and 1 222.

Trigonometric point position: about 6°00′54″ S, 35°02′15″ E.

Question 111

Study Figure 5.37 and answer: (a) determine the grid bearing and the distance of Kisiwa Island from the jetty at 223429; (b) describe the site of Ziwani town in one sentence; (c) deduce two functions of the town with evidence; (d) state one way Lake Ziwani moderates the local climate; (e) explain briefly why the printed fraction 1:50 000 matters when this sheet is compared with a wall map of the region.

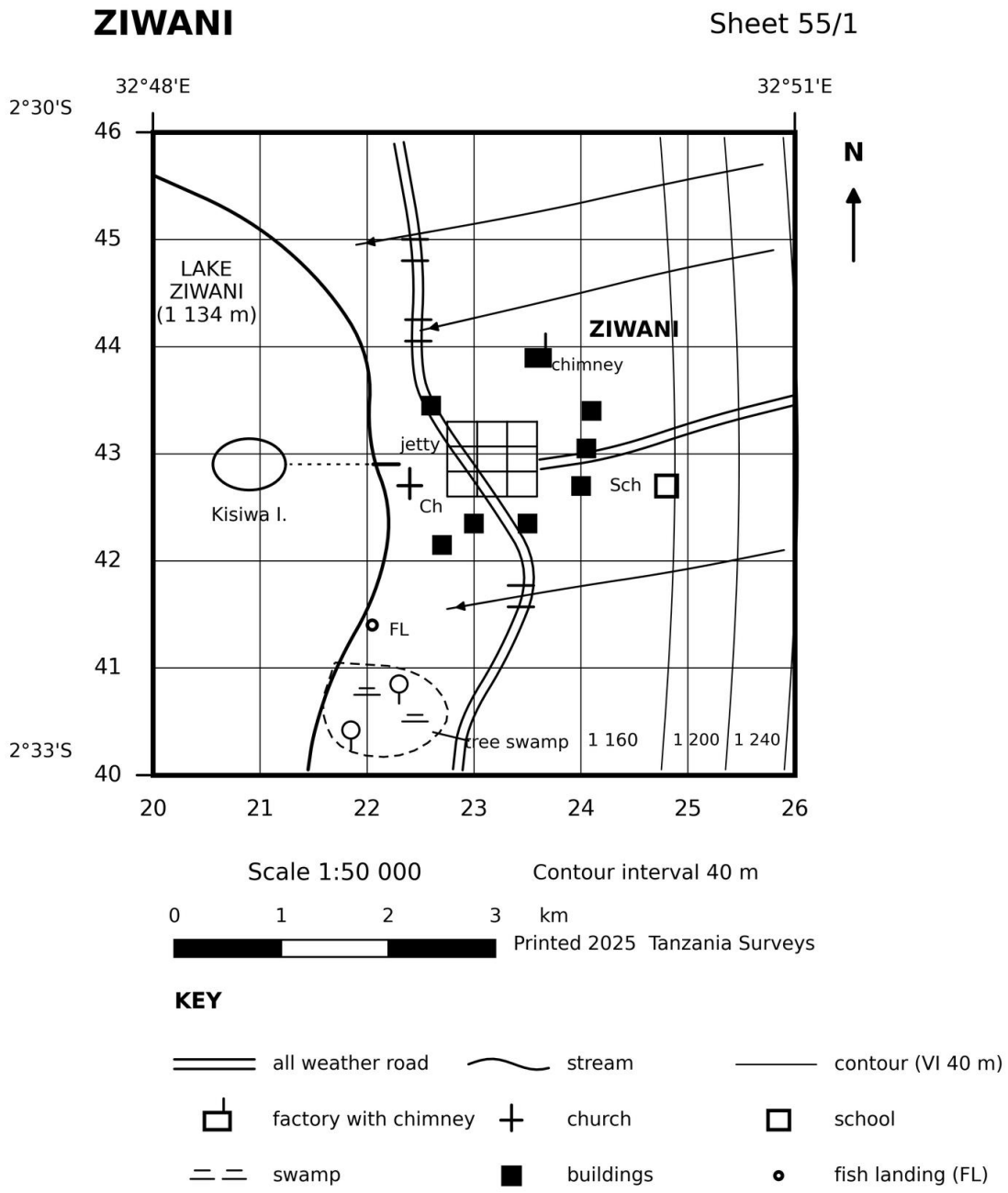


Figure 5.37: *The ZIWANI extract, Sheet 55/1 (scale 1:50 000)*

Model Answer

(a) Bearing and distance. The island centre at 209429 lies due west of the jetty, so the grid bearing is 270°, and the separation of 2.8 cm on the sheet converts to:

$$\text{distance} = 2.8 \times 0.5 \text{ km} = 1.4 \text{ km}$$

(b) Site: a gently shelving shore bench beside deep water, above the tree swamp, where a jetty can land boats, much like Mwanza on its Lake Victoria shore.

(c) Two functions: a port and fishing function, proved by the jetty, ferry and fish landing; and an industrial function, proved by the factory with its chimney north of the centre.

(d) Lake moderation: the water body cools hot afternoons and feeds moisture to lake breezes, so the shore is milder and slightly wetter than the country behind the eastern hills.

(e) Why the fraction matters: the wall map carries a much smaller scale, so only the printed fractions tell the user how the two maps relate; comparing distances without them turns kilometres into guesswork.

HOT QUESTIONS

Question 112

A planner in Babati notices that her district map sheet shows one dot where she knows forty scattered houses stand, and no trace of last year's new road. To what extent can a map that leaves out so much still be trusted?

Model Answer

A map remains trustworthy for what it claims, provided the reader respects generalisation and date.

The case for trust: generalisation is a design, not a defect, because a 1:50 000 sheet must sacrifice detail to stay readable, and what it keeps, measured distances, heights, drainage and the pattern of settlement, is surveyed and dependable.

The stated limits: a dot standing for forty unequal houses tells pattern, not census; and a sheet is only as young as its date of compilation, so the missing Babati road accuses the 2010 edition, not the method.

The reader's duty: check the scale, the key and the date before believing, and confirm changeable features, such as roads and settlement, on the ground or on a newer edition.

So the map deserves trust as a scaled model rather than a photograph, and the Babati planner should fault her sheet's age, not its honesty.

Question 113

A water charity must choose one map to plan boreholes across the whole of Singida region, and another to design the pump compound in a single village. Which type and scale of map would you defend for each task, and why?

Model Answer

Purpose decides the map, so the defensible answer pairs each task with its own type and scale.

The regional survey: a small to medium scale topographical or statistical sheet, about 1:250 000, because the charity needs the whole region on one sheet, comparing relief, drainage and settlement patterns to shortlist thirsty wards, and detail would only drown that comparison.

The compound design: a large scale plan, about 1:5 000, because pipe runs, plot boundaries and the pump house demand detail measured in metres, which no regional sheet can carry.

The trade off admitted: the small scale hides villages, and the large scale sees one village only, so neither map can do the other's work, and choosing one map for both tasks would fail both.

So the defence is the match of scale to question, a wide lens for where in Singida, a fine lens for how in the village.

Question 114

After the 2003 Hanang landslide and the repeated Morogoro floods, hazard maps were drawn to warn residents. Judging cartography as communication, how can map design help, and how can it mislead?

Model Answer

Design carries the message, and the same tools that clarify can distort.

Design that helps: hierarchy with harmony makes the danger zones stand out above the background, simplicity strips away distracting detail, and honest symbols with a clear key let a Morogoro resident read the flood limit at a glance.

Design that misleads: a bold colour can exaggerate a modest risk, a small scale can hide the very valley that slid at Hanang, an old compilation date can freeze a hazard that has since grown, and a biased publisher can shade the story a chosen way.

The test: a map communicates well when its purpose, scale, symbols and date all serve the same message, and badly when any one of them quietly serves another.

So a hazard map is an argument, not a mirror, and the reader of the Hanang or Morogoro sheets must judge the design before obeying the message.

Question 115

A road agency argues over one contract map for the Dodoma to Iringa corridor: engineers want 1:10 000, planners want 1:250 000. Assess which side should win for which purpose.

Model Answer

Both sides are right for their own purpose, and wrong for the other's.

The planners' case: at 1:250 000 the whole corridor fits a wall, alternative alignments can be compared, and regional relief and drainage read clearly, which is exactly the routing question.

The engineers' case: at 1:10 000 every culvert, gradient and plot boundary is measurable, which is exactly the construction question, and at 1:250 000 a village is a dot that cannot host a design.

The resolution: scale is a division of labour, so the agency needs the small scale to choose the line and the large scale to build it, in that order.

So the contract should specify both maps in sequence, because the corridor is first a regional argument and then a metre by metre drawing.

Question 116

A student photocopies a 1:50 000 sheet of the Kilombero valley at 200 percent and announces that his new map now shows more detail. Evaluate the claim.

Model Answer

The claim fails, because enlargement magnifies the drawing while the information stays fixed by the original survey.

What truly changes: lengths double, the effective scale becomes 1:25 000, symbols grow and the eye reads more comfortably.

What cannot change: no new stream, path or homestead appears, because the survey never recorded them; enlargement is arithmetic on paper, not new fieldwork.

The hidden damage: the printed fraction 1:50 000 is now false on the copy, so every conversion made from it doubles the truth unless the linear scale, which stretched with the paper, is used instead.

So the Kilombero copy is bigger, not better informed, and its only honest scale is now the bar, never the printed fraction.

Question 117

A candidate write: *one centimetre represents 2.5 kilometres, therefore the scale is 1:2 500.* Assess the error and establish the correct fraction.

Model Answer

The candidate divided by the wrong constant, forgetting that the ratio must stand in one unit.

Step 1: expose the fault. Writing 1:2 500 treats the 2.5 km as 2 500 cm, but 1 km = 100 000 cm, not 1 000 cm.

Step 2: convert correctly.

$$2.5 \text{ km} = 2.5 \times 100\,000 \text{ cm} = 250\,000 \text{ cm}$$

Step 3: state the fraction. 1 cm : 250 000 cm, and the units cancel.

Correct scale: 1:250 000.

False Confidence Alert
A ratio may only be written after both sides stand in the same unit. The error 1:2 500 makes the map a hundred times larger in scale than it is, which would turn a 100 km Moshi to Arusha journey into one kilometre.

Question 118

Three candidates must find the area of an irregular lake: one rules strips, one counts grid squares, one cuts the shape into triangles. Adjudicate which method deserves the marks, and when each would win.

Model Answer

For a ragged natural outline the grid method wins, but each method owns a shape it serves best.

The grid case: the sheet already carries the squares, the half rule averages the ragged edge fairly, and the method is fast and repeatable, which is why examiners set lakes and swamps for it.

When strips win: a long, smoothly tapering feature, such as a valley floor or an airstrip reserve, slices naturally into strips whose middle lengths are honest.

When geometry wins: a compact estate or plot with straight fences resolves into true rectangles and triangles, and there the formulas beat any counting for accuracy.

The judgement: match the method to the boundary: formulas for straight edges, strips for elongated tapers, the grid for wild outlines like a Tabora lake.

So the grid counter earns the marks on this lake, and the wise candidate keeps all three tools sharpened for the shapes that suit them.

Question 119

A surveyor at Kigoma checks a winding lakeshore road twice: once stepping dividers set to one kilometre, once with a thread laid along every bend. The answers differ by nearly two kilometres. Evaluate which measurement to trust and why.

Model Answer

Trust the thread, because stepped dividers secretly straighten every curve they stride across.

Why the dividers lose: each divider step is a chord, and a chord is always shorter than the arc it cuts, so on a winding road hundreds of small bends are shaved away, here nearly two kilometres of them.

Why the thread wins: the thread bends with the road, so its straightened length carries the bends to the scale instead of deleting them.

The fair hearing for dividers: on straight or gently curved lines the chord error is negligible and the dividers are quicker and stiffer than thread, so they remain the right tool there.

So the Kigoma road is as long as the thread says, and the divider figure should be filed as a lesson in chords, not distance.

False Confidence Alert
A smaller divider setting reduces the error but never removes it; only a method that follows the curve, thread or stepped paper edge, measures a winding feature honestly.

Question 120

Study Figure 5.34. The CHEMKA road from the junction at 205420 to the church at 240432 measures 8.0 cm on this 1:50 000 sheet. A district wall map at 1:100 000 shows the same stretch as 3.8 cm. Reconcile the two measurements and judge whether the wall map is in error.

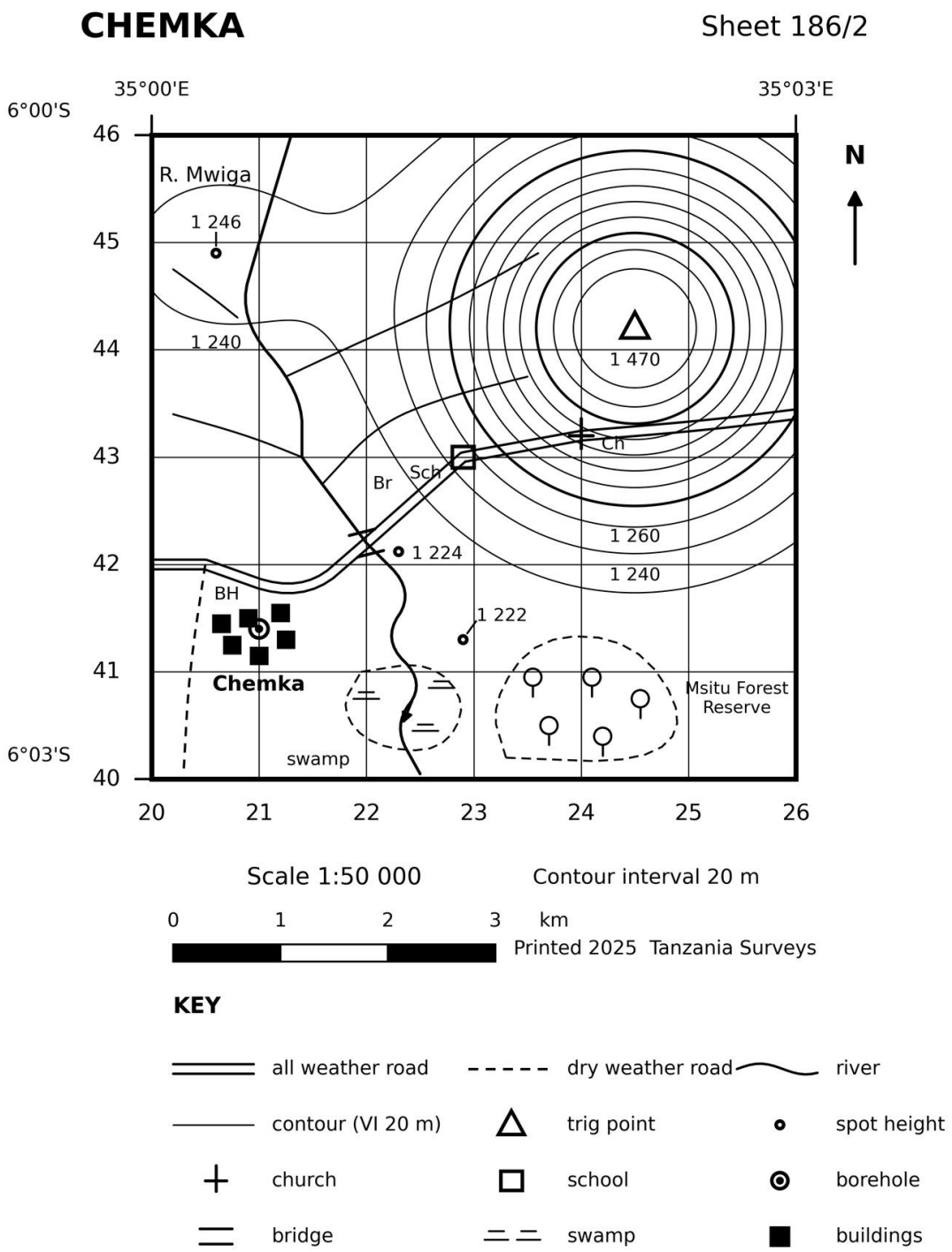


Figure 5.34: The CHEMKA extract, Sheet 186/2 (scale 1:50 000)

Model Answer

Convert both readings to ground distance before judging either.

Step 1: the sheet reading. At 1 cm = 0.5 km:

$$8.0 \times 0.5 \text{ km} = 4.0 \text{ km}$$

Step 2: the wall map reading. At 1:100 000, 1 cm = 1 km:

$$3.8 \times 1 \text{ km} = 3.8 \text{ km}$$

Step 3: weigh the difference. The gap of 0.2 km is about five percent. At 1:100 000 the cartographer generalises the bends near the bridge and the school, and a smoother drawn road is a shorter measured road, so a shortfall of this size is expected rather than alarming.

Sheet: 4.0 km; wall map: 3.8 km; the difference is generalisation, not error.

Interpretation. So the two maps agree within the honesty of their scales, and the engineer quotes 4.0 km from the larger scale sheet, forgiving the wall map its smoothed bends.

Question 121

Between 2010 and 2026 the magnetic variation at Kibo Hill changed by more than five degrees, yet the true bearing of the summit from the survey station never moved. Account for this constancy, and state what it implies for old survey records.

Model Answer

True bearing is anchored to a fixed pole, while variation follows a wandering one.

The fixed anchor: true north is the direction of the geographic pole, set by the earth's rotation axis, so the angle from that direction to a fixed summit cannot change while the mountain stands.

The wandering needle: magnetic north migrates as the fluid outer core shifts, so the variation, and with it every magnetic bearing, drifts year by year.

The implication for records: an old magnetic bearing is only usable after correction with the variation of its own date, whereas an old true bearing is usable forever, which is why survey records anchor to true or grid north and log the date of every compass reading.

So the constancy is the geometry of a fixed earth against a restless field, and the Kibo file stays valid precisely because its true bearings never inherited the needle's wandering.

Question 122

A protractor exercise on a sheet, a night compass march near Monduli, and a graticule position report to a Mwanza control room each mention north. Evaluate which north each task must use and the cost of mixing them.

Model Answer

Each task owns its north, and borrowing another's imports its error.

Grid north for the protractor: map bearings are measured against the vertical grid lines, so the sheet task uses grid north, and no compass is involved.

Magnetic north for the march: the compass needle obeys the magnetic pole, so the Monduli marcher sets magnetic bearings, first correcting the map's grid bearing by the current variation.

True north for the graticule: latitude and longitude hang on the meridians, which converge on the geographic pole, so the position report speaks in true terms.

The cost of mixing: with a variation of a few degrees, an uncorrected swap misplaces a night march by hundreds of metres per kilometre, and a misquoted graticule bearing misleads every distant reader.

So the three norths are three instruments, protractor, needle and meridian, and discipline lies in declaring which one every bearing serves.

Question 123

Study Figure 5.34. A drilling team is told only this: the new gauge stands on the meridian 35°01′E, at the point where that meridian crosses the all weather road. Pin the point, state its six figure grid reference, and determine its latitude by proportion.

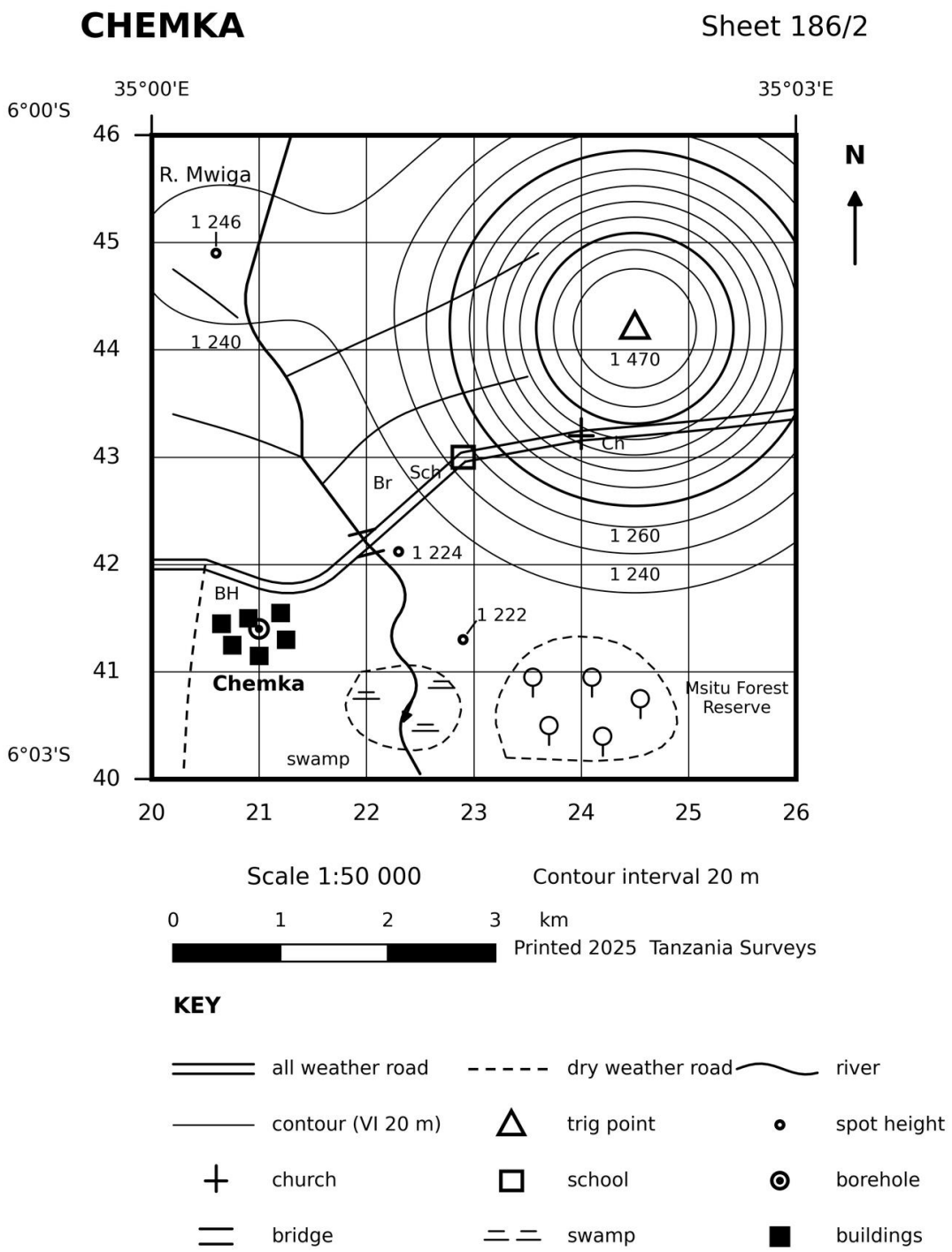


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Turn the meridian into an easting, intersect it with the road, then convert the northing back into latitude.

Step 1: place the meridian. The sheet spans 3′ of longitude across six grid squares, so each minute covers two squares, and 35°01'E stands on easting 22.

Step 2: intersect with the road. Easting 22 meets the all weather road at the bridge over the River Mwiga, at grid reference 220422.

Step 3: latitude by proportion. The point lies 3.8 of the six squares south of the 6°00′S parallel at northing 46:

$$\text{angle} = \frac{3.8}{6} \times 3' = 1'54'', \text{ so latitude} = 6°01'54'' \text{ S}$$

The gauge stands at the bridge, 220422, latitude about 6°01′54″ S, longitude 35°01′E.

So graticule and grid are two addresses for one point, and a team that can translate between them, as Mwanza survey crews must, is never lost by a half told instruction.

Question 124

Every Tanzanian 1:50 000 sheet leans on contour lines, yet the same sheets always add trig points, spot heights and names. Why do contours dominate, and why must they still be read with care?

Model Answer

Contours dominate because they alone draw the shape of the land quantitatively, yet they speak in steps and need witnesses.

The case for dominance: one family of lines yields heights, slopes, landforms, sections, gradients and intervisibility, no other single method carries such mathematics.

The care required: nothing smaller than the vertical interval can appear, crowded lines defeat the eye on scarps, and an untrained reader sees spaghetti rather than a hill.

The witnesses: trig points and spot heights pin exact values between the steps, and names such as swamp or scarp translate shape into speech, so the sheet reads reliably only as a chorus.

So contours are the backbone of relief on the Mkomazi or Uvinza sheets, and the careful reader always cross examines them against the surveyed points beside them.

Question 125

A geography club at Mbeya draws its cross sections at ten times vertical exaggeration and the hills look like the Alps. Assess whether vertical exaggeration helps or harms a profile.

Model Answer

Exaggeration is a magnifier, helpful in the drawer's hand and harmful in the believer's eye.

The help: true scale relief on a 1:50 000 section is nearly flat, so stretching the vertical axis makes valleys, shoulders and cols visible and comparable at all.

The harm: slopes steepen falsely, a one in ten climb looks like a cliff, and a reader who forgets the stretch judges gradients and intervisibility wrongly.

The discipline: choose the smallest exaggeration that shows the forms, print VE beside the profile, and quote gradients only from the map arithmetic, never from the drawing's appearance.

So the Mbeya club may keep its dramatic sections, provided every sheet confesses VE = 10, because an exaggeration declared is a tool and one concealed is a lie.

Question 126

Study Figure 5.34. A fire watcher argues that from the school at 229430 she will see the trig point at 245442, because the trig stands two hundred metres higher. Argue the intervisibility question properly and deliver a verdict.

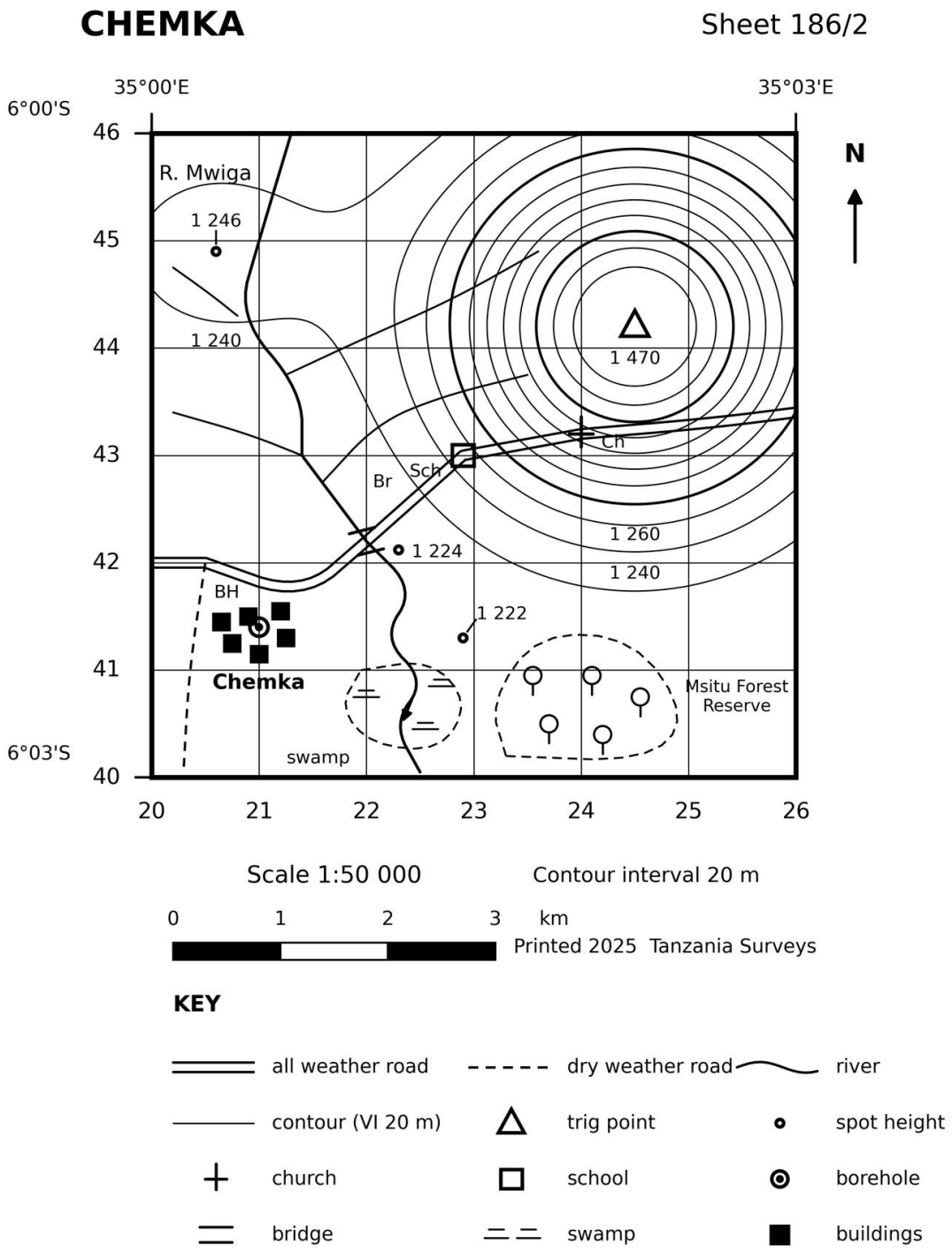


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Height difference alone decides nothing; the ground between holds the verdict.

The method: join the two points and read the contours along the line, comparing the ground at each crossing with the straight sight line rising from 1 270 m to 1 470 m.

The evidence: midway along the line the contours already read about 1 390 m, while the sight line at that point stands near 1 370 m, so the convex upper flank of the hill lifts above the line of sight.

The verdict with its reason: the two points are not intervisible, because a slope that is convex bulges between its foot and its summit, hiding each from the other even though one stands far higher.

False Confidence Alert
Higher does not mean visible. On a convex slope the shoulder blocks the summit from the foot; only a concave or even slope lets height translate into view.

Question 127

One examiner's favourite trap reads: *state the climate of the mapped area.* Using combined evidence as your standard, evaluate how a strong candidate reasons from a sheet like CHEMKA to a climate, rather than guessing one.

Model Answer

A strong answer builds a chain of independent witnesses and lets them converge.

Start with position: the graticule near 6°S promises a tropical regime, and the altitude above 1 200 m tempers it, two facts no symbol can overturn.

Add the water evidence: a perennial river beside a seasonal swamp and a village borehole testifies to rain that comes seasonally and stops, which one witness alone could not prove.

Add the cover and the works of people: protected forest only on the wetter flank, open bush elsewhere, and no tea or coffee estates, together rule out a wet highland climate.

The standard: each deduction must name its evidence, and the climate claimed must satisfy every witness at once, not merely the loudest one.

So the candidate reasons like a court of law, convicting the climate only when latitude, altitude, water, vegetation and land use all point the same way.

Question 128

A student concludes from a single sheet that Uvinza country receives 800 mm of rain in March and averages 24 degrees. Assess what a topographical map can never tell about climate, however well it is read.

Model Answer

The map yields climate by inference only, and inference has hard ceilings.

No numbers: no sheet carries rainfall totals, temperature records or the month the rains break, so 800 mm and 24 degrees are inventions, not readings.

No weather, no variability: a map drawn from one survey cannot show drought years, floods or the shifting onset that farmers fear most.

No microclimates or change: valley frosts, lakeside breezes and the drying of a swamp since compilation all escape the symbols.

What remains legitimate: the sheet supports only ranked statements, wetter than, drier than, seasonal rather than constant, and those must cite their features.

Question 129

Study Figure 5.34. Argue, as a connected explanation, how the relief of the CHEMKA area controls the drainage pattern the sheet displays.

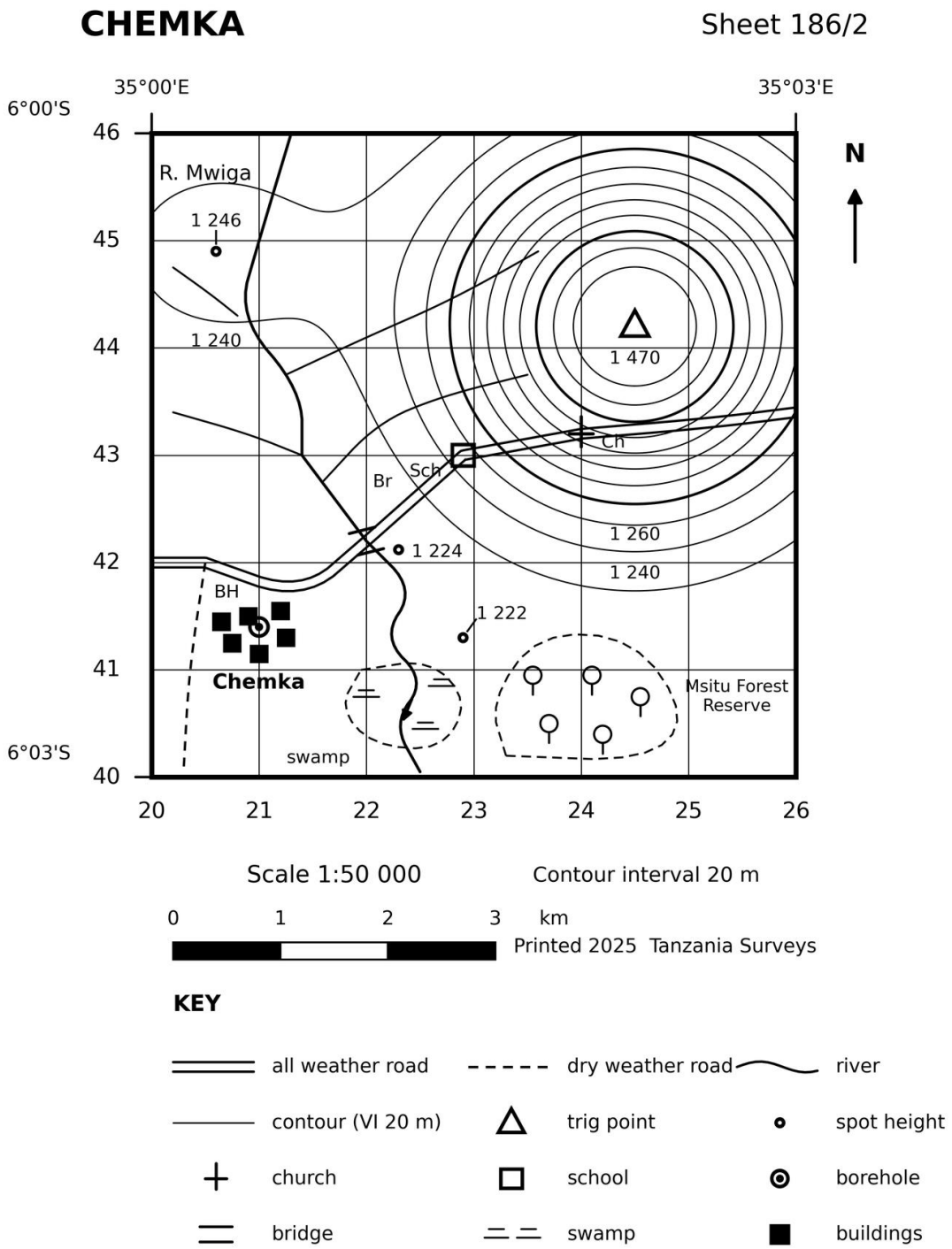


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The relief writes the drainage: a dome commands radial flow, a plain permits dendritic wandering, and a level floor forces water to rest.

On the hill: the closed contours of the north eastern dome shed tributaries outwards down every flank, a radial pattern owing nothing to rock and everything to gradient, as on the cone of Kilimanjaro.

On the plain: westwards the wide contour spacing leaves the tributaries free to join the Mwiga at acute angles, the tree like dendritic pattern of uniform, gently sloping country.

On the floodplain: south of the bridge the land flattens almost to stillness, so the river meanders and finally ponds into swamp, drainage defeated by the loss of slope.

The synthesis: one river system thus wears three faces in six kilometres, and each face is the local gradient made visible.

Question 130

Study Figure 5.39. A colleague insists the MBUYU area is above all a plantation economy; another says it lives by trade. Weigh the evidence and judge which activity dominates the mapped area.

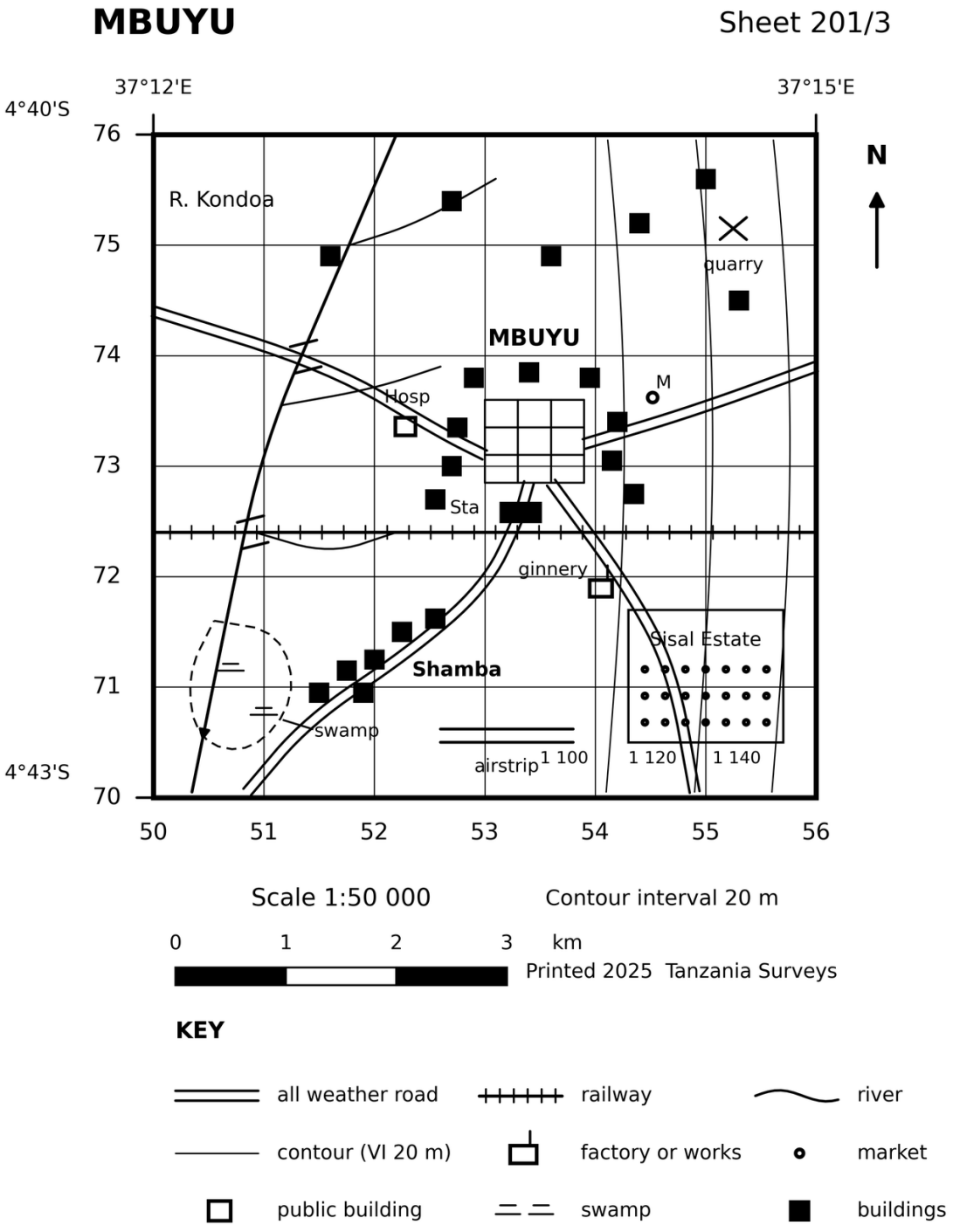


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

The verdict must weigh area, infrastructure and employment evidence, not the loudest symbol.

The plantation case: the sisal estate with its ginnery occupies the largest single land parcel and adds processing, so by area and investment it is the heaviest mark on the sheet, as sisal once was around Korogwe.

The trade case: the town holds the market, station, hospital and the meeting of five routes, so by employment and daily exchange the centre argues hard for commerce.

The smallholder undercurrent: the linear village and dispersed homesteads along the river speak for food farming that feeds both estate and town but shouts on no symbol.

The judgement: dominance by land use falls to plantation agriculture, while dominance by livelihood is shared with trade at the node; the strong answer states the criterion before the winner.

Question 131

Study Figure 5.39. Reason from the physical base to the human pattern: how have relief and water together arranged the settlement of the MBUYU area?

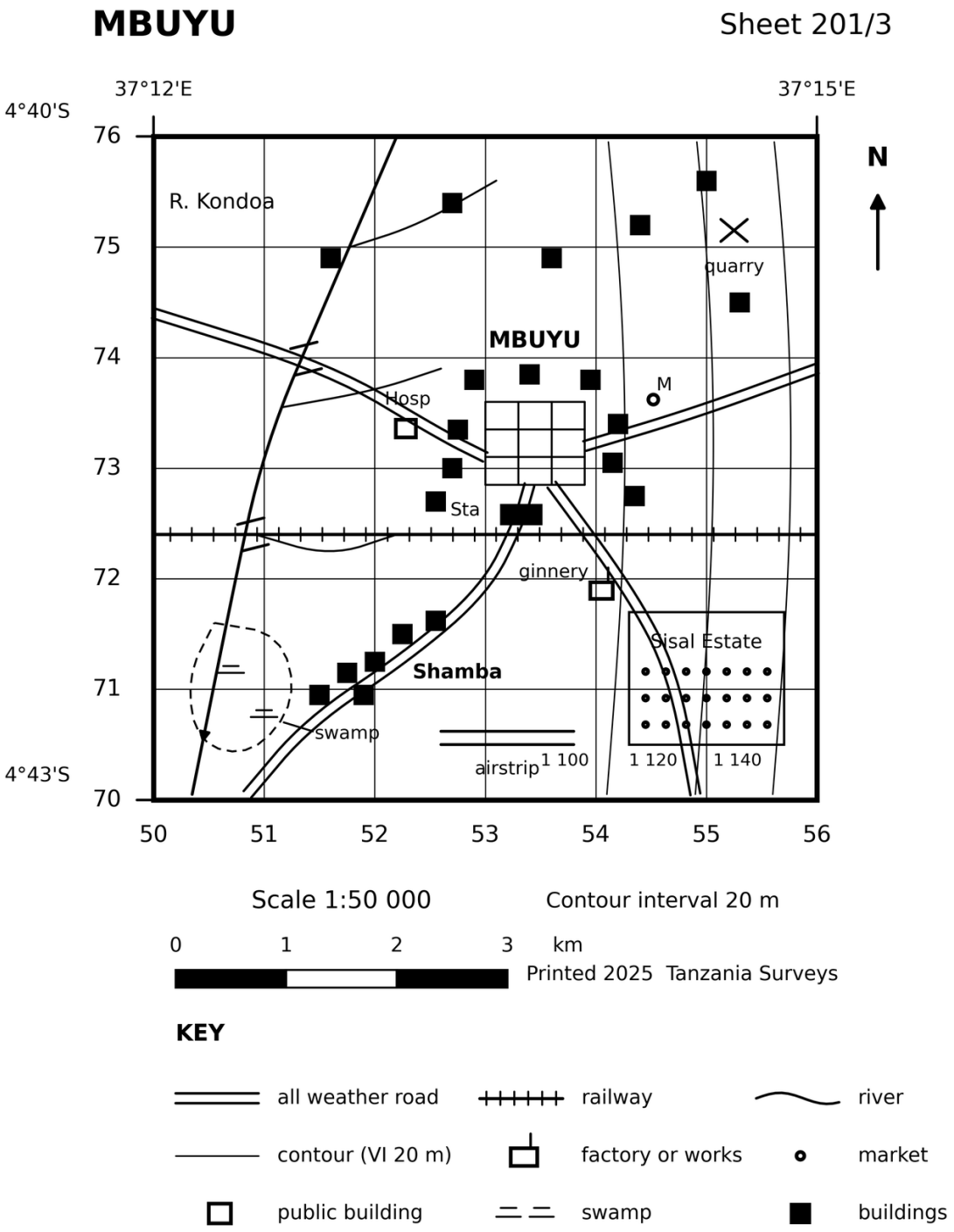


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

People settled where the land is level and the water is present but not in possession.

The town at the dry node: Mbuyu grew on the even interfluve where the railway could run straight and five roads could meet, close to the river for supply yet above its swamp.

The linear village on the safe margin: Shamba strings along the road on ground just above the wetland, each plot touching the route and the moisture without drowning in either.

The dispersed north: homesteads scatter where tributaries offer water everywhere, so no single point compels a cluster.

The empty quarter: the swamp itself and the wettest floodplain stay unsettled, the negative print of the same two controls.

So the settlement map is the relief and water map redrawn by human judgement, cluster at the node, ribbon at the margin, scatter where water is everywhere and absence where it is too much, the very logic that strings villages above the Kilombero floodplain.

Question 132

Study Figure 5.34. A cooperative seeks land for a mechanised maize farm of about four square kilometres in the CHEMKA area. Assess the suitability of the area and recommend, with evidence, where the farm should and should not go.

