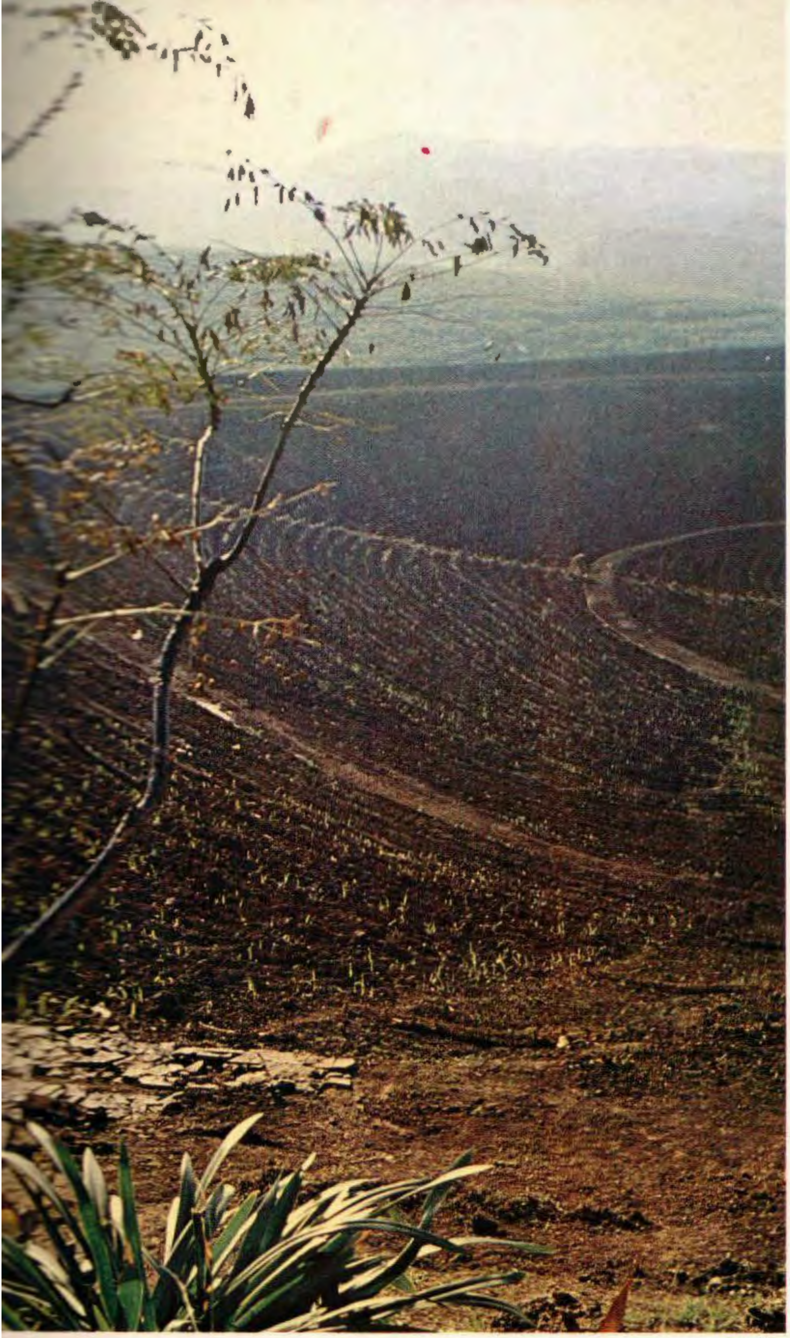


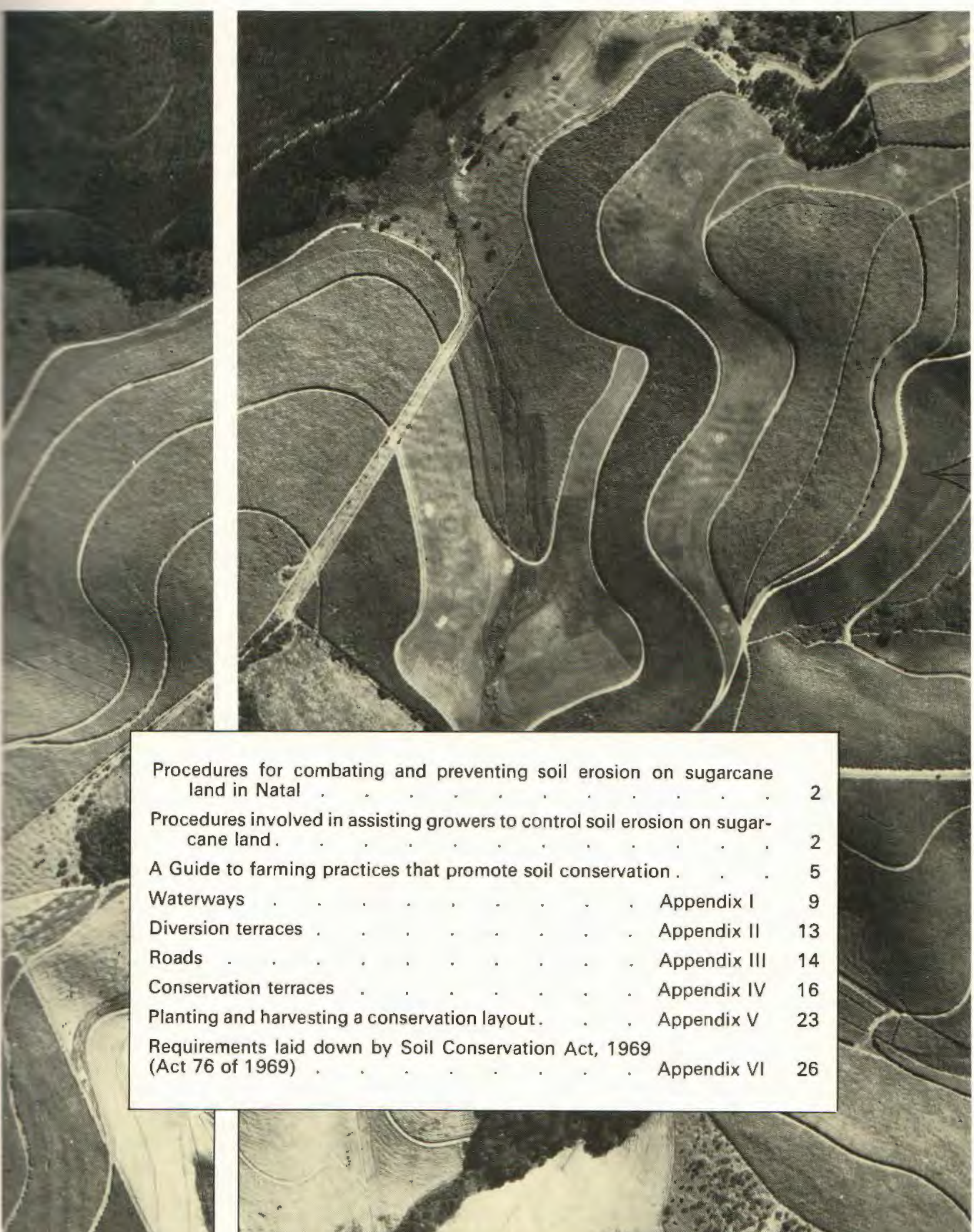
SOIL CONSERVATION

A guide to farming practices in the sugarcane industry

BULLETIN No. 20 NOVEMBER 1974

The Experiment Station of the South African Sugar Association

Contents



Procedures for combating and preventing soil erosion on sugarcane land in Natal

The South African Sugar Association and the Department of Agricultural Technical Services have reached agreement on procedures by which technical services for combating and preventing soil erosion on sugarcane lands in Natal are to be provided to cane growers.

Respective responsibilities

1 In terms of the Soil Conservation Act 1969 (Act 76 of 1969) each owner or occupier of land is responsible for observing the general provisions of the Act.

2 In the coastal areas where only sugarcane is grown, responsibility for technical planning, and the provision of plans and specifications, has been vested in the Experiment Station of the South African Sugar Association. Cane growers applying to the Department of Agricultural Technical Services will, in the first instance, be referred to the South African Sugar Association Experiment Station.

3 In areas where sugarcane forms only part of a mixed farming enterprise, as is the case in the Natal midlands, the Department of Agricultural Technical Services and the South African Sugar Association Experiment Station will jointly be responsible for providing these services. The choice of which organization he approaches is left to the individual cane grower.

4 Where State subsidies for anti-erosion works are sought, the Department of Agricultural Technical Services shall be the sole authority, and this is also the case where action is required on the part of the Division of Soil Protection of the Department of the Agricultural Technical Services.

5 In all the areas under their jurisdiction, Soil Conservation Committee members will retain the responsibilities prescribed in their terms of appointment, namely:

"A soil conservation committee shall, within the area in respect of which it has been established —

(*a*) advise the Minister, owner or occupier of land on all matters relating to soil conservation; and

(*b*) perform such other duties as the Minister may assign to it."

6 It is the responsibility of the owner or occupier to obtain, through his local Soil Conservation Committee, the approval of the Department of Agricultural Technical Services for the ploughing or cultivation of new land, or land not normally under cultivation, prior to the commencement of such operations.

Procedures involved in assisting growers to control soil erosion on sugarcane land

How to obtain assistance

1 A grower should first consult his S.A. Sugar Association extension officer and discuss his needs with him.

2 Any relevant information which the grower may be able to provide, including quota number, a map of the farm or an aerial photograph, especially in the case of new growers or new quota areas, should be brought to the attention of the extension officer.