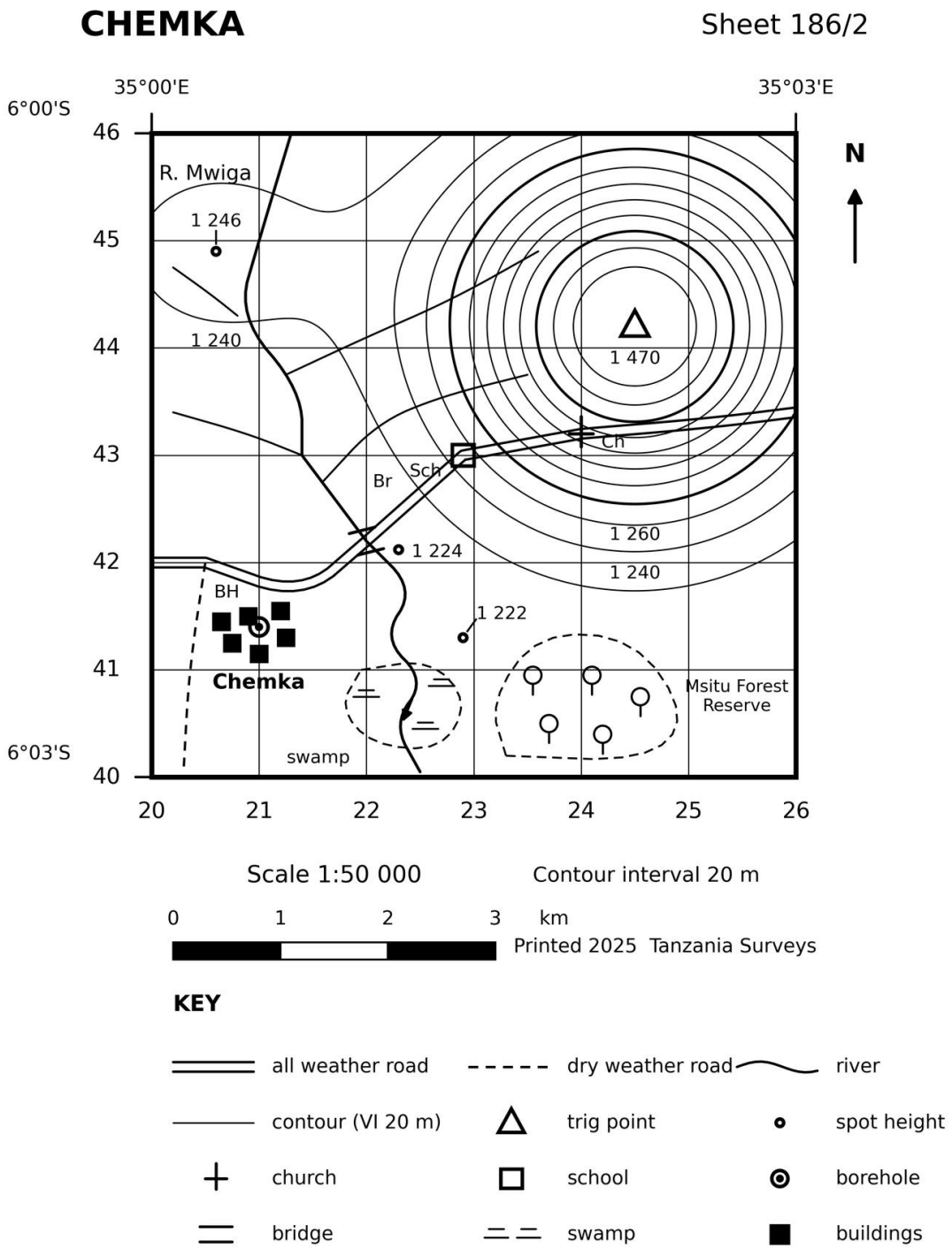


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The sheet offers one strong candidate zone, two forbidden zones and one costly temptation.

The candidate zone: the western and central plain between the village and easting 23, level by its wide contour spacing, watered by the river and the borehole, and already served by the all weather road and the dry weather branch.

Forbidden by water: the southern floodplain and swamp flood seasonally, and mechanised fields there would drown with the meanders.

Forbidden by law and slope: the Msitu Forest Reserve is gazetted, and the hill flank above the 1 300 m contour is too steep for machinery.

The costly temptation: the empty north east foot slopes look free, but they lie beyond the bridge bottleneck, adding haulage over one crossing point.

So the recommendation is the west central plain, roughly two grid squares of it, with the swamp, the reserve and the steep flank marked as no go, the same suitability reasoning the Usangu farms learnt the hard way.

Question 133

Study Figure 5.34. The district proposes a small earth dam on the River Mwiga to supply Chemka village. Assess the proposal and argue the best siting decision the sheet allows.

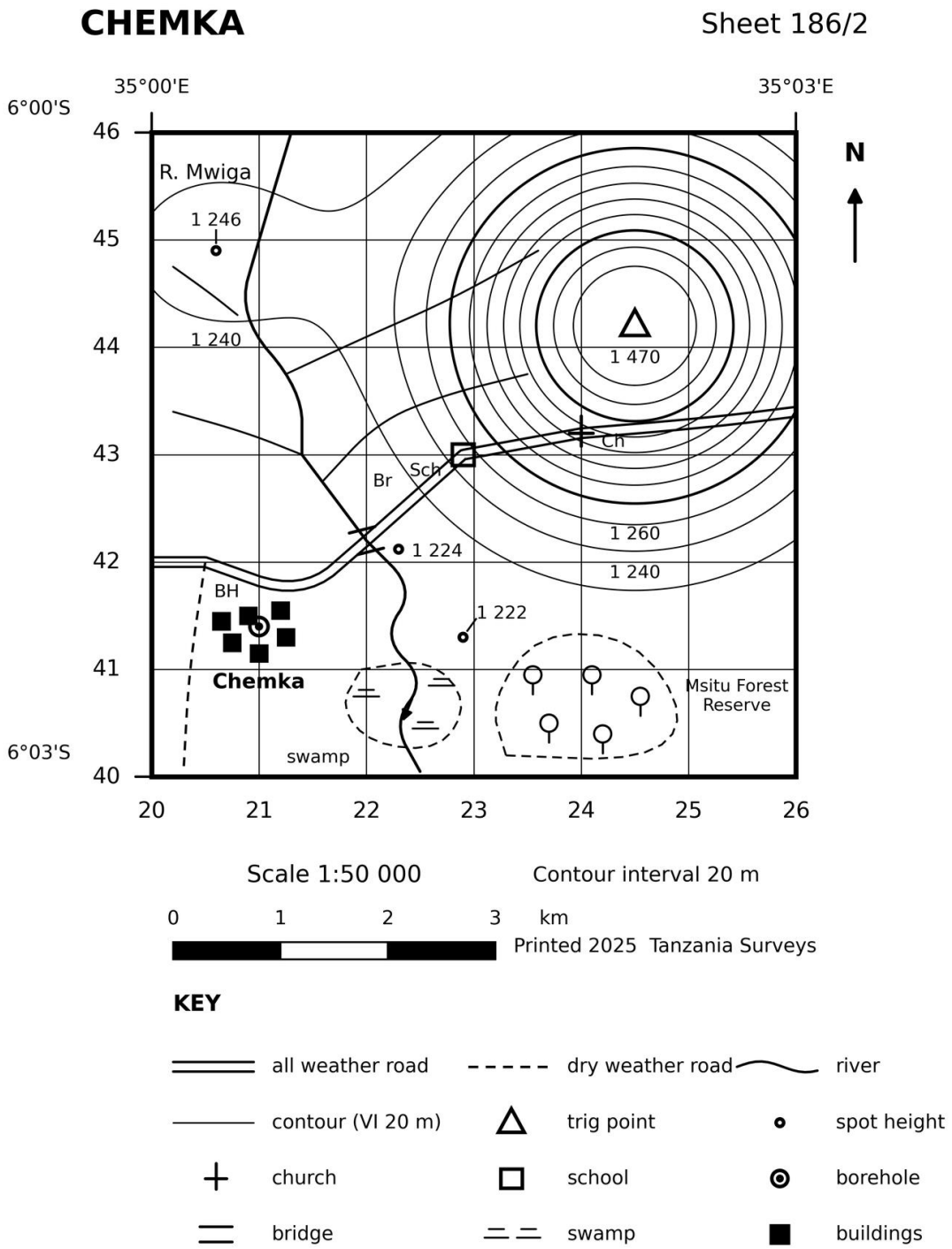


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The river can carry a small dam, but the sheet argues hard about where.

The case for the dam: the Mwiga is perennial, the village and borehole prove year round demand, and the road and bridge put construction traffic within one kilometre of any site near the crossing.

The case against the obvious site: at and below the bridge the valley is nearly flat, so a dam there would spread a shallow, evaporating sheet into the swamp, drown the road approach and trap the silt of the meanders.

The better siting: upstream of the bridge, between northings 43 and 44 where the contours pinch the valley below the hill flank, a short embankment gains depth over area, spares the road, and gravity feeds the village.

The residual risks: seasonal inflow demands a spillway sized for the wet months, and the forest reserve boundary must stay outside the pool.

So the verdict is yes, but upstream, a judgement of contours over convenience, exactly the reasoning that sited Mtera and Kidatu on constricted reaches rather than open plains.

Question 134

Study Figure 5.34. Contrast the country east and west of easting 23 on the CHEMKA extract, in relief, drainage and land use, and account for the contrast.

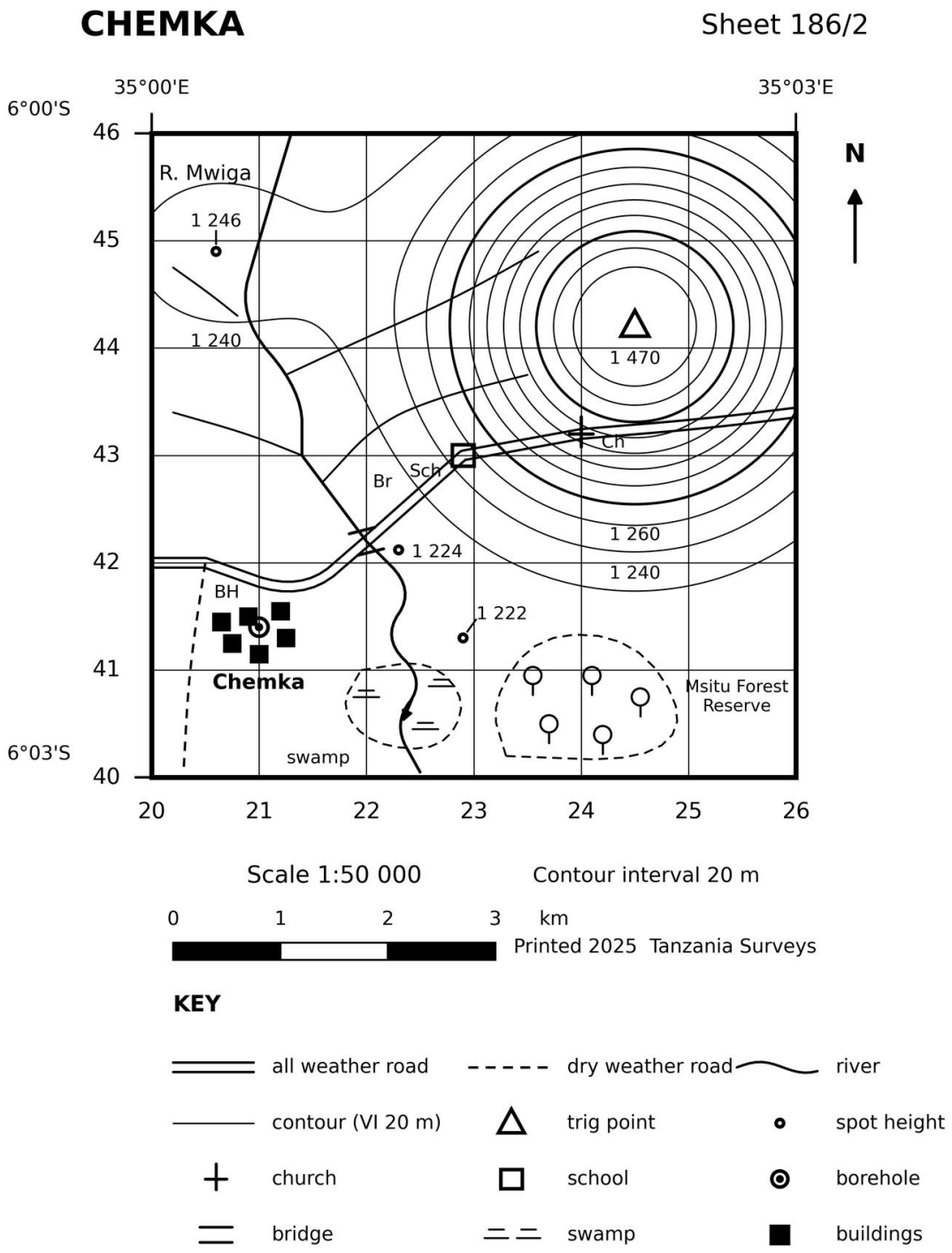


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

Easting 23 divides a working plain from a rising, protected flank.

Relief: the west lies low and level, almost contour free below 1 240 m, while the east climbs ring upon ring to the trig at 1 470 m.

Drainage: the west carries the collected river, its meanders and the swamp, while the east only sheds short radial tributaries that hurry off the dome.

Land use and settlement: the west holds the village, borehole, junction and dry weather road, the working country; the east holds the gazetted forest, the school and church at the flank foot, and otherwise keeps people off its slopes.

The account: one cause underlies all three contrasts, the hill: its slopes shed water and repel ploughs and houses, while its shadow of level ground gathers river, road and people.

So the sheet east and west reads like plateau Tanzania in miniature, people on the plains, forest on the heights, and the boundary is written by the contours, not by choice.

Question 135

Study Figure 5.39. A heritage writer claims that Mbuyu town owes its existence to the railway. Build the case from map evidence, then test it against rival explanations before delivering a verdict.

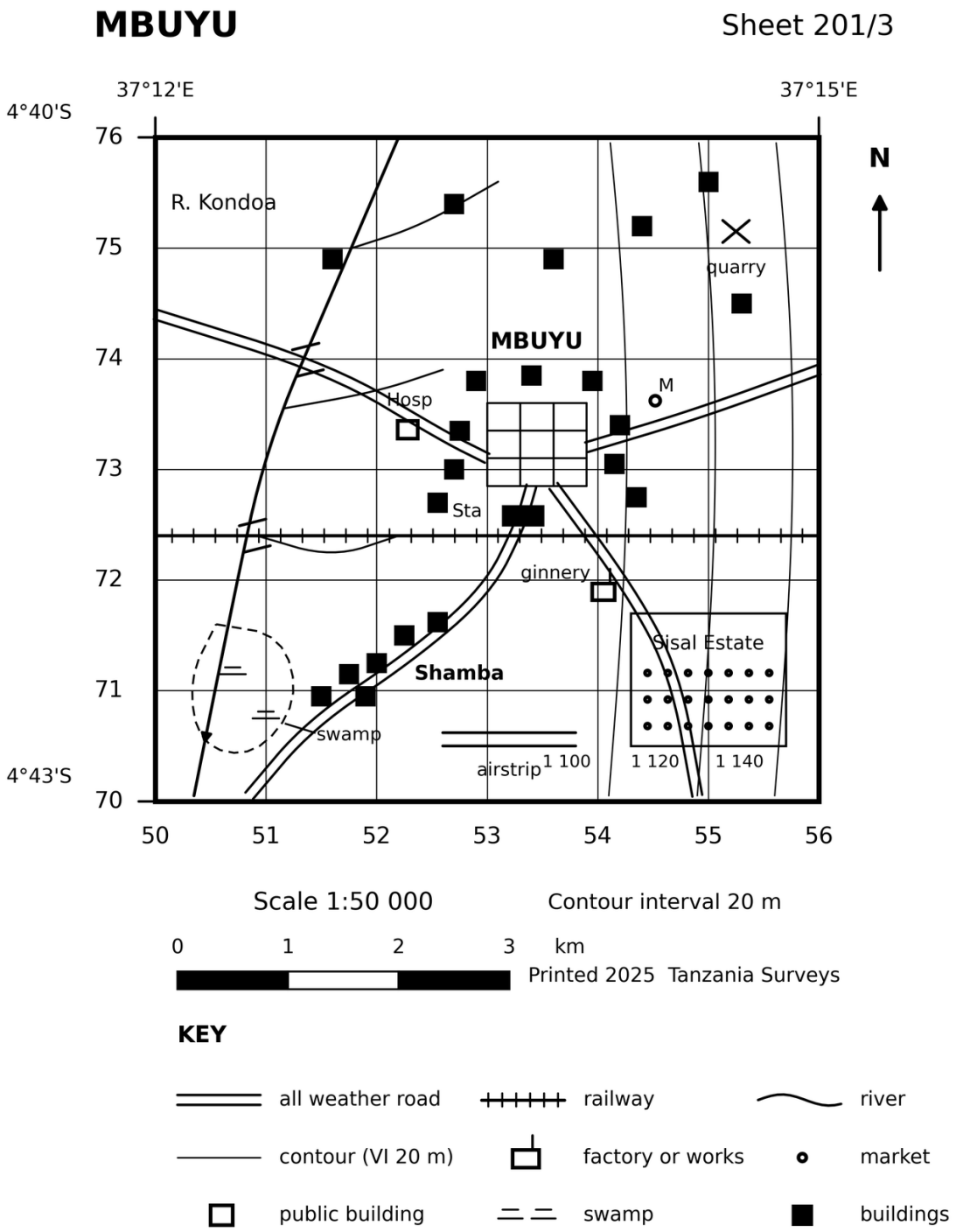


Figure 5.39: *The MBUYU extract, Sheet 201/3 (scale 1:50 000)*

Model Answer

The railway case is strong, but it must defeat the road and river cases to stand.

The railway case: the town's buildings crowd the station, the CBD grid faces the line, and the ginnery ships sisal by rail, so the town's working parts all touch the track, as Tabora's once did.

The road rival: five roads meet at Mbuyu, yet roads bend to serve towns as often as towns grow from roads, and these radiate from the station square itself.

The river rival: the Kondoa waters the plain but flows a kilometre west, with the swamp discouraging riverside building, so water explains the farms more than the town.

The verdict: the railway is the founder, the roads are the heirs, and the river is the neighbour; the station explains why the town is here rather than anywhere else on the plain.

So the writer's claim survives the trial, and the candidate's craft lies in convicting one cause only after honestly arraigning the others.

Question 136

Study Figure 5.34. A revision note circulating before the mock examination reads: CHEMKA enjoys heavy, reliable rainfall, proved by its permanent river. Detect what is wrong with this interpretation and correct it.

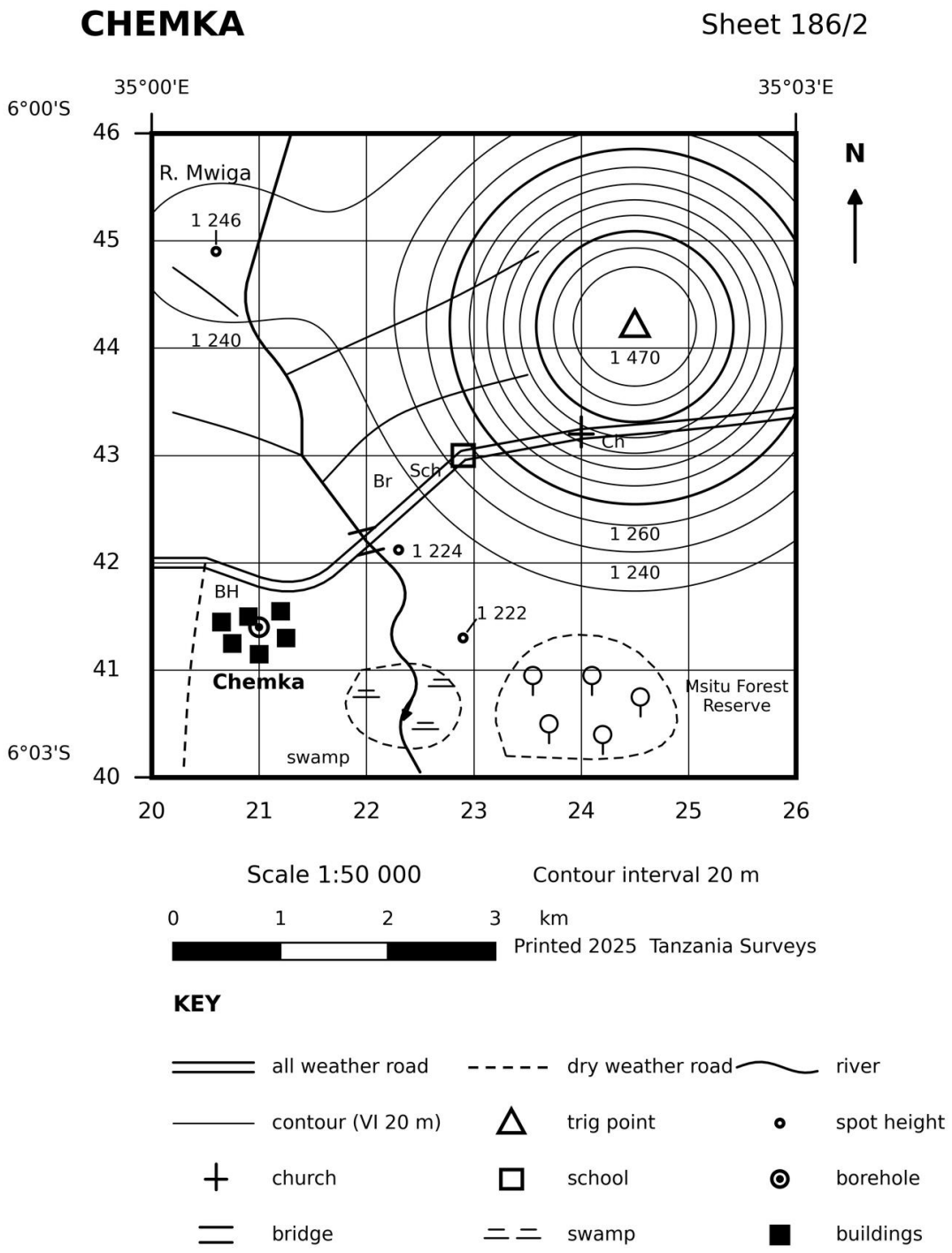


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The note mistakes one witness for the whole trial, and the witness is not even local.

The flaw of the single clue: a perennial river proves water arriving, not rain falling here; the Mwiga gathers its flow from the hill flank and beyond the northern edge, so it testifies about its source lands.

The ignored contrary evidence: the seasonal swamp, the village borehole, the absence of wet climate crops and the open bush all argue a marked dry season and modest totals.

The corrected reading: CHEMKA is better read as seasonally watered plateau country, its river permanent because the catchment is generous, not because the sky is.

So the note fails the combined evidence test, and the correction, semi arid with seasonal rain, is what the whole sheet, like the country around Dodoma, actually says.

Question 137

Study Figure 5.34. As the closing task of the chapter, synthesise a single connected regional account of the CHEMKA area, letting relief lead to drainage, drainage to climate and vegetation, and these to settlement and livelihood.

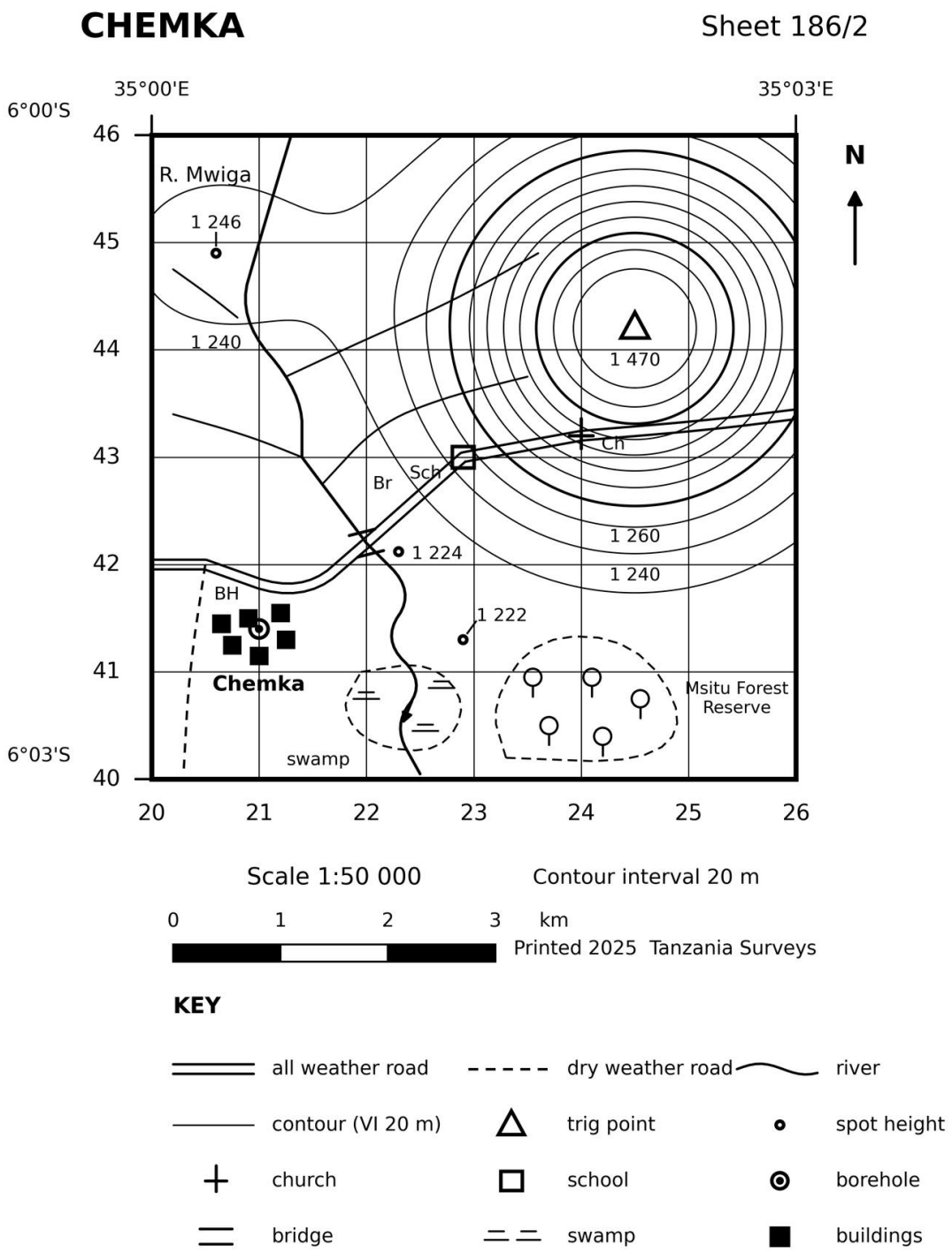


Figure 5.34: *The CHEMKA extract, Sheet 186/2 (scale 1:50 000)*

Model Answer

The account runs in one causal thread from the hill to the household.

The sheet is commanded by a single dome in the north east, rising ring by ring to the trig point at 1 470 m, and everything else follows from it. The dome sheds radial streams that unite westwards into the River Mwiga, which wanders as a dendritic system across a plain lying near 1 220 m and, losing slope in the south, meanders and drowns into a swamp before leaving the sheet. Position near 6°S and the plateau altitude make the area tropical and tempered; the seasonal swamp, the borehole beside a perennial river and the open bush confess rain that comes in a season and stops. Vegetation obeys the same masters, gazetted forest holding the moister flank, marsh plants in the drowned south, grass and bush on the working plain.

People have answered the physique precisely. Chemka village stands on the dry level ground within reach of river and borehole; the all weather road takes the one sensible line across the plain, pays its single toll at the bridge, and climbs past the school and church along the hill foot; the dry weather branch serves the southern plots in the dry months only. Farming keeps to the plain, the reserve locks the flank, and the swamp is left to grazing and birds. The area is, in miniature, the story of central Tanzania: a generous hill, a seasonal sky, and a people arranged carefully between water and slope.

So the synthesis binds every symbol into one argument, relief to river to rain to livelihood, and a candidate who can tell that story of any sheet, from Mpanda to Arusha 55/3, has finished this chapter ready for the examination.

PART TWO

EXAMINATIONS QUESTIONS

This examination section is where knowing becomes doing. The chapters before it have built your practical skill technique by technique; here that skill is put to work under the conditions of the national examination itself. Everything that follows is set at full examination standard, with no tiers and no scaffolding, and it is arranged in two parts: sixty multi-part short-answer questions, the first twenty worth twenty-five marks and the remaining forty worth fifteen, which test whether you can measure, plot, compute and interpret with precision, and eighty essay questions, each worth twenty marks, which ask you to argue a practical theme point by point from a clear introduction to a reasoned conclusion. Every question is drawn from the Form Five and Form Six practical syllabus and written in the language of recent Advanced papers, with Tanzania as the living ground throughout, in every map extract, every table of data and every photograph. Work each question first under the clock, with the solutions closed, as though the examiner were already waiting; only then turn to the model solutions, to mark yourself honestly and to see where the marks truly lie. Used in this way, the questions that follow are the surest bridge between the syllabus you have studied and the grade you intend to earn.

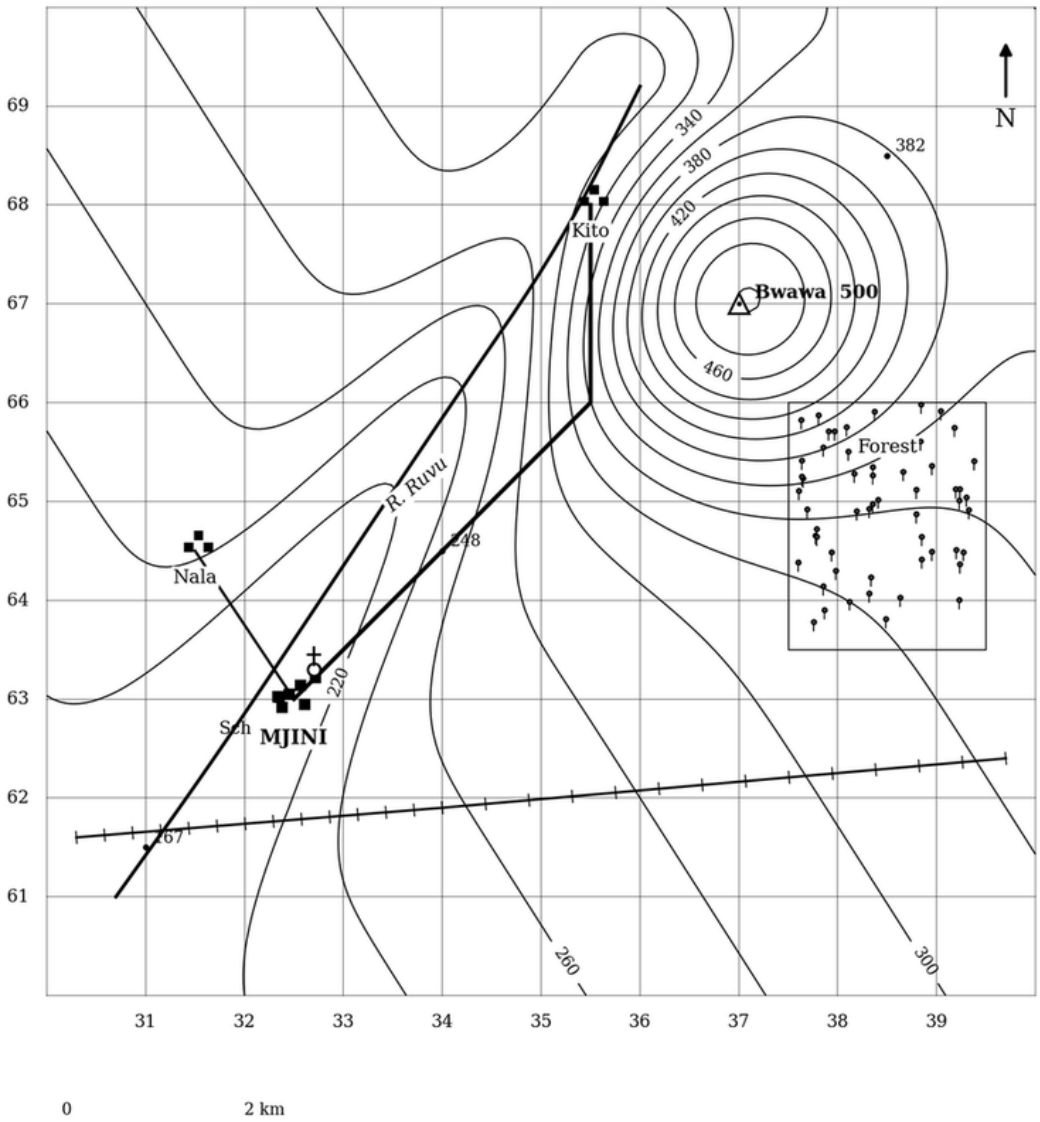
SHORT-ANSWER QUESTIONS

Question 1

Study the extract of the MJINI area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the MJINI area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of:

(i) the triangulation station on Bwawa hill;

(ii) the church near Mjini.

(b) Find the straight-line distance, in kilometres, from the triangulation station on Bwawa hill to the town of Mjini.

(c) Calculate the area of the forest in the east of the map, in square kilometres.

(d) Calculate the gradient from Mjini to the triangulation station on Bwawa hill.

(e) Draw a cross-section along northing 65 from grid reference 310650 to grid reference 390650, and use it to say whether the two ends are intervisible.

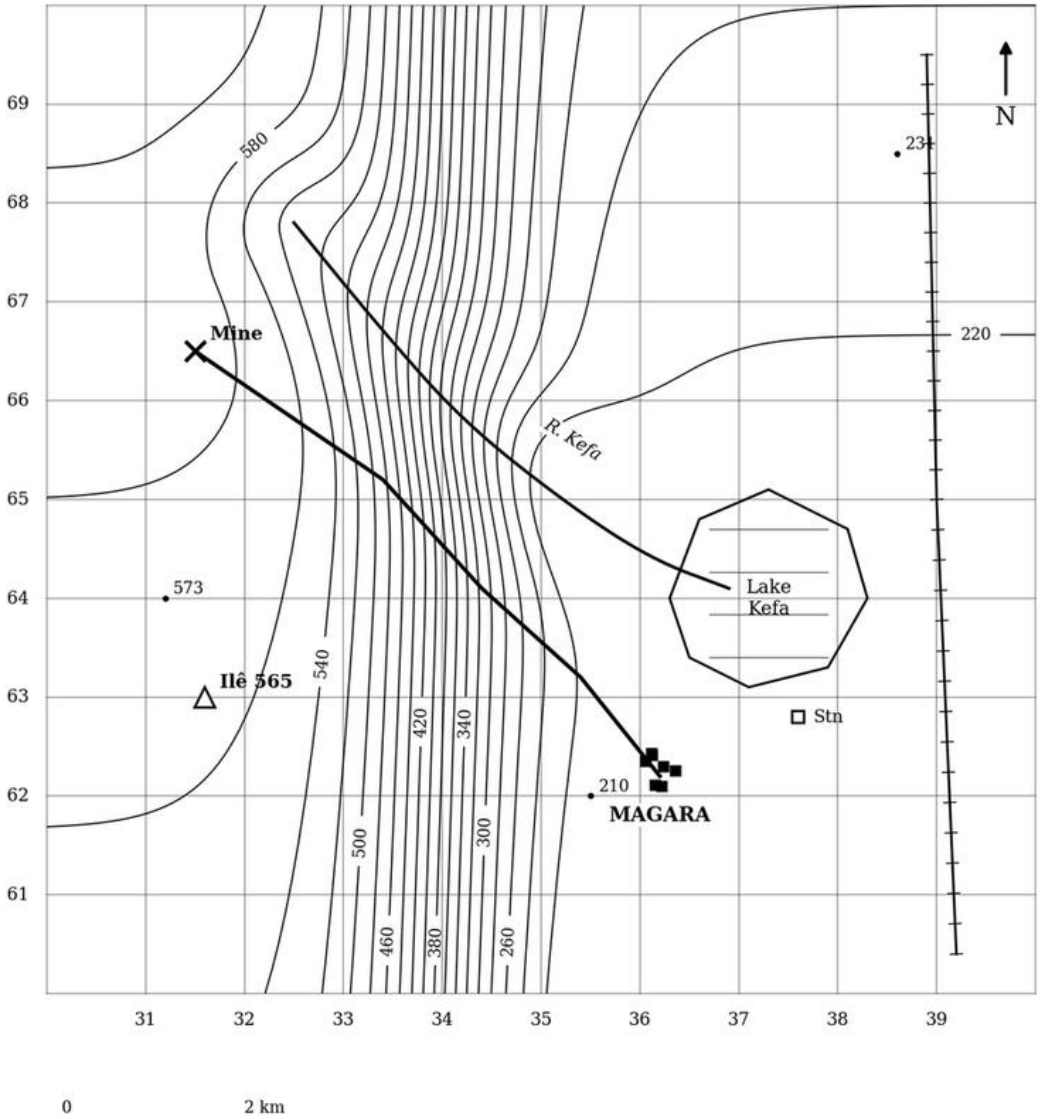
(f) Describe the relationship between relief and drainage shown by the map.

Question 2

Study the extract of the MAGARA area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the MAGARA area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the mine, and (ii) the railway station.

(b) Find the distance by road from Magara town to the mine, in kilometres.

(c) Estimate the area of Lake Kefa in square kilometres.

(d) A steep slope crosses the western half of the map. Name this feature and describe it.

(e) Draw a cross-section along northing 64 from grid reference 310640 to grid reference 390640, and describe the shape of the land it shows.

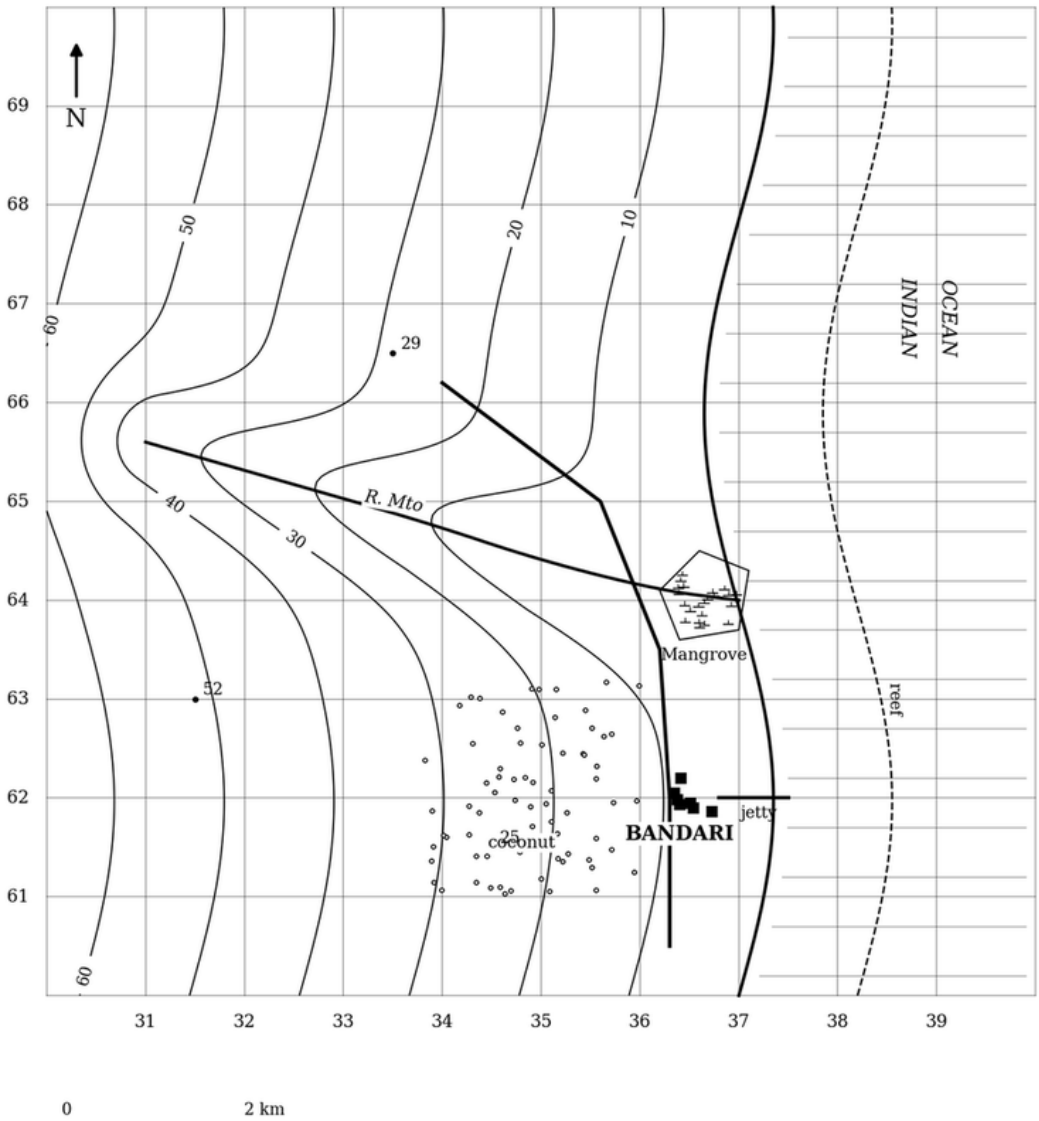
(f) Describe the relationship between relief and settlement shown by the map.

Question 3

Study the extract of the BANDARI area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the BANDARI area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the town of Bandari, and (ii) the river mouth.

(b) Find the compass bearing of the river mouth from Bandari.

(c) Find the straight-line distance from Bandari to the river mouth, in kilometres.

(d) Name the vegetation shown at the river mouth and the feature lying offshore, and state what each shows about the coast.

(e) Describe the main economic activities of the area and relate them to its physical features.

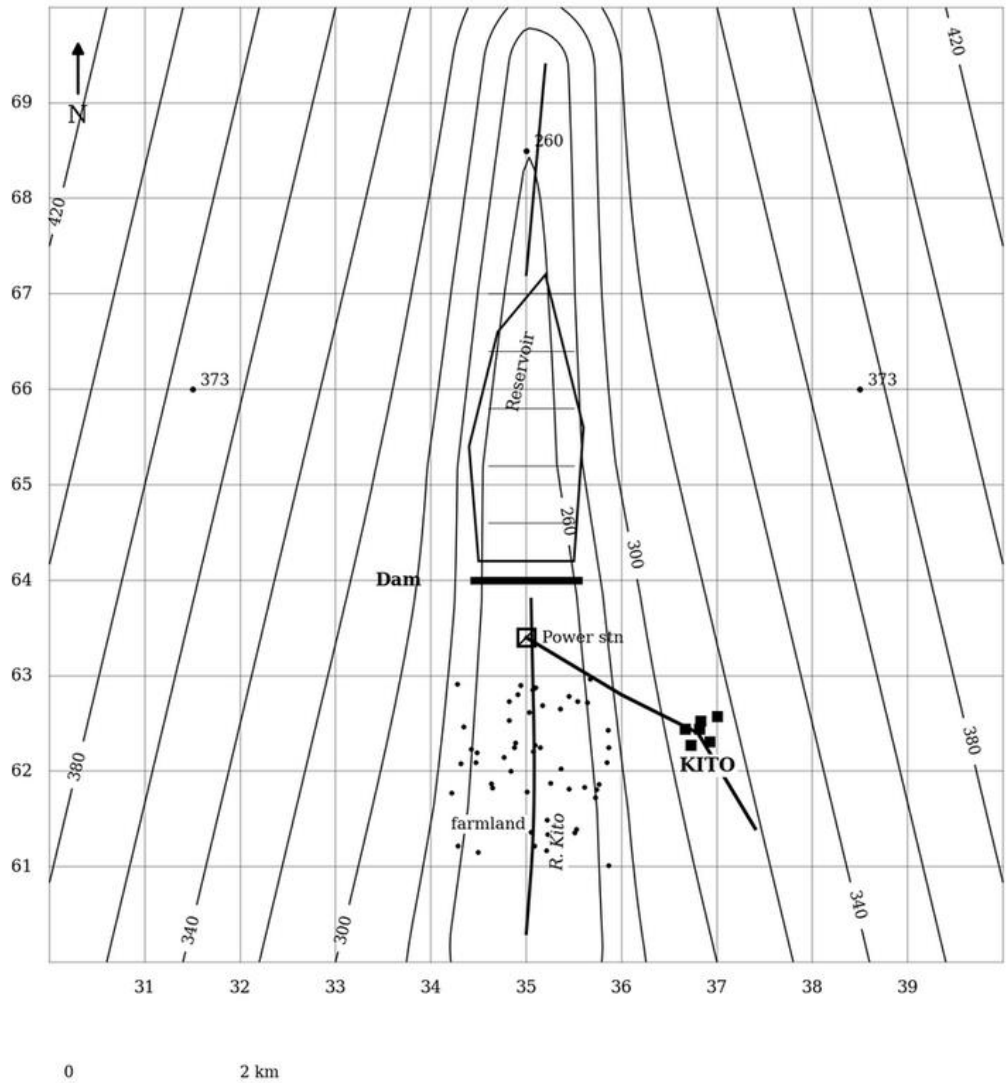
(f) Give three pieces of evidence that this is a low-lying coastal area.

Question 4

Study the extract of the KITO DAM area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the KITO DAM area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the dam, and (ii) the power station.

(b) Estimate the area of the reservoir in square kilometres.

(c) Name the feature held behind the dam and explain how it was formed.

(d) Give two reasons why this site was chosen for the dam.

(e) Describe three benefits the dam brings to the area.