3 Delays may be avoided by asking for assistance long before undertaking field work. This is necessary as a quite lengthy procedure is involved in formulating advice.

The formulation of advice

The initial development plan (I.D.P.)

1 During discussions with the grower, the *extension officer* will obtain full particulars of his needs and will then submit an official request for an I.D.P. to the Specialist Advisory Service at the Experiment Station.

2 The *Specialist Advisory Service* will process the request and refer it to the Land and Water Management Department for production of the I.D.P.

3 The *Land and Water Management Department* will identify the farm boundaries on a contact print of the relevant aerial photograph, order an enlargement to a scale of 1 : 6 000 from the air survey company concerned, mount this enlargement on a stiff backing, and submit it to a contractor for stereo interpretation and the provision of topographical data. The photograph is received from the contractor together with a transparent overlay showing all well-defined crests and valleys, as well as form or contour lines at vertical intervals of 5, 10, or 20 metres depending on the degree of slope. A further transparent overlay is then prepared showing the disposition of soil groups, and a blank transparency is added for the grower to use in planning. The whole plan is mounted, complete with cover, and returned to the Specialist Advisory Service for dispatch to the extension officer.

4 On receipt of the completed I.D.P. the *extension officer* will take it to the grower and use it as a basis for discussion about development planning. The grower can then re-plan his farm at his leisure. Using the I.D.P. he can, if he decides that a particular field needs urgent attention, plan changes which can be fitted into the eventual overall plan for the farm.

5 Should the *extension officer* feel that the services of the specialist advisory staff of the *Land and Water Management Department* are required at this or any other stage he will submit an official request for these.

The Land Use Plan (L.U.P.)

In discussing the I.D.P., the grower and extension officer may come to the conclusion that a comprehensive land use plan is required for the farm. In this event:

1 The *extension officer* will submit an official request for a L.U.P. through the Specialist Advisory Service to the *Land and Water Management Department.*

2 Specialists from the *Land and Water Management Department* will accompany the *extension officer* to the farm and, in consultation with the grower, assess the requirements and implications of a L.U.P.

3 The *Land and Water Management Department* will draw up a proposed comprehensive L.U.P. which will contain a complete farm diagram as well as full details of, and specifications for, areas where operations can be completely mechanized, waterways, diversion terraces, in-field structures, cropping procedures, farm roads, and fire protection.

4 Specialists from the *Land and Water Management Department* and the *extension officer* will present the L.U.P. to the grower, go over the farm with him and point out the salient features of the plan and how they immediately affect farming operations. Should the grower ask them to set out the main framework of the plan for him, this too, can be done.
Fields that are ready for immediate treatment can also be laid out as a demonstration.

5 As implementation of the plan is phased over a period of years the *extension officer* could be called upon by the grower to assist him over several seasons. Should the *extension officer* require the assistance of the *Land and Water Management Department* this would be made available.

6 Follow up visits by the *extension officer* are undertaken at the grower's request, and specialists from the *Land and Water Management Department* will visit the site when asked to do so by the *extension officer.*

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Centre: Initial development plan

Fig. 1 Surveying

Fig. 2 Building a conservation terrace

Fig. 3 Grassed waterway with checks

Fig. 4 Conservation layout

Fig. 5 Laying drain pipes

Fig. 6 Master line planting

Fig. 7 Strip cropping

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A guide to farming practices that promote soil conservation in the sugarcane industry

INTRODUCTION

Sugarcane is a perennial, deep-rooted, stool forming grass which has excellent soil and water conserving characteristics. These attributes are further enhanced by the management practices normally applied in the commercial production of cane, despite the fact that it is cultivated as a row-crop. It can in fact be considered to be equivalent to a long-term grass ley crop or a perennial fodder crop in terms of paras 2 and 4 of Annexure to the General Provisions of the Soil Conservation Act, 1969 (Appendix VI).

RECOMMEN-DATIONS

Terminology: *"Resource Conservation Glossary". Revised edition* 1970. *Published by the Soil Conservation Society of America.*

Whole farm plan

1 The first step is to obtain an Initial Development Plan (I.D.P.) through the local Extension Officer of the South African Sugar Association. This is a planning map based on an aerial photograph of the farm, enlarged to a scale of 1 : 6 000, so that it conforms with existing farm quota maps. A photograph costs about R4 for a 200 ha farm.

2 The I.D.P., which forms the basis for a comprehensive land use plan, should be discussed with the Extension Officer. The objective is to establish a framework for future development and management of the farm. During this discussion, requirements for total mechanization should receive particular attention.

3 The next step is to ask the Extension Officer for a Land Use Plan (L.U.P.) to be drawn up by specialist advisory staff of the S.A. Sugar Association Experiment Station. This plan would contain details and specifications with regard to:

(*a*) areas suitable for total mechanization

(*b*) waterways

(*c*) diversion terraces

(*d*) in-field structures

(*e*) cropping strips

(*f*) roads, and

(*g*) fire protection

The implementation of the plan is phased over a period of time to suit the grower's planting programme. Additional advice and assistance is always available from extension staff.

Waterways

1 Waterways should, where possible, be sited along the lowest lines of selected natural depressions.

2 If suitable natural depressions do not exist, artificial waterways may be constructed, to meet the requirements of the particular situation.

3 Specifications should ensure hydraulic stability.

4 Vegetated waterways should be planted to such suitable grasses as *Stenotaphrum secondatum* (coastal couch grass, buffalo grass), *Cynodon dactylon* (couch, ngwengwe), *Paspalum notatum* (Bahia grass), *P. urvillii* (Vasey grass) and the sedge, *Cyperus immensus* (sometimes called Kwane grass). They must be hydraulically stable before being put to use.

5 Vegetated waterways should be kept fertilized, mown and free from silt and debris. They should never be used as roads or paths.

6 Various types of waterway and their methods of construction are illustrated in Appendix I (pages 9—12).

Diversion terraces

1 Diversion terraces should be provided above all fields situated below such unconserved land as open veld, bush, hill tops, homestead areas or compounds. They should be properly designed and constructed.

2 Diversion terraces should discharge into the nearest planned waterway or other suitable disposal point.

3 Diversion terraces should be kept free from silt, weeds and debris. A suitable grass lining, closely mown at all times, is acceptable. They should never be used for any kind of traffic.

4 A typical cross section for a diversion terrace and suggested methods of construction can be found in Appendix II (page 13).

Farm roads

1 Adequate steps must be taken to cater for road drainage within the overall conservation plan for the farm.

2 Farm roads, other than those listed in 3 below, should follow crest lines and/or conservation terraces.

3 Steep diagonal roads, boundary roads, and cut-off or slope-break roads can be sited wherever they are needed to ensure that rational use is made of land.

4 Particular attention should be paid to the protection and drainage of roads listed under 3 above.

5 Channels of terraced roads should be kept free from silt and debris. They should be checked for line, level, grade, and cross section, especially during the first two seasons.

6 Crest road camber should be maintained at all times, and mitre drains should be constructed where wash can be expected between conservation terraces.

7 Examples and constructional details of some farm roads are given in Appendix III (pages 14 and 15).

Conservation terraces

1 Land on which erosion is likely to occur because of slope and/or soil characteristics, other than short run slopes in and adjacent to valley bottoms, should be protected by conservation terraces.

2 Conservation terraces are normally designed to convey surplus water from selected crestlines to selected waterways.

3 Spacing is influenced by slope, soil, and management practices.

4 The terraces should have variable accelerating gradients.

5 Terraces should be kept free from silt and debris and should be checked for line, level, grade and cross section, especially during the first two seasons.

6 Design criteria, and construction and maintenance details are given in Appendix IV (pages 16—22).

Row alignment

1 On slopes greater than 2%, other than short run slopes in and adjacent to valley bottoms, row alignment should be normal to the slope. To ensure free drainage for each furrow these should, ideally, be established by the masterline technique.

2 Ridge planting rather than furrow planting improves surface water management by providing an unobstructed furrow and at the same time facilitates in-field mechanization along the rows.

3 If, in the interests of mechanization, ridge and furrow cultivation is not practised, yet to eliminate short lines it is necessary to grow cane over conservation terraces, then specific advice on management should be obtained from the extension officer.

4 See Appendix V for further particulars (pages 23 and 25).

Strip planting and harvesting

1 Strip planting and harvesting across the slope should, where practicable, be employed on all steep land other than short run slopes in, and adjacent to, valley bottoms.

2 The width of strips, normal to the contour, should not exceed the limits for adequate soil protection and alternate strips should bear crops with an age difference of not less than three months.

3 If strip planting and harvesting are not practised, the standards for dimensions and location of conservation terraces should be adjusted appropriately.

4 See Appendix V for further particulars.

Fire protection

1 Requirements for fire protection are laid down by fire insurance companies.

2 Waterways and roads can be used as strategic firebreaks.

Trashing

Trash mulching is recommended wherever it is practicable, and unnecessary burning of cane which is to be ratooned should be avoided.

Irrigation

1 Irrigation should be practised only if drainage is adequate.

2 **Soil limitations in areas where irrigation is to be developed**

(*a*) Surface irrigation should not be used on soils less than 40 cm deep, if these are underlain by an impervious layer. These soils should be irrigated only by adequately designed overhead systems.

(*b*) Surface irrigation can be used on soils more than 40 cm deep, provided there are no other limitations, and the scheme has been properly designed and laid out.

3 **Slope limitations in areas where irrigation is to be developed**

(*a*) There is no slope limitation for overhead systems of irrigation.

(*b*) On slopes of over 6%, surface irrigation should not be used.