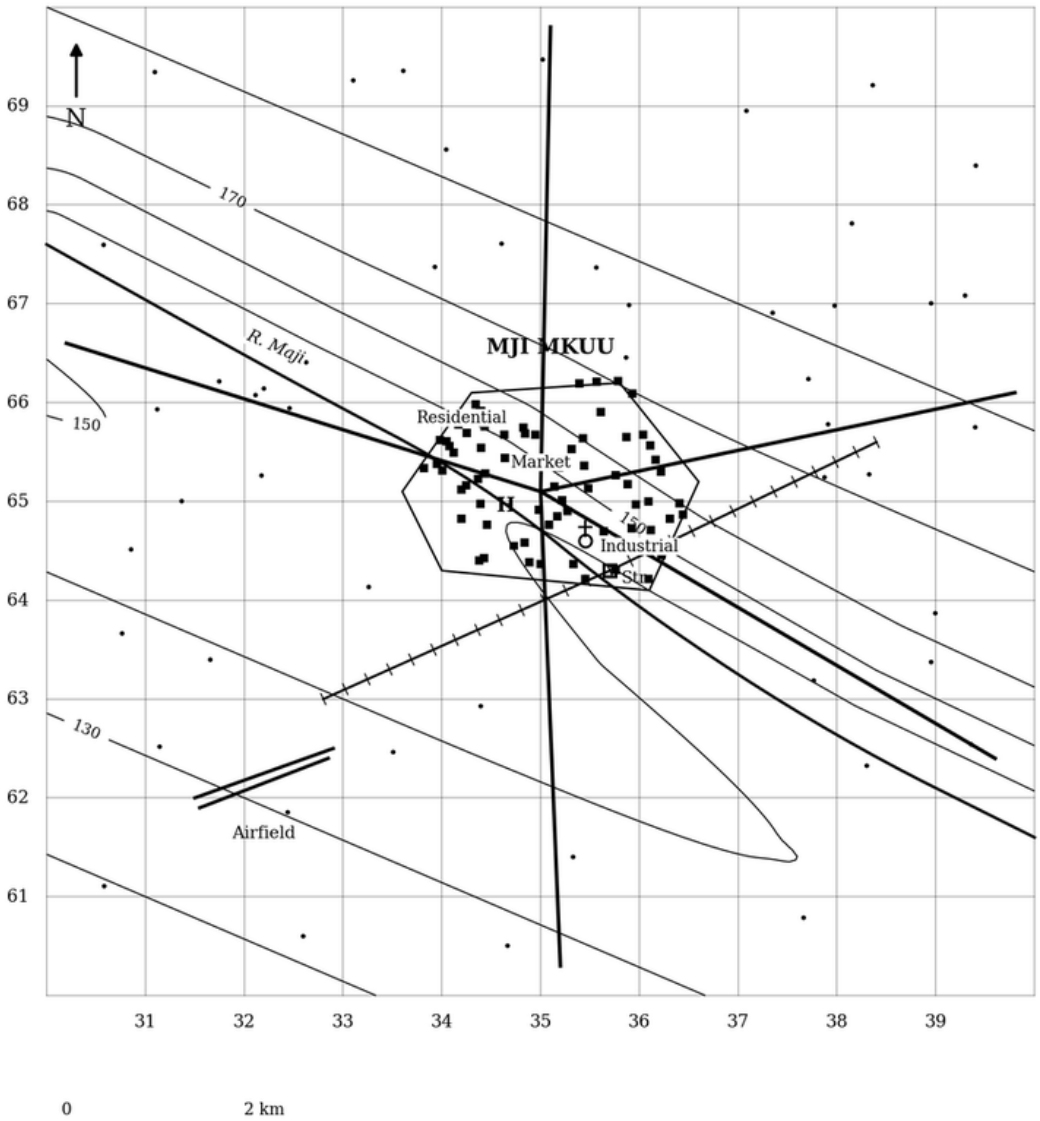
(f) Draw a cross-section across the valley from grid reference 310660 to 390660, and describe the shape of the valley.

Question 5

Study the extract of the MJI MKUU area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the MJI MKUU area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the railway station, and (ii) the airfield.

(b) MJI MKUU is described as a route centre. Give evidence from the map to support this.

(c) Identify two land-use zones within the built-up area and give evidence for each.

(d) Name three functions of the town, using evidence from the map.

(e) Give two reasons why the town grew at this site.

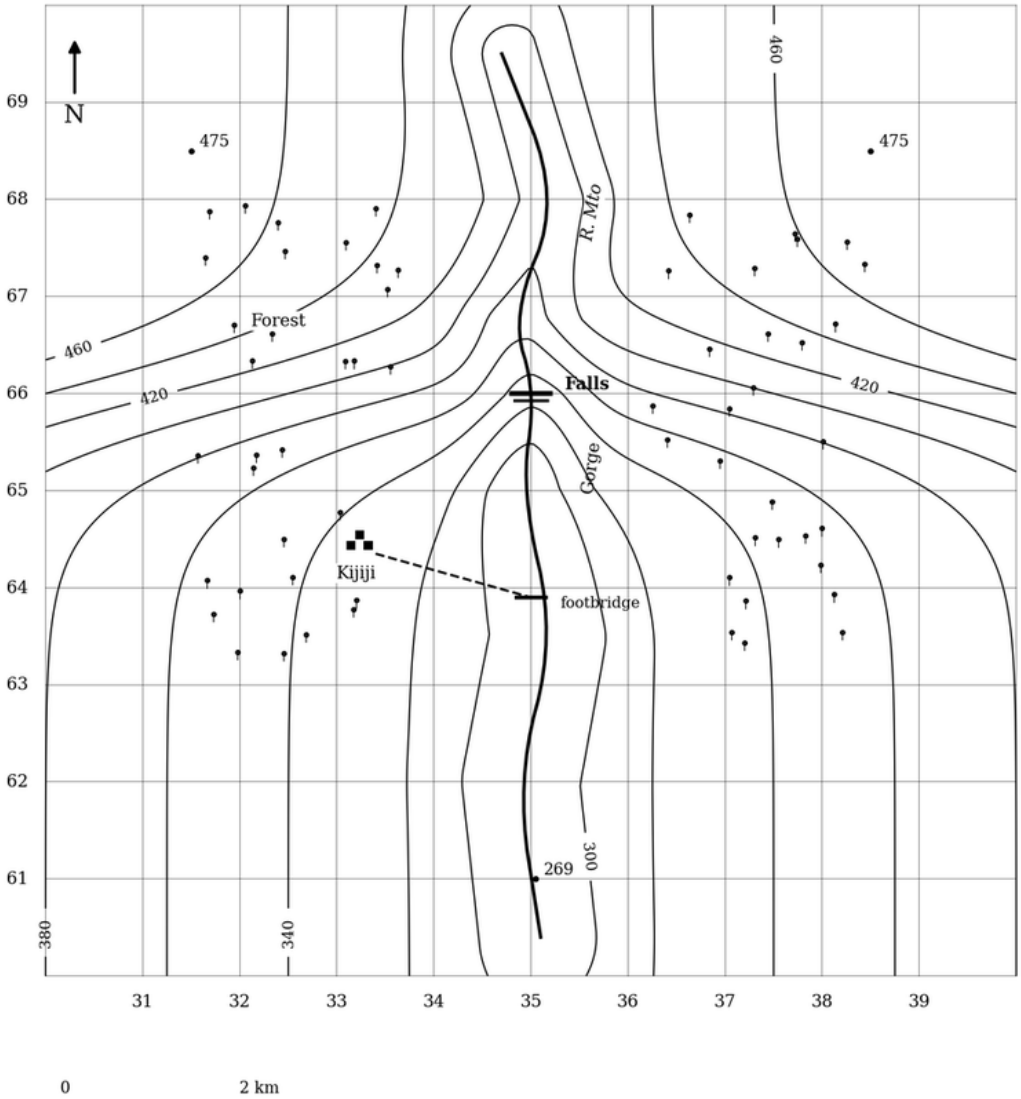
(f) Describe the pattern of settlement shown by the map.

Question 6

Study the extract of the MTO area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the MTO area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the falls, and (ii) the village of Kijiji.

(b) Name three features of the river and its valley shown on the map.

(c) Give two pieces of evidence that the river is in its young, or upper, stage.

(d) Draw a cross-section across the valley from grid reference 310640 to 390640, and describe its shape.

(e) Explain how the waterfall was probably formed.

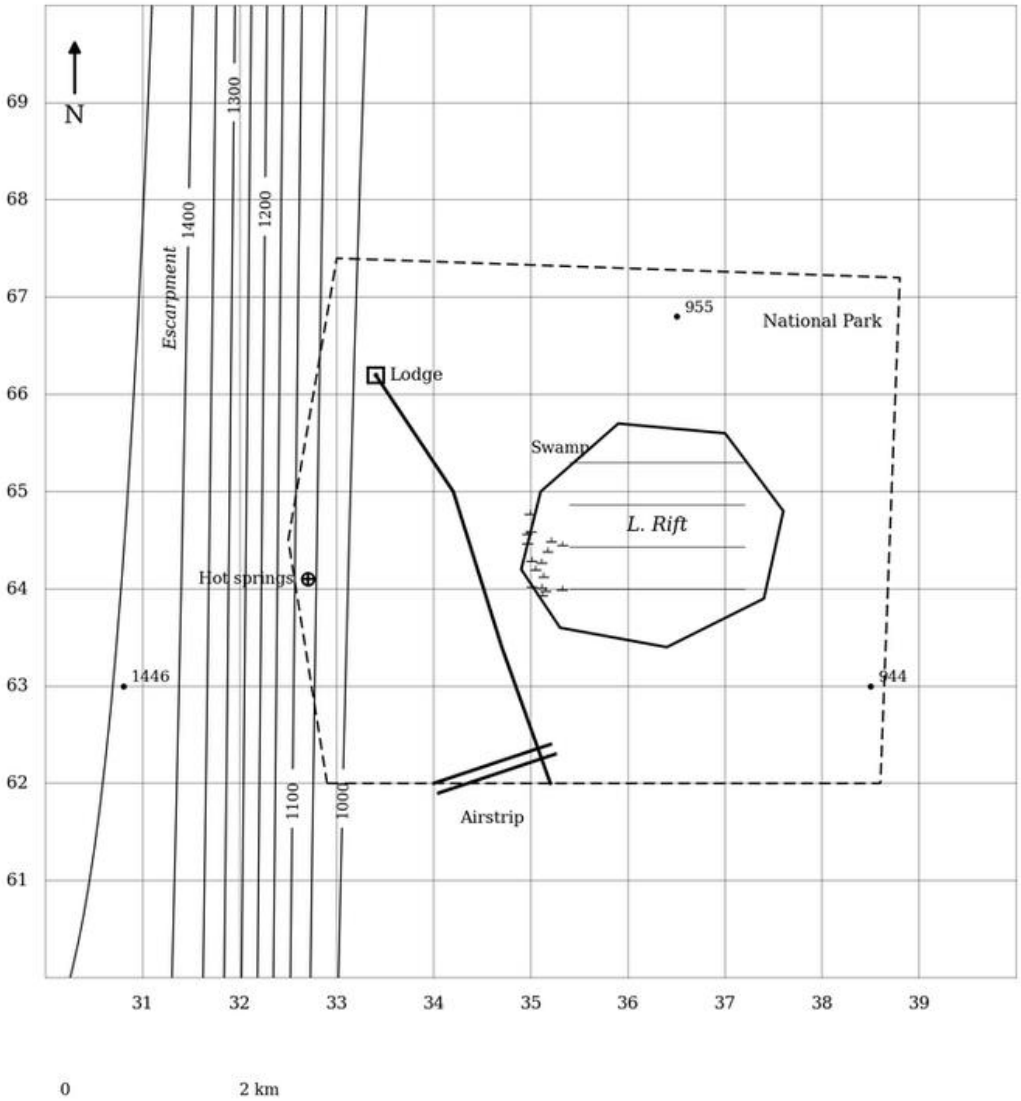
(f) How have the relief and the river affected settlement in the area?

Question 7

Study the extract of the LAKE RIFT area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the LAKE RIFT area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) the lodge, and (ii) the hot springs.

(b) Estimate the area of Lake Rift in square kilometres.

(c) Name the steep feature in the west of the map and the flat region to its east, and state how the steep feature is shown on the map.

(d) Give two pieces of evidence that the area is developed for tourism.

(e) Explain two ways in which the physical features of the area attract tourists.

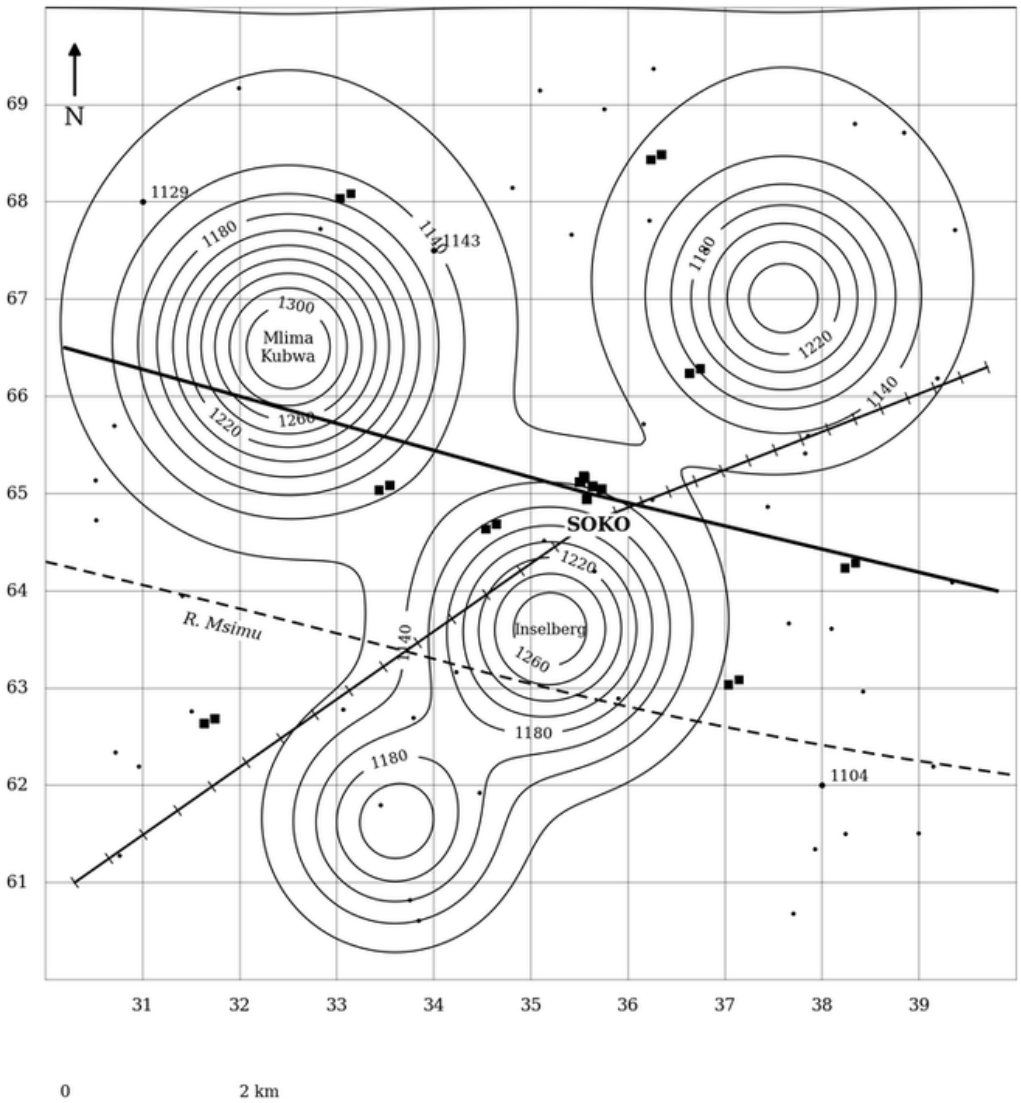
(f) Describe the change in relief from west to east across the map.

Question 8

Study the extract of the SOKO area (scale 1:50 000, grid interval 1 km) provided, then answer the questions that follow.

Extract of the SOKO area

Scale 1:50 000 (grid interval 1 km)



(a) Give the six-figure grid reference of (i) Mlima Kubwa, and (ii) the town of Soko.

(b) Name the isolated rocky hills that rise from the plain, and state how they are shown on the map.

(c) The river is drawn with a broken line. What does this show?

(d) Describe the pattern of settlement and suggest a reason for it.

(e) Give three pieces of evidence that the area has a dry climate.

(f) Describe the relief of the area.

Question 9

A planning officer in Njombe is preparing a regional development report. She must present the pattern of land use in the Southern Highlands and summarise the performance of a sample of geography candidates.

(a) The table below shows the percentage of land under four uses in five regions. Present the data using a compound divided percentage rectangle, at a vertical scale of 1 cm to 10 per cent.

Region	Agriculture	Forest	Settlement	Other
Njombe	45	35	12	8
Iringa	50	30	12	8
Mbeya	55	25	15	5
Ruvuma	40	45	10	5
Songwe	60	20	14	6

(b) The geography scores of eight candidates were 80, 70, 20, 90, 50, 10, 30 and 28.

(i) Calculate the standard deviation of the scores.

(ii) Calculate the coefficient of range.

(c) Give three merits and three demerits of the method of presentation you used in (a).

(d) Identify five roles of statistics in geography.

Question 10

A teacher in Shinyanga records the test marks of fifty candidates and groups them as shown below.

Marks	0-10	10-20	20-30	30-40	40-50	50-60
Frequency	2	5	12	15	10	6

(a) Draw a histogram to represent the data.

(b) Draw the cumulative frequency curve (ogive) for the data.

(c) From the ogive, estimate the median mark.

(d) Calculate the mean mark by the assumed-mean method.

Question 11

A weather station at a place in western Tanzania records the average monthly rainfall and temperature shown in the table below.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rain (mm)	120	110	140	90	30	5	2	3	10	40	100	130
Temp (°C)	24	24	24	23	22	20	20	21	23	24	24	24

(a) Draw a climate graph for the station, showing rainfall as bars and temperature as a line.

(b) Calculate the total annual rainfall and the mean annual temperature.

(c) State the month of highest rainfall and the annual range of temperature.

(d) Describe the climate shown by the graph.

Question 12

A forester in Mufindi records the age, in years, of thirty-five young trees in a plantation, grouped as shown below.

Age (years)	1-5	6-10	11-15	16-20	21-25
Number of trees	3	7	12	8	5

(a) Calculate the mean age of the trees.

(b) Calculate the median age.

(c) Calculate the modal age.

(d) Calculate the standard deviation of the ages.

(e) Comment on the shape of the distribution.

Question 13

The table below shows the cashew nut production of five coastal regions of Tanzania in a certain year.

Region	Tanga	Dar es Salaam	Pwani	Lindi	Mtwara
Cashew (tons)	1 000	500	1 600	2 500	2 900

(a) Using a scale of one dot to 300 tons, find the number of dots needed for each region.

(b) Draw a dot map on a sketch of Tanzania to represent the data.

(c) Describe the distribution of cashew production shown by your map.

(d) Give two merits and two demerits of the dot map as a method of presentation.

Question 14

A field party surveys an open compass traverse along a proposed feeder road that leaves a village at A and runs to E, recording the forward bearing and length of each line as below.

Line	Forward bearing	Length (m)
AB	45° 00′	300
BC	100° 00′	250
CD	150° 00′	350
DE	80° 00′	200

(a) Enter the lines in a field book and compute the back bearing of each.

(b) Plot the traverse to a scale of 1:5 000.

(c) Name the type of traverse and give one reason for your answer.

(d) Give four causes of error in compass traversing and state a remedy for each.

Question 15

A levelling team runs a line of levels from a bench mark of reduced level 100.000 m in order to set out a water pipe, booking the staff readings shown below.

Station	BS	IS	FS	Remarks
A	1.500			BM, RL 100.000
B		2.300		
C		1.100		
D	1.800		2.900	Change point
E		2.500		
F			1.200	

(a) Reduce the levels by the rise and fall method and apply the usual arithmetic check.

(b) Reduce the same levels by the height of collimation method and apply its check.

(c) State one situation in which each method is to be preferred.

Question 16

A survey party is to map a small estate near Kilosa with a plane table, plotting the detail directly in the field.

(a) Name the equipment used in plane table surveying.

(b) Describe how a plane table is set up over a station before observations begin.

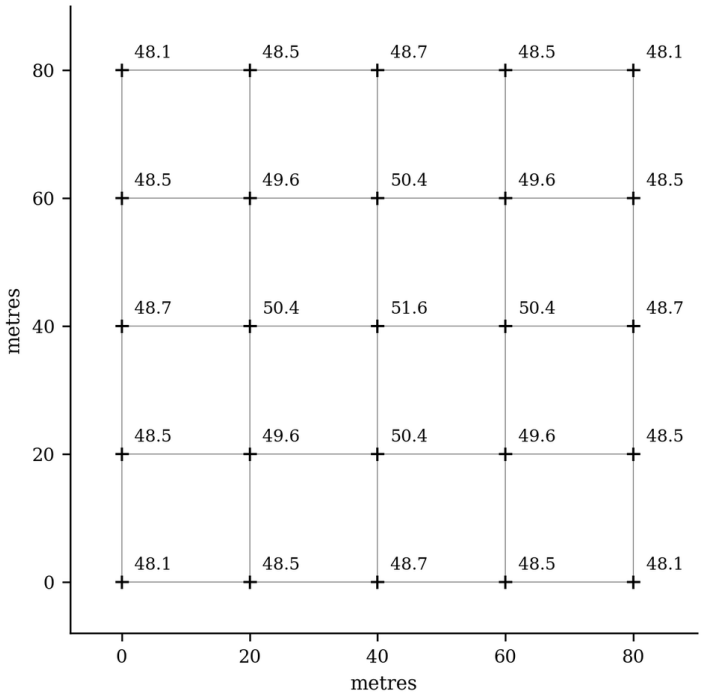
(c) Describe the radiation method of plane tabling.

(d) Give two situations in which plane tabling is suitable.

(e) State two limitations of plane table surveying.

Question 17

A survey team levels a grid of pegs 20 m apart over a field near Kilosa to map its relief. The reduced levels found, in metres, are shown on the grid below.



(a) Explain how the reduced levels of such a grid are obtained in the field.

(b) Using the reduced levels, draw contours at an interval of 0.5 m by interpolation.

(c) Describe the relief shown by your contours.

(d) State two uses of the contour map you have drawn.

Question 18

Study the photograph provided, then answer the questions that follow.

(a) Name the type of photograph and give one reason for your answer.

(b) Identify three natural features and three man-made features shown in the photograph.

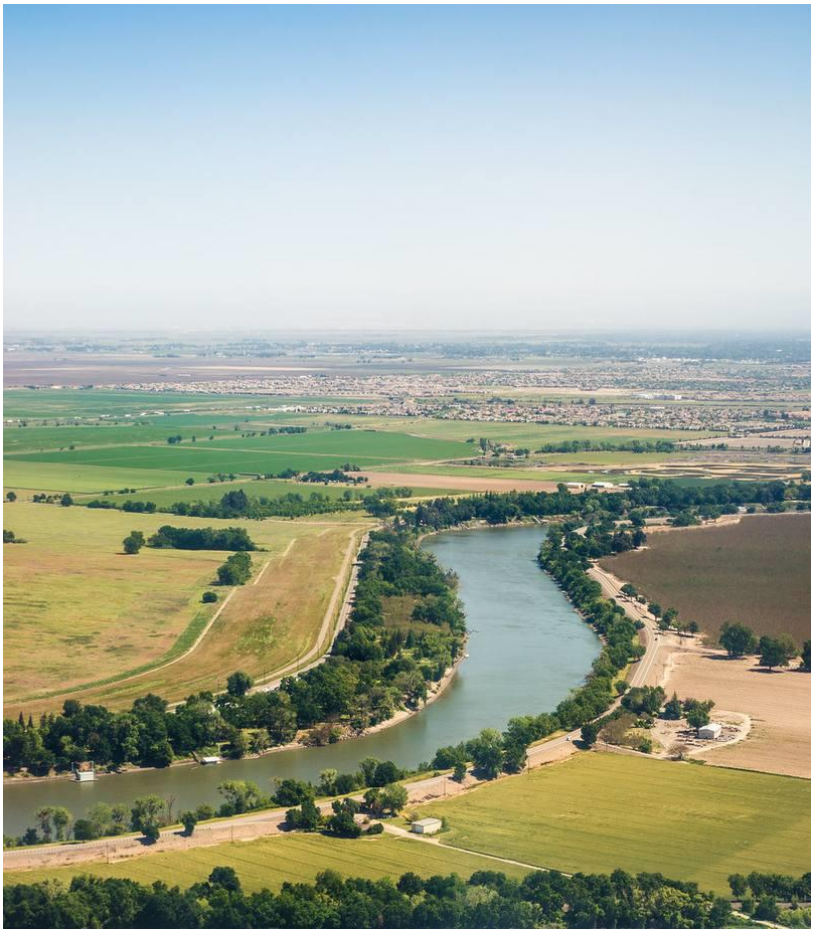
(c) State the main economic activity of the people here, give two pieces of evidence from the photograph, and name two other activities they might carry out.

(d) Draw a simple labelled sketch of the photograph, showing the water, the boats and the shore.

(e) Suggest three problems faced by a community that depends on this main activity.

Question 19

Study the photograph provided, then answer the questions that follow.



(a) Name the type of photograph and give one reason for your answer.

(b) Name the main feature formed by the river and describe it.

(c) Identify three types of land use shown, giving evidence for each.

(d) Give two reasons why the land beside the river is farmed so intensively.

(e) Draw a labelled sketch of the photograph, showing the river, its bend and the farmland.

(f) Suggest two dangers the river poses to the farmland, and one way of reducing each.

Question 20

Study the photograph provided, then answer the questions that follow.

(a) Name the type of photograph and give one reason for your answer.

(b) Name the main type of farming shown and give two pieces of evidence for it.

(c) Identify three other features shown in the photograph.

(d) Give two advantages of growing the trees in regular rows.

(e) Draw a labelled sketch of the photograph showing the plantation, the road and the surrounding woodland.

(f) Suggest two problems that a farmer growing a single tree crop like this may face.

Question 21

A survey student running a compass traverse near Mafinga records the bearings of his lines, and begins to suspect that iron rails beside one station have disturbed his needle.

(a) Convert the following whole-circle bearings to quadrantal bearings:

(i) 60°;

(ii) 210°;

(iii) 300°.

(b) The forward bearing of line PQ is 75°30'. Find its back bearing.

(c) The observed bearings of a line are a forward bearing of 130°00' and a back bearing of 312°00'. Show whether the line is free from local attraction, and state the difference a clean line should give.

Question 22

On a survey near Dodoma the magnetic declination is 3°30' West, and the true bearing of a boundary line is 210°00'.

(a) Define magnetic declination.

(b) Find the magnetic bearing of the line.

(c) If the declination grows by 6' West each year, find the declination and the magnetic bearing of the line after four years.

Question 23

A survey party in Tabora fixes a small plot with a chain and tape, running chain lines and taking offsets to the corners of a building.

(a) What is an offset? Distinguish a perpendicular offset from an oblique one.

(b) State the principle on which chain surveying is based.

(c) Explain the purpose of a check line in a chain survey.

Question 24

A survey party runs a compass traverse A, B, C and books the forward and back bearing of each line, suspecting that iron near one station has disturbed the needle.

Line	Forward bearing	Back bearing
AB	40° 00′	220° 00′
BC	100° 00′	278° 00′

(a) What is local attraction, and what causes it?

(b) How is local attraction detected from the bearings of a line?

(c) Using the readings above, identify the station affected and give the corrected back bearing of line BC.

Question 25

A closed compass traverse of total length 1 200 m is found, on plotting, to have a small closing error of 0.60 m, which must be distributed among its lines.

(a) State the Bowditch rule for adjusting a closed traverse.

(b) Calculate the correction to be applied to a line AB of length 300 m.

(c) State one assumption on which the Bowditch rule rests.

Question 26

A levelling team books the staff readings below, starting from a bench mark of reduced level 20.000 m.

Station	BS	IS	FS	Remarks
A	1.500			BM, RL 20.000
B		0.800		
C	1.900		2.300	Change point
D			0.700	

(a) Reduce the levels by the height of collimation method.

(b) Apply the arithmetic check.

(c) Explain what is meant by a change point.

Question 27

A student beginning levelling is confused by the many terms used in the level book and asks for their meanings.

(a) Define a back sight, an intermediate sight and a fore sight.

(b) What is meant by a datum and a reduced level?

(c) What is a bench mark?

Question 28

A field is measured with a chain of nominal length 30 m which, on being tested, is found to be 30.1 m long. A boundary line is recorded as 600 m.

(a) Give three causes of error in chaining.

(b) Find the true length of the boundary line.

(c) State whether the recorded length is too long or too short, and why.

Question 29

A levelling team books the readings below, starting from a bench mark of reduced level 25.000 m.

Station	BS	IS	FS
A	2.100		
B		1.500	
C			2.700

(a) Reduce the levels by the rise and fall method.

(b) Apply the arithmetic check.

(c) State which of the three points is the highest.

Question 30

A surveyor records the quadrantal bearings of four lines as N 40° E, S 60° E, S 30° W and N 70° W.

(a) Convert each quadrantal bearing to a whole-circle bearing.

(b) State the rule used to convert a quadrantal bearing to a whole-circle bearing in each of the four quadrants.

Question 31

A geography teacher in Iringa records the test marks of a class in the grouped table below.

Marks	0-20	20-40	40-60	60-80	80-100
Frequency	3	8	12	5	2

(a) Calculate the mean mark by the assumed-mean method.

(b) State one advantage of the assumed-mean method over the direct method.

Question 32

A geography teacher in Morogoro groups the marks of forty candidates as shown below.

Marks	0-20	20-40	40-60	60-80	80-100
Frequency	4	10	16	8	2

(a) Calculate the median mark.

(b) Calculate the modal mark.

Question 33

A village development committee near Tabora shares its yearly budget of 400 million shillings among five sectors as shown.

Sector	Agriculture	Education	Health	Water	Roads
Amount (million)	120	90	60	90	40

(a) Calculate the angle of the sector for each item.

(b) Construct a divided circle to represent the budget.

(c) Give one advantage of the divided circle as a method of presentation.

Question 34

The rainfall of ten stations in a region, in millimetres, was recorded as 12, 18, 7, 25, 15, 9, 20, 22, 14 and 11.

(a) Calculate the range of the rainfall.

(b) Calculate the lower quartile, the upper quartile and the inter-quartile range.

(c) Give one advantage of the inter-quartile range over the range.

Question 35

In one school a class of 30 pupils scored a mean of 45 marks in a test, while another class of 20 pupils scored a mean of 55 marks in the same test.

(a) Calculate the combined mean mark of the two classes.

(b) Explain why the combined mean is not simply the average of 45 and 55.

(c) What would the combined mean be if each class had 25 pupils?

Question 36

The population of a town was 20 000 in the year 1990 and had grown to 35 000 by the year 2020.

(a) Find the increase in the population over the period.

(b) Express the increase as a percentage of the 1990 population.

(c) Find the average increase in population per year over the thirty years.

Question 37

Seven pupils scored the following marks in a geography test: 12, 15, 15, 18, 20, 15 and 22.

(a) Calculate the mean mark.

(b) Find the median mark.

(c) Find the modal mark.

Question 38

The maize yield of a farm near Dodoma, in tonnes, over six years was 40, 44, 42, 48, 46 and 52.

(a) What is a moving average, and why is it used?

(b) Calculate the three-year moving averages of the yield.

(c) State the trend shown by the moving averages.

Question 39

The prices of three foods, in shillings, were 800, 1 500 and 1 200 in 2015, and 1 000, 1 800 and 1 400 in 2020.

(a) What is a price index?

(b) Taking 2015 as the base year, calculate the simple aggregate price index for 2020.

(c) State what the index shows about prices.

Question 40

A student is working on a topographical map of Tanzania drawn to a scale of 1:50 000.

(a) A road measures 12.4 cm on the map. Find its length on the ground in kilometres.

(b) Two towns are 8 km apart on the ground. How far apart are they on the map, in centimetres?

(c) Express the scale 1:50 000 as a statement of scale.

Question 41

A student works on a topographical map drawn to a scale of 1:50 000, on which the grid squares are one kilometre by one kilometre.

(a) A forest covers 24 complete squares and about 16 part-squares of the grid. Estimate the area of the forest in square kilometres.

(b) The height at A is 450 m and at B is 150 m, and the two points are 6 km apart. Calculate the gradient from A to B.

(c) Express that gradient as a percentage.

Question 42

A student draws a cross-section of a hill using a horizontal scale of 1:50 000 and a vertical scale of 1 cm to 50 m.

(a) What is meant by vertical exaggeration?

(b) Calculate the vertical exaggeration of the section.

(c) State one effect of vertical exaggeration on the appearance of the section.

Question 43

A field sketch records the bearings between three camps, P, Q and R, taken with a compass.

(a) What is meant by the back bearing of a line?

(b) The bearing of Q from P is 065°. Find the bearing of P from Q.

(c) The bearing of R from Q is 200°. Find the bearing of Q from R.

Question 44

A student is given a map drawn to a scale of 1:50 000 and asked to enlarge it to twice its size.

(a) What is meant by enlarging a map?

(b) Find the scale of the map after it has been enlarged two times.

(c) If a forest covered 6 cm² on the original map, what area will it cover on the enlarged map?

Question 45

On a map, the height of a hilltop is 400 m and that of a village at its foot is 150 m, and the two are 5 km apart.

(a) Calculate the gradient from the village to the hilltop, as a ratio.

(b) Express the gradient as a percentage.

(c) State whether this slope is steeper or gentler than a gradient of 1 in 25, and why.

Question 46

The area of an irregular lake is to be found from a map of scale 1:50 000 by the strip method.

(a) Briefly describe the strip method of finding area on a map.

(b) The lake is divided into strips 1 cm wide, whose lengths are 2.0, 3.5, 4.0, 3.0 and 1.5 cm. Find the area of the lake on the map, in square centimetres.

(c) Find the true area of the lake on the ground, in square kilometres.

Question 47

On a map of scale 1:50 000, a school is at grid reference 345623 and a dispensary at 378651.

(a) Find the straight-line distance between the school and the dispensary, in kilometres.

(b) Find the compass bearing of the dispensary from the school.

(c) What is the bearing of the school from the dispensary?

Question 48

A student meets scales written in different ways and must change one form into another.

(a) Express the statement scale, 2 cm to 1 km, as a representative fraction.

(b) Express the representative fraction 1:25 000 as a statement of scale.

(c) Which of these two scales is the larger, and why?

Question 49

Study the photograph provided, then answer the questions that follow.

(a) Name the type of photograph and give two of its characteristics.

(b) Identify three different types of land use shown, giving evidence for each.

(c) Give one advantage of this type of photograph for town planning.

Question 50

Study the photograph provided, then answer the questions that follow.

(a) Name the main physical feature shown and the type of photograph.

(b) Describe the vegetation and state what it suggests about the rainfall of the area.

(c) Give three reasons why such a forest should be conserved.

Question 51

A vertical aerial photograph is taken over Dodoma from an aircraft flying at 2 000 m above the ground, using a camera of focal length 200 mm.

(a) Find the scale of the photograph.

(b) A straight road measures 8 cm on the photograph. Find its true length on the ground, in metres.

(c) Give one way in which a vertical photograph differs from an oblique one.

Question 52

An aircraft flies along a strip of country taking a run of vertical photographs, each one overlapping the photograph before it.

(a) What is meant by overlap in aerial photography?

(b) Give two reasons why overlap is necessary.

(c) Distinguish a photo-mosaic from a single aerial photograph.

Question 53

From an aircraft the camera may be pointed straight down at the ground or held at an angle, giving two kinds of aerial photograph.

(a) Distinguish between a vertical and an oblique aerial photograph.

(b) Give two advantages of a vertical aerial photograph.

(c) Give one advantage of an oblique aerial photograph.

Question 54

On a vertical aerial photograph a straight road, known to be 2 km long on the ground, measures 5 cm.

(a) Find the scale of the photograph.

(b) On the same photograph a plantation measures 3 cm across. Find its true width on the ground, in metres.

(c) State one reason why the scale of an oblique photograph cannot be found in this simple way.

Question 55

A student interpreting a photograph must tell one kind of ground cover from another by the way each appears.

(a) What is meant by the tone and the texture of a feature on a photograph?

(b) How would you tell a forest from a lake on a photograph?

(c) How do shadows help in the interpretation?

Question 56

Kipute plans a study of how the amount of fertiliser used affects maize yield on the farms of Mbozi.

(a) Identify the independent and the dependent variable in her study.

(b) Distinguish between a continuous and a discrete variable, giving one example of each.

(c) Explain why she would study a sample rather than the whole population, giving two reasons.

Question 57

A researcher in Geita must draw a sample from a large, mixed population of miners and farmers.

(a) Distinguish between probability and non-probability sampling.

(b) Describe two probability sampling techniques.

(c) Give one situation in which purposive sampling is suitable.

Question 58

A researcher in Tabora prepares to collect data from many farmers by giving each of them a set of written questions to answer.

(a) What is a questionnaire?

(b) Give two advantages of the questionnaire as a method of collecting data.

(c) State three things the researcher should keep in mind when designing the questions.

Question 59

A researcher in Dodoma plans to study the water supply of the region's households by questioning a sample of them.

(a) Distinguish between a population and a sample.

(b) What is a sampling frame? Give an example.

(c) Give two reasons why a good sampling frame is important.

Question 60

Before collecting any data, a researcher studying whether fertiliser affects maize yield writes down clearly what she expects to find.

(a) What is a hypothesis?

(b) Distinguish between a null hypothesis and an alternative hypothesis.

(c) Give an example of each for her study of fertiliser and maize yield.

ESSAY QUESTIONS

Question 61

A newly created district in the Southern Highlands is about to open roads, demarcate farms and site a small dam, and the council is told that none of this may begin until the land has first been surveyed. Justify the council's insistence that nothing may begin until the land is surveyed, in six points.

Question 62

A national mapping team fixing control points across the whole country and a college class measuring a small school plot are told that they must use quite different kinds of survey. Account for the differences between geodetic and plane surveying, and show where each is used. Give six points.

Question 63

A survey party in Dodoma finds that its closed traverse does not return exactly to its starting point, and must account for the gap before the survey can be used. Discuss the sources of error in surveying and how they can be reduced. Give six points.

Question 64

An engineer laying a water canal near Iringa must know the exact fall of the land before a single trench is dug, for water will only run downhill. Explain to the engineer why he cannot begin his canal until the levelling is done, in six points.

Question 65

A survey instructor in Tabora tells his class that accuracy in surveying comes less from expensive instruments than from obeying a few settled principles. Discuss the principles that guide all good surveying. Give six points.

Question 66

A survey party filling in the detail of a small estate near Kilosa carries a plane table into the field and plots as it goes, without a field book. Advise the party whether the plane table is fit for the estate, weighing its strengths against its weaknesses, in six points.

Question 67

A survey student is handed two compasses, one with a prism and a card that turns and one whose needle swings free, and is told they are read in different ways. Account for the differences between the prismatic compass and the surveyor's compass. Give six points.

Question 68

One survey party runs a line of stations along a new road that begins at a town and ends at a far village, while another surveys the boundary of a farm and returns to where it began. Distinguish between an open and a closed traverse. Give six points.

Question 69

A survey class in Mafinga is sent out to run a compass traverse round a piece of ground and is reminded to follow the correct field procedure step by step. Explain the procedure of carrying out a compass traverse survey in the field. Give six points.

Question 70

A survey officer in Dodoma is handed three very different jobs, a national boundary, a town plot and a river course, and must choose a different method for each. Discuss the factors to consider when choosing a method of surveying. Give six points.

Question 71

A survey firm in Dodoma replaces its old chains and compasses with a total station and satellite receivers, and finds its work transformed. An old surveyor scoffs that the new instruments do nothing the chain and compass could not; show that he is wrong, in six points.

Question 72

A levelling team sets out from a bench mark in Kilosa to carry a line of levels across a valley, and is reminded to keep to the correct field procedure. Explain the field procedure of a levelling survey. Give six points.

Question 73

A survey party working in rough bush country, without costly instruments, finds that a simple magnetic compass serves it well. Discuss the uses of the magnetic compass in surveying. Give six points.

Question 74

A survey party must choose, for a small farm on open ground, between the chain and the compass, and weighs how the two methods differ. Account for the differences between chain surveying and compass surveying. Give six points.

Question 75

A regional office in Mtwara cannot decide where to sink its new boreholes, and is advised that only proper geographical research can point to the right answer. Explain why the Mtwara office cannot decide where to sink its boreholes without proper geographical research, in six points.

Question 76

A student in Tanga wants to know the views of the whole region on a proposed new market, but is advised to study only a few hundred people instead of everyone. Advise the student why he should study only a well-chosen sample rather than the whole region, in six points.

Question 77

A first-year college student in Iringa is eager to rush straight into collecting data, and is told instead that good research follows an orderly sequence of stages. Explain to the eager student why he should not rush into the field, and the stages he must first follow.

Question 78

A student in Singida keeps abandoning his research topic because it proves in turn too broad, too costly, or already fully studied by others. Explain to the student what qualities his research problem must have if he is to see it through, in six points.

Question 79

A research team in Rukwa must gather both hard figures on crop yields and people's honest opinions about a proposed new market. Advise the team on the methods by which it might gather both the figures and the opinions it needs, in six points.

Question 80

A researcher in Mbeya is told to state clearly, before she collects any data at all, exactly what she expects to find. Explain to the researcher why she should state her hypothesis before she collects any data, in six points.

Question 81

A researcher in Morogoro is impatient to start her fieldwork, but is told first to spend several weeks reading the studies that others have already made. Account for the functions of a literature review in geographical research. Give six points.

Question 82

A student in Dodoma must decide whether to gather fresh figures in the field or to rely on records and reports already published by others. Advise the student on the merits and the dangers of relying on secondary data, in six points.

Question 83

A student in Mwanza plans to interview fishermen about their falling catches, but fears they will not open up to a stranger with a notebook. Advise the student how to conduct the interviews so that the fishermen will speak freely, in six points.

Question 84

A researcher in Shinyanga is about to print two thousand questionnaires when a colleague advises her first to try a few on a handful of people. Advise the researcher why she should run a pilot study before printing two thousand questionnaires, in six points.

Question 85

A panel judging students' research projects in Dodoma must separate sound work from careless work, and looks for certain marks of good research. Explain the characteristics of good scientific research. Give six points.

Question 86

A student sets out full of confidence to collect data in a remote district of Kigoma, and returns worn down by one difficulty after another. Explain the challenges a researcher faces during fieldwork. Give six points.

Question 87

A university team in Dar es Salaam studies the movement of ocean currents purely to understand them, while a fisheries office studies the same currents to find where the fish will gather. Distinguish between basic and applied research. Give six points.

Question 88

A student in Morogoro is told he cannot begin fieldwork until his research proposal, setting out what he plans to do, has been written and approved. Assess the main parts of a research proposal. Give six points.

Question 89

A student is eager to do research but complains that he cannot think of a single problem worth studying, and is shown that problems lie all around him. Show the student where research problems may be found, since he complains that he can think of none, in six points.

Question 90

A student in Mwanza is puzzled that he must write about his study twice, once as a proposal before it and once as a report after it, and asks how the two differ. Distinguish between a research proposal and a research report. Give six points.

Question 91

A student's research keeps drifting because, though he has a topic, he has never set down clearly what he means to find out. Explain why the student's research keeps drifting, and what clear objectives would do to steady it, in six points.

Question 92

A researcher in Shinyanga draws a sample of farmers to study, and is warned that the worth of his whole study will depend on how good that sample is. Discuss the qualities of a good sample. Give six points.

Question 93

A researcher finishes her fieldwork in Tanga and is ready to rest, but is told that her study is not complete until the report is written. Explain to the researcher why her study is not finished until the report is written, in six points.

Question 94

A student setting out to study family life in the villages of Moshi is reminded that he must treat the people he studies with care and respect. Explain the ethical principles a researcher must observe. Give six points.

Question 95

A student has a broad interest in soil erosion but no definite question to study, and is shown how to shape his interest into a problem. Trace the steps in formulating a research problem. Give six points.

Question 96

A student in Mbeya has a clear problem and good objectives, but is told his study will fail unless he first settles on a sound research design. Explain to the student why his study will fail unless he first settles on a sound research design, in six points.

Question 97

A supervisor tells her students that research may be planned in several different designs, each suited to a different kind of question. Explain the main types of research design. Give six points.

Question 98

An examiner marking students' projects rejects one whose findings cannot be trusted because its measurements were neither sound nor consistent. Explain why the examiner was right to reject a project whose measurements were neither sound nor consistent, in six points.

Question 99

A government wishing to know the population of the whole country and a student wishing to know the views of one district are advised to use different methods of enquiry. Explain to the student why a sample survey, not a census, suits his study of one district, in six points.

Question 100

A geography teacher in Morogoro must choose between the mean, the median and the mode to describe one set of test marks, and finds that each of them tells a somewhat different story. Discuss the merits and demerits of the measures of central tendency. Give six points.

Question 101

A district officer in Kigoma must present figures of crop production to a meeting of farmers, and wonders whether a bar graph, a line graph or a divided circle would serve best. Discuss the merits and demerits of the graphical methods of presenting data. Give six points.

Question 102

Two classes in Mbeya have the same average mark, yet one is full of middling results while the other mixes very high with very low marks. Assess the importance of measures of dispersion in describing data. Give six points.

Question 103

A field team in Kigoma returns from a survey with a heap of filled forms, and is told that the raw figures are of no use until they have been processed. Trace the stages of processing raw geographical data into useful information. Give six points.

Question 104

A planner in Mtwara complains that the figures he has been given are old, patchy and gathered no one knows how, and cannot be trusted for his work. Discuss the qualities of good statistical data. Give six points.

Question 105

A researcher in Songea comes back from the field with a thick bundle of filled forms and is told to tabulate the figures before he attempts any analysis. Explain to the researcher why he must tabulate his figures before he attempts any analysis, in six points.