(*c*) On slopes between 4% and 6%, surface irrigation may be used, provided the conveyance and distribution methods are suitable, and there are no other limitations.

(*d*) On slopes up to 4% there are no restrictions to the form of irrigation.

4 All irrigation schemes should comply with the requirements of the Act.

Salinity/ sodicity

1 Soils with electrical conductivity levels of 2,0 millimhos/cm or more, should be drained to ensure that adequate leaching is achieved.

2 Water should not be used for irrigation if its average conductivity level exceeds 1,2 millimhos/cm.

3 Soil infiltration rates and permeability are normally reduced where the exchangeable sodium percentage (E.S.P.) of soil exceeds 15 in sands, 10 in loams and kaolinitic clays, and 5 in montmorillonitic clays (mainly black clays).

To displace excess sodium, ameliorants such as gypsum or sulphur should be applied. The resultant improvement in permeability permits effective leaching of salts.

4 Where a salinity hazard exists, adequate steps should be taken to prevent seepage and waterlogging from water storage and conveyance facilities. Furthermore, the application of irrigation water should be effectively controlled to prevent waste.

5 Where soil infiltration rates are too poor to permit effective leaching of salts, suitable ameliorants should be used to assist with reclamation.

Drainage

1 Sub-surface drainage should be provided:

(*a*) where, on cropped land, natural drainage is incapable of maintaining a uniformly and adequately low water table, and/or providing adequate leaching for rain grown cane.

(*b*) where irrigation induces the same conditions as in (*a*).

(*c*) where electrical conductivity (E.C.) is 2,5 or more or, exchangeable sodium percentage (E.S.P.) greater than 15 in sands, 10 in loams or kaolinitic clays and 5 in montmorillonitic clays.

2 Field drainage schemes should be approved by the South African Sugar Association Experiment Station at the planning stage, if D.A.T.S. subsidy is to be applied for.

Management

1 Divide the sugarcane land into 'production potential' categories, e.g. dry hilltop areas, well-drained hill slopes, and moist valley bottoms. Particular attention should be paid to areas which readily meet requirements for total mechanization.

2 Wherever possible, change existing field configuration to improve surface water management and facilitate total mechanization.

3 Improve land surface treatment to obtain a smooth even surface, high quality seedbed and as an aid to mechanical operations. Where soil conditions permit, the use of a landplane and/or blade terracer is recommended.

4 Introduce strip cropping on those hillsides where it is both practicable and consistent with the efficient utilization of machines.

5 Incorporate a fire control system in the basic reorganization of land as shown in a land use plan.

6 Institute and follow a purposeful maintenance programme on all structures, equipment, machines, installations, and treatments to ensure reliable and efficient operation.

7 Where irrigation is practised, an adequate form of scheduling should be followed to avoid over-irrigation which, in areas of limited drainage could cause salinization of soils. Extension officers should be consulted in this regard.

8 A careful check on the salinity levels of soils and irrigation water should be maintained at all times. Samples for analysis may be submitted to the Experiment Station through extension officers.

9 Efficient operation of drainage schemes should be ensured by regular inspection and cleaning of drains.

Conservation layout ▶

Waterways

Function

Waterways are hydraulically stable structures, protected either by vegetation or more durable material, and designed to safely convey the discharge from stormwater drains and run-off from in-field areas to natural streams and rivers.

Types of waterway

The type of waterway used will depend on the following:

1 **Topography.** A large, uniform sloping area, may, especially if it is steep, discharge into a single waterway which, if it were to be grassed, would be so wide that it would not be acceptable to a grower. In these circumstances, or in intensely undulating terrain with closely spaced natural depressions, low capacity piped underground waterways might be favoured.

2 **Soil type.** The erodibility of soils influences the dimensions of vegetated waterways, and thereby their acceptability. Heaving clays may preclude the use of concrete linings.

3 **Mechanized operations.** Rising costs and the diminishing supply of labour justifies greater mechanization. In these circumstances the benefits derived from long, uninterrupted crop rows may outweigh the extra cost of constructing underground waterways.

4 **Relative land values.** High land values could encourage the adoption of expensive and sophisticated management practices including special types of waterways designed to take up a minimum of crop land.

In most cases, the final choice will be a compromise between these considerations.

The following types of waterway can be recommended for use in the sugar industry.

Grassed waterways

Grassed waterways may be either parabolic (Fig. 1) or trapezoidal (Fig. 2) in shape. They must be hydraulically stable and capable of carrying expected flood waters from the catchment area they serve.

Fig. 1 Typical parabolic cross section

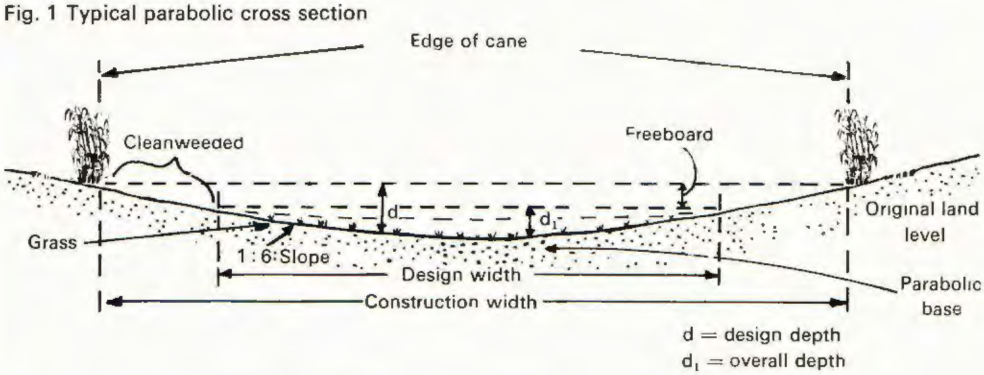
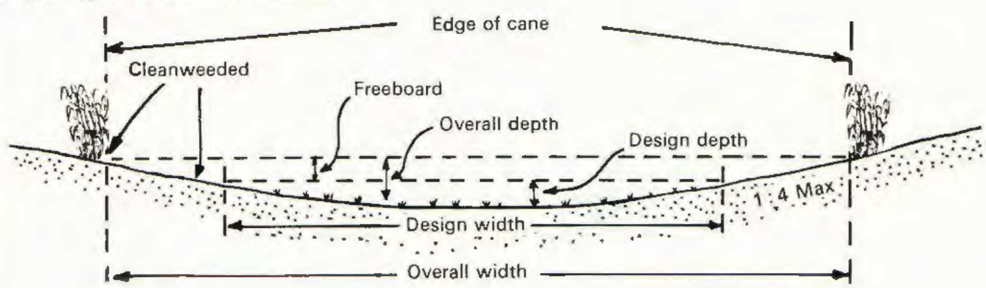
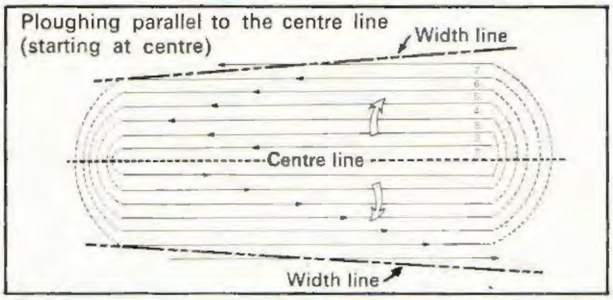


Fig. 2 Typical trapezoidal cross section





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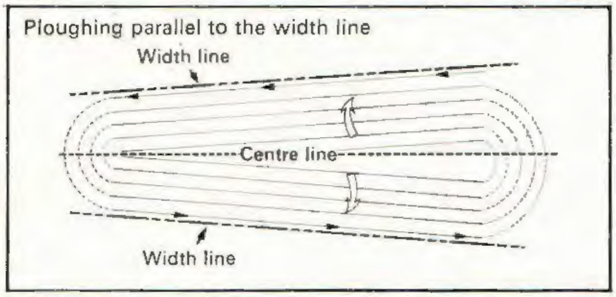

Fig. 3 Diagrammatic representation of ploughing patterns for construction of a waterway

Fig. 4 Constructing a waterway with a bulldozer

Fig. 5 Temporary protection of waterways while the grass cover is being established

Fig. 6 Grass runner pegged into the ground with a forked stick

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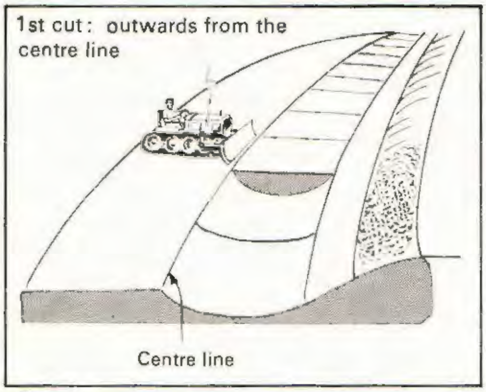

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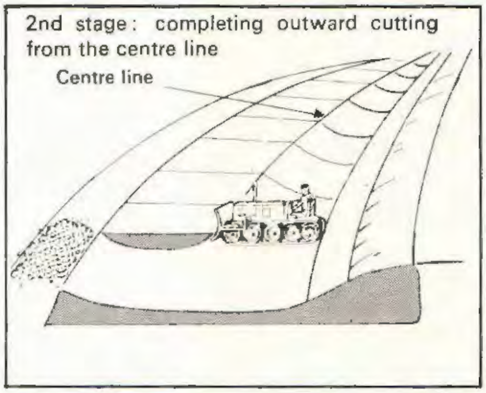