Question 106

A researcher in Iringa gathers both the exact yields of maize plots and the farmers' spoken opinions about their soil, and is told these are two different kinds of data. Account for the differences between qualitative and quantitative data. Give six points.

Question 107

A researcher in Lindi gathers some figures by measuring in the field himself and takes others from a published government report. Account for the differences between primary and secondary data. Give six points.

Question 108

A teacher in Iringa uses the arithmetic mean to describe her class marks, but a colleague warns that it can sometimes mislead. Advise the teacher when the mean serves well and when it may mislead her, in six points.

Question 109

A national planning ministry in Dodoma bases almost every decision it makes on tables of figures, and is lost without them. Account for the importance of statistics to national planning. Give six points.

Question 110

A geographer preparing to study a district needs figures on its people, its rainfall and its crops, and must know where such data may be found. Explain the sources of statistical data in geography. Give six points.

Question 111

A researcher finds that two rainfall stations have the same average, yet one is far more reliable than the other, and turns to measures of spread to show the difference. Account for the uses of the range and the standard deviation. Give six points.

Question 112

A researcher returns from the field with a jumble of mixed observations and is told to classify them before he does anything else. Explain why the researcher must classify his observations before he does anything else, in six points.

Question 113

A geographer comparing the crops of a large region with those of a small one finds the raw totals misleading, and turns to percentages to make a fair comparison. Evaluate the importance of percentages in presenting geographical data. Give six points.

Question 114

A survey office in Dodoma turns to aerial photographs for tasks as varied as drawing maps, planning towns and watching over floods. Justify the office's reliance on aerial photographs, in six points.

Question 115

A planning officer in Arusha has on his desk both an aerial photograph of a district and a topographical map of the same ground, and finds that each tells him something the other cannot. A colleague claims that the photograph makes the map useless; explain why he is mistaken, in six points.

Question 116

A student looking at a photograph for the first time cannot tell a forest from a field or a factory from a farmhouse, and asks how a geographer reads such a picture. Explain the elements a geographer uses to interpret features on a photograph. Give six points.

Question 117

A geography club in Mbeya has two pictures of the same valley, one taken from a hilltop and one from an aeroplane, and argues about which shows more. Distinguish between a ground photograph and an aerial photograph. Give six points.

Question 118

A geography department in Tanga builds up a collection of photographs of landscapes, towns and rivers, and finds many uses for them in its teaching and research. Explain the uses of photographs in geographical study. Give six points.

Question 119

An official in Mwanza who relies on aerial photographs is warned that, for all their value, they cannot do everything a map can. Explain to the official why he must not trust his aerial photographs too far, in six points.

Question 120

A mapping office prefers vertical aerial photographs above all others for its work, because of the special way in which they show the ground. Discuss the characteristics of a vertical aerial photograph. Give six points.

Question 121

A town planning office in Mwanza uses aerial photographs to guide the orderly growth of the fast-spreading city. Discuss the uses of aerial photographs in the planning of towns. Give six points.

Question 122

An agricultural office in Morogoro turns to aerial photographs to survey its farms and forests over a wide district. Account for the uses of aerial photographs in agriculture and forestry. Give six points.

Question 123

A student with only a simple camera wonders whether his ground photographs can be of any real use beside the costly aerial photographs used by the survey office. Discuss the advantages of a ground photograph over an aerial photograph. Give six points.

Question 124

A geographer studying the landforms of a rugged district finds that aerial photographs show him the shape of the land better than any ground visit. Explain the uses of aerial photographs in the study of physical features. Give six points.

Question 125

A student is handed an aerial photograph of an unknown district and asked to say what it shows, but does not know where to begin. Outline the steps a geographer follows in interpreting an aerial photograph. Give six points.

Question 126

A geographer studies an aerial photograph of a district he has never visited and finds he can learn a great deal about it. Discuss the information that can be obtained from an aerial photograph. Give six points.

Question 127

A survey office finds that some of its aerial photographs are sharp and useful while others are blurred and hard to read, and asks what makes the difference. Examine the factors that affect the quality of an aerial photograph. Give six points.

Question 128

A student notices that the shadows on a photograph, far from being a nuisance, actually help him to read it. Explain the uses of shadows in the interpretation of a photograph. Give six points.

Question 129

A cartographer must show the hills, ridges and valleys of a region on a flat sheet of paper, so that a reader can picture the true shape of the land. Discuss the methods used to represent relief on a topographical map. Give six points.

Question 130

A district planning office in Njombe keeps a topographical sheet on the wall and turns to it for one decision after another. Account for the uses of topographical maps to a developing country. Give six points.

Question 131

A student opens a topographical sheet and is told that the information printed around its margin is as important as the map itself. Explain the marginal information found on a topographical map and its uses. Give six points.

Question 132

A library in Arusha keeps many kinds of map, from a road atlas to a soil map, and a student is puzzled that maps come in so many forms. Explain the types of maps and their uses. Give six points.

Question 133

A student picking up a new map is told that the very first thing to look at is its scale, since almost everything else depends on it. A classmate says the scale is the least important thing on a map; explain why he is wrong, in six points.

Question 134

A beginner opening a topographical sheet finds it covered with little symbols, letters and colours that he cannot read, and asks why maps are drawn in such a code. Evaluate the importance of conventional signs on a map. Give six points.

Question 135

A rescue team is told that a stranded party lies at grid reference 384667, and finds the exact spot on the map at once. Assess the importance of the grid reference system on a map. Give six points.

Question 136

A student must find, from a map, both the straight distance between two towns and the true length of a winding road that joins them, and is unsure how to measure each. Explain the methods of measuring distance on a map. Give six points.

Question 137

A library holds a street plan of a single town and a map of the whole of Africa on sheets of the same size, and a student sees that they serve very different needs. Account for the differences between large-scale and small-scale maps. Give six points.

Question 138

A district officer new to Njombe is told that almost everything he needs to know about the land can be read from its topographical sheet. Show the new officer how much he can learn of his district from the topographical sheet alone, in six points.

Question 139

A traveller with a map and compass must set out on the correct bearing, and finds there are several ways of dealing with direction on a map. Explain the ways of showing and finding direction on a map. Give six points.

Question 140

A geographer in the field, without drawing instruments, records the layout of a village on a rough sketch map. Discuss the uses of a sketch map in geography. Give six points.

PART THREE
MODEL SOLUTIONS TO THE EXAMINATION QUESTIONS

SHORT-ANSWER SOLUTIONS

Question 1

(a) Reading eastings before northings:

(i) the triangulation station on Bwawa hill is at 370670;

(ii) the church near Mjini is at 327633.

(b) The town of Mjini is at 325630 and the station at 370670, so the difference is 4.5 km east and 4.0 km north:

$$\text{distance} = \sqrt{(37.0 - 32.5)^2 + (67.0 - 63.0)^2} = \sqrt{4.5^2 + 4.0^2} = \sqrt{36.25} = 6.0 \text{ km}$$

The distance is about 6.0 km.

(c) The forest fills a block two grid squares wide, from easting 37.5 to 39.5, and two and a half high, from northing 63.5 to 66.0, so at 1 km to a square:

$$\text{area} = 2 \times 2.5 = 5.0 \text{ km}^2$$

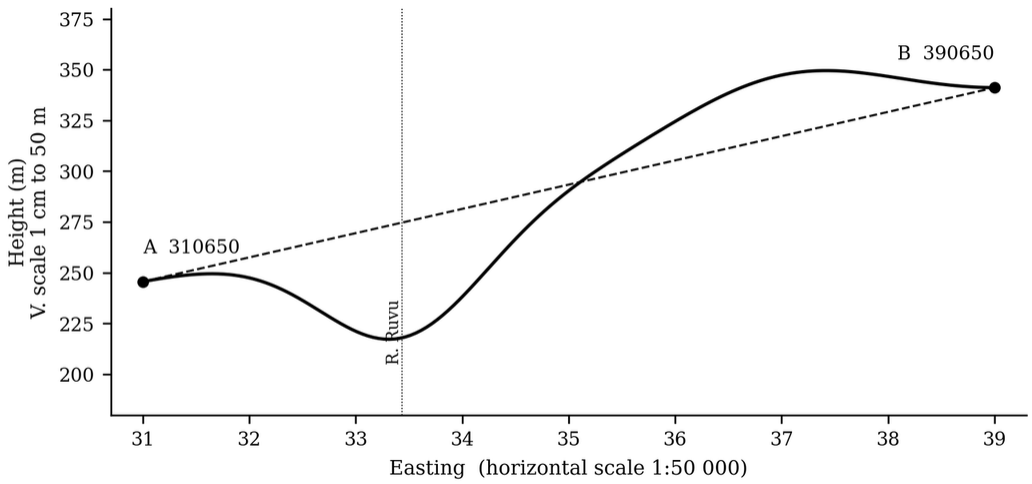
The area of the forest is about 5.0 km².

(d) Bwawa hill is marked 500 m, while Mjini lies just below the 220 m contour, at about 200 m, so the rise is about 300 m over the 6.0 km between them:

$$\text{gradient} = \frac{\text{rise}}{\text{distance}} = \frac{300 \text{ m}}{6\,000 \text{ m}} = \frac{1}{20}$$

The gradient is about 1 in 20.

(e) Along northing 65 the height of the ground is read at each easting and plotted against distance, using the map scale across and a vertical scale of 1 cm to 50 m up. The section is:



Cross-section along northing 65 from A (310650) to B (390650).

A stands at about 246 m and B at about 341 m, but they are not intervisible, because the ground rises to about 350 m near easting 37 and stands above the line of sight joining A and B, blocking the view.

(f) The high ground lies in the north-east, where Bwawa hill reaches 500 m, and the land falls away to the south-west to below 200 m. The River Ruvu rises in this high north-east and flows to the south-west, keeping to the lowest ground, and the contours bend upstream in sharp Vs where they cross it. The drainage therefore follows the slope, running from the high north-east to the low south-west.

Examiner's Note
Read eastings before northings in every grid reference; state the vertical scale before drawing the section; and judge intervisibility by the sight line, not by the two end heights alone.

False Confidence Alert
A six-figure reference gives the easting first and the northing second; reversing them puts the feature in the wrong part of the map and loses the mark.

Question 2

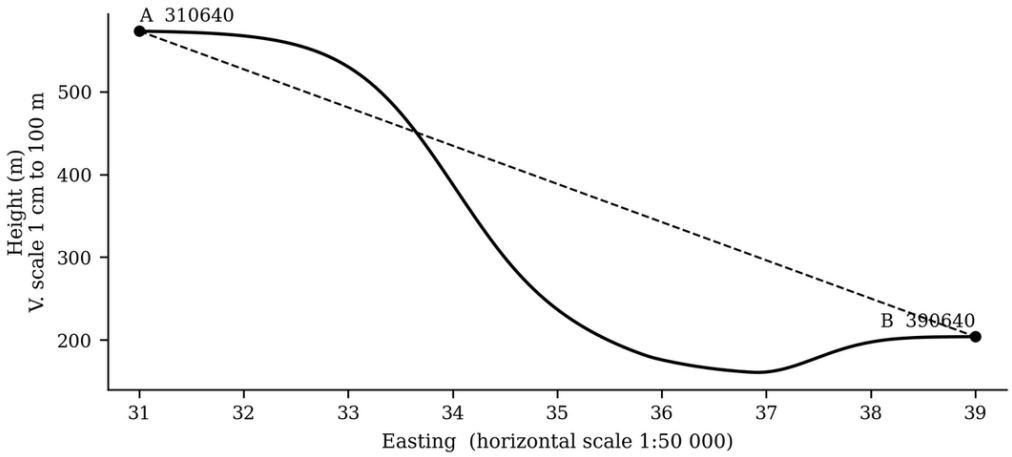
(a) Reading eastings before northings, the mine is at 315665 and the railway station is at 376628.

(b) Measured along the winding road with a piece of thread laid on it and then straightened against the scale, the road from Magara to the mine is about 6.4 km long.

(c) Counting the grid squares the lake covers, taking complete squares in full and part-squares as one half, Lake Kefa covers about 3 square kilometres.

(d) The feature is an escarpment, a steep face marked by contours packed very close together. It separates the high plateau in the west, standing above 560 m, from the low plain in the east at about 210 m, the land falling over 300 m within about two kilometres.

(e) Along northing 64 the height is read at each easting and plotted against distance, using the map scale across and a vertical scale of 1 cm to 100 m up.



Cross-section along northing 64 from A (310640) to B (390640).

The section shows high and fairly level ground in the west on the plateau at about 570 m, then a steep fall down the escarpment, and low, flat ground in the east on the plain at about 205 m.

(f) Settlement keeps to the low, flat plain in the east, where the town of Magara, the railway and the farmland lie, because there movement and building are easy. The steep escarpment and the high plateau are avoided, for they are hard to build on and to reach. Only the mine stands on the plateau, drawn there by the mineral rather than by good living conditions, much as the settlements below the Rift escarpment near Mbulu cling to the easier ground.

Examiner's Note
Read eastings before northings; the closely packed contours are the sign of the escarpment; and judge the shape of the cross-section from how the contour spacing changes across the line.

False Confidence Alert
Closely spaced contours mean a steep slope, not a high one; height is read from the contour values, while steepness is read from how close together they lie.

Question 3

(a) Reading eastings before northings, Bandari is at 365620 and the river mouth is at 370640.

(b) From Bandari the mouth lies 0.5 km east and 2.0 km north, so the bearing, measured clockwise from north, is:

$$\text{bearing} = \tan^{-1}\left(\frac{0.5}{2.0}\right) = 014° \text{ (approximately)}$$

The river mouth lies about 014° from Bandari, that is nearly due north.

(c) The distance follows from the same eastings and northings:

$$\text{distance} = \sqrt{0.5^2 + 2.0^2} = \sqrt{4.25} = 2.1 \text{ km}$$

Bandari is about 2.1 km from the river mouth.

(d) The vegetation at the river mouth is mangrove swamp, which shows a low, sheltered, muddy shore washed by the salt tides. The feature offshore is a coral reef, which shows a shallow, warm and clear sea, for coral grows only in such water.

(e) Fishing is the main activity, worked from the port of Bandari and its jetty out to the sheltered waters behind the reef, because the sea is the great resource of the coast. Coconut plantations cover the flat, sandy coastal plain, which suits the palm, and the mangrove supplies poles and firewood. Each activity thus follows a physical feature, much as on the coast at Bagamoyo.

(f) Evidence of a low-lying coast.

1) **The sea and coastline:** the Indian Ocean fills the east of the map against a coastline.

2) **Very low land:** every contour is below 60 m, so the land is low throughout.

3) **Coastal features:** the mangrove swamp at the river mouth, the coconut plantations and the offshore reef are all features of a low, warm coast.

Examiner's Note
Read eastings before northings; take the bearing clockwise from north; and in (e) tie each activity to the feature that makes it possible, the sea to fishing and the sandy plain to coconuts.

False Confidence Alert
Mangrove is not ordinary forest; it grows in salt, tidal water at a sheltered river mouth, which is why its presence points to a low, muddy coast.

Question 4

(a) Reading eastings before northings, the dam is at 350640 and the power station is at 350634.

(b) Counting the grid squares that the reservoir covers, taking complete squares in full and part-squares as one half, its area is about 2.6 square kilometres.

(c) The feature is a reservoir, an artificial lake. It was formed when the dam was built across the narrow valley and blocked the river, so that the water backed up behind the wall and flooded the valley upstream.

(d) The site was chosen because the valley here is narrow and deep with steep sides, so a fairly short, high wall can hold back a great deal of water, and because the river gives a steady flow to fill the reservoir and keep it full.

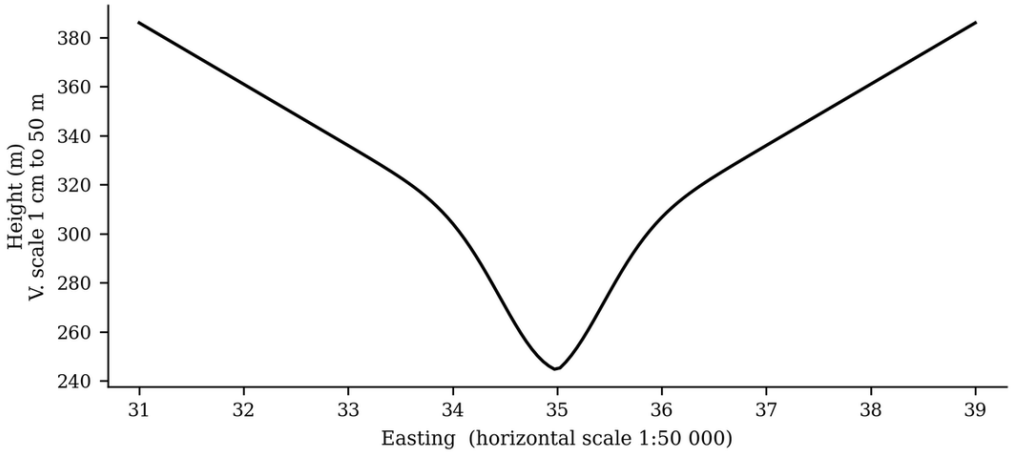
(e) Benefits of the dam.

1) **Hydro-electric power:** the water falling through the power station below the dam turns the turbines to make electricity, as at the Julius Nyerere Hydropower Project on the Rufiji.

2) **Irrigation:** water is led from the reservoir to the farmland below the dam, so that crops can be grown through the dry season.

3) **Water supply and flood control:** the stored water serves the town of Kito and guards against drought, while the dam holds back floods that would otherwise sweep the valley.

(f) Along northing 66 the height of the ground is read at each easting and plotted to a vertical scale of 1 cm to 50 m against the map scale across.



Cross-section across the valley from 310660 to 390660.

The section shows a deep, steep-sided valley whose floor lies at about 250 m between shoulders rising above 380 m on either hand, the narrow, deep shape that makes a good dam site.

Examiner's Note
Read eastings before northings; the reservoir is made by flooding, so explain the damming; and tie the choice of site in (d) to the narrow, deep valley seen in the contours and the section.

False Confidence Alert
The lake behind the dam is a reservoir, not a natural lake; its straight dam wall and the flooded valley behind it are the signs that it is made by people.

Question 5

(a) Reading eastings before northings, the railway station is at 357643 and the airfield is at 321622.

(b) The town is a route centre because five main roads and a railway meet at it, radiating outwards from the built-up area in every direction, so that routes from all sides converge on the one place.

(c) Land-use zones.

1) **Commercial core:** the dense mass of buildings at the centre, marked Market, where the shops and trade of the town are gathered.

2) **Industrial area:** the zone marked Industrial beside the railway and station, where factories are sited to use the transport.

(d) Functions of the town.

1) **A commercial function:** shown by the market and the mass of shops at the centre.

2) **An industrial function:** shown by the factories of the industrial area by the railway.

3) **A transport function:** shown by the railway station, the airfield and the meeting of the roads.

(e) The town grew at this site because it stands where many routes meet, so that trade naturally gathers there, and because it lies beside the River Maji, which gives a supply of water, on low and gently sloping land that is easy to build on.

(f) The settlement is nucleated, its buildings gathered into one compact built-up area rather than spread out. Around this cluster lies open farmland with only a few scattered dwellings, a pattern typical of a Tanzanian trading town that has grown up at a meeting of routes.

Examiner's Note
A route centre is a place where many routes meet; read the functions from the evidence on the map, the market, the factories and the station; and nucleated means clustered into one built-up mass.

False Confidence Alert
Roads meeting at a town make it a route centre, not merely a road junction; the evidence is that routes come in from all directions and gather there, which is why trade and the town grow at the meeting point.

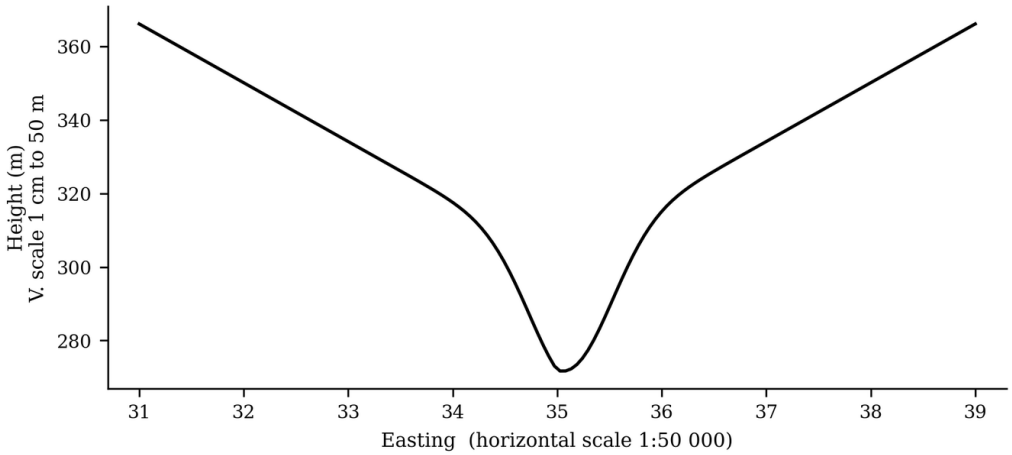
Question 6

(a) Reading eastings before northings, the falls are at 350660 and Kijiji is at 332644.

(b) Three features are the waterfall, where the river drops over a step of hard rock; the gorge, the steep, narrow section just below the falls; and the V-shaped valley, whose steep sides are shown by the closely spaced contours on either hand.

(c) The steep gradient, shown by the contours packed close together where the river falls quickly, and the V-shaped valley with no flood plain, together with the waterfall and gorge, are all evidence of a young river still cutting downward.

(d) Along northing 64 the height is read at each easting and plotted to a vertical scale of 1 cm to 50 m against the map scale across.



Cross-section across the valley from 310640 to 390640.

The section shows a deep, steep-sided V-shaped valley, its narrow floor at about 270 m between shoulders rising above 360 m, with no flood plain, the mark of a young river.

(e) The waterfall formed where a band of hard rock crosses the river. The softer rock downstream is worn away faster, so the river drops over the resistant band as a fall; as the fall undercuts and retreats upstream it leaves the steep-walled gorge below it, as at Kalambo Falls in Tanzania.

(f) The steep valley and gorge are avoided by settlement, for they are hard to build on and to cross. The village of Kijiji therefore stands on the gentler ground of a spur to the west, away from the gorge, and a footbridge is needed where a path must cross the deeply cut river.

Examiner's Note
Read eastings before northings; the contours packed across the river mark the waterfall; and a V-shaped valley with a waterfall and gorge is the sign of a young, downward-cutting river.

False Confidence Alert
The V-shaped valley here is cut by the river wearing downward, not opened by faulting; the stream at its foot and the contours V-ing upstream show river erosion, not a rift.

Question 7

(a) Reading eastings before northings, the lodge is at 334662 and the hot springs are at 327641.

(b) Counting the grid squares the lake covers, taking complete squares in full and part-squares as one half, Lake Rift covers about 4.6 square kilometres.

(c) The steep feature in the west is an escarpment, and the flat region to its east is the floor of a rift valley. The escarpment is shown by contours packed very close together, which mark the steep rise from the low floor to the high plateau above.

(d) Two signs of tourism are the tourist lodge marked near the escarpment and the airstrip on the floor by which visitors are flown in; the national park boundary and the road also serve the tourist trade.

(e) The lake draws great numbers of birds and animals to its water, giving fine game-viewing, while the hot springs at the foot of the escarpment are a natural wonder that visitors come to see; the bold wall of the escarpment adds dramatic scenery, much as at Lake Manyara below the rift wall.

(f) The land is high in the west, a plateau standing above 1 400 m, and then falls very steeply down the escarpment to the flat floor of the rift valley in the east, which lies at only about 950 m and holds the lake. This profile of a high plateau, a steep wall and a low flat floor is that of a rift valley.

Examiner's Note
Read eastings before northings; closely packed contours mark the escarpment; a flat floor below a steep wall is a rift valley; and read the tourism from the lodge, the airstrip and the park.

False Confidence Alert
Lake Rift lies on a flat floor let down between escarpments, so it is a rift-valley lake formed by faulting, not a lake held back by a dam or lying in a crater.

Question 8

(a) Reading eastings before northings, Mlima Kubwa is at 325665 and the town of Soko is at 356650.

(b) They are inselbergs, isolated steep-sided rocky hills standing abruptly out of the plain. They are shown by small rings of closed contours, packed close together and standing apart from one another.

(c) The broken line shows that the river is seasonal, or intermittent, flowing only after the rains and drying up for part of the year.

(d) The settlement is mainly scattered, single and double huts spread thinly over the plain, because the farmers live dispersed among their fields where land and water are spread out. Only at Soko, where the road and the railway meet, is the settlement gathered into a small nucleated town.

(e) Evidence of a dry climate.

1) **The seasonal river:** the River Msimu is drawn as a broken line, showing it flows only in the rains.
2) **Scattered dry farming:** the thinly spread settlement and the dot-farming point to a dry, thinly peopled land.
3) **Bare inselbergs and no forest:** the rocky hills stand bare and there is no forest, as in a dry region.

(f) The area is a gently undulating plain lying at about 1 100 to 1 140 m, out of which rise several isolated, steep rocky hills, or inselbergs, the highest, Mlima Kubwa, reaching over 1 300 m. A plain studded with inselbergs in this way is typical of the dry central plateau of Tanzania around Dodoma.

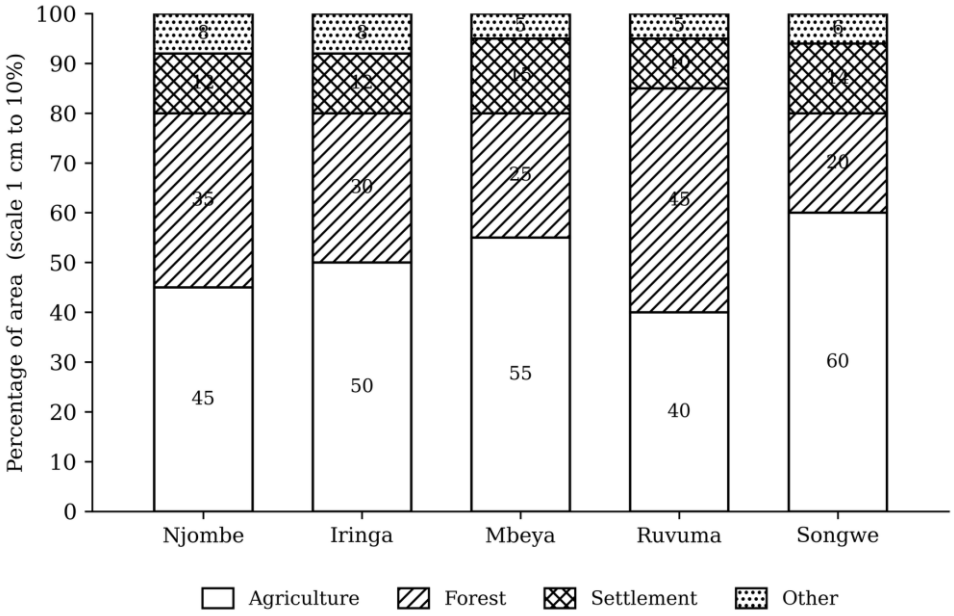
Examiner's Note
Read eastings before northings; small closed rings of contour standing alone are inselbergs; a broken river line means seasonal; and read the dry climate from the seasonal river and the scattered settlement.

False Confidence Alert
The broken line is a seasonal river, not a road or a boundary; a river that flows only in the rains is drawn broken to show that it is not permanent.

Question 9

(a) The percentages are turned into cumulative values, and each region is drawn as one bar of equal width and full height, its segments read off the cumulative table below at the scale of 1 cm to 10 per cent.

Region	Agriculture	to Forest	to Settlement	to Other
Njombe	45	80	92	100
Iringa	50	80	92	100
Mbeya	55	80	95	100
Ruvuma	40	85	95	100
Songwe	60	80	94	100



Compound divided percentage rectangle of land use in five Southern Highlands regions.

(b) Setting out the scores in a table of x and x^2:

x	x^2
80	6 400
70	4 900
20	400
90	8 100
50	2 500
10	100
30	900
28	784
$\Sigma x = 378$	$\Sigma x^2 = 24\ 084$

The standard deviation follows from the totals, with n = 8:

$$\bar{x} = \frac{\Sigma x}{n} = \frac{378}{8} = 47.25$$

$$s = \sqrt{\frac{\Sigma x^2}{n} - \frac{\Sigma x^2}{n}} = \sqrt{3010.5 - 2232.5625} = \sqrt{777.9375} = 27.89$$

The standard deviation is 27.89 marks. For the coefficient of range, with a largest score $L = 90$ and a smallest $S = 10$:

$$\text{Coefficient of range} = \frac{L - S}{L + S} = \frac{90 - 10}{90 + 10} = \frac{80}{100} = 0.8$$

The coefficient of range is 0.8.

(c) Merits:

1) **Shows composition:** it displays the proportion of each land use within a region at a glance.
2) **Allows fair comparison:** because every bar reaches the same height, regions of different sizes are compared on equal terms.
3) **Compact:** several regions and several land uses are shown in one small figure.

Demerits:

1) **Hides totals:** it shows proportions only, so the actual area of each region cannot be read from it.
2) **Slow to construct:** the percentages must be calculated and the segments measured and shaded accurately.
3) **Crowded by detail:** too many land uses make the shading hard to tell apart.

(d) Roles of statistics in geography.

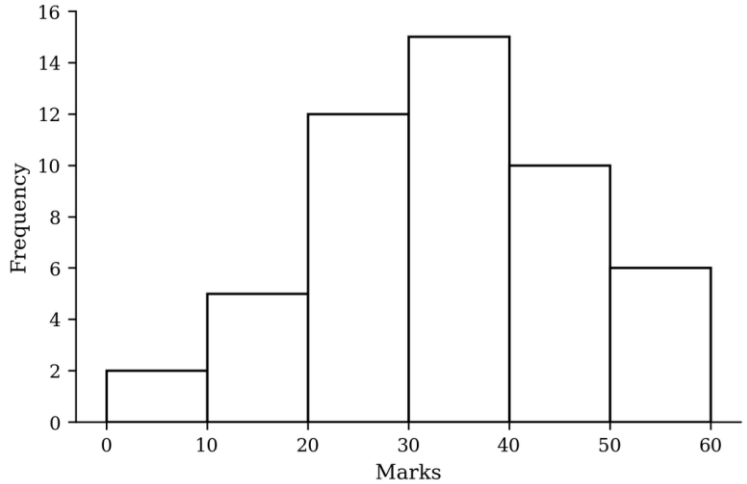
1) **Summarising:** it reduces large sets of field data to means, totals and rates.
2) **Comparing:** it allows places and periods to be compared on a common measure.
3) **Showing relationships:** it reveals correlation between variables such as rainfall and yield.
4) **Presenting:** it turns figures into graphs and maps that can be read and interpreted.
5) **Forecasting and planning:** it supports prediction and sound decisions in development.

Examiner's Note
Present means draw to the stated scale; in (a) the marks lie in correct proportions, neat shading and a key, and in (b) in the working, not the final figure. Give exactly the number of points asked in (c) and (d).

False Confidence Alert
A percentage rectangle shows proportions, not amounts, so it cannot tell you which region has the largest area of farmland.

Question 10

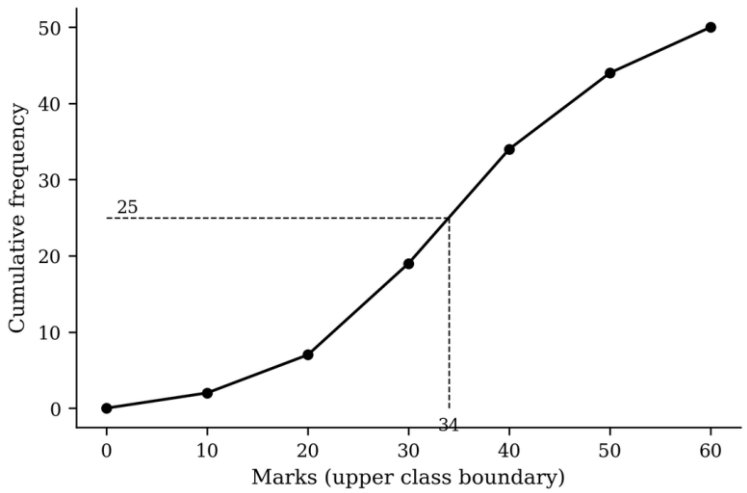
(a) The marks are set out along the base and the frequency up the side, and each class is drawn as a bar of equal width and of height equal to its frequency.



Histogram of the fifty candidates' marks.

(b) The cumulative frequencies are found by adding the frequencies in turn, then plotted against the upper boundary of each class and joined by a smooth curve.

Upper boundary	10	20	30	40	50	60
Cumulative frequency	2	7	19	34	44	50



Cumulative frequency curve (ogive) of the marks.

(c) The median is the mark of the middle candidate. Reading across from a cumulative frequency of $\frac{N}{2} = 25$ to the curve and down to the base gives a median of about 34 marks.

(d) Taking the mid-values x with an assumed mean $A = 35$, the deviations $d = x - 35$ give:

Mid-value x	5	15	25	35	45	55
Frequency f	2	5	12	15	10	6
$d = x - 35$	−30	−20	−10	0	10	20
f d	−60	−100	−120	0	100	120

With $\Sigma f = 50$ and $\Sigma fd = -60$:

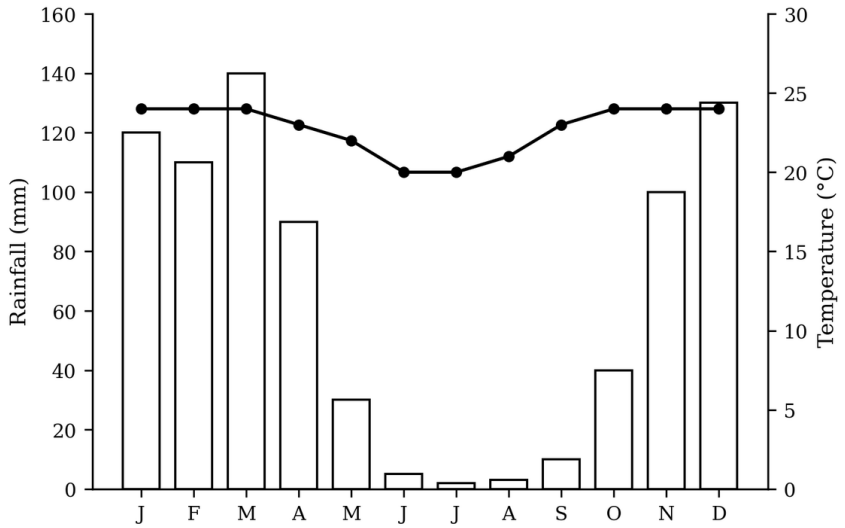
$$\bar{x} = A + \frac{\Sigma fd}{\Sigma f} = 35 + \frac{-60}{50} = 35 - 1.2 = 33.8$$

The mean mark is 33.8, which agrees closely with the median of about 34.

Examiner's Note
In (a) the bars touch because the data are continuous; in (b) plot the cumulative frequency at the upper boundary, not the mid-value; and keep the sign of Σfd in (d).

Question 11

(a) The months are set along the base, rainfall is shown by bars against a scale on the left, and temperature is shown by a line against a scale on the right.



Climate graph of the station: rainfall (bars) and temperature (line).

(b) Adding the twelve rainfall figures and averaging the twelve temperatures:

$$\text{total rainfall} = 120 + 110 + \ldots + 130 = 780 \text{ mm}$$

$$\text{mean temperature} = \frac{273}{12} = 22.8\ °\text{C}$$

The total annual rainfall is 780 mm and the mean annual temperature about 22.8°C.

(c) The highest rainfall is in March, with 140 mm. The annual range of temperature is the highest monthly mean less the lowest, 24°C - 20°C = 4°C.

(d) The station is hot throughout the year, with every month above 20°C and only a small range, which shows a tropical station near the Equator. The rain falls in a marked wet season from November to April and almost ceases in a dry season from May to October. This pattern of high heat and a single wet and dry season is the tropical wet-and-dry, or savanna, climate found over much of Tanzania.

Examiner's Note

Plot rainfall as bars and temperature as a line on their separate scales; in (d) read both the heat and the seasonal rainfall from the graph, and name the climate type.

Question 12

(a) The mid-values, frequencies and the columns needed for all the measures are set out together, taking an assumed mean of 13 for the deviations:

Class	x	f	cf	f x	d = x − 13	f d	f d²
1-5	3	3	3	9	−10	−30	300
6-10	8	7	10	56	−5	−35	175
11-15	13	12	22	156	0	0	0
16-20	18	8	30	144	5	40	200
21-25	23	5	35	115	10	50	500
Sum		35		480		25	1 175

The mean is the sum of f x divided by $N = 35$:

$$\bar{x} = \frac{\Sigma f\,x}{N} = \frac{480}{35} = 13.7 \text{ years}$$

(b) The median lies at the $\frac{N}{2} = 17.5$th tree, which falls in the 11-15 class ($L = 10.5$, $cf = 10$, $f = 12$, $h = 5$):

$$\text{Median} = L + \frac{N/2 - cf}{f} \times h = 10.5 + \frac{17.5 - 10}{12} \times 5 = 13.6 \text{ years}$$

(c) The modal class is 11-15, the tallest ($f_1 = 12$, $f_0 = 7$, $f_2 = 8$):

$$\text{Mode} = L + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times h = 10.5 + \frac{5}{9} \times 5 = 13.3 \text{ years}$$

(d) The standard deviation follows from the f d and f d^2 totals, with $\Sigma f\,d = 25$ and $\Sigma f\,d^2 = 1\,175$:

$$s = \sqrt{\frac{\Sigma f\,d^2}{N} - \frac{\Sigma f\,d^2}{N}} = \sqrt{33.57 - 0.51} = \sqrt{33.06} = 5.75 \text{ years}$$

(e) The mean, median and mode are all close together, at about 13 to 14 years, so the distribution is nearly symmetrical, with no strong lean to either side. The standard deviation of 5.75 years shows a moderate spread of ages about that centre, so the trees are of fairly mixed but not widely scattered age.

Examiner's Note
Build one working table and read every measure from its columns; keep the sign of Σf d in (d); and in (e) judge the shape from how close the three averages lie.

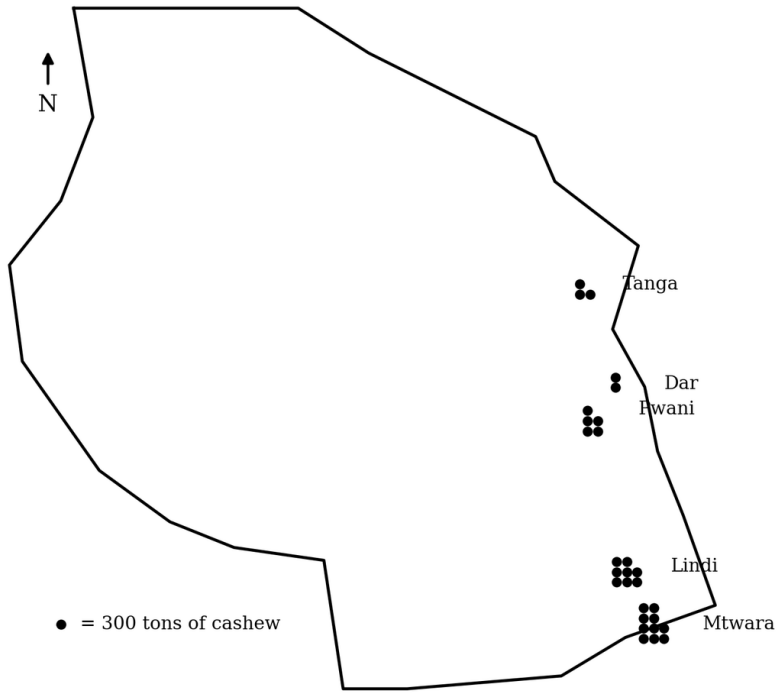
Question 13

(a) The totals are not exact multiples of 300, so the number of dots for each region is found by dividing its production by 300 and rounding to the nearest whole dot:

Region	Tanga	Dar es Salaam	Pwani	Lindi	Mtwara
Tons	1 000	500	1 600	2 500	2 900
Tons ÷ 300	3.3	1.7	5.3	8.3	9.7
Dots	3	2	5	8	10

(b) The dots are placed within each region on a sketch map of Tanzania, evenly spread over the region, with a key stating their value.

Dot map of cashew production, coastal regions



Dot map of cashew production in the coastal regions.

(c) Cashew production is wholly coastal and strongly concentrated in the south-east, being greatest at Mtwara and Lindi. It falls away northward along the coast, to a moderate amount in Pwani and little in Dar es Salaam and Tanga. The crop is therefore a southern, coastal one, thinning towards the north.

(d) Merits and demerits.

Merits:

1) **Shows distribution:** it shows at a glance where the crop is grown and how thickly, joining amount and place in one map.
2) **Simple to read:** the density of dots gives an immediate picture of concentration.

Demerits.

1) **Hard to count:** where dots are many and crowded, as at Mtwara, they cannot be counted exactly.
2) **Placing is uneven:** the dots must be placed by judgement, and a region with none looks empty though it may still produce a little.

Examiner's Note
Divide each total by 300 and round to the nearest whole dot, since the figures are not exact multiples; place the dots inside the right region, and in (c) read the pattern of coastal concentration falling to the north.

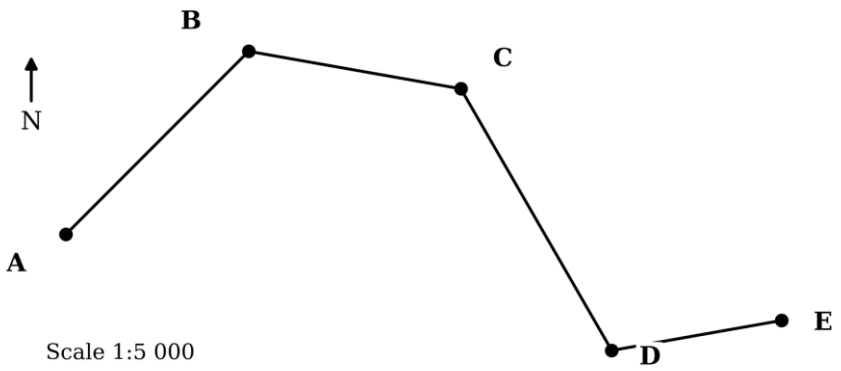
False Confidence Alert
The dots show each total only to the nearest 300 tons, so a region's dots cannot be read back as its exact production; rounding is unavoidable in a dot map.

Question 14

(a) Each back bearing is the forward bearing plus 180°, since every forward bearing here is less than 180°. The completed field book is:

Line	Forward bearing	Back bearing
AB	45° 00′	225° 00′
BC	100° 00′	280° 00′
CD	150° 00′	330° 00′
DE	80° 00′	260° 00′

(b) Taking A as origin, each line is drawn to its bearing and its length scaled at 1:5 000 (so 300 m plots as 6 cm). The traverse plots as below.



Plot of the open traverse A to E at 1:5 000.

(c) It is an open traverse, because it begins at A and ends at a different point E without returning to its start or closing on a known station.

(d) Causes of error and their remedies.

1) **Local attraction:** iron objects near a station deflect the needle; keep the compass away from iron and detect the fault by the 180° test on forward and back bearings.

2) **Faulty centring or levelling:** the compass is not truly over the station or not level; set it carefully over the peg and level it before reading.

3) **Careless reading of the ring:** the graduation is misread; read slowly, and take the mean of two readings.

4) **Errors in the chained lengths:** the tape sags or is not standard; use a standardised tape and pull it taut along the line.

Examiner's Note

Apply BB = FB ± 180° consistently in (a); in (b) the marks are in an accurate plot, so choose a scale that fills the space and mark the north; in (d) each cause must be paired with its own remedy.

Question 15

(a) Each reading is compared with the one before it: a smaller following reading is a rise, a larger one a fall, and the reduced levels build up from the bench mark.

Station	BS	IS	FS	Rise	Fall	RL	Remarks
A	1.500					100.000	BM
B		2.300			0.800	99.200	
C		1.100		1.200		100.400	
D	1.800		2.900		1.800	98.600	CP
E		2.500			0.700	97.900	
F			1.200	1.300		99.200	
Sum	3.300		4.100	2.500	3.300		

The three totals agree, which proves the arithmetic:

$$\Sigma BS - \Sigma FS = 3.300 - 4.100 = -0.800$$

$$\Sigma Rise - \Sigma Fall = 2.500 - 3.300 = -0.800$$

$$\text{Last RL} - \text{First RL} = 99.200 - 100.000 = -0.800$$

(b) By the height of collimation, the plane of collimation is fixed by the back sight, and every reading is subtracted from it until a new back sight is taken.

Station	BS	IS	FS	HC	RL	Remarks
A	1.500			101.500	100.000	BM
B		2.300			99.200	
C		1.100			100.400	
D	1.800		2.900	100.400	98.600	CP
E		2.500			97.900	
F			1.200		99.200	
Sum	3.300		4.100			

The check on this method compares the two sums with the change in reduced level:

$$\Sigma BS - \Sigma FS = 3.300 - 4.100 = -0.800 = \text{Last RL} - \text{First RL}$$

(c) The rise and fall method is preferred where there are many intermediate sights, because its check tests every reduced level; the height of collimation method is preferred where the sights are few and speed matters, as in setting out.

Examiner's Note
The check must be shown, not assumed; note that the height of collimation check only balances the sums and does not test the intermediate levels, which is where its weakness lies.