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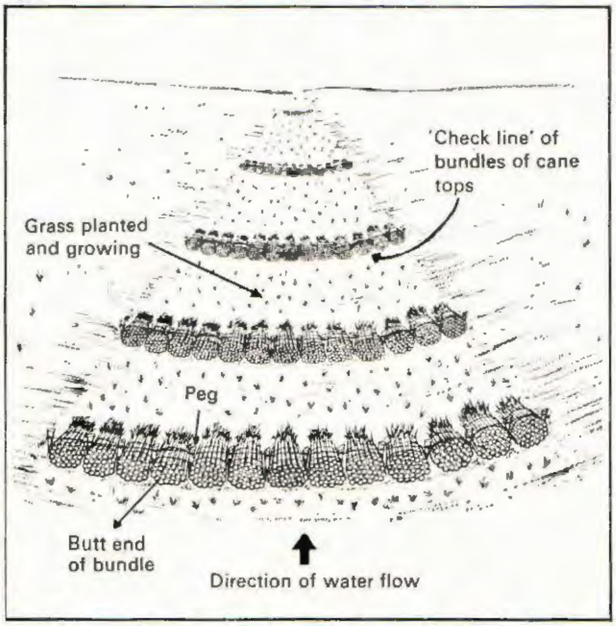

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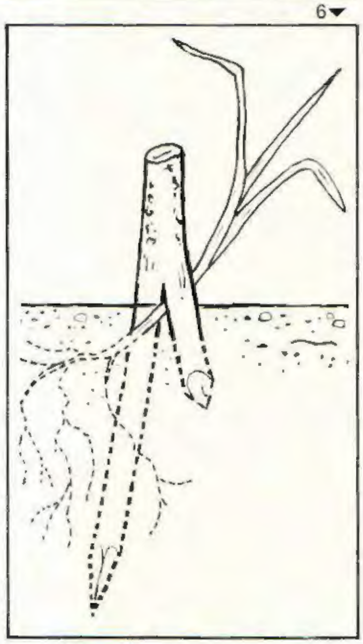


Construction. Position the centre line pegs by pegging a level line across the proposed waterway, the pegs being not more than 5 metres apart. The up-slope apex of this line will indicate the lowest point. Continue this procedure for the full length of the waterway, spacing the lines at regular intervals down the slope. Small deviations in the centre line can be corrected to obtain a smoother line. The specified width pegs are now located opposite each centre line peg.

Using a plough or one-way disc harrow, start ploughing at the bottom end of the centre line, going up the slope, 1 metre to the right of the line (see Fig. 3a). Turn at the top end and plough down the slope, again 1 metre to the right of the line. Make a shallow cut, moving in a high gear to fling the soil as far to the right as possible on both passes. On the second pass straddle the soil from the first pass, ploughing as before but penetrating the unploughed soil underneath, moving it further to the right. Repeat for the third pass and all subsequent passes until the width line is reached. As the waterway widens from top to bottom, the plough should be lifted at this width line. Repeat the process until the requisite depth has been achieved. Now plough out the centre strip, which is approximately 2 metres wide, to fill in the plough furrows and smooth out into the adjoining field area the banks formed at the outer extremities of the waterway. Depth measurement must not be taken from these banks before smoothing. An alternative method is illustrated in Fig. 3b where ploughing starts at the bottom end of the right hand width line and is continued down the left hand width line, ploughing in the normal way. When the centre line is reached the plough must be lifted and the tractor turned in the ploughed area. When the whole area has been ploughed the procedure is repeated until the requisite depth below the flattened banks is achieved. This method creates a V-shaped channel along the centre line and it should be reshaped to a parabolic section.

Where a large quantity of water is to be carried, a trapezoidal cross-section may be preferred (Fig. 2). This can be obtained by shaping with a blade terracer or road grader following ploughing.

Where slopes are too steep for a tractor and plough to negotiate up-and-down, a bulldozer may be used to construct the waterway, cutting outwards from the centre line across the slope (Fig. 4).

Ideally, grassed waterways should be established a full season before they are to receive the discharge from conservation structures — the best time being in a freshly cut ratoon, one crop before ploughout. This, however, is not always possible and then some way of protecting the 'raw' waterway becomes necessary. Checks, consisting of bundles of cane tops fastened in rows across the waterway with their butts facing upslope are very effective (Fig. 5). Flow is retarded without being dammed, water flowing over the leaves on the down stream side. Each bundle is conveniently secured in place by wooden pegs driven through them into the ground. The check should not be of a permanent nature as maintenance of the stabilised waterway involves mowing. Directly a waterway has been shaped it should be planted with a suitable grass or sodded with strips of grass. The objective is to produce a good grass cover before the summer storms. A useful technique is to peg grass runners into the ground with forked sticks (Fig. 6).