False Confidence Alert
The two-line collimation check can balance even when an intermediate reduced level is wrong; only the rise and fall check tests each intermediate point.

Question 16

(a) The equipment is the plane table board with its tripod, the alidade for sighting and drawing lines, a spirit level for levelling the board, a trough compass for orienting it, a plumbing fork for centring it over the station, and the drawing paper fixed to the board.

(b) Setting up has three steps, remembered as centring, levelling and orienting.

1) **Centring:** the board is set on its tripod over the station and moved with the plumbing fork until the plotted point lies exactly above the ground station.

2) **Levelling:** the board is made truly horizontal by the spirit level, adjusting the tripod legs until the bubble is central.

3) **Orienting:** the board is turned until its drawn north agrees with the trough compass, or until a line to a known plotted point runs along its ground direction, so that the sheet lies parallel to the ground.

(c) In the radiation method the table is set up at one station that commands the area. The alidade is laid against the plotted station and sighted to each feature in turn, and a ray is drawn along the alidade towards each. The distance to each feature is measured on the ground and scaled off along its ray, so that all the points are fixed from the one station like spokes from a hub.

(d) Plane tabling is suitable for mapping a small area, and for filling in detail quickly onto a framework already surveyed, as on the Kilosa estate.

(e) It is not accurate enough for large or precise surveys, and it cannot be used in wet or windy weather, since the sheet is drawn out of doors.

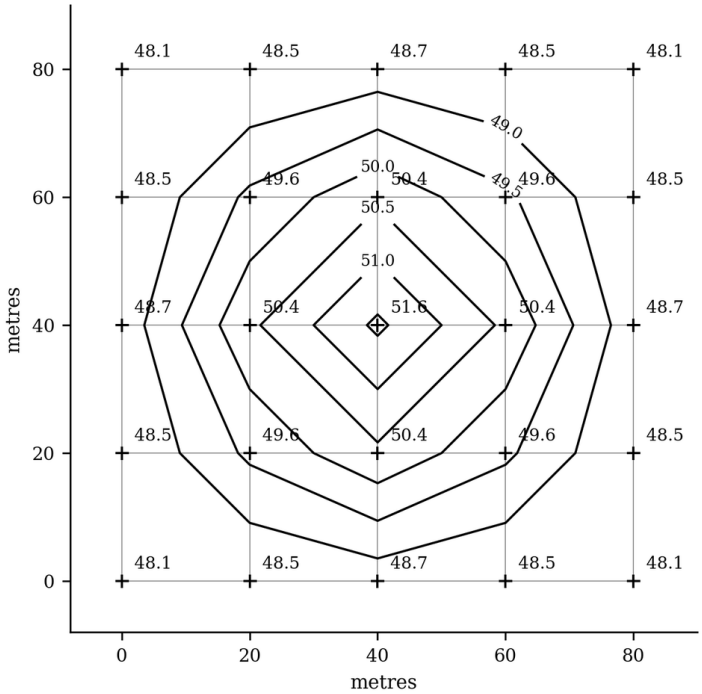
Examiner's Note

Set up in the order centring, levelling, orienting; in radiation every point is fixed from one station by a ray and a measured distance, which is why it suits only ground that can all be seen from that station.

Question 17

(a) The pegs are set out in a square grid at equal spacing, and a level is set up so that it commands them all. A back sight is taken on a bench mark of known height to fix the height of collimation, and the staff is then read on each peg in turn. The reduced level of each peg is the height of collimation less its staff reading, and a change point is used to move the level if the whole grid cannot be seen from one setting.

(b) Each contour is drawn by interpolating its position proportionally between the pegs whose levels it falls between, and the equal-valued points are then joined by a smooth line.



Contours drawn by interpolation from the grid of reduced levels.

(c) The ground rises from about 48 m at the corners of the field to a rounded summit of 51.6 m at the centre. The contours close in rings about this summit, evenly spaced on all sides, which shows a low, symmetrical hill, or knoll, standing in the middle of the field.

(d) The contour map can be used to show the shape and steepness of the ground for planning any work upon it, and to compute the volumes of cut and fill, or to choose a level building site or lay out drainage.

Examiner's Note
Interpolate each contour proportionally between the pegs, not by guess; closed rings of contour mean a hill, and the innermost ring is the highest ground.

False Confidence Alert
Contours that close in rings show a hill only when the values rise inwards; the same rings would show a hollow if the values fell inwards, so always read the heights before naming the feature.

Question 18

(a) It is a ground oblique photograph, because it was taken from ground level looking across the scene, so the objects in the foreground are large, they grow smaller towards the back, and part of the sky and the far horizon can be seen.

(b) Natural and man-made features.

Natural features:

1) **The water:** the calm open water of the lake.
2) **The forested hills:** the tree-covered high ground across the water.
3) **The beach:** the sandy foreshore on which the boats rest.

Man-made features:

1) **The boats:** the wooden fishing boats drawn up on the beach.
2) **The mooring posts:** the timber posts set in the sand to tie the boats.
3) **The nets:** the fishing nets and floats laid out on the shore.

(c) The main activity is fishing. The evidence is the wooden fishing boats drawn up on the beach and the fishing nets and floats laid out beside them. Two other activities they might carry out are boat building and repair, and trade or transport of goods across the water, as at the fishing shore of Kigoma on Lake Tanganyika.

(d) Your sketch should outline the far hills and the open water across the top, the boats drawn up on the beach, and the mooring posts and nets in the foreground, with each of these labelled.

(e) Problems facing the community.

1) **Declining catches:** overfishing and small mesh nets have reduced the fish, so each trip earns less.

2) **Rough water:** sudden storms on the open water damage the small boats and endanger the fishermen.

3) **Poor storage and markets:** without cold storage the catch spoils quickly and fetches a low price.

Examiner's Note
Take the type from the viewpoint and the large foreground, not from the subject; in (c) the marks are for evidence pointed to in the photograph, so name the boats and the nets, not merely the word fishing.

False Confidence Alert
Saying the activity is fishing is only half the answer; the marks in (c) sit in the evidence, so a candidate who names no feature of the photograph earns little.

Question 19

(a) It is a high oblique aerial photograph, because it was taken from an aircraft with the camera tilted, so that the ground, the far horizon and a little of the sky are all seen together and features grow smaller into the distance.

(b) The main feature is a large meander, a sweeping bend of the river across its flood plain. The river swings in a broad curve, wearing away the outer bank where the current is swift and dropping sand and silt on the gentle inner bank, and it runs through a wide, flat valley floor.

(c) Types of land use.

1) **Arable and irrigated farming:** the many green and brown rectangular fields laid out on the flat land beside the river.

2) **Grazing land:** the open, rough grassland along the banks where the fields give way to pasture.

3) **Settlement:** the town spreading across the far side of the plain in the distance.

(d) Reasons for the intensive farming.

1) **Water for irrigation:** the river gives a steady supply of water that can be led onto the fields even in the dry season.

2) **Fertile alluvial soil:** the flood plain is floored with deep, rich silt renewed whenever the river floods, so it yields well, as on the Kilombero flood plain.

(e) Your sketch should show the river winding across the middle in its broad meander, the raised banks or levees along its sides, the blocks of fields on either hand, and the distant town, with each of these labelled.

(f) Dangers and their remedies.

1) **Flooding of the fields:** in the wet season the river may overflow and drown the crops; building embankments and drainage channels along the banks holds the water back.

2) **Bank erosion:** the swift water on the outer bend cuts into the farmland and carries it away; planting the bank with grass and trees or facing it with stone checks the wearing.

Examiner's Note
Take the type from the tilt and the visible horizon; back each land use in (c) with what is actually seen; and let the meander and its flood plain explain the intensive farming in (d).

False Confidence Alert
The wide bend is a meander, not a delta or an ox-bow lake; a delta forms where a river meets the sea, and an ox-bow is a cut-off loop, neither of which is shown here.

Question 20

(a) It is a low oblique aerial photograph, because it was taken from an aircraft with the camera tilted so that a wide area and the distant ground are seen, but no horizon or sky appears.

(b) The main farming is plantation, or orchard, agriculture, in which one tree crop is grown. The evidence is that the trees stand in long, straight, regular rows, evenly spaced, quite unlike the scattered growth of natural woodland around them.

(c) Other features.

1) **A road:** the straight surfaced road running along the left of the plantation.

2) **A power line:** the line of poles following the road.

3) **Natural woodland:** the darker, irregular forest surrounding the planted rows.

(d) Advantages of the regular rows.

1) **Easy management:** the even rows let workers and machines move between the trees to weed, spray and harvest.

2) **Even spacing:** each tree gets its fair share of light, water and soil, so the crop grows evenly and yields well.

(e) Your sketch should show the blocks of trees in their straight rows across the centre, the road and its line of poles down the left, and the darker natural woodland around the edges, with each of these labelled.

(f) Problems of a single tree crop.

1) **Pests and disease:** a single crop over a wide area is easily swept by one pest or disease, as in the coffee of the Kilimanjaro slopes.

2) **Dependence on one market:** the farmer's income rests on the price of the one crop, so a fall in that price hits him hard.

Examiner's Note
Take the type from the tilt and the absence of a horizon; the straight rows are the key evidence of a plantation; and in (f) tie the problem to the fact that only one crop is grown.

False Confidence Alert
Regular rows of trees are a planted crop, not natural forest; the evenness and spacing, not the mere presence of trees, are what prove cultivation.

Question 21

(a) Each whole-circle bearing is named from north or south towards east or west.

(i) $60°$ lies in the first quadrant, so it is N $60°$ E.

(ii) $210°$ lies in the third quadrant, $210° - 180° = 30°$, so it is S $30°$ W.

(iii) $300°$ lies in the fourth quadrant, $360° - 300° = 60°$, so it is N $60°$ W.

(b) The back bearing is the forward bearing plus $180°$, since the forward bearing is less than $180°$:

$$BB = FB + 180° = 75°30' + 180° = 255°30'$$

(c) A line free from local attraction shows a forward and back bearing differing by exactly $180°$. Here the difference is:

$$312°00' - 130°00' = 182°00'$$

The difference is 2° more than 180°, so the line is not free from local attraction; a clean line should give exactly 180°.

Examiner's Note
In (a) name the quadrant, then measure from north or south; in (c) the whole test is the 180° difference, so state the two-degree excess as the evidence of attraction rather than leaving it unread.

Question 22

(a) Magnetic declination is the horizontal angle at a place, at a stated time, between true north and magnetic north, named East or West according to the side on which the compass needle lies.

(b) With a West declination the magnetic north lies west of true north, so the magnetic bearing is the true bearing plus the declination:

$$\text{MB} = \text{TB} + \text{declination} = 210°00' + 3°30' = 213°30'$$

The magnetic bearing is 213°30′.

(c) The change over four years is added to the present declination, and the new declination is then applied:

$$\text{change} = 4 \times 6' = 24', \quad \text{declination} = 3°30' + 24' = 3°54'\ \text{W}$$

$$\text{MB} = 210°00' + 3°54' = 213°54'$$

After four years the declination is 3°54′ West and the magnetic bearing is 213°54′.

Examiner's Note
The sign depends on the side: a West declination is added to the true bearing, an East one subtracted, so name the side before you compute.

Question 23

(a) An offset is a short measurement taken from the chain line to fix a nearby feature. A perpendicular offset is measured at a right angle to the chain line, while an oblique offset is measured to the feature at some other, recorded angle, which is used when setting out a true right angle would be awkward.

(b) Chain surveying is based on the principle of triangulation. The area is covered with a framework of triangles, because a triangle is the only figure that is fixed in shape once the lengths of its three sides are known, so the whole plot can be plotted from measured lengths alone without measuring any angles.

(c) A check line is a line measured across a triangle to a fixed point on another side. Its purpose is to test the accuracy of the survey, for if the plotted length of the check line agrees with its measured length the triangle is correct, and if the two disagree an error is revealed before the survey is used.

Examiner's Note
In (a) define the offset first, then contrast the two kinds by the angle to the chain line; in (c) the point is that the check line tests the work, not that it fixes a feature.

Question 24

(a) Local attraction is the deflection of a compass needle away from the magnetic meridian by nearby magnetic material. It is caused by iron and steel objects such as rails, roofs, pipes, wire fences or iron ore lying close to the compass station.

(b) It is detected by the difference between the forward and back bearing of a line. A line free from local attraction has a forward and back bearing differing by exactly 180°; if the difference is not 180°, at least one end of the line is affected.

(c) Line AB gives 220°00' - 40°00' = 180°, so both A and B are free from attraction. Line BC gives 278°00' - 100°00' = 178°, which is 2° short of 180°. Since B is already free, the fault lies at C, and the back bearing of BC is corrected by adding the 2° to give 280°00'.

Examiner's Note
Test each line by the 180° rule, then reason from a station known to be free to fix which end is affected; only the reading at the faulty station is corrected.

Question 25

(a) The Bowditch rule distributes the closing error among the lines of a closed traverse in proportion to their lengths, so that a long line receives a larger share of the correction than a short one.

(b) The correction to a line is the closing error multiplied by the ratio of that line's length to the whole perimeter:

$$\text{correction} = \text{closing error} \times \frac{\text{length of AB}}{\text{perimeter}} = 0.60 \times \frac{300}{1\,200} = 0.60 \times 0.25 = 0.15 \text{ m}$$

The correction applied to line AB is 0.15 m.

(c) The rule assumes that the errors are equally likely in all the lines, so that the error in a line is proportional to its length; in other words, that the angles and the distances are measured with the same care throughout.

Examiner's Note
The correction shares the error by length, so keep length and perimeter in the same unit; the longest line takes the largest correction.

Question 26

(a) The plane of collimation is fixed by each back sight, and every reading is subtracted from it until a new back sight is taken.

Station	BS	IS	FS	HC	RL	Remarks
A	1.500			21.500	20.000	BM
B		0.800			20.700	
C	1.900		2.300	21.100	19.200	CP
D			0.700		20.400	
Sum	3.400		3.000			

(b) The check compares the two sums with the change in reduced level:

$$\Sigma\text{BS} - \Sigma\text{FS} = 3.400 - 3.000 = 0.400 = \text{Last RL} - \text{First RL} = 20.400 - 20.000$$

The two sides agree at 0.400 m, so the reduction is correct.

(c) A change point is a staff station on which both a fore sight and, after the level is moved, a back sight are taken. It carries the levelling forward from one setting of the instrument to the next, so its reduced level is common to both.

Examiner's Note
Take a new height of collimation at every back sight; the change point takes both a fore sight and a back sight, which is why the level can be moved there without losing height.

Question 27

(a) A back sight is the first staff reading taken after the level is set up, on a point of known reduced level. An intermediate sight is any reading taken between the back sight and the fore sight at the same setting. A fore sight is the last reading taken before the level is moved, on the point whose level is being carried forward.

(b) A datum is the level surface, such as mean sea level, from which all heights are measured. A reduced level is the height of a point above that datum, worked out from the staff readings.

(c) A bench mark is a fixed point of known reduced level, marked permanently on the ground or on a building, from which a levelling survey can start and to which it can be tied.

Examiner's Note
Distinguish the three sights by when they are taken at a setting; the reduced level is always a height above the datum, and the bench mark is the known starting height.

Question 28

(a) Causes of error in chaining.

1) **Wrong length of chain:** the chain may be stretched, worn or bent, so that it is not truly its nominal length.

2) **Sag of the chain:** a chain not pulled taut hangs in a curve and measures short.

3) **Sloping ground:** if the chain is laid along a slope instead of horizontally, the measured distance is too long.

(b) The true length is the recorded length multiplied by the ratio of the true chain length to its nominal length:

$$\text{true length} = 600 \times \frac{30.1}{30} = 602 \text{ m}$$

The true length of the line is 602 m.

(c) The recorded length of 600 m is too short. Because the chain is longer than it should be, each throw of the chain covers a little more ground than the 30 m credited to it, so fewer chain-lengths are counted and the line is under-measured; the true length, 602 m, is therefore greater than the record.

Examiner's Note
A chain that is too long gives a recorded distance that is too short, and one that is too short gives a distance too long; multiply by the ratio of true to nominal length to correct it.

Question 29

(a) Each reading is compared with the one before: a smaller following reading is a rise, a larger one a fall.

Station	BS	IS	FS	Rise	Fall	RL
A	2.100					25.000
B		1.500		0.600		25.600
C			2.700		1.200	24.400
Sum	2.100		2.700	0.600	1.200	

(b) The three totals agree:

$$\Sigma BS - \Sigma FS = 2.100 - 2.700 = -0.600 = \Sigma Rise - \Sigma Fall = \text{Last RL} - \text{First RL}$$

(c) Point B, with a reduced level of 25.600 m, is the highest of the three.

Examiner's Note
Compare each reading with the one before to get the rise or fall; the highest reduced level is the highest point on the ground.

Question 30

(a) Each is converted according to its quadrant:

Quadrantal bearing	N 40° E	S 60° E	S 30° W	N 70° W
Whole-circle bearing	40°	120°	210°	290°

For example, S 60° E = 180° - 60° = 120° and N 70° W = 360° - 70° = 290°.

(b) The rule depends on the quadrant.

1) **First quadrant, N ... E:** the whole-circle bearing equals the quadrantal angle.
2) **Second quadrant, S ... E:** subtract the angle from 180°.
3) **Third quadrant, S ... W:** add the angle to 180°.
4) **Fourth quadrant, N ... W:** subtract the angle from 360°.

Examiner's Note
Name the quadrant from the letters, then apply its rule; the whole-circle bearing is always measured clockwise from north.

Question 31

(a) Taking the mid-values x with an assumed mean A = 50, the deviations d = x - 50 give:

Mid-value x	10	30	50	70	90
Frequency f	3	8	12	5	2
d = x − 50	−40	−20	0	20	40
f d	−120	−160	0	100	80

With Σf = 30 and Σfd = -100:

$$\bar{x} = A + \frac{\Sigma fd}{\Sigma f} = 50 + \frac{-100}{30} = 50 - 3.33 = 46.67$$

The mean mark is 46.67.

(b) The assumed-mean method works with small deviations instead of the large mid-values, so the arithmetic is lighter and less liable to error.

Examiner's Note
The mean is A plus the average deviation; keep the sign of Σfd, since dropping the minus turns a mean of 46.67 into a wrong 53.33.

Question 32

(a) The cumulative frequencies locate the classes:

Marks	0-20	20-40	40-60	60-80	80-100
Frequency f	4	10	16	8	2
Cumulative cf	4	14	30	38	40

With $N = 40$, the half-way value $\frac{N}{2} = 20$ falls in the 40-60 class, so $L = 40$, $cf = 14$, $f = 16$, $h = 20$:

$$\text{Median} = L + \frac{N/2 - cf}{f} \times h = 40 + \frac{20 - 14}{16} \times 20 = 40 + 7.5 = 47.5$$

The median mark is 47.5.

(b) The modal class is 40-60, the tallest, with $f_1 = 16$, $f_0 = 10$, $f_2 = 8$:

$$\text{Mode} = L + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times h = 40 + \frac{16 - 10}{32 - 10 - 8} \times 20$$

$$= 40 + \frac{6}{14} \times 20 = 40 + 8.57 = 48.57$$

The modal mark is 48.57.

Examiner's Note

Show the cumulative column, since the median class cannot be found without it; the modal formula needs the frequencies on either side of the tallest class, so read them off carefully.

Question 33

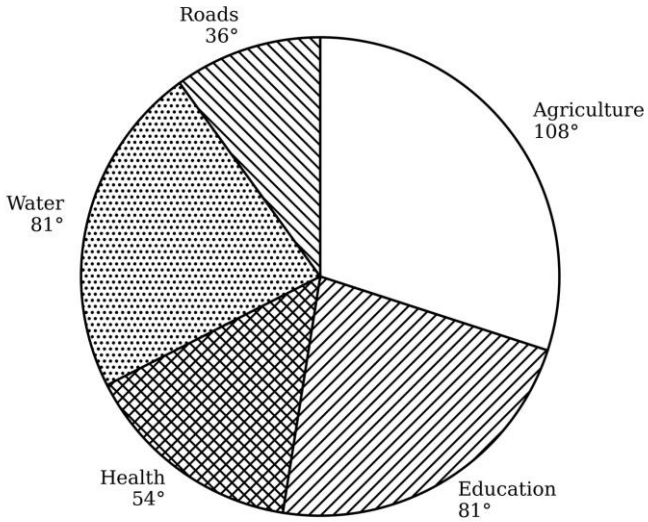
(a) Each angle is the item as a fraction of the whole turned into degrees, the total being 400 million:

Sector	Amount	Angle
Agriculture	120	108°
Education	90	81°
Health	60	54°
Water	90	81°
Roads	40	36°
Total	400	360°

For example, the agriculture sector is:

$$\text{Sector angle} = \frac{120}{400} \times 360° = 108°$$

(b) The circle is drawn and the sectors set out in order with a protractor, largest first, each labelled.



Divided circle of the village budget.

(c) The divided circle shows at a glance the share of the whole taken by each sector, so the balance of the budget is seen immediately.

Examiner's Note

The angles must total 360°, so check the sum before drawing; in (b) the marks are in accurate angles set out with a protractor and clear labelling.

Question 34

(a) The range is the largest value less the smallest:

$$\text{range} = 25 - 7 = 18 \text{ mm}$$

The range is 18 mm.

(b) Arranged in order the values are 7, 9, 11, 12, 14, 15, 18, 20, 22, 25, with $n = 10$. The quartiles fall at:

$$Q_1 \text{ at } \frac{n+1}{4} = 2.75\text{th value} = 9 + 0.75(11 - 9) = 10.5 \text{ mm}$$

$$Q_3 \text{ at } \frac{3(n+1)}{4} = 8.25\text{th value} = 20 + 0.25(22 - 20) = 20.5 \text{ mm}$$

$$\text{inter-quartile range} = Q_3 - Q_1 = 20.5 - 10.5 = 10 \text{ mm}$$

The lower quartile is 10.5 mm, the upper quartile 20.5 mm, and the inter-quartile range 10 mm.

(c) The inter-quartile range uses only the middle half of the data, so it is not affected by a single very high or very low value as the range is.

Examiner's Note

Order the data before reading the quartiles; the inter-quartile range is the spread of the middle half and so resists extreme values.

Question 35

(a) The combined mean is the total of all the marks divided by the total number of pupils:

$$\text{combined mean} = \frac{(30 \times 45) + (20 \times 55)}{30 + 20} = \frac{1\,350 + 1\,100}{50} = \frac{2\,450}{50} = 49$$

The combined mean is 49 marks.

(b) The two classes are of different sizes, so their means do not carry equal weight. The larger class of 30 pulls the combined mean towards its own mean of 45, which is why the answer, 49, lies nearer 45 than 55 rather than at the midpoint 50.

(c) If each class had 25 pupils the two would carry equal weight, and the combined mean would then be the simple average, $\frac{45+55}{2} = 50$.

Examiner's Note

Weight each mean by the size of its class; the simple average is right only when the groups are equal in size, as part (c) shows.

Question 36

(a) The increase is the later figure less the earlier:

$$\text{increase} = 35\,000 - 20\,000 = 15\,000 \text{ people}$$

The population increased by 15 000.

(b) The percentage increase is the increase as a fraction of the 1990 figure, times a hundred:

$$\text{percentage increase} = \frac{15\,000}{20\,000} \times 100 = 75\%$$

The population increased by 75 per cent.

(c) The average yearly increase is the total increase shared over the thirty years:

$$\text{average per year} = \frac{15\,000}{30} = 500 \text{ people}$$

On average the population grew by 500 people a year.

Examiner's Note

The percentage increase is always taken on the earlier, or base, figure, not the later one; keep the base clear before dividing.

Question 37

(a) The mean is the sum of the marks divided by their number:

$$\bar{x} = \frac{12+15+15+18+20+15+22}{7} = \frac{117}{7} = 16.7$$

The mean mark is about 16.7.

(b) Arranged in order the marks are 12, 15, 15, 15, 18, 20, 22. With seven marks the middle, or fourth, value is the median, which is 15.

(c) The mark that occurs most often is 15, which appears three times, so the modal mark is 15.

Examiner's Note

Order the data before reading the median; the median of seven values is the fourth, and the mode is simply the most frequent value.

Question 38

(a) A moving average is the average of a fixed number of successive values in a series, worked out again and again as it is moved one step along the series. It is used to smooth out the short-term ups and downs so that the underlying trend can be seen clearly.

(b) Each three-year moving average is the mean of three successive yields:

Years	40, 44, 42	44, 42, 48	42, 48, 46	48, 46, 52
Moving average	42.0	44.7	45.3	48.7

For example, the first is $\frac{40+44+42}{3} = 42.0$.

(c) The moving averages rise steadily from 42.0 to 48.7, so they show a clear upward trend in the maize yield over the six years.

Examiner's Note

Average three successive values, then move along by one year; the moving average removes the year-to-year jumps and leaves the trend.

Question 39

(a) A price index is a number that shows how the general level of prices in one year compares with that in a chosen base year, the base being taken as 100.

(b) The simple aggregate index is the total of the current prices over the total of the base prices, times a hundred:

$$\text{index} = \frac{1\,000 + 1\,800 + 1\,400}{800 + 1\,500 + 1\,200} \times 100 = \frac{4\,200}{3\,500} \times 100 = 120$$

The price index for 2020 is 120.

(c) An index of 120, against the base of 100, shows that prices rose by 20 per cent between 2015 and 2020.

Examiner's Note

Add the prices in each year, then divide the current total by the base total and multiply by a hundred; an index above 100 means prices have risen.

Question 40

(a) The ground length is the map length multiplied by the scale, then changed to kilometres:

$$\text{ground} = 12.4 \times 50\,000 = 620\,000 \text{ cm} = 6.2 \text{ km}$$

The road is 6.2 km long.

(b) The map length is the ground length divided by the scale, with the ground length first put into centimetres:

$$\text{map} = \frac{8 \text{ km}}{50\,000} = \frac{800\,000 \text{ cm}}{50\,000} = 16 \text{ cm}$$

The towns are 16 cm apart on the map.

(c) A scale of 1:50 000 means 1 cm on the map stands for 50 000 cm on the ground, which is 0.5 km, so the statement of scale is 1 cm to 0.5 km, or 2 cm to 1 km.

Examiner's Note

Change units at the end, not the start; the commonest error is to forget that 50 000 cm is only 0.5 km, which turns a 6.2 km road into a wrong 620 km.

Question 41

(a) Complete squares are counted in full and part-squares are counted as one half each, so the area is:

$$\text{area} = 24 + \frac{16}{2} = 24 + 8 = 32\ \text{km}^2$$

The forest covers about 32 km².

(b) The gradient is the fall in height over the horizontal distance, both in the same unit, with 6 km = 6 000 m:

$$\text{gradient} = \frac{450 - 150}{6\,000} = \frac{300}{6\,000} = \frac{1}{20}$$

The gradient is 1 in 20.

(c) As a percentage the gradient is the same fraction multiplied by a hundred:

$$\frac{300}{6\,000} \times 100 = 5\%$$

The gradient is 5 per cent.

Examiner's Note

Count part-squares as one half each in (a); in (b) and (c) put the distance into metres before dividing, and remember the gradient is a ratio.

Question 42

(a) Vertical exaggeration is the number of times the vertical scale of a cross-section is greater than its horizontal scale. It is used because relief drawn to the true horizontal scale would be too flat to see, so the heights are stretched.

(b) It is the vertical scale divided by the horizontal scale, with the vertical scale of 1 cm to 50 m written as a fraction, 1 cm to 50 m = 1:5 000:

$$\text{vertical exaggeration} = \frac{\text{vertical scale}}{\text{horizontal scale}} = \frac{\frac{1}{5\,000}}{\frac{1}{50\,000}} = \frac{50\,000}{5\,000} = 10$$

The vertical exaggeration is 10 times.

(c) It makes slopes appear far steeper than they really are, so that gentle relief looks bold and hilly on the section.

Examiner's Note

Both scales must be written as representative fractions before dividing; a vertical exaggeration greater than one always steepens the drawn slopes.

Question 43

(a) The back bearing of a line is the bearing of that line measured in the opposite direction, that is the bearing of the starting point taken from the far point. It differs from the forward bearing by exactly 180 degrees.

(b) Since the forward bearing is less than 180 degrees, add 180 degrees:

$$\text{bearing of P from Q} = 065° + 180° = 245°$$

The bearing of P from Q is 245°.

(c) Since the forward bearing is more than 180 degrees, subtract 180 degrees:

$$\text{bearing of Q from R} = 200° - 180° = 020°$$

The bearing of Q from R is 020°.

Examiner's Note

Add 180° when the forward bearing is below 180°, and subtract 180° when it is above; the back bearing is always the forward bearing turned through a straight angle.

Question 44

(a) Enlarging a map is redrawing it to a larger size, so that every length on it is increased in a fixed ratio while the shape stays the same. The scale then becomes larger and more detail can be shown.

(b) Enlarging two times doubles every length, so the ground represented by 1 cm is halved and the scale becomes larger:

$$\text{new scale} = \frac{1}{50\,000} \times 2 = \frac{1}{25\,000}$$

The enlarged map has a scale of 1:25 000.

(c) Area increases as the square of the linear enlargement, so doubling the lengths multiplies the area by four:

$$\text{new area} = 6 \times 2^2 = 6 \times 4 = 24\ \text{cm}^2$$

The forest will cover 24 cm² on the enlarged map.

Examiner's Note

Enlarging makes the scale fraction larger, so 1:50 000 becomes 1:25 000; remember that area changes as the square of the linear factor, not in simple proportion.

Question 45

(a) The gradient is the rise in height over the horizontal distance, both in the same unit, with 5 km = 5 000 m:

$$\text{gradient} = \frac{400 - 150}{5\,000} = \frac{250}{5\,000} = \frac{1}{20}$$

The gradient is 1 in 20.

(b) As a percentage it is the same fraction times a hundred:

$$\frac{250}{5\,000} \times 100 = 5\%$$

The gradient is 5 per cent.

(c) A gradient of 1 in 20 is steeper than one of 1 in 25, because the smaller the number after the one, the steeper the slope; a rise of one metre over twenty is steeper than a rise of one over twenty-five.

Examiner's Note

Put the distance into metres before dividing; and remember that of two gradients written as 1 in n, the one with the smaller n is the steeper.

Question 46

(a) In the strip method the shape is divided into parallel strips of equal width. The length of each strip is measured at its middle, the lengths are added, and the total is multiplied by the width of a strip to give the area.

(b) The map area is the strip width times the sum of the lengths:

$$\text{area} = 1 \times (2.0 + 3.5 + 4.0 + 3.0 + 1.5) = 1 \times 14 = 14\ \text{cm}^2$$

The area on the map is 14 cm².

(c) On a 1:50 000 map 1 cm is 0.5 km, so 1 cm² is 0.25 km²:

$$\text{true area} = 14 \times 0.25 = 3.5 \text{ km}^2$$

The true area of the lake is 3.5 km².

> **Examiner's Note**
>
> Add the strip lengths, then multiply by the width; and remember that 1 cm² on a 1:50 000 map stands for 0.25 km² on the ground, not 0.5.

Question 47

(a) The dispensary lies 3.3 km east and 2.8 km north of the school, so:

$$\text{distance} = \sqrt{3.3^2 + 2.8^2} = \sqrt{18.73} = 4.3 \text{ km}$$

The distance is about 4.3 km.

(b) The bearing, measured clockwise from north, is:

$$\text{bearing} = \tan^{-1}\left(\frac{3.3}{2.8}\right) = 050° \text{ (approximately)}$$

The dispensary lies about 050° from the school.

(c) The bearing of the school from the dispensary is the back bearing, $050° + 180° = 230°$.

> **Examiner's Note**
>
> Take the east and north differences from the grid references; the bearing is clockwise from north, and the reverse bearing differs by 180°.

Question 48

(a) Since 1 km is 100 000 cm, 2 cm stands for 100 000 cm, so 1 cm stands for 50 000 cm:

$$\text{representative fraction} = 1 : \frac{100\,000}{2} = 1 : 50\,000$$

The statement 2 cm to 1 km is the representative fraction 1:50 000.

(b) A fraction of 1:25 000 means 1 cm stands for 25 000 cm, which is 0.25 km, so the statement is 1 cm to 0.25 km, or 4 cm to 1 km.

(c) The scale 1:25 000 is the larger, because the smaller the number after the one, the larger the scale; 1:25 000 shows the ground larger and in more detail than 1:50 000.

> **Examiner's Note**
>
> Change the kilometres to centimetres before forming the fraction; of two fractions, the one with the smaller denominator is the larger scale.

Question 49

(a) It is a vertical aerial photograph. Two characteristics are that it is taken from directly above with the camera pointing straight down, so features appear in plan as on a map, and that the scale is nearly the same across the whole photograph, with no sky or horizon in view.

(b) Types of land use.

1) **Commercial or central business:** the large blocks of buildings and the car parks in the middle of the town.

2) **Residential:** the regular rows of smaller roofs away from the centre.

3) **Transport:** the network of streets, roundabouts and parking that ties the town together.

(c) A vertical aerial photograph shows the whole town at a nearly uniform scale, so distances and areas can be measured from it and the town plan kept up to date, as could be done for a growing Tanzanian town such as Mwanza.

Examiner's Note

A characteristic is a property of the photograph itself, the plan view and even scale, not a description of the town; back each land use in (b) with what is actually seen.

Question 50

(a) The main feature is a small waterfall, or rapids, where a stream drops over steps of rock; the view is a ground oblique photograph.

(b) The vegetation is dense evergreen forest, with ferns, mosses and tall trees crowding the banks and a mossy fallen log across the stream. This shows a wet area of heavy, well-spread rainfall and high humidity, like the Eastern Arc forests of the Uluguru and Udzungwa mountains in Tanzania.

(c) Reasons for conserving the forest.

1) **It protects the catchment:** the forest holds and releases water slowly, keeping the stream and the rivers below it flowing through the year.

2) **It checks erosion:** the roots bind the soil on the steep slopes, so the heavy rain does not wash it away.

3) **It is a store of life and resources:** it shelters wildlife and supplies timber, medicines and a place for tourism.

Examiner's Note

Read the climate from the vegetation, since dense evergreen forest means heavy rainfall; tie the answer to a named Tanzanian forest rather than leaving it general.

Question 51

(a) The scale of a vertical photograph is the focal length divided by the flying height, both in the same unit, with the focal length $200\ \text{mm} = 0.2\ \text{m}$:

$$\text{scale} = \frac{\text{f}}{\text{H}} = \frac{0.2\ \text{m}}{2\ 000\ \text{m}} = \frac{1}{10\ 000}$$

The scale is 1:10 000.

(b) The ground length is the photo length multiplied by the scale:

$$\text{ground} = 8 \times 10\ 000 = 80\ 000\ \text{cm} = 800\ \text{m}$$

The road is 800 m long.

(c) A vertical photograph is taken with the camera pointing straight down and shows features in plan like a map, whereas an oblique photograph is taken with the camera tilted and shows a side view with the horizon in it.

Examiner's Note

Put the focal length and the height into the same unit before dividing; the scale is a ratio, so it has no units.

Question 52

(a) Overlap is the part of the ground that appears on two successive photographs because each is taken before the aircraft has wholly passed the ground of the last. The overlap along the line of flight, the forward overlap, is usually about 60 per cent, and that between neighbouring strips, the side overlap, about 30 per cent.

(b) Reasons for overlap.

1) **For stereoscopic viewing:** the two overlapping views of the same ground allow it to be seen in three dimensions under a stereoscope, so that relief can be studied.

2) **To leave no gaps:** the overlap makes sure that no strip of ground is missed between one photograph and the next, giving complete cover.

(c) A single aerial photograph covers only the small area caught in one exposure. A photo-mosaic is many overlapping photographs trimmed and joined together to show a large area as one continuous picture, in the manner of a map.

Examiner's Note

Overlap is the shared ground between photographs; keep the two reasons distinct, one for seeing relief and one for complete cover.

Question 53

(a) A vertical aerial photograph is taken with the camera pointing straight down, so that features are seen in plan, as on a map, and no horizon appears. An oblique aerial photograph is taken with the camera tilted, so that features are seen from the side and, in a high oblique, the horizon comes into view.

(b) Advantages of the vertical photograph.

1) **Uniform scale:** its scale is nearly the same across the photograph, so distances and areas can be measured from it and maps drawn.

2) **Plan view:** it shows features in plan like a map, and overlapping pairs can be viewed in three dimensions to show relief.

(c) An oblique photograph covers a much larger area of ground in a single exposure and shows the sides of features in a natural, easily understood view.

Examiner's Note

Take the difference from the tilt of the camera; the vertical is the one used for measurement and mapping, the oblique for wide coverage and a natural view.

Question 54

(a) The scale is the photo length over the ground length, in the same unit, with 2 km = 200 000 cm:

$$\text{scale} = \frac{5\text{ cm}}{200\,000\text{ cm}} = \frac{1}{40\,000}$$

The scale is 1:40 000.

(b) The ground width is the photo width times the scale:

$$\text{ground width} = 3 \times 40\,000 = 120\,000\text{ cm} = 1\,200\text{ m}$$

The plantation is 1 200 m wide.

(c) On an oblique photograph the scale is not the same across the picture, growing smaller from foreground to distance, so a single scale worked from one measurement would not apply elsewhere.

Examiner's Note

Put both lengths into the same unit before dividing; the simple scale rule holds only for a vertical photograph, where the scale is nearly constant.

Question 55

(a) Tone is the lightness or darkness of a feature on the photograph, from white through greys to black. Texture is the smoothness or roughness of its surface as it appears, whether even or broken.

(b) A lake appears in a smooth, even tone, usually dark and unbroken, because its water is flat. A forest appears in a rough, broken texture of light and shade, because its canopy is uneven; so the smooth dark patch is the lake and the rough mottled patch the forest.

(c) Shadows show the height and shape of raised features and reveal the direction of the sun, so that tall trees, buildings and slopes can be recognised by the shadows they cast.

Examiner's Note

Define tone by lightness and texture by roughness; a lake is smooth and even, a forest rough and mottled, and shadows betray what stands up from the ground.

Question 56

(a) The independent variable is the amount of fertiliser used, since that is the cause Neema sets and varies; the dependent variable is the maize yield, since that is the effect she measures as it responds.

(b) A continuous variable can take any value within a range, such as the rainfall on a farm, which may be 812.5 mm; a discrete variable takes only separate whole values, such as the number of farms, which cannot be 8.5.

(c) Reasons for sampling.

1) **The population is too large:** studying every farm in Mbozi would cost more time and money than the study allows.

2) **A sample is enough:** a well-chosen sample represents the whole closely, so reliable conclusions are reached sooner and more cheaply.

Examiner's Note

In (a) tie each variable to its role of cause or effect, not just its name; in (c) the stem fixes the number at two, so give exactly two developed reasons.

Question 57

(a) In probability sampling every member of the population has a known and equal chance of being chosen, so the sample is unbiased and can fairly represent the whole. In non-probability sampling the members are instead chosen by the researcher's judgement or by convenience, so the chance of selection is not known and bias may enter the results.

(b) Two probability techniques.

1) **Simple random sampling:** every member is numbered and the sample is drawn by lot or by random numbers, so that each has an exactly equal chance of selection.

2) **Stratified sampling:** the population is first divided into groups such as miners and farmers, and a random sample is then taken from each group in proportion to its size, so that every group is fairly represented.

(c) Purposive sampling is suitable when the researcher needs particular informants who hold special knowledge, such as choosing the village elders or the mine managers who alone can explain how the work is organised.

Examiner's Note

In (a) the key difference is whether the chance of selection is known; in (b) name the technique and say how it is drawn, not merely its name.

Question 58

(a) A questionnaire is a set of written questions given to people so that they may answer them, used to collect the same information from many respondents in a standard form.

(b) Advantages of the questionnaire.

1) **It reaches many people:** the same questions can be given to a large number of farmers quickly and cheaply.

2) **It gives comparable answers:** because everyone answers the same questions, the replies can be tabulated and compared directly.

(c) Points to keep in mind when designing the questions.

1) **Keep them clear and simple:** each question should ask one thing in plain language the farmer understands.

2) **Avoid leading questions:** the wording should not push the farmer towards a particular answer.

3) **Order them well:** the questions should run in a sensible order, from easy to harder, and be short enough not to tire the respondent.

Examiner's Note

Define the instrument first; in (c) the marks are for points of good design, clear wording, no leading, sensible order, not for the topic of the questions.

Question 59

(a) A population is the whole set of units the researcher wishes to study, here all the households of the region. A sample is the small part of that population which is actually selected and studied in place of the whole.

(b) A sampling frame is the list of all the units in the population, from which the sample is drawn. An example is a register of all the households in the region, such as a voters' roll or a census list.

(c) Reasons a good sampling frame matters.

1) **It ensures every unit can be chosen:** only units on the frame can be selected, so a complete frame gives each household a fair chance and keeps the sample representative.

2) **It prevents bias:** a frame with gaps or repeats would leave some households out or count others twice, biasing the sample and the findings.

Examiner's Note

The population is the whole, the sample the part; the frame is the list the sample is drawn from, and its completeness decides whether the sample can be fair.

Question 60

(a) A hypothesis is a clear, testable statement of the relationship a researcher expects to find, put forward before the data are collected so that it may be tested against them.

(b) A null hypothesis states that there is no relationship or no difference between the things studied. An alternative hypothesis states that there is a relationship or a difference; the study tests the null and, if it is rejected, accepts the alternative.

(c) For her study, the null hypothesis is that the amount of fertiliser used has no effect on maize yield, and the alternative hypothesis is that a greater use of fertiliser increases the maize yield.

Examiner's Note

A hypothesis is a statement to be tested, not a question; the null denies a relationship and the alternative asserts one, and the two are always a pair.

ESSAY SOLUTIONS

Question 61

Land surveying is the accurate measurement and mapping of positions, distances, bearings and heights on the surface of the earth. In a developing country like Tanzania it is the quiet first step behind almost every project on the ground, because before a road is aligned, a farm is titled or a dam is sited, the land must first be surveyed. Its importance is therefore out of all proportion to how little of it the public ever sees.

It provides the accurate maps on which all planning rests. Every development plan, from a district land-use scheme to a national road network, is drawn on a surveyed base map. Without reliable maps of relief, drainage and settlement a government is planning blind and its projects go astray. The topographical mapping of the country by the survey authority is what makes ordered planning possible at all.

It fixes land boundaries and secures land tenure. Cadastral surveys mark the exact corners of each parcel so that title deeds can be issued and defended in law. This security gives farmers and investors the confidence to develop their land rather than fear losing it. Much of the bitter land conflict on the fast-growing fringes of Dar es Salaam is settled only by returning to the surveyed boundary.

It guides the location and construction of infrastructure. Roads, railways and pipelines must be set out on the ground from surveyed lines and levels before a single machine moves. This is how the alignment and gentle gradients of the Standard Gauge Railway were fixed across the country. Accurate setting out keeps such works to grade and prevents the costly errors that follow careless work.

It underpins large engineering works. Dams, bridges and power stations are positioned and built from precise survey control of the ground and the water. The siting and setting out of the Julius Nyerere Hydropower Project on the Rufiji depended on detailed survey of the whole valley. At this scale a few centimetres of survey error can be very expensive to put right.

It makes orderly town planning possible. Surveyed plots, streets and service lines turn unplanned growth into a workable town in which people can be served. The laying out of the new government functions at Dodoma rests on such survey. Where survey is skipped, towns grow into the crowded, unserviced sprawl that is hard and costly to correct later.

It supports agriculture and irrigation. Levelling and area survey lay out irrigation canals to a fall that water will actually follow, and measure fields for fair allocation among farmers. This is the work behind the paddy schemes of the Kilombero valley. Good survey is often the difference between a scheme that drains as intended and one that floods and fails.

It serves mineral and resource development. Mine surveys fix the position and depth of underground workings and the boundaries of mining licences. At the gold mines of Geita this keeps extraction both safe and lawful. A nation cannot develop or fairly tax its mineral wealth without first knowing exactly where it lies.

It provides the foundation for modern spatial data. Every layer in a geographic information system, from utilities to census mapping, is tied to surveyed control points on the ground. So even the newest digital mapping still begins with survey. Without that accurate framework the most advanced technology has nothing firm on which to stand.

In each of these ways land surveying converts empty ground into planned, titled and buildable space, so that a country cannot lay a road, raise a dam or issue a title without first calling in the surveyor. It is therefore not a technical afterthought but one of the true foundations on which national development is built, which is why the district is rightly told to survey before it builds.

Examiner's Note

The claim to justify is that survey must come before all else; argue point by point why each step of development needs it rather than merely listing uses. Any six developed points earn full marks, with a clear introduction and conclusion.

Question 62

Surveying is divided into two great branches according to whether the curvature of the earth is taken into account. Geodetic surveying allows for that curvature and treats the earth as the curved body it truly is, while plane surveying ignores the curvature and treats the piece of ground as flat. The choice between them turns chiefly on the size of the area and the accuracy the work demands.

They treat the earth's curvature differently. Geodetic surveying works on the true curved surface of the earth and corrects for it in every measurement. Plane surveying instead assumes the surface is flat and uses ordinary plane geometry. This single difference is the root of all the others, because curvature only makes itself felt over large distances.

They cover very different sizes of area. Plane surveying is used for small areas, up to about 250 square kilometres, where the error from ignoring curvature is far too small to matter. Geodetic surveying is used for large areas, whole regions and countries, where that same error would grow serious. The extent of the ground therefore decides which is proper.

They demand different accuracy and instruments. Geodetic work demands the very highest accuracy and uses precise instruments and satellite methods to achieve it. Plane work uses ordinary chains, tapes, compasses and levels to an accuracy that is quite good enough for local purposes. The cost of the instruments matches the precision each branch must reach.

They serve different purposes. Geodetic surveying provides the national framework of control points on which all other survey is later hung. Plane surveying produces the local plans of farms, plots and building sites that people use day to day. The first serves the whole nation while the second serves a single owner or scheme.

They differ greatly in cost and time. Because it is so precise and covers such large areas, geodetic surveying is slow and expensive and is carried out by the national survey authority. Plane surveying is quick and cheap and lies within the reach of an ordinary survey party. A school would never pay for geodetic methods to measure its own field.

They correct for the figure of the earth differently. In geodetic surveying measured lengths are reduced to a curved reference surface and spherical rules are applied throughout. In plane surveying plane trigonometry is enough because the ground is treated as a level plane. The mathematics of each branch follows directly from the surface it assumes.

They are seen in different examples. The fixing of the primary control and international boundaries of Tanzania is geodetic work of national scope. The survey of a plot in Morogoro or a school field is plane work of local scope. Each example shows the method matched to the size and importance of its task.

In short, the two branches are not rivals but partners scaled to their task, for geodetic surveying lays down the accurate curved framework of the whole country while plane surveying fills in the local detail upon it. The mapping team must work geodetically because it spans the nation, and the class may work by plane methods because its plot is small, each choosing according to the area and the accuracy required.

Examiner's Note

The command is account for, so bring out why the two differ, not merely that they differ; any six of these contrasts, each with its reason, earn full marks, and the introduction and conclusion carry their own.

Question 63

No survey is ever perfectly exact, and small errors creep in from the instruments, from the observer and from the conditions of the day. Understanding where these errors come from is the first step towards keeping them small, as the Dodoma party must now do. The aim is never a perfect result but one whose small remaining error is known and controlled.

Instrumental errors arise from the equipment. A chain that has stretched with use or a compass that is out of adjustment gives readings that are wrong by a fixed amount. Such errors repeat themselves

throughout the work and can badly distort it. They are reduced by testing and adjusting every instrument against a standard before the survey begins.

Personal errors arise from the observer. The surveyor may misjudge a fine reading on a scale or write the wrong figure in the field book. Because people vary, these errors are sometimes too large and sometimes too small. Careful, unhurried reading and taking the mean of several readings reduce their effect.

Natural errors arise from the conditions. Heat expands a steel tape, wind makes it sag, and the sun and earth pull on a compass needle. These natural effects change the measurements in ways the surveyor does not intend. Applying corrections for temperature and sag, and choosing calm conditions, keep them in check.

Local attraction disturbs the compass. Iron rails, roofs or ore near a station deflect the magnetic needle from its true direction. A line read near such iron is wrong even though the compass is sound. Keeping the instrument well clear of iron, and testing forward against back bearings for the correct 180-degree difference, detect and correct the fault.

Mistakes or blunders are gross errors. A whole reading may be dropped, a station missed, or a figure written in the wrong column. Unlike small errors these can throw the survey out completely. Independent check lines and careful re-measurement of doubtful lines catch such blunders before they spread.

Errors accumulate along the survey. Even tiny errors, each too small to see, add together along a long chain of measurements. By the end of a traverse they may show as a visible gap on closing. Closing the survey on a known point and adjusting the misclosure by a fair rule spreads this accumulated error back through the work.

Errors also enter in the plotting. Careless drawing, a blunt pencil or a poorly chosen scale add fresh error after the field work is done. Good field data can still yield a poor plan. Plotting to a suitable large scale with sharp, accurate instruments keeps this final error small.

Because errors can never be removed entirely, the surveyor's true aim is to keep them small and to spread whatever remains by proper checks and adjustment. The Dodoma party should therefore look first for a blunder, then adjust the small closing error fairly around the traverse, so that the finished survey closes within an acceptable limit rather than exactly.

Examiner's Note

The command is discuss, so name the source and give its remedy together; any six paired points earn full marks, and the introduction and conclusion carry their own.

Question 64

Levelling is the branch of surveying that finds the difference in height between points and refers them to a common datum. Because so many works depend on the exact slope and height of the ground, levelling is one of the most useful of all survey operations. Its importance to engineering and development appears in many ways.

It provides reduced levels for all works. Levelling fixes the height of each point above a chosen datum, giving a framework of known heights across the site. Every later operation, from design to setting out, rests on these reduced levels. Without them the vertical position of the work could not be controlled.

It sets out gradients for canals and pipes. Water flows only by gravity, so a canal or pipe must fall steadily from source to outlet. Levelling establishes the exact gradient that will carry the water without either ponding or racing. This is precisely the knowledge the Iringa engineer needs before digging.

It controls road and railway grades. Roads and railways must rise and fall within safe and gentle limits if vehicles are to climb them. Levelling measures the ground profile so that cuttings and embankments can be designed to hold the grade. The smooth gradients of a new highway are the fruit of careful levelling.

It makes contouring possible. By taking levels over a grid of points, the surveyor can draw contours that show the shape of the land. These contour maps are the basis of relief representation and of much planning. Levelling thus feeds directly into mapping.

It allows earthwork volumes to be computed. From the levels before and after work, the volumes of cut and fill are calculated. This lets the engineer balance the earth moved and estimate the cost. Accurate levelling therefore saves both soil and money.

It aids drainage and flood control. Levelling shows which way water will run and where it will collect on a site. Drains and flood works are then laid to lead the water safely away. In flat areas such as parts of the coast this control is vital.

It fixes foundations and floor levels. Buildings need level floors and footings set to a planned height above the ground. Levelling transfers the correct height to every part of the structure. A building set out without it would settle and stand unevenly.

In all these ways levelling supplies the heights on which canals, roads, drains and buildings depend, so that works fit the land and water goes where it is wanted. The engineer near Iringa is therefore right to level the ground first, for in engineering and development the control of height is as important as the control of position.

Examiner's Note

Explain by showing what depends on knowing the fall of the land; any six developed points earn full marks, with a clear introduction and conclusion.

Question 65

Surveying is the art of measuring and mapping the ground, and its results are trusted only when a few basic principles are obeyed. These principles have grown out of long experience and hold whatever the instrument used. The instructor in Tabora is therefore right to stress them above the tools.

Work from the whole to the part. The surveyor first fixes a framework of a few main points over the whole area, and only then fills in the detail within it. This controls the survey and stops small errors from spreading across the work. Building up in the reverse order, from part to whole, lets error accumulate unchecked.

Fix each point by at least two measurements. Every new point should be located by two independent measurements, such as two distances or a distance and a bearing. This makes its position certain and guards against a single mistaken reading. A point fixed by only one measurement cannot be checked at all.

Always provide a check. The survey should include measurements, such as check lines, that test the work independently. If the check agrees the work is sound, and if it does not an error is revealed before the survey is used. Surveying without checks is merely hoping the readings were right.

Use well-conditioned figures. Where triangles are used they should be near equilateral rather than long and thin. A well-shaped triangle plots accurately, while a narrow one magnifies any small error in its sides. The strength of the framework depends on the shape of its figures.

Match the accuracy to the purpose. The care taken should suit the use to which the survey will be put. A national boundary demands the highest precision, while a rough farm plan does not. Effort spent on needless accuracy wastes time and money.

Book the field data systematically. Readings must be recorded clearly and in order in the field book as they are taken. Neat, systematic booking prevents confusion and loss when the survey is later plotted. A careless field book can spoil the most careful measurement.

Set permanent reference marks. Lasting marks are fixed at key stations so that the survey can be recovered and extended later. These allow future work to tie in to the same framework. Without them a survey cannot be checked or continued once the party leaves.

Taken together, these principles ensure that a survey is controlled from the whole down to the part, that every point is fixed and checked, and that the work can be trusted and recovered later. It is by obeying them, far more than by owning fine instruments, that the Tabora class will produce surveys that close and endure.

Examiner's Note

The command is discuss, so give the principle and say why it guards accuracy; any six developed points earn full marks, with a clear introduction and conclusion.

Question 66

Plane table surveying is a method in which the map is drawn in the field on a board while the ground itself is in view. Because plotting and observing go on together, the method has clear strengths but also real limits. The party near Kilosa must weigh both before trusting it with the estate.

It plots directly in the field. The map is drawn on the spot while the features are still in sight of the surveyor. Mistakes can be seen and put right at once, before leaving the ground. This is the chief advantage of the method.

It avoids booking errors. Because there is no field book to write and later copy, the errors of wrong entry and misreading are avoided. What is seen is drawn directly onto the sheet. A whole class of clerical mistakes is thus removed.

It is cheap and simple. The equipment is inexpensive and the method easy to learn and use. A survey party needs no costly instruments to carry it out. This suits a small job on a modest budget, such as the estate.

It is quick for small areas. For filling in detail over a small area the plane table is fast, since observing and plotting are one operation. A good deal of ground can be mapped in a day. It is well matched to the party's task.

It is unsuitable for large or precise work. The method is not accurate enough for large surveys or for work needing high precision. Over great distances its small errors grow too large. For such work more precise instruments are required.

It is affected by the weather. Because the map is drawn out of doors, rain, wind and damp can stop the work or spoil the sheet. The board is awkward to shelter in bad weather. A wet day can halt the survey altogether.

It is heavy and awkward to carry. The table, tripod and fittings are bulky to move from station to station. Over rough or distant ground this is tiring and slow. The equipment, though cheap, is not convenient to transport.

Weighed together, the plane table is a cheap, direct and speedy way to map small areas and to fill in detail, but it is neither accurate enough for large precise surveys nor comfortable in bad weather or rough country. The party near Kilosa is therefore right to use it on the small estate, while reserving more precise methods for work that demands them.

Examiner's Note

Advise by balancing the merits of the plane table against its demerits; any six developed points earn full marks, with a clear introduction and conclusion.

Question 67

The prismatic compass and the surveyor's compass are the two instruments used to measure bearings in compass surveying. Though both point to magnetic north, they are built and read in different ways. The student must know these differences to use each correctly.

Their systems of graduation differ. The prismatic compass is graduated all the way round from 0 to 360 degrees. The surveyor's compass is graduated only from 0 to 90 in each of four quadrants. This shapes the kind of bearing each one gives.

The bearings they give differ. The prismatic compass reads the whole-circle bearing directly, measured clockwise from north. The surveyor's compass reads the quadrant, or reduced, bearing from north or south towards east or west. The reading must therefore be interpreted differently on each.

The graduated part that moves differs. In the prismatic compass the graduated card is fixed to the needle and turns with it. In the surveyor's compass the graduated ring is fixed to the box and only the needle turns. What the observer reads against thus differs.

The way they are read differs. The prismatic compass is read through a prism while the object is still sighted, so observing and reading happen together. The surveyor's compass is read from directly above after the needle settles. This makes the prismatic the quicker to use.

The sighting arrangement differs. The prismatic compass carries a prism and a slit through which the bearing is read as the object is sighted. The surveyor's compass has open sights and no prism, and is read separately. The prism is the mark of the one and its absence of the other.

Their accuracy and use differ. The prismatic compass is generally more convenient and is the common field instrument. The surveyor's compass, read from above, is often mounted and used more deliberately. Each suits the style of work for which it is made.

The direction of the figures differs. On the prismatic compass the figures are written in reverse so that they read correctly through the prism. On the surveyor's compass they are written the normal way up for reading from above. This small difference reflects how each is viewed.

In short, the prismatic compass reads whole-circle bearings through a prism from a turning card, while the surveyor's compass reads quadrant bearings from above against a fixed ring, so that the two differ in graduation, reading and use. The student who grasps these differences will read each instrument correctly and record the right kind of bearing.

Examiner's Note

The command is account for, so bring out each contrast on both instruments; any six developed points earn full marks, with a clear introduction and conclusion.

Question 68

A traverse is a survey made by measuring the lengths and bearings of a connected series of lines. It may be open or closed according to whether it returns to its start, and the two forms differ in important ways. The two parties are running the two kinds, and the differences decide how each may be used.

Their form differs. An open traverse runs from one point to a different point and does not return. A closed traverse returns to its starting point or ends on another point of known position. This basic difference in shape leads to all the others.

The closing check differs. A closed traverse can be checked by seeing whether it closes back on its start, giving a closing error. An open traverse has nothing to close on and so offers no such check. This makes the closed traverse self-testing.

Error detection differs. In a closed traverse a mistake shows itself as a misclosure that can be measured. In an open traverse an error passes unnoticed unless the line is tied to known points. Errors are therefore far easier to catch in a closed traverse.

Adjustment differs. A closed traverse can have its small closing error distributed among the lines by a rule such as Bowditch's. An open traverse cannot be adjusted in this way, since there is no misclosure to share out. The closed traverse can thus be refined, the open cannot.

Their uses differ. An open traverse suits long, narrow features such as a road, a river or a pipeline. A closed traverse suits the survey of an area or a boundary, such as a farm. The shape of the job decides which is used.

Their reliability differs. Because it can be checked and adjusted, the closed traverse is the more reliable of the two. The open traverse, lacking these checks, is trusted less. Where accuracy matters, the closed form is preferred.

Their examples differ. The party running the road is making an open traverse from town to village. The party round the farm is making a closed traverse. Each example shows the form matched to its task.

In short, a closed traverse returns on itself and so can be checked and adjusted, while an open traverse runs on to a new point and cannot, which is why the closed form is the more reliable and the open form is kept for long linear features. The two parties have each rightly chosen the form that fits the ground they are surveying.

Examiner's Note

The command is distinguish, so bring out each contrast on both forms; any six developed points earn full marks, with a clear introduction and conclusion.

Question 69

A compass traverse fixes the shape of a piece of ground by measuring the bearing and length of each of its lines. Done well, it follows an orderly field procedure, for a step taken out of turn or skipped leads to error. The Mafinga class must work through the steps in order.

Reconnaissance of the ground. The party first walks over the whole area to see its shape and to choose the best positions for the stations. This overview lets the traverse be planned as a whole before any measuring begins. Good reconnaissance saves much trouble later.

Marking the stations. Pegs or ranging rods are firmly fixed at each chosen station so that they can be seen and returned to. Clear, lasting marks keep the survey in order. A lost station can spoil the whole traverse.

Measuring the bearings. At each station the forward and back bearing of the line is read with the compass. Taking both guards against error and allows the survey to be checked. The bearings fix the direction of each line.

Measuring the lengths. Each line between stations is measured with a chain or tape, on the level where possible. Careful chaining fixes the length of each line. Length and bearing together define each line fully.

Booking the readings. The bearings and lengths are entered neatly and in order in the field book as they are taken. Systematic booking prevents confusion when the survey is later plotted. A careless book undoes careful measurement.

Testing for local attraction. The forward and back bearings of each line are compared to see whether they differ by exactly 180 degrees. A different value warns that iron has disturbed the needle at one end. This check keeps the bearings sound.

Plotting and checking. Back in the office the traverse is plotted to scale, and if closed its closing error is examined and adjusted. This turns the field data into a finished plan. The check confirms that the work is sound.

Followed in this order, from reconnaissance through measuring and booking to plotting and checking, the procedure turns a walk round the ground into an accurate plan of it. The Mafinga class should therefore keep to the steps in turn, for the discipline of the method is what makes the compass traverse trustworthy.

Examiner's Note

Explain the steps in order and say what each achieves; any six developed points earn full marks, with a clear introduction and conclusion.

Question 70

Surveying can be carried out by several methods, from the chain and compass to the level and the satellite, and no one method suits every task. The surveyor must weigh a number of factors before choosing. The officer in Dodoma, faced with three unlike jobs, must judge each on these grounds.

The size of the area. A small plot can be surveyed by simple methods such as the chain, while a whole region or country needs geodetic methods. The larger the area, the more the curvature of the earth and the spread of error must be allowed for. Size is therefore the first factor to weigh.

The accuracy required. A national boundary demands the highest precision, whereas a rough farm plan does not. The method must be able to reach the accuracy the job needs, and no more. Choosing a precise method for a rough job merely wastes effort.

The purpose of the survey. The use to which the survey will be put shapes the choice, for a survey for a title deed differs from one for a sketch. The method must give the kind of result the purpose calls for. Purpose and method must match.

The nature of the ground. Flat, open ground suits the chain, while broken or wooded country may need the compass or the level. Obstacles such as rivers and hills affect what can be used. The lie of the land narrows the choice.

The time available. A method that is quick, such as plane tabling, suits a job that must be finished fast. A precise but slow method suits work that can take its time. The deadline weighs on the choice.

The cost and equipment. Precise methods need costly instruments and trained staff, which not every job can afford. The surveyor must choose a method within the means available. Cost often decides between what is ideal and what is possible.

The skill available. The method chosen must be one the survey party can carry out well. A method beyond the skill of the team will yield poor work whatever its merits. The people, not only the instruments, must fit the method.

Weighing the size of the area, the accuracy needed, the purpose, the ground, the time and the means, the surveyor chooses the method that best fits each job. The Dodoma officer will therefore use geodetic methods for the boundary, plane methods for the plot and a traverse for the river, each chosen on these grounds.

Examiner's Note

The command is discuss, so give the factor and show how it bears on the choice; any six developed points earn full marks, with a clear introduction and conclusion.

Question 71

Modern instruments such as the total station and the satellite receiver have largely replaced the chain and compass in professional surveying. They measure the same distances and directions but in new and better ways. The firm in Dodoma is enjoying the advantages that these instruments bring.

They are faster. A total station measures distance and angle together in a moment, where the chain and compass took much longer. A whole survey is finished in a fraction of the old time. This speed lets more work be done in a day.

They are more accurate. The electronic and satellite instruments measure to a far finer degree than the chain and compass could. Small errors of reading and chaining are removed. The result is a survey of much higher precision.

They record data digitally. The readings are stored electronically and can be fed straight into a computer. There is no field book to write or copy, and the plan can be drawn by machine. This removes the errors of hand booking and plotting.

They need fewer people. One surveyor with a modern instrument can do work that once needed a whole chaining party. Labour is thus saved. A small team can cover a large task.

They work over long distances. Satellite and electronic instruments fix points many kilometres apart without a continuous chain of measurement. Rivers and hills that would stop a chain are crossed with ease. Large areas are surveyed as one.

They reduce human error. Because the instruments measure and record automatically, the mistakes of misreading and miswriting are largely removed. The work depends less on the steadiness of the observer. Reliability is thereby increased.

They integrate the measurements. A total station combines distance, angle and height in one instrument and one reading. The surveyor need not switch between chain, compass and level. This makes the fieldwork simpler and quicker.

In speed, accuracy, digital recording and reach, the total station and the satellite receiver far surpass the chain and compass, doing more work with fewer hands and less error. The Dodoma firm is therefore right to adopt them, for they mark the advance of surveying into the modern age.

Examiner's Note

Prove the old surveyor wrong by the gains the new instruments bring; any six developed points earn full marks, with a clear introduction and conclusion.

Question 72

Levelling carries a known height from a bench mark across the ground to fix the reduced levels of other points. Done well, it follows a set field procedure, for a step taken carelessly loses the height it should carry. The Kilosa team must work through the steps in order.

Set the level on firm ground. The instrument is placed on solid, level ground midway between the points to be read and its bubble is centred. A firm setting keeps it steady while readings are taken. A level that shifts spoils every reading from that setting.

Take a back sight on the bench mark. The first reading is taken on the staff held on the bench mark of known height. Added to that height it fixes the height of collimation. This ties the whole survey to a known level.

Read the intermediate points. The staff is then held in turn on the points whose levels are wanted, and each is read. These intermediate sights give the reduced levels along the line. They are the detail the survey is gathering.

Use change points to move forward. When the level must be moved, a fore sight and then a back sight are taken on a firm change point. The height is thus carried forward without loss. Change points are what let a long line be levelled from several settings.

Book the readings systematically. Every reading is entered at once in its proper column of the level book. Neat, ordered booking prevents confusion in the later reduction. A careless book undoes careful reading.

Close on a bench mark. The line is ended, where possible, on another bench mark of known height. The height carried is then checked against the known one. Any difference reveals the error in the work.

Reduce and check the levels. Back in the office the reduced levels are worked out and the arithmetic checked. This turns the field readings into finished heights. The check confirms that the levelling holds together.

Followed in this order, from the firm setting and the back sight on the bench mark, through the intermediate sights and change points, to closing and reduction, the procedure carries height accurately across the valley. The Kilosa team should keep to the steps in turn, for the discipline of levelling is what makes its heights trustworthy.

Examiner's Note

Explain the steps in order and say what each achieves; any six developed points earn full marks, with a clear introduction and conclusion.

Question 73

The magnetic compass is a simple instrument that shows direction by a magnetised needle pointing to magnetic north. Cheap and easy to carry, it has many uses in the field, especially where more costly instruments cannot go. The party in the bush finds it a ready tool.

It measures the bearings of lines. The compass gives the bearing of a line from magnetic north, which fixes its direction. This is its chief use in surveying. From bearings and lengths a survey can be built up.

It runs a compass traverse. By taking the bearing and length of each line in turn, the party runs a traverse round or along the ground. This is the main way the compass surveys an area. It suits open, rough country well.

It orients the plane table. The compass is used to turn the plane table until its drawn north agrees with magnetic north. The sheet is thus set parallel to the ground. Here the compass serves another instrument.

It fills in detail. On a framework fixed by more accurate means, the compass is used to add the lesser detail quickly. Fine accuracy is not needed for such filling in. The compass is fast enough for the task.

It aids reconnaissance. In the first walk over the ground the compass gives rough directions that help plan the survey. A quick bearing settles the lie of the land. This guides the party before careful work begins.

It checks other work. A compass bearing can be taken to test the direction found by another method. Any large error then shows up. The compass thus serves as a ready check.

It is cheap and portable. The compass is light, simple and inexpensive, so it can be carried where heavy instruments cannot. In rough or remote country this is a great advantage. It is often the only instrument a small party can take.

By measuring bearings, running traverses, orienting the plane table and filling in detail, the magnetic compass is a versatile tool, most valuable where its cheapness and portability tell. The party in the bush is therefore well served by it, for in rough country a simple compass often does what costlier instruments cannot.

Examiner's Note

The command is discuss, so give the use and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 74

Chain surveying and compass surveying are two simple methods of surveying small areas. Chain surveying measures only distances, while compass surveying measures directions as well. The party must know how they differ to choose between them for the farm.

The measurements taken differ. Chain surveying measures only the lengths of lines, using no angles. Compass surveying measures the bearing of each line as well as its length. The one works by distance alone, the other by distance and direction.

The instruments differ. Chain surveying uses the chain or tape and ranging rods. Compass surveying adds the magnetic compass to measure bearings. The compass is the mark of the second method.

The principle differs. Chain surveying works by dividing the area into triangles fixed by their sides. Compass surveying works by running a traverse of lines fixed by bearing and length. Their underlying methods are thus different.

The suitable ground differs. Chain surveying suits small, fairly flat and open areas where triangles can be laid out. Compass surveying suits ground where a traverse must wind, such as along a road or through bush. The lie of the land favours one or the other.

Their use differs. Chain surveying suits the survey of a compact area, such as the farm. Compass surveying suits a long, narrow feature or a wandering boundary. Each is chosen for the shape of the task.

Their accuracy differs. Chain surveying, with its check lines, can be quite accurate over a small area. Compass surveying is liable to error from local attraction on the needle. Chaining is the more certain where it can be used.

Their speed differs. Compass surveying is often quicker, since a line is fixed at once by one bearing and one length. Chaining, with its triangles and offsets, may take longer. Speed can favour the compass.

In short, chain surveying measures distances only and suits small open areas, while compass surveying measures directions as well and suits winding traverses, so that the two differ in measurement, principle and use. For the small farm on open ground the party may well choose the chain, keeping the compass for ground that a traverse must follow.

Examiner's Note

The command is account for, so bring out each contrast on both methods; any six developed points earn full marks, with a clear introduction and conclusion.

Question 75

Geographical research is the systematic and objective study of the earth and the life upon it, carried out to answer a stated question or to solve a stated problem. In a developing country it is far more than an academic exercise, because sound decisions about land, water and people can rest only on reliable knowledge. That knowledge is exactly what careful research provides.

It identifies and defines real problems. Research turns a vague, felt difficulty into a clear and studied problem that can be tackled. It was such study that traced the true causes of the severe soil erosion at Kondoa before any remedy was attempted. A problem once well defined is already half way to being solved.

It provides reliable data for planning. Every development plan needs firm figures on population, rainfall, soils and resources if it is to succeed. Research collects and checks these figures so that planners build on evidence rather than on guesswork. Without such data a plan is little more than a hopeful wish.

It guides policy and day-to-day decisions. The very question facing Mtwara, where to sink a borehole, is settled by the findings of research into the underground water. Research points to the option that the weight of evidence best supports. In this way scarce public money is spent where it will do the most good.

It evaluates projects and programmes. Research measures whether an irrigation scheme or a health campaign has actually worked as intended. This allows what succeeds to be repeated and what fails to be corrected before still more is spent. Development thus learns from its own experience instead of repeating its mistakes.

It builds and keeps knowledge up to date. Each careful study adds to what is known about the country and its changing conditions. This keeps maps, records and understanding abreast of a land that is always changing. A nation that stops studying itself soon plans on out-of-date knowledge.

It guides the wise use of resources. By showing where soils, water, forests and minerals lie, and how fast they are being used, research allows them to be developed without being exhausted. It warns, for example, when a fishery or a woodland is being pressed too hard. This is the difference between using a resource and destroying it.

It supports preparedness for hazards. Study of the floods along the Rufiji or of the droughts of the central regions shows where and when danger is likely. Armed with this a community can prepare in good time rather than merely react to disaster. Research thus turns helpless suffering into planned defence.

Taken together these services make research the very eyes of development, for a country that plans without it is guessing in the dark, while one that grounds its choices in careful study spends its scarce means where they will do the most good. The Mtwara office should therefore research its ground water first, and site its boreholes on the evidence, which is why geographical research is a foundation of development and not a luxury.

Examiner's Note

Explain by what research supplies that guesswork cannot; any six developed points earn full marks, with a clear introduction and conclusion.

Question 76

Sampling is the selection of a small part of a population to stand for the whole in a study. Although it may seem safer to question everyone, in practice a researcher almost always studies a sample instead. There are sound reasons why a well-chosen sample is not only enough but often better than any attempt at the whole.

The population is often far too large. To question every person in the whole of Tanga region would be an enormous and slow undertaking. A carefully chosen sample of a few hundred can instead stand faithfully for them all. Sheer size alone makes the study of the entire population impractical.

It saves valuable time. A study that tried to reach the whole population would take so long to finish that its answer might arrive too late to be of any use. A sample gives a timely result on which action can still be taken. In a fast-changing situation this speed is often decisive.

It saves money and effort. Reaching every member of a population would cost far more in transport, staff and materials than most studies can ever afford. A sample brings the work comfortably within the available budget. The money saved can then be spent on doing the study well.

Some populations cannot be fully reached. When a population is very large, widely scattered or constantly changing, it is simply impossible to study every single unit. In such cases a sample is not merely convenient but the only practical way into the problem. Trying to reach everyone would guarantee failure.

A good sample is accurate enough. A sample that is properly and randomly drawn represents the whole population so closely that its findings can be trusted. Very little of value is therefore gained by the great extra labour of studying everyone. Beyond a certain point more numbers add cost without adding truth.

It keeps the data manageable. A smaller, well-chosen set of data can be collected, checked and analysed with real care. A flood of data from the whole population, by contrast, is hard to handle and invites error. Quality of analysis often matters more than sheer quantity of data.

It allows deeper study of each unit. With fewer units to examine, the researcher can look far more closely at each one. This yields a depth of understanding that a hurried count of everyone would simply lose. Depth and breadth must be balanced, and a sample buys depth.

For all these reasons the student in Tanga is rightly advised to study a sample rather than the whole region, for it is quicker, cheaper and more manageable, and when the sample is properly chosen it speaks reliably for the whole. Sampling is therefore not a poor second best but the normal and sensible way to study a population.

Examiner's Note

You are asked to advise, so give the reasons that make a sample the wiser choice; any six developed points earn full marks, with a clear introduction and conclusion.

Question 77

Geographical research is a systematic process, and much of its strength comes from following a set order of stages rather than plunging at once into fieldwork. Each stage rests upon the one before it, so that a fault left uncorrected early runs on through the whole study. The student in Iringa must therefore learn to walk through the stages in turn.

It begins by identifying and defining the problem. The researcher turns a broad concern, such as falling crop yields around Iringa, into a clear and answerable question. This fixes exactly what the study is about and marks off its limits. A problem that is well defined at the start is already half solved.

It reviews the related literature. The researcher reads what others have already found on the same or a similar question. This shows what is known, where opinions differ, and where a real gap remains to be filled. The new study is thus built upon past work instead of blindly repeating it.

It sets objectives and a hypothesis. Clear objectives state what the study will find out, and a testable hypothesis states the relationship it expects to find. Together they give the whole study a definite direction and purpose. Without them the researcher is apt to wander and collect data aimlessly.

It chooses a research design and methods. The researcher decides whether the study is best carried out as a survey, a case study or an experiment. The instruments of data collection, such as questionnaires or measuring equipment, are chosen to suit that design. A design well matched to the problem makes the later work far easier.

It selects the study area and the sample. A study area that truly represents the problem is chosen, and from it a sample is drawn by a sound method. This ensures that the findings will fairly stand for the whole. A biased or careless choice here quietly spoils everything that follows.

It collects the data in the field. Using the chosen instruments, the researcher gathers the evidence in the field carefully and records it accurately. This is the stage the eager student wants to reach first, yet it succeeds only when the earlier stages have prepared for it. Careful, honest recording here is the heart of the whole exercise.

It processes and analyses the data. The raw data are sorted, tabulated and worked into means, graphs and statistical tests. From this working the pattern hidden in the figures is at last made plain. Sound analysis turns a heap of numbers into a clear finding.

It writes and presents the report. Finally the findings, conclusions and recommendations are written up in an orderly report and shared with others. This completes the cycle and puts the new knowledge to use. A study never written up might almost never have been done.

Carried out in this order, the stages together turn a first vague curiosity into reliable and useful knowledge, and because each stage feeds directly into the next, the care taken early is repaid at every step that follows. The Iringa student should therefore hold back from the field until the problem, the reading and the design have prepared the way.

Examiner's Note

Examine and develop the stages in their proper order; a bare list of names without explanation earns little, and a clear introduction and conclusion are expected.

Question 78

A research problem is the very question that a study sets out to answer, and much of the success of the whole work depends on choosing it well. A good problem has several qualities together, and the student in Singida is failing to meet them one by one. Understanding these qualities would save him from starting studies he cannot finish.

It is researchable. A good problem is one that can actually be answered by collecting and analysing evidence, and not merely argued about endlessly. This keeps the study on the firm ground of fact rather than opinion. A question that no evidence could ever settle is not a research problem at all.

It is clear and specific. The problem must be narrow enough to be studied fully within the time and means available. A vague, sprawling topic, such as the student keeps choosing, cannot be pinned down or finished. Sharpening the question is often the single most useful step a researcher takes.

It is significant. Answering the problem should be genuinely useful, whether to knowledge or to society. A study that could improve the water supply of a dry district plainly matters. A problem whose answer would interest no one is hardly worth the labour of studying.

It is novel. A good problem addresses a real gap and does not simply repeat a question that others have already fully answered. This is exactly where the student stumbles when he picks over-studied topics. Fresh ground, however small, is what gives a study its value.

It is feasible. The problem must be one that can actually be carried out with the time, money, skills and data the researcher can command. A question needing costly equipment or years of travel is beyond a student. Feasibility, not ambition, decides what can really be done.

It is interesting to the researcher. A genuine personal interest in the question keeps the researcher going through the hard, dull middle of the work. Without it the study is likely to be abandoned, as the student's studies keep being abandoned. Interest is the fuel that carries a study to its end.

It is ethically acceptable. A good problem can be studied without harm to the people or places involved and with their willing consent. This protects both the subjects and the good name of research itself. A question that could only be answered by wronging people should not be pursued.

A problem that is clear, significant, feasible and fresh gives a study firm ground to stand on, whereas one that is vague, over-studied or beyond the researcher's means collapses before it truly begins. If the student in Singida measured each new topic against these qualities, he would choose one he could finish, which is why choosing well at the start is half the battle.

Examiner's Note

Explain by the stages he must follow in their proper order; any six developed points earn full marks, with a clear introduction and conclusion.

Question 79

Data collection is the stage at which a study gathers the evidence on which all its conclusions will later rest. A geographer has several methods to choose from, and each is suited to a particular kind of information. The team in Rukwa, needing both figures and opinions, will clearly have to use more than one of them.

The questionnaire gathers standard information. A set of written questions is given to many people to answer in the same form. This quickly collects comparable information from a large sample, such as the sizes of farms across a district. Its weakness is that it captures only what the fixed questions happen to ask.

The interview draws out fuller answers. Here the researcher questions people face to face and can follow up whatever they say. This yields deeper and richer answers than a questionnaire allows, and suits the opinions the Rukwa team wants. Its cost is that it reaches far fewer people in the same time.

Observation records what actually happens. The researcher watches events directly and records them, such as counting the traffic entering a market. This gives first-hand evidence that is free of what people merely claim to do. It cannot, however, reveal the reasons that lie behind the behaviour seen.

The focus group discussion compares views. A small group is guided through a topic together so that their opinions are drawn out and weighed against one another. This is well suited to gauging feeling about the proposed market. The skill of the person leading the group strongly affects what it yields.

Field measurement gives precise physical data. Instruments are used to measure things on the ground directly, such as river discharge, slope or soil depth. This produces exact and objective figures of the kind the crop-yield study needs. It calls for proper equipment and the training to use it correctly.

Documentary sources supply ready evidence. Records, reports, statistics and maps already collected by others provide background and figures at little cost. These secondary sources save the researcher from gathering everything afresh. Their weakness is that they were collected for another purpose and may be dated or incomplete.

The transect walk reveals spatial change. The researcher walks along a chosen line across the area, noting the changes in land use, soils and features encountered. This shows in a direct way how conditions vary from place to place. It suits a first reconnaissance better than a precise measurement of quantities.

Because each method has both its strengths and its blind spots, a sound study usually combines several of them together. The Rukwa team should therefore pair the figures won by questionnaire and field measurement with the opinions drawn from interviews and group discussion, so that its evidence is at once wide in reach and deep in understanding.

Examiner's Note

Advise by giving the methods and when each is used; any six developed points earn full marks, with a clear introduction and conclusion.

Question 80

A hypothesis is a clear and testable statement of the relationship a researcher expects to find, put forward before the data are collected. Far from being a mere guess to be defended at all costs, it is a working tool that shapes the whole study. The advice given to the researcher in Mbeya is therefore sound, as its several uses show.

It gives the study direction. The hypothesis fixes exactly what the study is trying to find out from the very start. This keeps the researcher from wandering or gathering data with no clear aim. A study with a firm hypothesis moves straight towards its goal.

It states an expected relationship. A hypothesis proposes a definite link, such as that crop yields rise as fertiliser use rises. This turns a vague hunch into a precise claim that can be examined. The sharper the claim, the more clearly it can be put to the test.

It makes the study testable. Because a hypothesis can be shown either true or false by evidence, it turns an idea into a question that data can actually settle. This is what raises research above mere opinion. A statement that no evidence could test would be of no use as a hypothesis.

It guides the choice of data and methods. Knowing exactly what must be tested tells the researcher precisely which data to collect and how to collect them. This saves much wasted effort on information that would not bear on the question. The hypothesis thus quietly plans the fieldwork.

It allows objective testing. By setting the claim in a null and an alternative form, the hypothesis lets the researcher test fairly rather than merely hunt for support. This guards the study against the natural wish to prove oneself right. Honest testing is the mark of sound research.

It links the study to existing theory. A hypothesis usually grows out of what is already known and understood about the subject. In this way it ties the new study firmly to the body of established knowledge. The findings can then be compared with what theory led one to expect.

It provides the basis for the conclusion. At the end the findings are judged against the hypothesis that was set at the start. Whether it is upheld or rejected forms the very heart of the study's conclusion. The whole enquiry thus comes full circle to the statement with which it began.

In all these ways the hypothesis serves as the backbone of a piece of research, holding it to one clear purpose from the first question through to the final conclusion. This is precisely why the researcher in Mbeya is right to frame her hypothesis before she begins, for it will steer every step of the work that follows.

Examiner's Note

Explain by showing what the hypothesis does for the study; any six developed points earn full marks, with a clear introduction and conclusion.

Question 81

A literature review is the careful reading and summary of the work that others have already done on a research topic. Far from being wasted time, it prepares the ground for a sound study and shapes it in several important ways. The advice given to the researcher in Morogoro is therefore wise.

It shows what is already known. The review gathers the findings that earlier workers have established on the subject. This tells the researcher where the settled ground lies and what need not be proved afresh. She thus begins from the frontier of knowledge rather than from the beginning.

It reveals the gap to be filled. By showing what has been studied, the review also shows what has not. This gap is exactly where a fresh and worthwhile study can be placed. Finding it saves the researcher from choosing an over-worked topic.

It prevents needless repetition. Reading past work stops the researcher from unknowingly repeating a study already well done. Effort is thus spent on new ground instead of covering old. This alone can save months of wasted labour.

It sharpens the problem and objectives. Seeing how others framed their questions helps the researcher to state her own problem clearly. The objectives can then be set with precision. A problem refined against the literature is far stronger than one framed in ignorance.

It suggests suitable methods. The review shows which instruments and methods other workers used and how well these served. The researcher can borrow what worked and avoid what failed. This guides her own choice of design and tools.

It provides a framework for interpretation. Past studies supply the theories and ideas against which new findings can be understood. The researcher can then say how her results agree with or differ from earlier work. This ties the new study into the wider body of knowledge.

It identifies key sources and experts. The review points to the leading writers, reports and data sources on the subject. These become a store the researcher can draw on throughout. Knowing whom and what to consult strengthens the whole study.

Through these functions the literature review turns a private curiosity into an informed enquiry that builds upon the work of others rather than ignoring it. The weeks the Morogoro researcher spends reading are therefore an investment, for they sharpen her problem, guide her methods, and set her findings in their proper place.

Examiner's Note

The command is account for, so give the function and say how it helps the study; any six developed points earn full marks, with a clear introduction and conclusion.

Question 82

Secondary data are data that were collected earlier by someone else and are used again by a later researcher, such as census reports, rainfall records and published statistics. They can be very useful, yet they carry real dangers, and the student in Dodoma must weigh the two sides. A balanced view shows both their merits and their demerits.

They are cheap and quick to obtain. Because the data already exist, the researcher is spared the cost and labour of collecting them afresh. A study can then be carried out with little money and in a short time. This is a great advantage to a student with slender means.

They cover long periods and wide areas. Published records may stretch back many years and span the whole country. A single researcher could never gather such a sweep of data alone. This makes secondary sources ideal for studies of change over time or space.

They allow comparison and trends. Because the same figures are recorded year after year, they can be compared to reveal trends. The researcher can trace, for example, how rainfall or population has changed. Such long trends are among the most valuable uses of secondary data.

They were collected for another purpose. The chief danger is that the data were gathered to answer a different question. They may therefore not fit the researcher's own problem exactly. Forcing an ill-fitting record to serve can mislead the study.

They may be out of date. Records are collected at one time and may since have gone stale. A population figure from an old census may no longer describe the present. Relying on it can give a false picture of today.

Their accuracy cannot always be checked. The later user did not see how the data were collected and cannot judge how carefully it was done. Errors or bias hidden in the original gathering are carried forward unseen. The researcher must therefore trust figures she cannot verify.

They may be incomplete. Published sources sometimes have gaps, missing years or missing districts. These holes can weaken an analysis that depends on a full record. The researcher may then have to fill or work around them.

Weighed together, secondary data offer a cheap, broad and ready source that no researcher should ignore, yet they must be used with care because they were made for another purpose and cannot be fully checked. The Dodoma student is therefore wise to draw on them for background and trends, while collecting fresh data of his own where accuracy and fit really matter.

Examiner's Note

Advise by weighing the merits of secondary data against its dangers; any six developed points earn full marks, with a clear introduction and conclusion.

Question 83

An interview is a method of collecting data in which the researcher questions people face to face and records their answers. Its success depends less on the questions alone than on the conditions in which it is held. The student in Mwanza must arrange these conditions with care if the fishermen are to speak freely.

There must be trust between the two. The respondent must feel at ease and believe that the researcher means him no harm. A few friendly words and an explanation of the purpose help to build this trust. Without it the fisherman will give guarded or false answers.

The purpose must be made clear. The respondent should understand why the study is being done and how his answers will be used. This removes suspicion and encourages honest replies. People who do not know why they are asked often refuse or mislead.

A good interview guide is needed. The researcher should prepare an ordered set of clear questions to follow. This keeps the interview on track and ensures nothing important is forgotten. A rambling, unprepared interview wastes both parties' time.

The place and time must suit the respondent. The interview should be held where the respondent is comfortable and free from disturbance, and at a time that suits him. A fisherman is best met when his work is done, not when the catch is being landed. A poor place or time cuts the interview short.

The interviewer must be skilled. The researcher should listen well, avoid arguing, and put questions gently and clearly. Skill in drawing people out yields fuller answers. A clumsy or impatient manner makes the respondent close up.

Leading questions must be avoided. Questions should not be framed so as to suggest the answer the researcher wants. A leading question produces the reply the fisherman thinks is wanted, not the truth. Neutral wording keeps the data honest.

A common language must be used. The interview should be conducted in a language the respondent speaks well, such as Kiswahili among the fishermen. Answers given in a poorly understood tongue are easily mistaken. Clear communication is the whole basis of the method.

When trust is built, the purpose explained, the questions well framed and the setting suitable, the fishermen of Mwanza will speak openly and the interview will yield true and useful data. The student should therefore

prepare these conditions with as much care as the questions themselves, for they are what turn a wary encounter into sound research.

Examiner's Note

Advise by giving the conditions that make an interview succeed; any six developed points earn full marks, with a clear introduction and conclusion.

Question 84

A pilot study is a small trial run of a research instrument or method carried out before the main study. It is done on a few subjects to see how the plan works in practice. The advice given to the researcher in Shinyanga is sound, for a pilot study serves the main study in several ways.

It tests the research instrument. The pilot tries out the questionnaire or interview guide on a few people first. This shows whether the questions actually work as intended. A fault found now is cheap to mend, while one found later is costly.

It reveals unclear questions. Questions that are confusing or open to more than one meaning show themselves when real people try to answer them. The researcher can then reword them before the main run. This saves the study from gathering muddled data.

It checks the time and cost. The pilot shows how long each interview takes and what it costs to reach people. From this the researcher can plan the time and budget of the whole study. Nasty surprises of time and money are thus avoided.

It trains the researcher. Carrying out the pilot gives the researcher and any assistants practice in the method. They grow more skilled and confident before the main work. A well-drilled team collects better data.

It tests the analysis. By working through the few pilot returns, the researcher checks that the data can actually be analysed as planned. Any gap in the questions is caught before it spoils the whole. This ensures the answers will fit the questions asked.

It estimates the likely response. The pilot shows how willing people are to take part and answer fully. From this the researcher can judge how large a sample to aim for. A poor response seen early can be planned around.

It improves the whole design. Taken together, the lessons of the pilot let the researcher refine the problem, the instrument and the plan. The main study then goes forward on a tested footing. Time spent piloting is repaid many times over.

Because it catches faults while they are still cheap to cure, the pilot study protects the main study from wasted questionnaires, muddled data and broken budgets. The researcher in Shinyanga is therefore wise to test a few before printing two thousand, for a small trial now may save the whole enquiry later.

Examiner's Note

Advise her by showing what the pilot protects the main study from; any six developed points earn full marks, with a clear introduction and conclusion.

Question 85

Good scientific research is not merely a collection of facts but an enquiry carried out in a disciplined way. Certain characteristics mark it out and allow its findings to be trusted. The Dodoma panel looks for exactly these signs in the students' work.

It is systematic. Good research follows an orderly plan, moving step by step from problem to conclusion. Nothing is done at random or out of turn. This order is what keeps the enquiry under control.

It is objective. The researcher sets aside personal wishes and reports what the evidence shows. Findings are not bent to suit a hope or a prejudice. This honesty is the very heart of science.

It is empirical. Good research rests on evidence gathered by observation and measurement, not on mere opinion. Its conclusions can be checked against the real world. What cannot be tested against evidence is not science.

It is logical. The reasoning moves soundly from the evidence to the conclusions drawn. Each step follows from the one before. A leap unsupported by the data has no place in good research.

It is replicable. The method is described so clearly that another worker could repeat the study and test the result. A finding that cannot be repeated cannot be trusted. Replication is the check that science places on itself.

It is based on adequate data. Good research collects enough sound data to support its conclusions. Findings drawn from too little or poor data are unsafe. The weight of the conclusion must match the weight of the evidence.

Its findings can be generalised. Where the sample is well chosen, the findings can be extended with care to the wider population. This gives the research a value beyond the cases actually studied. A study whose results apply only to itself is of little use.

Taken together, these characteristics of being systematic, objective, empirical, logical, replicable and well grounded are what raise research above mere opinion into knowledge that can be trusted. The Dodoma panel is therefore right to look for them, for a project that shows them is sound while one that lacks them is not.

Examiner's Note

The command is explain, so name the characteristic and say why it matters; any six developed points earn full marks, with a clear introduction and conclusion.

Question 86

Fieldwork is the stage at which a researcher leaves the desk and gathers data on the ground. However well planned, it meets many practical difficulties that can slow or spoil the work. The Kigoma student has run into the challenges that fieldwork so often brings.

Difficulty of access. Remote districts may be hard to reach, with poor roads and long distances. Reaching the study area can cost days and much effort. Some places may be all but cut off in the rains.

High cost. Travel, accommodation, materials and helpers all cost money that a student rarely has in plenty. Fieldwork can prove far more expensive than expected. A thin budget limits how much can be done.

Uncooperative respondents. People may refuse to answer, give false replies, or suspect the researcher's purpose. Without their willing help the data suffer. Winning trust takes time the researcher may not have.

Language barriers. The researcher and the local people may not share a language well. Questions and answers are then easily misunderstood. This can quietly corrupt the data collected.

Harsh weather and conditions. Rain, heat and rough terrain can halt or delay the work and tire the researcher. Instruments and papers may be damaged. Nature does not wait upon the research timetable.

Unreliable or missing data. Records that were expected may be missing, and measurements may go wrong. The researcher may reach a place only to find the needed information is not there. Gaps and errors then weaken the study.

Shortage of time. Fieldwork often takes longer than planned, while the time allowed is fixed. The researcher may be forced to cut the work short. Rushed data are poorer data.

Access, cost, wary people, language, weather, poor records and want of time together make fieldwork the hardest stage of research. The Kigoma student, forewarned of these challenges, would plan for them next time, for the researcher who expects difficulty is the one best able to overcome it.

Examiner's Note

The command is explain, so give the challenge and its effect on the work; any six developed points earn full marks, with a clear introduction and conclusion.

Question 87

Research is often divided into basic and applied according to the aim with which it is carried out. Basic, or pure, research seeks knowledge for its own sake, while applied research seeks knowledge to solve a practical problem. The two teams studying the currents show the difference plainly.

Their purpose differs. Basic research is done to understand how something works, without any immediate use in view. Applied research is done to solve a particular practical problem. The university team seeks understanding, the fisheries office seeks a catch.

Their aim differs. Basic research aims to add to the general store of knowledge and theory. Applied research aims at a useful result that can be put to work at once. One enlarges what is known, the other uses it.

Their use of findings differs. The findings of basic research may not be used for many years, if ever, in practice. The findings of applied research are put to use straight away. The one is a store for the future, the other a tool for the present.

Their setting differs. Basic research is often carried out in universities and by scholars. Applied research is often carried out by government offices, firms and industries. The two grow in different soils.

Their examples differ. A study of why ocean currents behave as they do is basic research. A study of how those currents can guide the fishing fleet is applied research. Each example turns on the aim behind it.

Their funding differs. Basic research is often paid for by governments and grants for the sake of knowledge. Applied research is often paid for by those who will use its results. Who pays reflects who benefits.

Their relationship differs. Basic research often supplies the understanding that applied research later puts to use. The two are thus linked, the pure leading and the applied following. Neither is complete without the other.

In short, basic research seeks to know while applied research seeks to use, so that they differ in purpose, setting and the fate of their findings, yet the one feeds the other. The current study in Dar es Salaam and the fisheries study are the two faces of enquiry, understanding first and application after.

Examiner's Note

The command is distinguish, so bring out each contrast on both kinds; any six developed points earn full marks, with a clear introduction and conclusion.

Question 88

A research proposal is a written plan that sets out what a researcher intends to study and how. It is prepared and approved before the work begins, so that the plan can be judged sound. The student in Morogoro must include in his proposal the parts that such a plan requires.

The title and introduction. The proposal opens with a clear title and an introduction that sets out the background to the study. This shows at once what the research is about and why it matters. A sharp title and introduction frame the whole plan.

The statement of the problem. The proposal states clearly the problem the study will address. This fixes exactly what question is to be answered. Without a clear problem the rest of the plan has no aim.

The objectives. The proposal lists the specific objectives the study will pursue. These break the broad problem into definite things to be found out. They give the study its precise targets.

The literature review. The proposal reviews what earlier workers have found on the topic. This shows the gap the study will fill and how it builds on past work. It sets the new study in its place among others.

The methodology. The proposal describes how the data will be collected and analysed, the study area, the sample and the instruments. This shows that the plan can actually be carried out. The methodology is the practical heart of the proposal.

The work plan and budget. The proposal sets out the time the work will take and the money it will cost. This shows that the study is feasible within its means. A plan without a budget cannot be judged practical.

The references. The proposal ends with a list of the works cited in it. This gives credit to earlier writers and lets the reader check them. It also shows the depth of the background reading.

Taken together, the title, the problem, the objectives, the literature, the methodology, the work plan and the references make up a proposal that shows both what the study will do and that it can be done. The Morogoro student who includes them all will have a plan fit to be approved, which is why the proposal comes before the fieldwork.

Examiner's Note

The command is assess, so name the part and say what it contributes; any six developed points earn full marks, with a clear introduction and conclusion.

Question 89

A research problem is the question a study sets out to answer, and finding a good one is the first task of the researcher. Such problems do not appear from nowhere but are drawn from definite sources. The student who thinks he has none has simply not looked in the right places.

Personal experience. The researcher's own observations and daily life throw up puzzles worth studying. A farmer's failing harvest or a flooded street can each become a problem. What one notices is often where a study begins.

Reading and the literature. Books, journals and reports raise questions and point to what is not yet known. A study often ends by naming the problems it could not solve. Reading widely is a rich source of problems.

Gaps in previous studies. Earlier research frequently leaves matters unsettled or opens new questions. These gaps invite fresh study to fill them. Building on what others have left undone is a sound way to choose a problem.

Theory. A theory suggests relationships that can be tested in the real world. The researcher asks whether what the theory predicts actually holds. Testing theory is a common origin of research problems.

Social and practical issues. The problems facing society, such as erosion, disease or poor water, cry out for study. A pressing practical need points straight to a problem worth solving. Much applied research is born this way.

Consultation with experts. Teachers, officials and specialists know where knowledge is lacking and what needs study. A talk with them can suggest a fruitful problem. Their experience guides the beginner to good ground.

Technological and social change. New methods, tools and ways of living raise fresh questions never asked before. The spread of the mobile phone or a new crop opens new fields of study. Change is a constant source of new problems.

From personal experience, from reading, from the gaps in past work, from theory and from the needs of society, research problems are drawn in plenty. The student has only to look about him with a questioning eye, for once he learns where problems come from he will find more than he can ever study.

Examiner's Note

Show the student the sources of a problem and how each yields one; any six developed points earn full marks, with a clear introduction and conclusion.

Question 90

A research proposal and a research report both describe a piece of research, yet they are written at different times and for different ends. The proposal is a plan made before the work, the report an account given after it. The student must see how the two differ.

The time of writing differs. The proposal is written before the research is carried out, while the report is written after it is finished. One looks forward to work to be done, the other back on work completed. Their whole standpoint in time is opposite.

Their purpose differs. The proposal sets out a plan and seeks approval and perhaps funds to proceed. The report gives an account of what was done and found. One asks leave to begin, the other tells what came of it.

The tense differs. The proposal is written in the future tense, saying what the study will do. The report is written in the past tense, saying what the study did. The very grammar marks them apart.

Their treatment of findings differs. The proposal has no findings, for the work is not yet done. The report is built around the findings and their meaning. This is the largest difference between the two.

Their length differs. The proposal is usually short, setting out only the plan. The report is longer, holding the data, the analysis and the conclusions. The finished account naturally exceeds the plan.

Their contents differ. The proposal ends with a work plan and budget for work to come. The report ends with results, conclusions and recommendations. Each carries the parts that suit its stage.

Their certainty differs. The proposal speaks of what is intended and may yet change. The report speaks of what actually happened and is now fixed. The one is provisional, the other final.

In short, the proposal is a forward-looking plan seeking approval, while the report is a backward-looking account presenting findings, so that they differ in time, tense, purpose and content. The Mwanza student writes twice because research must first be planned and then, when done, be told, which are two different tasks.

Examiner's Note

The command is examine, so bring out each contrast on both documents; any six developed points earn full marks, with a clear introduction and conclusion.

Question 91

Research objectives are the specific things a study sets out to find out, drawn from its broad problem. Setting them down clearly at the start shapes the whole study that follows. The student's drifting shows exactly what happens when they are missing.

They give the study direction. Clear objectives fix precisely what the study is to achieve. The researcher then works towards definite ends rather than wandering. Direction is the first gift of good objectives.

They guide data collection. Knowing what must be found out tells the researcher exactly what data to collect. Effort is not wasted on information that does not bear on the aim. The objectives thus plan the fieldwork.

They form the basis of analysis. The data are analysed to answer the objectives one by one. The objectives therefore shape how the findings are worked out and set out. Analysis without them has no target.

They allow success to be judged. At the end the study is measured by whether its objectives were met. This gives a clear test of whether the work succeeded. Without objectives there is no way to tell.

They keep the study focused. Clear objectives hold the researcher to the point and keep out matter that does not belong. The study stays within manageable bounds. This is just the focus the drifting student lacks.

They break the problem into parts. The broad problem is split into a few definite objectives that can each be tackled. A large task is thus made manageable. The researcher deals with the parts in turn.

They communicate the study's aim. Stated objectives tell supervisors and readers exactly what the study intends. Others can then judge and help the work. The aim is made plain to all.

By giving direction, guiding the data, focusing the work and providing a test of success, clear objectives are what hold a study together from start to finish. Once the student sets down plainly what he means to find out, his research will cease to drift, for the objectives are the study's steering.

Examiner's Note

The drifting is the symptom and the missing objectives the cause; show what clear objectives would supply. Any six developed points earn full marks, with a clear introduction and conclusion.

Question 92

A sample is the small part of a population that a researcher actually studies in place of the whole. Because the findings are read back onto the whole population, the sample must have certain qualities if it is to be trusted. The researcher in Shinyanga must draw his sample with these in mind.

It is representative. A good sample mirrors the whole population, holding the same kinds of members in the same proportions. What is true of it is then likely to be true of the whole. Representativeness is the first and greatest quality.

It is of adequate size. The sample must be large enough to give reliable results and to reflect the variety of the population. Too small a sample may mislead by chance. Size must suit the spread of the population.

It is drawn without bias. A good sample is selected by a fair method that gives every member a proper chance of being chosen. No group is favoured or left out. Freedom from bias is what makes the sample honest.

It is drawn by a suitable method. The way of choosing, whether random, systematic or stratified, must suit the population and the study. The right method for a mixed population, for instance, is stratified. A method well chosen protects the sample's quality.

It is feasible to study. A good sample can actually be reached and studied with the time and means available. A sample too scattered or too costly defeats the study. Practicality is a real quality of a good sample.

It gives precise results. A well-drawn sample yields findings close to the truth, with only a small margin of error. The narrower that margin, the better the sample. Precision is the fruit of the other qualities.

It is adequately recorded. The way the sample was drawn is set down clearly so that others can judge and repeat it. This openness lets the sample be trusted and checked. A sample no one can examine cannot be relied on.

Representative, large enough, unbiased and drawn by a fitting method, a good sample lets the researcher speak of the whole population with confidence. The Shinyanga researcher must therefore take pains over these qualities, for on the goodness of the sample the worth of his whole study depends.

Examiner's Note

The command is discuss, so give the quality and why it matters; any six developed points earn full marks, with a clear introduction and conclusion.

Question 93

A research report is the written account of a completed study, its methods, findings and conclusions. It is the final stage of research, and far from a mere formality it is what gives the whole study its worth. The researcher in Tanga must write it before her work can count for anything.

It records the findings. The report sets down permanently what the study found. Without it the results would live only in the researcher's memory and soon be lost. The report is thus the lasting store of the work.

It shares the knowledge. Through the report the findings are made known to others who could not do the study themselves. Knowledge shut in one head helps no one. The report carries what was learned to those who can use it.

It provides a basis for action. Planners and officials act on the findings set out in the report. A study of water shortage, once reported, can guide the sinking of wells. The report turns knowledge into a guide for doing.

It allows the work to be checked. Because the report describes the methods and data, others can judge whether the conclusions are sound. Research that cannot be examined cannot be trusted. The report opens the work to scrutiny.

It adds to the body of knowledge. The report takes its place among other studies and adds its findings to what is known. Later workers build upon it. In this way each report advances the subject.

It guides future research. By naming the questions it could not answer, the report points the way for studies to come. It hands on problems as well as findings. Research thus continues from one report to the next.

It fulfils the purpose of the study. The whole aim of the study was to answer a question and make the answer known, and only the report does this. Without it the labour of the fieldwork is wasted. The report is the study's very reason for being.

Because it records, shares and opens the findings to use and to checking, the report is what turns a private piece of fieldwork into public and lasting knowledge. The Tanga researcher is therefore rightly told that her study is unfinished until it is written, for a study never reported might almost never have been done.

Examiner's Note

You must explain why the report matters; treat each point as a reason the study is unfinished without it. Any six developed points earn full marks, with a clear introduction and conclusion.

Question 94

Ethics in research are the principles of right conduct that a researcher must follow towards the people and places he studies. Because research deals with real people, it can do harm if carried on carelessly. The student in Moshi must observe these principles as he enters the villages.

Informed consent. The people studied should agree to take part after being told what the study is and how their answers will be used. They are not to be studied by stealth. Their willing agreement is the first ethical duty.

Voluntary participation. No one should be forced or tricked into taking part, and any may withdraw if they wish. Participation must be free. Pressing people against their will is wrong.

Confidentiality. The information people give must be kept private, and their names not revealed without leave. What is told in confidence stays in confidence. This protects the people from harm through exposure.

Avoiding harm. The research must not injure the people studied in body, mind or standing. Their welfare comes before the study's convenience. A researcher who harms his subjects has failed however good his data.

Honesty. The researcher must report truthfully and neither invent nor twist his data. Fabrication corrupts the whole of research. Honesty is the very soul of the enquiry.

Respect for culture and permission. The researcher must respect the customs of the people and obtain the permission of their leaders before he begins. He is a guest among them. Respect opens doors that force would close.

Acknowledgement of others. Where the researcher uses the work or words of others, he must give them credit. To pass off another's work as one's own is theft. Proper acknowledgement is an ethical duty.

By seeking consent, guarding confidences, avoiding harm and reporting honestly, the researcher protects both the people he studies and the good name of research itself. The student in Moshi must therefore carry these principles into the villages, for research that wrongs its subjects is not worth the knowledge it gains.

Examiner's Note

The command is explain, so give the principle and why it matters; any six developed points earn full marks, with a clear introduction and conclusion.

Question 95

Formulating a research problem is the work of turning a broad interest into a clear, studiable question. It is done step by step, and doing it well shapes the whole study that follows. The student with only a broad interest must work through these steps.

Choose a broad area of interest. The researcher first settles on a general field that interests him, such as soil erosion. This gives a direction in which to look. A genuine interest here will carry the study forward.

Read around the area. He reads the literature to learn what is already known and where opinions differ. This shows him the lie of the ground. Reading turns a vague interest into an informed one.

Identify a gap. From his reading he finds a question that has not been answered or a matter still in doubt. This gap is where a worthwhile study can be placed. Finding it is the heart of the work.

Narrow to a specific question. He cuts the broad interest down to one definite, manageable question, such as the effect of a particular practice on erosion in one district. A sharp question replaces the broad theme. This is what the student most needs to do.

State the problem clearly. He writes the problem in plain, exact words so that its meaning cannot be mistaken. A clearly stated problem guides everything after it. Vagueness here spreads through the whole study.

Check its feasibility. He asks whether the problem can be studied with the time, money and data he has. A problem beyond his means must be trimmed or changed. Feasibility keeps the study within reach.

Refine after a trial. A small trial or discussion may show that the problem needs sharpening, and he refines it. The problem is thus improved before the main work. A well-tested problem gives the study a firm start.

By moving from a broad interest, through reading and the finding of a gap, to a clear and feasible question, the researcher formulates a sound problem. The student should therefore work down from his interest in erosion to one definite question, for a problem well formulated is the firm foundation of the whole study.

Examiner's Note

Trace the steps in order and say what each achieves; any six developed points earn full marks, with a clear introduction and conclusion.

Question 96

A research design is the overall plan by which a study is carried out, showing how the data will be collected and analysed to answer the problem. It is settled before the fieldwork and shapes all that follows. The student in Mbeya is rightly warned that without it his study may fail.

It provides a plan of action. The design lays out in advance how the whole study will proceed. The researcher then works to a settled plan rather than improvising. A plan made beforehand keeps the study under control.

It guides data collection. The design fixes what data are to be collected and by what means. Effort is thus spent only on what the study needs. This saves the researcher from gathering useless information.

It ensures the data fit the problem. A sound design makes sure that the data collected will actually answer the question asked. The findings then bear on the problem. A poor design gathers data that miss the point.

It makes efficient use of resources. By planning the work, the design lets the time, money and staff be used to best effect. Waste and duplication are avoided. Scarce means are thus stretched further.

It provides for the control of variables. In an experimental design, the plan arranges for other influences to be held steady so that one cause can be tested. This keeps the result trustworthy. Control is built into the design.

It is the basis of the analysis. The way the data are to be analysed is decided in the design. The analysis then follows a settled scheme. This prevents confusion when the findings are worked out.

It gives the study validity. A good design ensures that the study really measures what it sets out to measure. The conclusions can then be trusted. Validity, the soundness of the whole, rests on the design.

Because it plans the collection, ensures the fit of the data and provides for their analysis, the research design is what holds a study together and makes its findings sound. The Mbeya student must therefore settle his design before he begins, for good objectives without a good design lead only to a study that cannot deliver them.

Examiner's Note

Explain by what the design supplies to the study; any six developed points earn full marks, with a clear introduction and conclusion.

Question 97

A research design is the plan by which a study is carried out, and there is no one design for every question. Several types have been developed, each fitted to a particular purpose. The students must learn to match the design to the question they ask.

The descriptive design. This sets out to describe a situation as it is, such as the pattern of land use in a district. It answers the question of what exists. It is used where the aim is a faithful picture rather than a cause.

The survey design. This gathers information from many people or places, usually by questionnaire, to learn about a whole population. It suits the study of opinions, conditions or numbers over a wide group. It is common in human geography.

The case study design. This studies one place, group or event in close and full detail. It gives depth rather than breadth. It suits a problem that needs to be understood thoroughly in one instance.

The experimental design. This tests the effect of one factor by changing it while holding others steady. It answers questions of cause and effect. It is used, for instance, to test how fertiliser affects yield.

The correlational design. This looks for a relationship between two things, such as rainfall and crop yield, without changing either. It shows whether they vary together. It suits the study of how factors are linked.

The longitudinal design. This studies the same subject over a long period, taking readings at intervals. It reveals change through time. It suits the study of how a place or group develops.

The cross-sectional design. This studies different subjects at one point in time and compares them. It gives a snapshot across a group. It is quicker than the longitudinal and suits comparison at a moment.

From the descriptive and survey designs to the experimental, correlational and longitudinal, each type of research design is fitted to a particular kind of question. The students must therefore choose the design that suits their question, for a study is only as sound as the design on which it is planned.

Examiner's Note

The command is explain, so name the design and its use; any six developed points earn full marks, with a clear introduction and conclusion.

Question 98

Reliability and validity are the two great tests of the soundness of research. Reliability is the consistency of a measurement, and validity is whether it measures what it is meant to measure. The project the examiner rejected failed both, which is why its findings could not be trusted.

Validity ensures the right thing is measured. A valid instrument measures exactly what the study intends, and no other thing. A test of rainfall that really measured something else would be worthless. Validity keeps the study on its true target.

Reliability ensures consistency. A reliable instrument gives the same result when used again under the same conditions. Measurements that jump about cannot be trusted. Consistency is the mark of reliability.

They give trust in the findings. Only findings that are both valid and reliable can be believed. Together they are the ground of confidence in a study. Without them the conclusions rest on sand.

They allow comparison. Reliable, valid measurements can be fairly compared between places and times. Loose measurements cannot. Sound comparison depends upon them.

They allow replication. Because a reliable method gives the same result each time, another worker can repeat the study and test it. This is how research checks itself. Replication needs reliability.

They protect against error and bias. Attending to validity and reliability guards the study from measuring the wrong thing or measuring it inconsistently. Many errors are caught in this way. The quality of the data is thereby raised.

They lead to sound conclusions. Conclusions drawn from valid and reliable data are themselves sound and defensible. Poor measurements lead to false conclusions however careful the reasoning. Good data are the root of good conclusions.

Because they decide whether a study measures the right thing and measures it consistently, reliability and validity are the very foundations of trustworthy research. The examiner is therefore right to reject a project that lacks them, for findings that are neither sound nor consistent can teach us nothing.

Examiner's Note

Explain by what reliability and validity guarantee; any six developed points earn full marks, with a clear introduction and conclusion.

Question 99

A census and a sample survey are two ways of gathering information from a population. A census studies every unit in the population, while a sample survey studies only a chosen part of it. The government and the student are advised to different methods because their needs differ.

Their coverage differs. A census covers every member of the population without exception. A sample survey covers only a selected part. The one is complete, the other partial.

Their cost differs. A census is very costly, since everyone must be reached. A sample survey is far cheaper, needing only a few to be studied. Cost often decides which is possible.

Their time differs. A census takes a long time to carry out and to process. A sample survey is quicker, giving results sooner. Speed favours the sample.

Their accuracy differs. A census, if well done, gives exact totals for the whole population. A sample gives an estimate with a margin of error. For exact totals the census is needed.

Their frequency differs. Because it is so costly, a census is taken only rarely, as every ten years. A sample survey can be repeated often. The sample keeps knowledge more up to date.

Their uses differ. A census suits the counting of a whole population, as for planning national services. A sample survey suits the study of opinions or conditions in a group. Each is chosen for its task.

Their examples differ. The national population count is a census, while the study of one district's views is a sample survey. The government needs the first, the student the second. Each example fits its need.

In short, a census studies everyone exactly but at great cost and rarely, while a sample survey studies a part quickly and cheaply for an estimate, so that the two differ in coverage, cost and use. The government rightly takes a census of the nation, and the student rightly samples the district, each choosing the method that fits the task.

Examiner's Note

Explain by the differences and why the sample suits one district; any six developed points earn full marks, with a clear introduction and conclusion.

Question 100

The measures of central tendency, namely the mean, the median and the mode, each give a single value to stand for a whole set of data. Yet each of them reaches that value in its own way, and so carries its own strengths and its own weaknesses. The teacher in Morogoro must therefore weigh them before choosing.

The mean uses every value in the set. Because it is worked out from all the data, the mean takes account of every mark and is the natural basis for further statistics. This makes it the fullest of the three measures. Its weakness is that a few very high or very low marks pull it away from the true centre.

The mean is disturbed by extreme values. In a set that contains one unusually high mark, the mean is dragged upward and no longer represents the typical case. A single outlier can thus give a misleading picture. Where such extremes exist, the mean should be read with caution.

The median is unaffected by extremes. As the middle value when the data are put in order, the median ignores how large or small the outliers are. This makes it a fair centre for skewed data, such as incomes with a few very rich people. Its cost is that it uses only position and not the actual size of the values.

The median needs the data to be ordered. Before the median can be found, the whole set must first be arranged in order of size. For grouped data it must then be estimated by a formula rather than read off directly. This makes it a little more troublesome to obtain than the mean.

The mode shows the most common value. The mode is simply the value that occurs most often, and it is the only measure that can be used for categories such as crop types. This makes it useful where the most frequent case is what matters. However, a set may have no mode at all, or may have several.

The mode can be unstable. A small change in the data can shift the mode sharply from one value to another. This makes it a less reliable centre than either the mean or the median. It is best treated as a rough guide rather than a precise measure.

Each measure suits a different situation. The mean is best where the data are fairly even and further calculation is needed, the median where a few extreme values would distort the picture, and the mode where the most frequent category is the point of interest. No one of them is best for every set. Choosing the right measure is itself part of the skill of statistics.

Because no single measure is best for every set of data, the wise teacher chooses according to the marks in hand, taking the mean for symmetrical results, the median where a few extreme marks distort the picture, and the mode where the most common result is what matters. Understanding the merits and demerits of each is therefore what allows a fair and honest summary to be given.

Examiner's Note

Balance merits against demerits across the three measures; any six developed points earn full marks, with a clear introduction and conclusion.

Question 101

Graphical methods present numerical data as pictures such as bar graphs, line graphs and divided circles, so that figures can be grasped at a glance. Each method has its own strengths and weaknesses, and none is

best for every kind of data. The officer in Kigoma must therefore match the method to what he wishes to show.

The bar graph compares items clearly. A bar graph shows the size of separate items by the height of bars, so that quantities are compared at a glance. It is simple to draw and easy for farmers to read. Its weakness is that it shows only totals and cannot display the make-up of each item.

The line graph shows trends well. A line graph joins points to show how a quantity changes, and is excellent for trends over time such as yearly rainfall. The rise and fall of the line tells the story clearly. However, it needs continuous data and can mislead badly if the vertical scale is chosen unfairly.

The divided circle shows composition. A divided circle, or pie, splits a whole into sectors to show the share taken by each part. It displays the composition of a total at one glance. Its drawbacks are that the sector angles must first be calculated, and that several pies are hard to compare.

The divided rectangle allows comparison. A compound divided rectangle shows the composition of several totals side by side. It therefore combines the strengths of the pie and the bar. But it is slow to construct and becomes crowded when there are many divisions.

Graphs are quickly understood. In general a graph turns a mass of figures into a picture that even a non-expert can read. This makes it a powerful way to communicate with an audience such as the farmers. Its cost is that the exact values are lost, since one reads the graph only approximately.

Graphs can reveal patterns. A well-drawn graph brings out patterns and relationships that a table of figures hides. Peaks, troughs and trends leap to the eye. Yet the same power can deceive, for a graph with a distorted scale can suggest a pattern that is not really there.

Graphs summarise large data sets. A single chart can stand for a whole page of figures, saving space and effort. This makes reports shorter and clearer. The summary, however, hides the individual figures that a careful reader might want.

Because each method has its own merits and demerits, the officer should choose according to his purpose, taking the bar graph to compare crops, the line graph to show change over the years, and the divided circle to show the share of each crop in the whole. Used wisely, graphical methods make figures speak, but used carelessly they can mislead as easily as they inform.

Examiner's Note

Balance merits and demerits across the methods; any six developed points earn full marks, with a clear introduction and conclusion.

Question 102

Measures of dispersion, such as the range, the quartiles and the standard deviation, show how widely the values in a set are spread about their centre. They are needed because an average alone cannot tell the whole story of a set of data. The two Mbeya classes, alike in their mean yet so different in spread, show exactly why they matter.

They show the spread of the data. A measure of dispersion states how far the values scatter from the average. This reveals whether the data are tightly bunched or widely spread. The mean alone cannot show this at all.

They distinguish sets with equal means. Two sets may share the same average yet differ greatly in their spread, as the Mbeya classes do. A measure of dispersion brings out this difference clearly. Without it the two classes would wrongly seem identical.

They test the reliability of the average. When the spread is small the mean represents the data well, but when it is large the mean is less trustworthy. Dispersion therefore tells us how much to rely on the average. This guards against being misled by a single figure.

They measure consistency. A small dispersion shows steady, consistent values, while a large one shows erratic ones. This is useful in comparing, say, the reliability of rainfall at two stations. The steadier station is revealed by its smaller spread.

They reveal extremes and inequality. The range and quartiles show how far the highest and lowest values reach. This exposes inequality, such as a wide gap between rich and poor incomes. An average hides such gaps that dispersion lays bare.

They are needed for further statistics. The standard deviation, a measure of dispersion, is the basis of many higher statistical tests and of comparison between sets. Much advanced analysis cannot proceed without it. It is thus a foundation for deeper study.

They complete the picture with central tendency. Dispersion works alongside the average to describe a set fully, one giving the centre and the other the spread. Together they describe data far better than either alone. A good summary always reports both.

Because an average by itself can hide as much as it shows, measures of dispersion are needed to reveal how the data are spread and how far the average may be trusted. Only by reporting both centre and spread can the teacher describe the two Mbeya classes truthfully, which is why dispersion is as important as the average itself.

Examiner's Note

The command is assess, so give the use and show what dispersion adds beyond the average; any six developed points earn full marks, with a clear introduction and conclusion.

Question 103

Data processing is the ordered set of steps by which raw figures gathered in the field are turned into clear and useful information. Raw returns, as the Kigoma team has found, are at first a confused heap of little use. Processing carries them stage by stage towards meaning.

The data are edited and checked. The returns are gone through to find and correct errors, gaps and doubtful entries. This weeds out mistakes before they spread into the analysis. Clean data are the foundation of every step that follows.

The data are classified. The figures are sorted into groups or classes according to some common feature, such as age or crop. This brings like with like and imposes order on the heap. Classified data are far easier to handle than a jumble.

The data are coded and tabulated. Each class is given a code and the counts are set out in tables of rows and columns. The table shows the figures compactly and in order. From a good table the pattern begins to appear.

Summary measures are calculated. Averages, totals, percentages and measures of spread are worked out from the tables. These few figures stand for the whole mass of data. They make the data easy to grasp and to compare.

The data are presented graphically. The processed figures are drawn as graphs, charts and maps. These pictures show the pattern at a glance to any reader. Presentation turns numbers into something the eye can read.

The results are interpreted. The tables, measures and graphs are read to draw out their meaning. The researcher says what the figures show about the problem studied. Interpretation is where data at last become knowledge.

The findings are stored and reported. The processed data and their meaning are written up and kept for use and for others. This makes the work available and lasting. Data well stored can serve again in later studies.

Carried through these stages, the confused heap of forms that the Kigoma team brought back becomes a clear body of information that answers the question they set out to study. Processing is therefore not a mere

tidying but the very work that turns raw data into knowledge, without which the fieldwork would have been in vain.

Examiner's Note

The command is trace, so give the stage and show what it contributes; any six developed points earn full marks, with a clear introduction and conclusion.

Question 104

Statistical data are the figures on which analysis and planning are built, and their value depends entirely on their quality. Poor data, like those the Mtwara planner complains of, lead to poor decisions however carefully they are worked. Good data show several qualities.

They are accurate. Good data are collected and recorded correctly, free of serious error. Figures that are wrong at the source mislead every step that follows. Accuracy is the first and greatest quality of data.

They are relevant. Good data bear directly on the problem in hand. Figures gathered for some other purpose may not fit the question asked. Data must answer the very question the planner is asking.

They are complete. Good data cover the whole of what is needed, without large gaps. A record full of holes cannot support a firm conclusion. The Mtwara planner's patchy figures fail on exactly this count.

They are up to date. Good data describe the present situation, not one long past. Old figures may no longer match a changed world. Current data are essential where conditions change quickly.

They are unbiased. Good data are gathered by a fair method that favours no particular answer. Data collected to prove a point are worthless as evidence. Freedom from bias is what makes data trustworthy.

They are comparable. Good data are collected on the same basis over time and place so that they can be set side by side. Figures measured in different ways cannot fairly be compared. Comparability lets trends and differences be read.

They are adequate and representative. Good data are enough in quantity and drawn so as to stand for the whole. Too few, or an unrepresentative sample, cannot bear a general conclusion. The data must be sufficient for the weight placed on them.

Because analysis can be no better than the figures it works on, data must be accurate, relevant, complete, current, unbiased and comparable if they are to be trusted. The Mtwara planner is therefore right to reject his poor figures, for sound planning must rest on sound data or it rests on nothing.

Examiner's Note

The command is discuss, so give the quality and say why it matters; any six developed points earn full marks, with a clear introduction and conclusion.

Question 105

Tabulation is the arranging of data into rows and columns in a table. It is one of the first steps in processing, coming before graphs and calculation. The advice to the Songea researcher is sound, for tabulation serves the later work in several ways.

It brings order to the data. Tabulation gathers a scattered mass of figures into an orderly arrangement. What was a confused bundle becomes a neat table. This order is the first gain and the basis of all that follows.

It reveals the pattern. Set out in rows and columns, the figures begin to show their trends and relationships. A rise or a difference that was hidden in the bundle becomes visible. The table lets the pattern speak.

It is compact. A table holds a great many figures in a small space in a form easy to scan. Pages of raw returns are reduced to a single clear table. This makes the data manageable.

It aids calculation. Once tabulated, the figures are easy to total, average and work upon. The columns lend themselves to adding and comparing. Much of the later statistics is made simpler by a good table.

It allows comparison. Rows and columns set figures side by side so that places and periods can be compared. Differences and similarities are read directly across the table. Comparison is one of the table's chief uses.

It is the basis for graphs. Graphs, charts and maps are drawn from the ordered figures of a table. The table is thus the source from which presentation flows. Without it the graphs could not be built.

It reveals errors and gaps. Laid out in a table, missing entries and odd figures stand out plainly. The researcher can then correct or fill them. Tabulation is thus also a check on the data.

Because it brings order, reveals pattern and prepares the way for calculation and graphing, tabulation turns a raw bundle of forms into a working body of data. The Songea researcher is therefore right to tabulate first, for the table is the orderly foundation on which sound analysis is built.

Examiner's Note

Explain by what tabulation does for the later analysis; any six developed points earn full marks, with a clear introduction and conclusion.

Question 106

Data in geography are of two broad kinds, the quantitative, which are counted or measured, and the qualitative, which describe qualities in words. Both are useful, but they differ in nature and handling. The Iringa researcher is gathering one of each and must treat them differently.

Their nature differs. Quantitative data are numbers, such as yields, rainfall or population counts. Qualitative data are descriptions in words, such as the colour of a soil or a farmer's opinion. One is measured, the other described.

Their form differs. Quantitative data come as figures that can be set in tables and worked upon. Qualitative data come as words, notes and impressions. The figure and the phrase are handled in different ways.

Their collection differs. Quantitative data are collected by counting and measuring with instruments. Qualitative data are collected by observing, listening and describing. The methods of gathering the two are not the same.

Their analysis differs. Quantitative data are analysed by statistics, with means, graphs and tests. Qualitative data are analysed by sorting, grouping and interpreting their meaning. Numbers are calculated, words are interpreted.

Their objectivity differs. Quantitative data, being measured, are the same for any careful observer. Qualitative data depend more on the judgement of the observer and may vary. The one is firmer, the other more open to view.

Their strengths differ. Quantitative data are precise and easy to compare, but they cannot capture feelings or reasons. Qualitative data are rich and revealing, but hard to compare and to summarise. Each shows what the other cannot.

Their examples differ. The exact maize yield of a plot is quantitative, while the farmer's opinion that his soil is tired is qualitative. The two together describe the plot more fully than either alone. This is why the researcher gathers both.

In short, quantitative data are measured numbers analysed by statistics, while qualitative data are described qualities interpreted for their meaning, so that the two differ in nature, collection and handling. The wise researcher in Iringa gathers both, using the yields to measure and the opinions to explain.

Examiner's Note

The command is account for, so bring out each contrast on both kinds; any six developed points earn full marks, with a clear introduction and conclusion.

Question 107

Data used in research are of two kinds, primary and secondary, according to who first collected them. Primary data are gathered afresh by the researcher, while secondary data are taken from what others collected before. The researcher in Lindi is using one of each.

Their source differs. Primary data are collected first-hand by the researcher for the study in hand. Secondary data are drawn from records already made by others. One is gathered, the other borrowed.

Their freshness differs. Primary data are new and describe the present situation exactly. Secondary data may be old and describe a situation now changed. The first is current, the second may be dated.

Their cost and effort differ. Primary data cost much time, money and labour to collect in the field. Secondary data are cheap and quick, being already to hand. Gathering afresh is dear, borrowing is cheap.

Their fit to the study differs. Primary data are collected to answer the researcher's own question exactly. Secondary data were collected for another purpose and may not fit. The one is made to measure, the other ready-made.

The control over quality differs. With primary data the researcher knows how they were collected and can trust them. With secondary data the method is unknown and hidden errors may lurk. Control is full in the one, absent in the other.

Their coverage differs. Primary data usually cover only the small area the researcher can reach. Secondary data may cover a whole country and many years. For breadth the secondary source is stronger.

Their examples differ. The researcher's own field measurements in Lindi are primary data. The figures from the government report are secondary data. Each example shows the difference in origin.

In short, primary data are fresh, fitted and trustworthy but costly, while secondary data are cheap and wide but may be dated and ill-fitting, so that the two differ in source, cost and control. The wise researcher in Lindi uses both, collecting his own where accuracy matters and borrowing where breadth is needed.

Examiner's Note

The command is examine, so bring out each contrast on both kinds; any six developed points earn full marks, with a clear introduction and conclusion.

Question 108

The arithmetic mean, or average, is found by adding all the values and dividing by their number. It is the commonest measure of central tendency, yet it has weaknesses as well as strengths. The teacher and her colleague are weighing the two sides.

It uses every value. The mean takes account of all the data, since every value enters the sum. Nothing is left out of the reckoning. This makes it the fullest of the averages.

It is easy to understand and compute. The mean is worked out by a simple rule that anyone can follow. It is widely known and readily grasped. This ease is part of why it is so much used.

It is the basis for further statistics. The mean is used in working out the standard deviation and many other measures. Much higher statistics rest upon it. This makes it a foundation and not merely a summary.

It is affected by extreme values. A single very high or very low value pulls the mean towards itself. The average is then dragged away from the typical case. This is the chief weakness the colleague fears.

It may not be an actual value. The mean can come out as a figure that no member of the data actually has, such as an average of 2.4 children. Such a value can seem unreal. It describes the set rather than any one case.

It can mislead for skewed data. Where the data are lopsided, with a few very large values, the mean gives a false picture of the centre. The median then serves better. For such data the mean should be used with care.

It cannot be found for open classes. Where a grouped table has an open first or last class, the mid-value is unknown and the mean cannot be worked out exactly. The measure then fails. In such cases another average must be used.

The mean is full, familiar and the basis of much further work, yet it is pulled by extremes and can mislead for lopsided data. The Iringa teacher may therefore use it for her fairly even marks, but should turn to the median where a few extreme marks would distort the picture, heeding her colleague's warning.

Examiner's Note

To advise well, weigh where the mean serves against where it misleads; any six developed points earn full marks, with a clear introduction and conclusion.

Question 109

Statistics are the figures that describe a country, its people, its resources and its economy. Planning a nation's development calls for sound knowledge of these, and that knowledge comes as statistics. The ministry that is lost without its figures shows how central they are.

They measure the population. Census statistics show how many people there are, where they live and how fast they grow. Planning of schools, clinics and housing rests on these figures. Without them services cannot be matched to the people.

They assess resources. Statistics of land, water, minerals and crops show what the country has to work with. Development is planned around these known resources. A nation must count its wealth before it can use it.

They guide the budget. Figures of revenue and spending let the government plan how to raise and share out money. The budget is built on such statistics. Sound finance depends on accurate figures.

They allow comparison between regions. Statistics show which regions are rich or poor, served or neglected. Planners can then direct help where it is most needed. Fairness in development leans on such comparison.

They monitor progress. By comparing figures over time, the ministry sees whether development is advancing or lagging. Success and failure are measured in numbers. This lets plans be corrected as they run.

They support forecasting. From past and present figures, planners predict future needs for food, water, power and jobs. The nation can then prepare in good time. Foresight in planning rests on statistics.

They inform policy. Firm figures give policy a footing in fact rather than guesswork. Decisions can be defended and explained by the data behind them. Statistics thus lend authority to planning.

Because they measure the people, the resources and the progress of the nation, statistics are the very foundation on which sound national planning is built. The Dodoma ministry is right to lean on its figures, for a country that plans without them is planning in the dark.

Examiner's Note

The command is account for, so give the use and its value to planning; any six developed points earn full marks, with a clear introduction and conclusion.

Question 110

Statistical data are the figures a geographer works with, and they are drawn from a variety of sources. Knowing where to find reliable figures is the first step in any study that uses them. The geographer of the district must gather his data from these sources.

The population census. The national census gives figures on the number, age and distribution of the people. It is the great store of population data. A study of settlement or services leans upon it.

Field measurement and survey. The geographer collects his own figures by measuring in the field, such as river discharge or slope. These first-hand data are exactly fitted to his study. Fieldwork is a prime source of fresh data.

Questionnaires and interviews. By questioning people the geographer gathers figures on their farming, income or opinions. This yields data not held in any record. It is a common source in human geography.

Maps and aerial photographs. Distances, areas and land-use figures are measured from maps and photographs. Remote sensing adds data over wide areas. These sources turn the map itself into a store of figures.

Published reports and journals. Government departments, firms and scholars publish statistics in their reports and journals. Much ready data is found in them. They are a rich source of secondary figures.

Weather stations. Stations record the temperature, rainfall and other elements of the weather day by day. Their registers are the source of climatic data. A study of climate depends on them.

Offices and the internet. Local offices keep records, and databases on the internet hold great quantities of figures. These are searched for the data a study needs. Modern research draws increasingly upon them.

From the census, from fieldwork, from questionnaires, maps, publications and weather stations, the geographer gathers the figures his study requires. The geographer of the district must therefore know these sources well, for the quality of his study will depend on the quality of the data he can find.

Examiner's Note

The command is explain, so name the source and what it yields; any six developed points earn full marks, with a clear introduction and conclusion.

Question 111

The range and the standard deviation are measures of dispersion, showing how widely the values in a set are spread about their average. They are needed because an average alone hides the spread. The researcher uses them to bring out the difference the average conceals.

They measure the spread of data. Both the range and the standard deviation state how far the values scatter from the centre. This reveals whether the data are bunched or spread. The average by itself cannot show this.

They compare the consistency of sets. Of two sets with the same average, the one with the smaller spread is the more consistent. The two rainfall stations are told apart in just this way. Consistency is read from the measure of dispersion.

They test the reliability of the average. A small spread means the average represents the data well, a large spread that it does not. The measures thus show how far the average may be trusted. This guards against being misled by a single figure.

They reveal extremes. The range in particular shows the gap between the highest and lowest values. This exposes how far the data reach. Extremes hidden by the average are laid bare.

The standard deviation is the basis of further statistics. Many higher measures and tests are built upon the standard deviation. It is used in comparing sets and in judging significance. It is thus a foundation for deeper analysis.

They aid quality control and comparison. In checking rainfall, yields or measurements, a small standard deviation shows steady, dependable values. Places and periods are compared by their spread. This is central to judging reliability.

The range is quick and simple. The range is found at once from the largest and smallest values, giving a rough measure of spread with little work. It is useful for a quick comparison. Its ease is its chief merit, though it ignores the middle values.

By measuring spread, comparing consistency and testing the reliability of the average, the range and the standard deviation reveal what the average alone conceals. The researcher is therefore right to turn to them, for only by reporting both average and spread can the two rainfall stations be truly compared.

Examiner's Note

The command is account for, so give the use and what the measure shows; any six developed points earn full marks, with a clear introduction and conclusion.

Question 112

Classifying data is the sorting of them into groups or classes according to some common feature. It is an early step in processing, coming before tabulation and analysis. The researcher with his jumble of observations is rightly told to classify first.

It brings order to the data. Classification gathers a confused mass of observations into orderly groups. What was a jumble becomes arranged. This order is the foundation of all that follows.

It groups like with like. By sorting the data, classification places similar items together and separates the unlike. Each group then holds one kind of thing. This makes the data far easier to handle.

It reveals patterns. Once the data are grouped, the way they fall into classes shows a pattern, such as most farms being small. Such patterns are hidden in an unsorted heap. Classification lets them appear.

It aids comparison. Grouped data allow one class to be set against another, such as large farms against small. Differences are then read directly. Comparison depends on the data being classified.

It is the basis of tabulation. Data must be classified before they can be set out in a table of rows and columns. Classification thus prepares the way for the table. Without it a table cannot be built.

It simplifies large data sets. By reducing many separate observations to a few classes, classification makes a large set manageable. The mass is boiled down to a handful of groups. This simplification is essential for analysis.

It reveals errors and gaps. When the data are sorted, odd or missing items stand out from their class. The researcher can then correct or fill them. Classification thus also serves as a check.

By bringing order, grouping like with like and preparing the way for tabulation, classification turns a jumble of observations into a workable body of data. The researcher must therefore classify first, for on the ordering of the data all the later analysis is built.

Examiner's Note

Explain by what classification does for the data; any six developed points earn full marks, with a clear introduction and conclusion.

Question 113

A percentage expresses a quantity as a part of a hundred, so that different quantities can be compared on a common base. In geography, where places and totals differ greatly in size, percentages are of much use. The geographer comparing the two regions turns to them for good reason.

They allow fair comparison of unequal totals. By reducing figures to a common base of a hundred, percentages let a large region and a small one be compared fairly. The raw totals, being of different sizes, would mislead. This is the geographer's very difficulty solved.

They show proportion. A percentage shows what share of the whole each part takes, such as the fraction of land under a crop. The make-up of a total is thus made plain. Proportion is read at once.

They are easily understood. Percentages are familiar and quickly grasped by any reader. A figure out of a hundred is easy to picture. This makes data clear to non-experts.

They reveal change. A rise or fall can be expressed as a percentage increase or decrease. The size of a change is then plain. This is useful in showing growth over time.

They are the basis of some graphs. Divided circles and percentage bars are drawn from percentages. The presentation of composition rests on them. Many charts could not be made without them.

They standardise data. By putting different sets on the same base of a hundred, percentages make them directly comparable. Sets otherwise unlike are brought to a common footing. This is central to fair analysis.

They simplify large figures. A percentage replaces a large, awkward figure with a small, tidy one. The data become easier to handle and to remember. Complexity is thus reduced.

By reducing unequal figures to a common base, percentages make fair comparison possible and show proportion clearly, which raw totals cannot. The geographer is therefore right to use them in comparing the two regions, for the percentage is one of the simplest and most powerful tools in the presentation of data.

Examiner's Note

The command is evaluate, so give the point and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 114

An aerial photograph is a picture of the ground taken from an aircraft above it, capturing in a single moment a wealth of detail that a survey party would take weeks to record. For a developing country that must map and manage vast areas with limited means, this makes the aerial photograph a tool of real value. Its many uses show why the Dodoma office relies on it.

It provides the base for mapping. Accurate topographical maps are drawn and later revised directly from aerial photographs. This gives a country the very maps on which all its planning depends. Without such photographs the slow labour of mapping vast areas on the ground would scarcely be possible.

It aids town and land-use planning. A single photograph shows the whole layout of a growing town such as Mwanza at one glance. Planners can then study its streets and quarters and guide its future growth. Keeping the town plan up to date becomes a matter of taking a fresh photograph.

It serves agriculture and forestry. Crops and forests, and their health, can be surveyed from the air over wide areas at once. This helps in planning farming and in watching the steady shrinking of the woodlands. Ground survey could never cover such areas so quickly or so cheaply.

It supports the monitoring of disasters. Floods spreading along the Rufiji, or the advance of a bush fire, can be seen and measured from the air when the ground itself is unreachable. This gives those in charge a true picture on which to act. Timely images can be the difference between a managed response and a helpless one.

It helps in choosing routes and sites. Engineers study the relief and drainage shown on the photographs when choosing the line of a new road or the site of a dam. The best route can be picked before anyone sets foot on the ground. This saves both money and costly mistakes in construction.

It allows counting and census work. Settlements, houses and even herds of livestock can be counted from the air with fair accuracy. This assists population studies and the assessment of resources. Areas too remote to reach on foot are thus brought within reach of the counter.

It saves time and reaches difficult ground. Remote, rugged or dangerous country is recorded quickly and safely from the air. This is achieved at far less cost than sending survey parties into every such area. Speed and reach together make the photograph especially valuable in a large country.

Weighed all together, these uses make the aerial photograph a cheap and powerful eye upon the land, able to map, count and watch over areas that would otherwise defeat a survey party. For a country that must plan and manage so much with so little, its value to development is therefore considerable, which is why the Dodoma office turns to it so readily.

Examiner's Note

Justify the reliance by the value that each use brings; any six developed points earn full marks, with a clear introduction and conclusion.

Question 115

A map is a selective, drawn representation of the ground, while an aerial photograph is a picture of the ground taken from the air. Though both show the same district, they differ in important ways, and the planner in Arusha needs to understand these differences to use each well. Their contrasts run through several features.

Selection differs. A map shows only the features the mapmaker chooses, drawn clearly and free of clutter. A photograph, by contrast, records everything before the lens, wanted or not. The map is therefore clearer, while the photograph is fuller.

Scale differs. A map is drawn to one uniform scale over the whole sheet, so distances can be measured anywhere on it. On an oblique photograph the scale changes from foreground to background, making measurement harder. Uniform scale is a real advantage of the map.

Symbols differ. A map uses conventional signs and a key to name and mark features. A photograph shows features by their actual appearance, which must be interpreted. The map thus tells directly what the photograph only shows.

Height is shown differently. A map shows relief by contours and spot heights, so exact heights can be read. A single photograph does not give heights directly and needs special pairs to show relief. For the study of slope the map is superior.

Names and boundaries differ. A map carries the names of places, rivers and roads, and marks administrative boundaries. A photograph shows none of these, for such things are not visible on the ground. The map therefore carries information the camera cannot capture.

Currency differs. A photograph records the ground exactly as it was at the instant of exposure, catching the very latest changes. A map may be years old and out of date. For up-to-date detail the photograph is the better.

Detail and appearance differ. A photograph shows the true appearance, colour and texture of the ground in fine detail. A map reduces all this to lines and symbols. The photograph is thus more lifelike, the map more abstract.

In short, the map is selective, uniform in scale and rich in names and heights, while the photograph is complete, lifelike and up to date, so that each has strengths the other lacks. The wise planner in Arusha therefore uses them together, reading heights and names from the map and the latest detail from the photograph.

Examiner's Note

Prove the colleague wrong by what the map does that the photograph cannot; any six developed contrasts earn full marks, with a clear introduction and conclusion.

Question 116

Interpreting a photograph means working out what the features on it are and what they mean. A geographer does this not by guessing but by reading a set of clues that the picture offers. These elements of interpretation are what the puzzled student must learn to use.

Tone. Tone is the lightness or darkness of a feature on the photograph. Water often appears dark and bare sand light, so tone helps tell one surface from another. It is usually the first clue the eye notices.

Texture. Texture is the smoothness or roughness of the surface as it appears. A forest looks rough and broken while a lake looks smooth. This difference helps separate features that share the same tone.

Shape. Shape is the outline or form of a feature. Regular straight-edged shapes usually mean the work of people, while irregular ones are often natural. A rectangular field is thus told from a winding river.

Size. Size is judged from the scale of the photograph and helps identify a feature. A large building is more likely a factory than a house. Comparing sizes prevents confusing the great with the small.

Shadow. Shadow shows the height and form of tall objects and reveals the direction of the sun. A tall chimney casts a long shadow that betrays its height. Shadows also tell the time of day.

Pattern. Pattern is the arrangement of features in relation to one another. Trees in regular rows suggest a plantation, while scattered ones suggest natural bush. The way things are ordered is a strong clue to their nature.

Association and site. Association is the way features occur together, and site is where a feature sits. A cluster of buildings by a railway suggests a station, and a mill sits by a river. What lies near a feature, and where it stands, help to name it.

By reading tone, texture, shape, size, shadow, pattern and the setting of a feature, the geographer builds up a sure interpretation from clues rather than guesses. Once the student learns to use these elements together, the forest, the field and the factory will each declare themselves, for a photograph read in this way becomes an open book.

Examiner's Note

The command is explain, so name the element and say what it reveals; any six developed points earn full marks, with a clear introduction and conclusion.

Question 117

A ground photograph is taken with the camera held on or near the ground, while an aerial photograph is taken from an aircraft above. Though both may show the same valley, they differ in what they capture and how they are used. The club in Mbeya is really weighing these differences.

The viewpoint differs. A ground photograph is taken looking across the scene from the side. An aerial photograph looks down on it from above. This single difference in viewpoint changes everything else.

The area covered differs. A ground photograph shows only a narrow strip of what lies before the camera. An aerial photograph takes in a wide area at one exposure. For extent the aerial view is far the greater.

The foreground differs. In a ground photograph the foreground objects are large and may hide what lies behind them. In an aerial photograph all features are seen more evenly from above. Nothing tall blocks the aerial view.

The scale differs. In a ground photograph the scale changes sharply from the large foreground to the small distance. In a vertical aerial photograph the scale is nearly the same across the whole picture. Measurement is therefore easier on the aerial.

The detail shown differs. A ground photograph shows the sides and shapes of things as a person on the spot would see them. An aerial photograph shows the tops and the plan of features. Each reveals what the other hides.

Their uses differ. The ground photograph is best for recording the appearance of a particular feature close to. The aerial photograph is best for mapping and for studying the layout of a wide area. The club would use each for a different purpose.

The ease of taking them differs. A ground photograph is taken cheaply and easily with an ordinary camera. An aerial photograph needs an aircraft and special equipment. The ground view is thus within everyone's reach, the aerial not.

In short, the ground photograph gives a close, familiar side-view of a small area, while the aerial photograph gives a wide, even, plan view from above, so that each shows what the other cannot. The Mbeya club

should therefore value both, using the ground view for detail and the aerial view for the whole layout of their valley.

Examiner's Note

The command is distinguish, so bring out each contrast on both kinds; any six developed points earn full marks, with a clear introduction and conclusion.

Question 118

A photograph is a picture of the ground that records its features exactly as they were at the moment it was taken. Because it captures so much detail so faithfully, it has many uses in the study of geography. The Tanga department draws on its collection in several ways.

They record the appearance of features. A photograph preserves exactly how a landscape, a town or a river looked. This gives a faithful record that words and sketches cannot match. Such records are a lasting store of geographical fact.

They train interpretation. Students learn to read the land by working out what the features on a photograph are and mean. This builds the skill of interpretation that the syllabus requires. The photograph is thus a tool for teaching a practical skill.

They aid mapping. Aerial photographs are the base from which accurate maps are drawn and revised. Much of a country's mapping begins with them. In this way the photograph feeds directly into cartography.

They show change over time. Photographs of the same place taken years apart reveal how it has changed, such as the growth of a town or the wearing of a coast. This makes them valuable in studying processes. Change invisible in a single visit stands out between two photographs.

They reach inaccessible places. A photograph can show a place that is remote, rugged or dangerous to visit. The geographer can study it without going there. This extends the reach of study far beyond where one can walk.

They provide evidence for reports. A photograph supports a field report with firm visual proof of what was found. Readers can see for themselves rather than take the writer's word. This lends weight and clearness to the report.

They illustrate and teach. In the classroom a photograph makes a distant landscape vivid and real to students. It brings the world outside into the lesson. This helps understanding far more than description alone.

Through these uses the photograph serves the geographer as record, teacher, mapping base and evidence all at once, bringing the far and the past within reach of study. The Tanga department is therefore right to build its collection, for a good photograph is a piece of the world kept for study.

Examiner's Note

The command is explain, so give the use and show its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 119

An aerial photograph is a rich and faithful record of the ground, yet it has real weaknesses that limit its use. Knowing these limits keeps the user from trusting the photograph too far. The Mwanza official must weigh them against its undoubted value.

It carries no names or boundaries. A photograph shows the ground but names no place, river or road, and marks no administrative boundary. Such information, plain on a map, is simply absent. The user must supply it from other sources.

It does not give heights directly. A single photograph does not show the height of the land as contours do on a map. Relief can be judged only from shadows or by using special overlapping pairs. For exact heights the photograph is of little use alone.

Its scale is not uniform. On an oblique photograph the scale changes from the large foreground to the small distance. Even a vertical photograph varies in scale where the ground is high or low. This makes measurement from a photograph less reliable than from a map.

It may be distorted. Tilt of the aircraft and the height of tall objects cause features to lean or shift on the photograph. These distortions can mislead the unwary reader. Correcting them needs skill and instruments.

It depends on the weather. Cloud, haze and smoke can hide the ground or spoil the photograph. Good photographs need clear, still conditions. The method is thus at the mercy of the weather.

It needs skill and instruments to interpret. Reading a photograph correctly calls for training and often a stereoscope. An untrained eye may mistake one feature for another. This limits who can use it well.

It records only a moment. A photograph captures the ground only as it was at the instant of exposure. Anything that has changed since is not shown. For current detail a fresh photograph is needed.

For all their richness, aerial photographs cannot name places, give heights directly or hold a steady scale, and they depend on clear weather and skilled reading. The Mwanza official is therefore rightly warned to use them alongside maps and fieldwork, drawing on each where it is strong.

Examiner's Note

Explain by the limitations that make the photograph less than a map; any six developed points earn full marks, with a clear introduction and conclusion.

Question 120

A vertical aerial photograph is one taken from an aircraft with the camera pointing straight down at the ground. This viewpoint gives it a set of characteristics that set it apart from oblique and ground photographs. They are the very features that make the mapping office prefer it.

It gives a plan view. Because the camera looks straight down, features appear from above in plan, as they would on a map. Roofs, fields and roads are seen as shapes on the ground. This map-like view is its most useful trait.

Its scale is nearly uniform. Over flat ground the scale is almost the same across the whole photograph. Distances and areas can therefore be measured from it with fair confidence. This near-constant scale is what suits it to mapping.

It shows no horizon or sky. Since the camera points down, the photograph shows only the ground, with no horizon or sky in view. The whole frame is filled with useful detail. Nothing is wasted on empty sky.

It has a principal point. At the centre of a vertical photograph lies the principal point, directly below the camera. Around this point the geometry of the photograph is most nearly true. It serves as the reference for measurement.

It is taken with overlap. Vertical photographs are taken in a run so that each overlaps the next along the line of flight. This overlap allows successive pairs to be viewed in three dimensions. It also ensures complete cover with no gaps.

It allows stereoscopic viewing. Because of the overlap, an overlapping pair seen through a stereoscope shows the ground in relief. Height and slope can then be judged. This is how relief is drawn from vertical photographs.

It resembles a map most closely. Of all photographs the vertical is the nearest to a map in its view and its even scale. This is why it is the basis from which maps are made. The mapping office prefers it for exactly this reason.

The plan view, the even scale, the absence of sky, the central principal point and the overlap that gives relief together make the vertical aerial photograph the most map-like of all photographs. It is for these characteristics that the mapping office prefers it, since they are the very qualities that mapping demands.

Examiner's Note

The command is discuss, so give the characteristic and its value for mapping; any six developed points earn full marks, with a clear introduction and conclusion.

Question 121

An aerial photograph shows a whole town at a glance, its streets, houses and open spaces laid out as on a map. This makes it a powerful tool for those who must plan the growth of a town. The Mwanza office draws on it in several ways.

It shows the whole layout. The photograph reveals the entire plan of the town, its streets, blocks and quarters, at one view. Planners can study how the town is arranged. This overview is hard to gain on the ground.

It guides orderly expansion. By showing where the town ends and open land begins, the photograph helps planners direct where new building should go. Growth can be guided onto suitable land. This prevents haphazard sprawl.

It helps site services. The photograph shows where roads, water and other services are needed and where they can run. New services can be planned to fit the existing town. This makes their laying out cheaper and better.

It monitors the growth of the town. Photographs taken at different times show how fast and where the town has spread. Planners can measure the change and plan ahead. The pace of growth is thus kept in view.

It reveals crowded and unplanned areas. The photograph shows at once where housing is dense and disorderly, such as an unplanned settlement. Planners can then target these areas for improvement. Problems hidden on the ground stand out from the air.

It aids the planning of roads. The layout seen from the air helps planners fit new roads into the town without needless demolition. The best lines can be chosen on the photograph. This eases movement in the growing city.

It provides a base for the town map. The photograph is the base from which an accurate, up-to-date town plan is drawn. Planning rests on such a plan. The photograph thus underlies the whole planning effort.

By showing the whole town, guiding its expansion and helping to site its roads and services, the aerial photograph is a central tool in town planning. The Mwanza office is therefore right to rely on it, for orderly growth begins with the clear view of the town that only the air can give.

Examiner's Note

The command is discuss, so give the use and its value to planning; any six developed points earn full marks, with a clear introduction and conclusion.

Question 122

Aerial photographs show large areas of farmland and forest at a glance, in detail that would take a survey party weeks to gather on foot. This makes them a valuable tool to those who manage crops and trees. The Morogoro office finds many uses for them.

They map land use. The photograph shows at one view how the land is used, which parts are cropped, grazed or wooded. A land-use map is drawn from it. This is the basis of planning farming over a district.

They survey crops. The kinds and extent of crops can be identified and measured from the photograph. The office can estimate the area under each crop. This aids the forecasting of harvests.

They take stock of forests. The extent and type of forest can be surveyed and even the number of trees estimated from the air. This gives a forest inventory over wide areas. Such stock-taking on the ground would be very slow.

They detect damage and disease. Crops or trees struck by pest, disease or drought show a change of tone or pattern on the photograph. The office can spot the trouble and its spread early. Timely action can then be taken.

They plan irrigation and layout. The relief and drainage seen on the photograph help in laying out irrigation and in siting fields. The best use of the land can be planned from above. This improves the design of farms.

They monitor change. Photographs taken at different times show the advance of farming or the loss of forest. The office can measure how fast the land is changing. Deforestation, for one, is watched in this way.

They save time over wide areas. A single photograph covers a great area of farm and forest at once. The office surveys in a day what would take a ground party far longer. This reach is especially useful over a wide district.

By mapping land use, surveying crops and forests, detecting damage and watching change, aerial photographs serve agriculture and forestry over areas too wide to walk. The Morogoro office is therefore right to use them, for they give the manager of crops and trees an eye in the sky over all his land.

Examiner's Note

The command is account for, so give the use and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 123

A ground photograph is taken with the camera held on or near the ground, looking across the scene. Though it lacks the sweep of an aerial photograph, it has real advantages of its own. The student's simple camera is more useful than he fears.

It is cheap and easy to take. A ground photograph needs only an ordinary camera and costs almost nothing. An aerial photograph needs an aircraft and special equipment at great cost. The ground view is thus within everyone's reach.

It shows the sides of features. A ground photograph shows the fronts and sides of buildings, hills and trees as a person sees them. An aerial view shows only their tops. For the appearance of a feature the ground view is better.

It gives a familiar view. The ground photograph shows the scene as the eye naturally sees it, and so is easy for anyone to understand. An aerial photograph shows an unfamiliar view from above that must be interpreted. The ground view needs no special training to read.

It records fine detail of a feature. A ground photograph can capture the close detail of a single feature, such as the carving on a building or the bark of a tree. The aerial view is too distant for such detail. For a particular object the ground photograph excels.

It can be taken at any time. A ground photograph can be taken whenever and wherever the photographer stands. An aerial photograph needs an aircraft, clear weather and planning. The ground view is far more readily obtained.

It needs no special skill to interpret. Because it shows the ordinary view, a ground photograph is read at a glance by anyone. An aerial photograph often needs a stereoscope and training. The ground view is open to all.

It is useful for study and record. The student can record a landform, a settlement or a land use for his study with his own camera. This first-hand record supports his fieldwork directly. Simple though it is, it is genuinely useful.

Cheap, familiar and rich in the close detail of a feature, the ground photograph has clear advantages over the costly aerial view, each being strong where the other is weak. The student should therefore value his simple camera, for the ground photograph is a genuine and useful tool of geographical study.

Examiner's Note

The command is discuss, so give the advantage on the ground side; any six developed points earn full marks, with a clear introduction and conclusion.

Question 124

Aerial photographs show the surface of the land from above over wide areas, revealing the pattern of its physical features at a glance. This makes them a valuable tool in the study of landforms and drainage. The geographer of the rugged district finds them serving him in several ways.

They show relief. When overlapping photographs are viewed together in three dimensions, the shape and height of the land stand out clearly. Hills, valleys and ridges are seen in relief. This reveals the lie of the land better than a walk over it.

They reveal the drainage pattern. The rivers, lakes and their branching pattern are shown spread out over a wide area. The whole drainage system is seen at once. This helps in understanding how the area is watered and worn.

They display landforms. Features such as meanders, deltas, escarpments and volcanic cones appear plainly on the photograph. Their form and setting can be studied. The photograph is thus a store of landforms for study.

They show coastal features. Along the coast the photograph reveals beaches, spits, reefs and mangrove in their true arrangement. The shape of the coast is laid out to view. This aids the study of coastal processes.

They reveal signs of erosion. Gullies, landslides and eroded slopes show clearly on the photograph by their tone and form. The extent of erosion can be measured. This warns where the land is being worn away.

They suggest the underlying geology. The pattern of ridges, valleys and drainage often hints at the rocks and structures beneath. A trained eye reads the geology from the surface form. The photograph thus aids even the study of what lies below.

They cover inaccessible ground. Rugged, remote country that is hard to reach on foot is recorded from the air with ease. The geographer studies it without the toil of the climb. This is especially useful in a rugged district.

By showing relief, drainage, landforms and the signs of erosion over wide and rugged areas, aerial photographs are a powerful aid to the study of physical features. The geographer is therefore right to lean on them, for they lay out the shape of the land more fully than the ground itself allows.

Examiner's Note

The command is explain, so give the use and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 125

Interpreting an aerial photograph means working out, step by step, what it shows and what that means. A geographer does not guess at random but follows an orderly method. The student who learns these steps will know where to begin.

Determine the type and scale. The geographer first decides whether the photograph is vertical or oblique and judges its scale. This tells him how the ground is viewed and how large the features are. It is the necessary first step before any detail is read.

Orient the photograph. He fixes the direction of north, from shadows or from known features, so that he can speak of north, south, east and west. Orientation lets the layout be described properly. Without it directions cannot be given.

Identify the natural features. He picks out the relief, the rivers, the vegetation and other works of nature. These form the physical setting of the scene. Naming them is the first step in reading the land.

Identify the human features. He then picks out the settlements, roads, farms and other works of people. These show how the land is used and occupied. Together with the natural features they complete the inventory.

Note the patterns and relationships. He observes how the features are arranged and how they relate, such as a village set by a river or fields following the flat land. These relationships reveal the working of the area. Pattern is where interpretation deepens into understanding.

Draw conclusions about activities. From the features and their pattern he infers the economic activities, such as fishing, farming or trade. The photograph is thus made to tell how the people live. This is the goal of interpretation.

Relate the scene to a region. Finally he judges what kind of region the photograph shows, such as a coastal lowland or a highland valley. The scene is placed in its wider setting. This rounds off the reading of the photograph.

By fixing the type and scale, orienting the view, naming the natural and human features, reading their pattern and drawing out the activities, the geographer builds a full interpretation from an orderly method. The student who follows these steps will always know where to begin, for interpretation is a discipline and not a guess.

Examiner's Note

Outline the steps in order and say what each achieves; any six developed points earn full marks, with a clear introduction and conclusion.

Question 126

An aerial photograph records the surface of the ground in fine detail from above. To the trained eye it is a store of information about a place, read without ever setting foot there. The geographer studying the unknown district draws much from it.

The relief. From the shadows, and from overlapping pairs seen in three dimensions, the shape and height of the land can be judged. Hills, valleys and slopes are made out. The lie of the land is thus read from the photograph.

The drainage. The rivers, lakes and their branching pattern show plainly on the photograph. The way the area is watered is seen at a glance. Its drainage is laid out to view.

The vegetation. Forest, grassland and cultivation are told apart by their tone and texture. The plant cover of the district is mapped from the photograph. This bears on both climate and land use.

The settlement. Towns, villages and scattered houses appear by their shapes and patterns. Where and how people live is read from the photograph. The settlement pattern is plain from above.

The communications. Roads, railways and tracks stand out as lines across the ground. How the district is linked is seen at once. The network of routes is read from the photograph.

The land use. Fields, plantations, mines and industry show by their forms and settings. How the land is used is worked out. This reveals the economy of the district.

The economic activities. From the land use, the settlement and the routes together, the geographer infers how the people make their living, whether by farming, fishing or trade. The photograph is thus made to tell of the life of the place.

Relief, drainage, vegetation, settlement, routes and land use can all be read from an aerial photograph, so that a geographer may study a district in detail without visiting it. The photograph is therefore a store of geographical information, teaching the geographer his district before ever he walks it.

Examiner's Note

The command is discuss, so name the information and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 127

The quality of an aerial photograph is how sharp, clear and useful it is for study. Several factors decide it, and when they go wrong the photograph is blurred or poor. The survey office must attend to these factors to get good photographs.

The weather and clarity of the air. Cloud, haze, smoke or dust between the camera and the ground blur the photograph. A clear, still atmosphere gives a sharp picture. The weather is thus a first factor in quality.

The height of the flight. The flying height fixes the scale and the detail captured; too high a flight makes small features too small to see. The height must suit the purpose. This governs how much the photograph can show.

The camera and lens. A good camera with a fine lens gives a sharp, true image, while a poor one blurs and distorts. The instrument itself limits the quality. Better equipment yields better photographs.

The stability of the aircraft. If the aircraft tilts or vibrates as the photograph is taken, the image is distorted or blurred. A steady platform is needed for a true vertical photograph. Stability affects both sharpness and geometry.

The time of day. The angle of the sun decides the light and the length of shadows; a very low sun casts long shadows that hide detail, while a high sun lights the ground evenly. A suitable time gives the clearest view. Timing thus affects quality.

The film and its processing. The resolving power of the film and the care of its developing decide how fine the detail comes out. Poor film or careless processing spoils an otherwise good exposure. The final quality depends on this last stage.

The speed of the aircraft. If the aircraft moves too fast for the exposure, the image is smeared along the line of flight. The speed must be matched to the camera. This too bears on the sharpness of the result.

Clear air, a suitable flying height, a good camera on a steady aircraft, and careful timing and processing together make a sharp and useful aerial photograph, while a fault in any of them blurs it. The survey office must therefore watch all these factors, for the worth of a photograph for study depends upon its quality.

Examiner's Note

The command is examine, so give the factor and its effect on quality; any six developed points earn full marks, with a clear introduction and conclusion.

Question 128

Shadows are the dark shapes cast by objects when the sun lights them from one side. On a photograph they are more than a blemish, for they carry information that helps the interpreter. The student is right to find them useful in reading the photograph.

They show the height of objects. A tall object casts a long shadow and a short one a short shadow. From the length of the shadow the height of a chimney or a tree can be judged. Shadows thus measure height on a flat photograph.

They reveal the shape of objects. The outline of a shadow shows the profile of the object that casts it. A tower, a bridge or a hill is known by its shadow's shape. This helps identify features seen only from above.

They show the time of day. Short shadows near the foot of objects mean a high midday sun, while long shadows thrown to one side mean early morning or late afternoon. The shadows thus tell when the photograph was taken. This is a common use in interpretation.

They show the direction of the sun. The side to which the shadows fall shows from which side the sun was shining. The interpreter can then reckon the points of the compass. Direction is thus read from the shadows.

They reveal relief. Shadows in a valley or on a slope bring out the shape of the land, making hills and hollows stand forth. Relief that would be flat and hard to see is picked out by shadow. This helps in reading the lie of the land.

They help distinguish features. A raised object with a shadow is told from a flat mark that has none. The shadow shows that the object stands up from the ground. This separates buildings and trees from mere patches of tone.

They can also hide detail. Very long shadows, however, may cover and hide the detail behind them. The interpreter must allow for this. Shadows thus help most when they are not too long.

By showing height, shape, the time of day and the lie of the land, shadows are a real aid to the interpreter, though very long ones may hide as much as they reveal. The student is therefore right to use them, for a shadow read with care tells much about the object that casts it.

Examiner's Note

The command is explain, so give the use and what the shadow reveals; any six developed points earn full marks, with a clear introduction and conclusion.

Question 129

Relief is the shape and height of the land, and to show a three-dimensional surface upon flat paper is one of the mapmaker's central problems. Several methods have been devised for it, and they are often used together, each contributing its own strength. The cartographer must understand them all in order to choose wisely.

Contours are the chief method. Contours are lines joining all points of equal height above sea level. From their spacing and pattern the reader can judge the exact height, the steepness and the shape of the land. They are the main method on topographical maps, though a beginner must first learn to read them.

Spot heights fix particular points. A spot height is a dot marked with the exact height of one chosen point, such as a hilltop or a road junction. It fixes heights at places that fall between the contour lines. Together with contours it gives the reader precise values to work from.

Trigonometrical and bench marks give the framework. These are points whose heights have been fixed with great precision and marked by a small triangle or an arrow. They form the framework of accurate heights on which the rest of the map is built. The reader can trust them as the firmest heights on the sheet.

Hachures suggest the slopes. Hachures are short lines drawn down the direction of the slope, heavy for steep ground and light for gentle. They give a quick visual impression of where the hills and valleys lie. Their weakness is that they show no exact heights, only the general lie of the land.

Layer tinting shows broad patterns. In this method bands of colour or shade are placed between chosen heights, with darker tones for the higher ground. This shows the broad pattern of relief across a region at a single glance. It is excellent for a general view but too coarse for fine detail.

Hill shading gives a solid impression. Here shadow is drawn as though the land were lit from one side, so that the hills seem to stand up from the page. This gives a strong and lifelike three-dimensional impression. Like hachures, however, it conveys shape far better than it conveys exact height.

Form lines sketch unsurveyed ground. Form lines are broken lines that sketch the probable shape of the land where accurate contours have not yet been surveyed. They fill a gap until proper survey can be done. Being only approximate, they are drawn broken to warn the reader not to trust them as true contours.

Because no single method can show everything at once, a good map combines several of them, using contours and spot heights for accuracy while adding colour or shading for a quick impression. In this way the cartographer allows the reader both to measure the land exactly and to picture its shape at a glance, which is the whole aim of representing relief.

Examiner's Note

Give the method and what it shows, together with its strength or limit; any six developed points earn full marks, with a clear introduction and conclusion.

Question 130

A topographical map shows both the natural and the human features of an area, drawn to scale with relief marked by contours. Because it packs so much information into one sheet, it is a tool of daily value to a developing country. The many uses of such a map explain why the Njombe office relies on it so heavily.

It shows relief and drainage. The contours and rivers on the map reveal the shape of the land and the way the water runs. Planners can see at once where the high ground and the valleys lie. This guides where roads, farms and dams may sensibly go.

It locates features by grid reference. The grid allows any feature to be given an exact reference that others can find again. A school, a well or a proposed site can thus be pinpointed and communicated. This precise location is essential for orderly planning.

It allows distance and area to be measured. Because the map is drawn to a known scale, distances and areas can be measured from it directly. The length of a road or the size of a forest can be found without visiting the ground. This saves much time and travel in a large district.

It guides the planning of settlement and land use. By showing where people already live and how land is used, the map helps planners guide future growth. New settlements and land uses can be sited where they fit the land. This prevents the disorderly sprawl that unplanned growth brings.

It aids the siting of engineering works. The relief and drainage shown on the map help engineers choose the line of a road or the site of a dam. The best position can be studied on paper before any survey party is sent. This lowers both the cost and the risk of the work.

It serves security and disaster planning. The detail of ground, routes and settlement on the map is used in security and in preparing for floods or fires. Those in charge can plan movement and rescue from the map. In an emergency this ready picture of the ground is invaluable.

It is a base for education and research. Students and researchers use topographical maps to learn map reading and to study the landscape. The map becomes the starting point for much geographical work. In this way it builds the very skills the country needs.

Through all these uses the topographical map serves as a compact store of knowledge about the land, guiding the planner, the engineer and the student alike. For a developing country that must manage wide areas with limited means, such a map is therefore not a mere convenience but a working tool of development, which is why it hangs on the Njombe wall.

Examiner's Note

The command is account for, so give the use and tie it to a development need; any six developed points earn full marks, with a clear introduction and conclusion.

Question 131

The margin of a topographical map carries the notes and keys that tell the reader how to use the map correctly. Though it lies outside the mapped area, this information is essential, for without it the map cannot be read with confidence. The student is therefore rightly told not to ignore it.

The title and sheet number. The margin names the area covered and gives the sheet its number in the national series. This tells the reader what ground the map shows and how to order the next sheet. Without it one cannot be sure which area is in hand.

The scale. The scale is stated as a ratio and often drawn as a scale line as well. It allows distances and areas on the map to be turned into real ground measurements. No measurement can be made from the map without it.

The north points. The margin shows true north, magnetic north and grid north, with the angle between them. This lets the reader orient the map and convert between true and magnetic bearings. It is essential for use with a compass in the field.

The key or legend. The key explains the conventional signs and colours used on the map. Only through it can the reader tell a road from a railway or a marsh from a forest. The key is thus the dictionary of the map.

The grid reference system. The margin explains the grid and its numbering so that any point can be given a reference. This lets features be located and communicated exactly. It is the basis of finding and naming positions.

The date and edition. The margin gives the date of survey and the edition of the map. This warns the reader how up to date the information is likely to be. An old edition may no longer match the changed ground.

The contour interval and adjoining sheets. The margin states the vertical interval between contours and names the sheets that adjoin on each side. The first lets heights and slopes be read correctly, and the second lets the map be extended. Both help the reader work beyond a single sheet.

Taken together, the marginal information tells the reader what the map shows, how to measure and orient it, how to read its symbols and how current it is, so that the map can be used with full confidence. The student should therefore study the margin first, for it is the very instruction manual of the map.

Examiner's Note

The command is explain, so name the item and give its use; any six developed points earn full marks, with a clear introduction and conclusion.

Question 132

A map is a drawing of the earth's surface to scale, but maps are made in many kinds according to their purpose. Each type is designed to show certain information and to serve a certain need. The student in Arusha must learn to tell them apart.

Topographical maps. These show both the natural and human features of an area with relief marked by contours. They are used for detailed study of the land and for planning works upon it. They are the general-purpose maps of a country.

Atlas or general maps. Drawn to a small scale, these show large areas such as continents and countries. They are used for reference and teaching about the wider world. Their small scale means they show only the main features.

Thematic or distribution maps. These show the spread of one particular thing, such as rainfall, soils or population. They are used to study how that feature varies from place to place. A soil map in the library is of this kind.

Cadastral maps. Drawn to a large scale, these show the exact boundaries of land parcels and plots. They are used for land ownership, titling and taxation. They are the maps of the surveyor and the land office.

Political maps. These show countries, regions and their boundaries and capitals. They are used in administration and in the study of nations. They emphasise borders rather than physical detail.

Weather and climate maps. These show temperature, pressure, rainfall or winds over an area. They are used by forecasters and in the study of climate. They change from day to day as the weather changes.

Sketch maps. These are rough, not-to-scale maps that show the main features simply. They are used to give a quick idea of a place or a route. Their value is in speed and clearness rather than precision.

Because each kind of map is built for its own purpose, the reader must choose the type that fits the task, taking a topographical sheet to plan works, a distribution map to study a feature, and a cadastral map for land. Knowing the types and their uses, as the Arusha student is learning, is the first step to using maps well.

Examiner's Note

The command is explain, so name the type and give its use; any six developed points earn full marks, with a clear introduction and conclusion.

Question 133

The scale of a map is the ratio between a distance on the map and the same distance on the ground. It is the key that unlocks the map, for without it the map is only a picture. The student is therefore rightly told to look at it first.

It allows distance to be measured. The scale turns a distance measured on the map into the real distance on the ground. Without it no length read from the map has any meaning. This is the most basic use of the scale.

It allows area to be measured. From the scale the real area of a field, forest or lake can be worked out. Areas measured on the map are converted to ground areas. Planning of land depends on this.

It fixes the detail that can be shown. A large-scale map shows a small area in great detail, while a small-scale map shows much detail only roughly. The scale therefore decides how much can be drawn. The user must match the scale to the detail needed.

It fixes the area covered. On one sheet a small scale covers a wide area and a large scale only a little. The scale thus decides how much ground the map holds. The choice depends on whether breadth or detail is wanted.

It allows maps to be compared. Two maps drawn to the same scale can be laid side by side and compared directly. Different scales must first be reconciled. Comparison of areas and distances rests on knowing the scale.

It is the basis for enlargement and reduction. A map can be enlarged or reduced by changing its scale in a known ratio. The scale tells the mapmaker how much to change. This is how a map is redrawn to a new size.

It guides the choice of map. Knowing the scale, the user can choose the right map for the task, a large scale to plan a plot and a small scale to view a region. The purpose decides the scale required. Scale and purpose go together.

Because distance, area, detail and coverage all flow from it, the scale is truly the foundation on which the usefulness of a map rests. The student who reads the scale first, as advised, will know at once what the map can and cannot do, which is why scale is the first thing to look at on any map.

Examiner's Note

Refute the classmate by showing what depends on the scale; any six developed points earn full marks, with a clear introduction and conclusion.

Question 134

Conventional signs are the standard symbols, letters and colours by which features are shown on a map. They form a code that every map reader learns, and they are essential to how a map works. The beginner must learn them before the sheet will speak to him.

They save space. A small symbol can stand for a feature that it would be impossible to draw in full at the map's scale. A church, a well or a windmill is shown by a tiny sign. This lets a crowded landscape be shown on a small sheet.

They are standard and universal. The same signs are used on maps everywhere, so that any trained reader can read any map. A stranger to the area can still understand it. This common code is what makes maps widely useful.

They show many features clearly. By using distinct signs, a map can show roads, rivers, forests and buildings together without confusion. Each feature is told from the others at a glance. The map stays readable however much it holds.

They enable interpretation. By reading the signs the geographer works out the character of the land, its farming, settlement and routes. The signs are the vocabulary of that reading. Without them the landscape on the map is dumb.

They represent what cannot be drawn to scale. Small but important features, such as a single church or a boundary stone, are shown by a sign though far too small to draw true to size. The sign marks their position and kind. This records features a scale drawing would lose.

They are explained by a key. Each map carries a key that lists its signs and their meanings. The reader can always look up a sign he does not know. The key makes the code open to all.

They allow quick reading. Once learned, the signs let a reader take in the map rapidly. A glance shows where the roads, rivers and towns lie. This speed is vital when a map is used in the field.

Because they pack so much meaning into so little space in a form every reader can learn, conventional signs are what allow a small sheet of paper to carry a whole landscape. Once the beginner has learned the code and its key, the crowded sheet becomes a clear and readable map, which is why the signs matter so much.

Examiner's Note

The command is evaluate, so give the point and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 135

A grid reference system is the network of numbered squares drawn over a map by which any point can be given an exact reference. It turns a sheet of detail into a means of pinpointing places. The rescue team's quick find shows just how useful it is.

It locates any point exactly. By its reference a feature can be found on the map with no doubt or searching. A six-figure reference fixes a point to within a hundred metres. This exactness is the chief value of the grid.

It allows position to be communicated. A reference such as 384667 can be passed by radio or letter and understood by anyone with the map. The rescue team was guided to the very spot in this way. The grid gives places a common address.

It removes ambiguity. Places that share a name, or have no name at all, are still told apart by their references. There is no confusion over which is meant. The grid speaks where names fail.

It aids measurement. Because the grid lines are a known distance apart, distances and areas can be worked out from the squares. The grid is thus a ready scale across the map. Measurement leans on it constantly.

It helps in navigation. A traveller can fix a present position and a destination by their references and set a course between them. The grid underlies movement across the ground. It is essential to finding one's way with map and compass.

It ties the map to the ground. The same grid is marked on the ground by survey, so a map reference matches a real position. Map and land are locked together by the grid. This is what makes the reference trustworthy.

It is standard and universal. The grid is drawn and numbered by a fixed rule that every reader learns. Any trained user can give and read references on any sheet. This common system makes the grid widely useful.

Because it fixes, communicates and measures position without ambiguity, the grid reference system is what turns a map from a picture into a precise instrument of location. The rescue team's swift find is the plain proof of its worth, which is why every topographical map is drawn upon a grid.

Examiner's Note

The command is assess, so give the use and its value; any six developed points earn full marks, with a clear introduction and conclusion.

Question 136

Measuring distance is one of the commonest tasks done with a map, and there are several ways to do it according to whether the line is straight or curved. Each method has its place, and the student must choose the right one for each measurement. The straight and the winding line call for different tools.

A straight edge for straight lines. For a straight distance a ruler or the straight edge of a paper is laid between the two points. The length is read and then turned into ground distance by the scale. This is the simplest method for a straight line.

A pair of dividers. Dividers are opened to the two points and the distance is carried to the scale line to be read. They are quick and neat for straight distances. Set to a small span, they can also step along a gently curved line.

A piece of thread for curves. For a winding road or river a thread is laid carefully along the curve, then lifted, straightened against the scale and read. This follows the bends that a ruler cannot. It is the usual way to measure a winding line, such as the road the student faces.

Stepping with dividers. A curved line may also be measured by walking a pair of dividers, set to a small span, along it in short steps. The number of steps multiplied by the span gives the length. This suits a line of gentle curves.

The opisometer. An opisometer, or map measurer, is a small wheel run along the line whose turning records the distance. It measures curved lines quickly. Where one is available it saves much trouble on a winding route.

Using the scale line. Whatever tool is used, the measured length is turned into real distance by laying it against the map's scale line or applying the representative fraction. The scale is the final step in every method. Without it the measurement has no meaning.

Using the grid. Because the grid lines are a known distance apart, a rough distance can be judged by counting the squares a line crosses. This gives a quick estimate. It is useful as a check on the other methods.

For the straight distance the student may use a ruler or dividers, and for the winding road a thread or an opisometer, turning each measured length into ground distance by the scale. Knowing these methods and when to use each, the student can measure any line on the map, whether it runs straight or bends.

Examiner's Note

The command is explain, so give the method and say what line it suits; any six developed points earn full marks, with a clear introduction and conclusion.

Question 137

Maps are described as large-scale or small-scale according to the size of the representative fraction they use. A large-scale map has a large fraction and a small-scale map a small one, and the two differ in what they can show. The town plan and the map of Africa are the two extremes.

The area covered differs. A large-scale map shows only a small area, such as a single town, on its sheet. A small-scale map shows a large area, such as a whole continent, on the same sheet. The smaller the scale, the greater the ground covered.

The detail shown differs. A large-scale map shows much detail, down to single buildings and streets. A small-scale map shows only the main features, such as large towns and rivers. Detail is lost as the scale grows smaller.

The size of features differs. On a large-scale map features are drawn large and clear. On a small-scale map the same features are small or reduced to symbols. A town that fills the large-scale sheet is a mere dot on the small-scale one.

Their accuracy of measurement differs. Distances and areas can be measured closely from a large-scale map. On a small-scale map the same measurements are only rough. Fine measurement needs a large scale.

Their uses differ. A large-scale map suits the detailed planning of a small area, such as laying out a town. A small-scale map suits a broad view of a region or continent. Each is chosen for the task that fits it.

Their representative fractions differ. A large-scale map has a large fraction, such as one to fifty thousand. A small-scale map has a small fraction, such as one to several million. The fraction itself tells which kind a map is.

Their examples differ. The street plan of the town is a large-scale map, while the map of Africa is a small-scale one. The student sees the two side by side. Each example shows the scale matched to its purpose.

In short, a large-scale map shows a small area in great detail while a small-scale map shows a large area in little, so that the two differ in coverage, detail and use. The student is right to see that the town plan and the map of Africa serve different needs, each being drawn to the scale its purpose demands.

Examiner's Note

The command is account for, so bring out each contrast on both kinds; any six developed points earn full marks, with a clear introduction and conclusion.

Question 138

A topographical map shows the natural and human features of an area drawn to scale, and packs a wealth of information into one sheet. A reader who knows how to use it can learn much about a place without visiting it. The officer new to Njombe can read his district from the map.

The relief of the land. From the contours and spot heights the reader learns the shape, height and steepness of the land. Hills, valleys and plains are all revealed. This tells the officer where the ground is high or low, gentle or steep.

The drainage. The rivers, lakes and swamps drawn on the map show how the area is watered and how the water flows. The pattern of the streams reveals the run of the land. Water supply and flood risk can both be judged from it.

The settlement. The towns, villages and scattered houses show where and how thickly people live. The reader sees the pattern of settlement across the district. This guides the planning of services.

The communications. Roads, railways and tracks show how the area is linked and how one may travel through it. The network of routes is read at a glance. This tells the officer how places connect.

The land use and vegetation. Forests, farmland, plantations and grazing are shown by their signs. The reader learns how the land is used and clothed. This bears on farming and on the economy of the district.

The position of features. By the grid any feature can be given an exact reference and its distance and direction from another found. Position, distance and bearing are all read from the map. This lets places be located and measured precisely.

Boundaries and administration. The map marks administrative boundaries and the names of places. The reader sees how the district is divided and named. This is essential to the officer's work of administration.

Relief, drainage, settlement, routes, land use and exact position can all be read from the topographical sheet, so that it serves almost as the district itself laid out on paper. The officer new to Njombe is therefore rightly told to study it, for the map will teach him his district before ever he walks it.

Examiner's Note

Show by the information the map yields; any six developed points earn full marks, with a clear introduction and conclusion.

Question 139

Direction is one of the things a map must convey, so that a reader can orient himself and travel the right way. There are several ways in which direction is shown on a map and found from it. The traveller must understand them to set his course.

The north points. The margin of the map shows true north, magnetic north and grid north, with the angles between them. These fix the directions on the sheet. From them all other directions are reckoned.

The grid lines. The grid lines run north to south and east to west across the map. They give a ready framework of direction. A feature can be said to lie north or east of another by the grid.

Bearings. A bearing is the angle, measured clockwise from north, of one point from another. It states direction exactly in degrees. Bearings are the precise way of giving direction on a map.

The compass. Laid on the map, the magnetic compass shows the direction of magnetic north, and so lets the map be oriented to the ground. The traveller uses it to face the map the right way. Map and compass together give direction in the field.

The magnetic declination. Because magnetic north differs from true north, the map states the declination so that a bearing may be converted between the two. This keeps compass and map in agreement. Direction found on the map is thus made true on the ground.

Orienting the map. The map is turned until its north matches north on the ground, whether by compass or by lining up features. It then lies parallel to the country. Directions on it then agree with directions before the eye.

Named features and coasts. The run of a coast, a range or a river, once known, also helps the reader judge direction roughly. These give a general sense of the lie of the land. They support the exact methods with a rough check.

Through the north points, the grid, bearings and the compass, direction is both shown on a map and found from it, and by allowing for declination the two are kept true. The traveller who masters these ways can always set his course, for a map without direction would be of little use to one who must travel by it.

Examiner's Note

The command is explain, so give the way and how it serves; any six developed points earn full marks, with a clear introduction and conclusion.

Question 140

A sketch map is a rough map drawn freehand, not to exact scale, to show the main features of a place. Simple and quick, it has many uses in geography, especially in the field. The geographer recording the village finds it just the tool he needs.

It records features quickly. A sketch map is drawn rapidly on the spot, catching the layout before it is forgotten. Speed is its first virtue. In the field, where time is short, this is a great advantage.

It needs no instruments. A sketch map is made freehand with only pencil and paper. No costly drawing instruments are required. This makes it available anywhere, even in rough country.

It shows a route. A sketch map is well suited to showing the way from one place to another, marking the roads and turnings. A traveller can follow it easily. This is one of its commonest uses.

It illustrates a description. A sketch map placed beside written work makes a description clear at a glance. Words are hard to follow without it. The sketch turns description into a picture.

It summarises the main features. By leaving out the lesser detail, a sketch map brings out the important features boldly. The main pattern is seen clearly. This is useful for teaching and for reports.

It aids fieldwork. In the field the geographer sketches the ground to record what he sees for later study. The sketch is his field note in map form. Much fieldwork depends on such sketches.

It plans a fuller map. A sketch may serve as the rough first draft from which an accurate map is later drawn. It fixes the plan before the careful work. It is thus a step towards the finished map.

Quick, needing no instruments and clear in its main features, the sketch map is a handy tool for recording, illustrating and planning in geography. The geographer in the field is therefore right to use one, for where speed and simplicity matter more than exact scale the sketch map serves best.

Examiner's Note

The command is discuss, so give the use and its value; any six developed points earn full marks, with a clear introduction and conclusion.

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