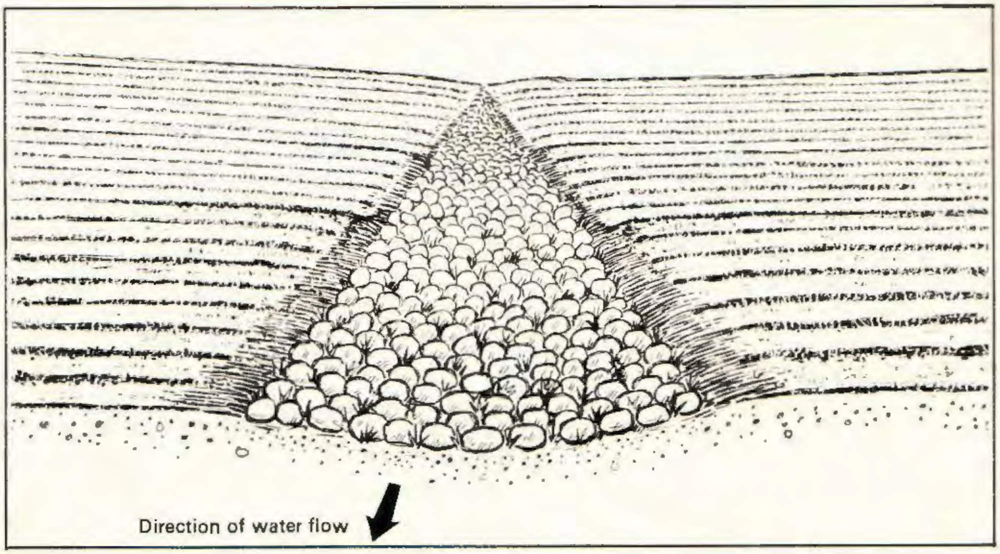
Lined waterways

These are used where grassed waterways would be unsuitable or unacceptable due to excessive slope, where soils are highly erodible, where there is a need to maintain the maximum possible area in crop production, or where open drains create an obstruction or inconvenience to mechanized operations. Various materials and construction methods have been employed, but only such permanent linings as hard stone with grass between, or concrete, are recommended, or in the case of underground pipes, plastic, pitch fibre and concrete.

As considerations for total mechanization are of paramount importance, open, lined in-field channels are not normally recommended. A stone-lined and grassed waterway which can be traversed by machines is illustrated in Fig. 7 overleaf.

An underground waterway of concrete pipes with an entry which permits flow from an in-field terrace is illustrated in Fig. 8. It would be used for major waterways, and spaced so that the inlet structures do not impede or interrupt the runs of harvesting machines or other forms of equipment.

Fig. 7 A stone-lined waterway with grass growing between the stones



The use of underground drain pipes as waterways and as outlets for retention bays in parallel and straightened broadbased or bench terraces is illustrated in Fig. 9. Their advantage lies in preventing concentration of run-off between terraces, eliminating obstructions to machine traffic, and promoting smooth, even, straight terraces.

Fig. 8 Major underground waterway constructed from concrete pipes

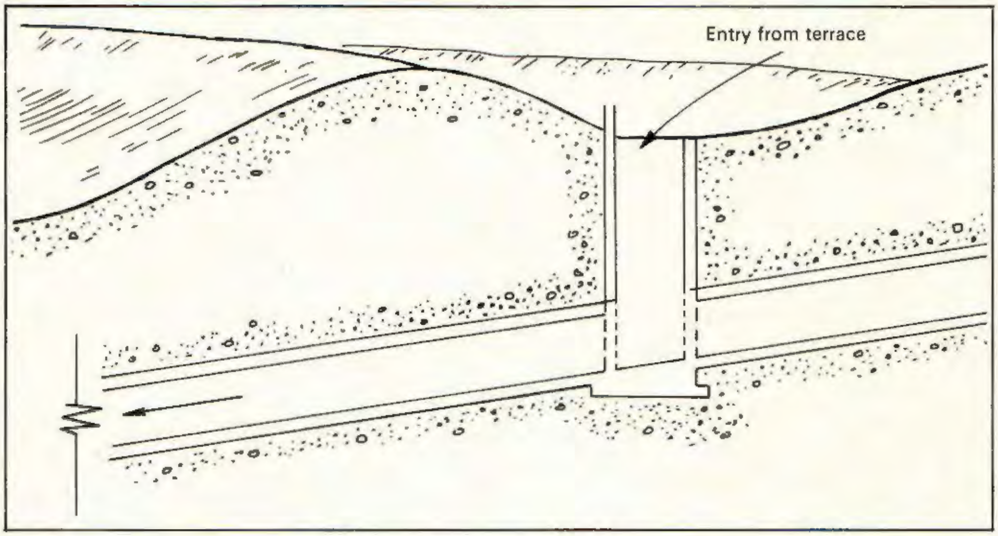
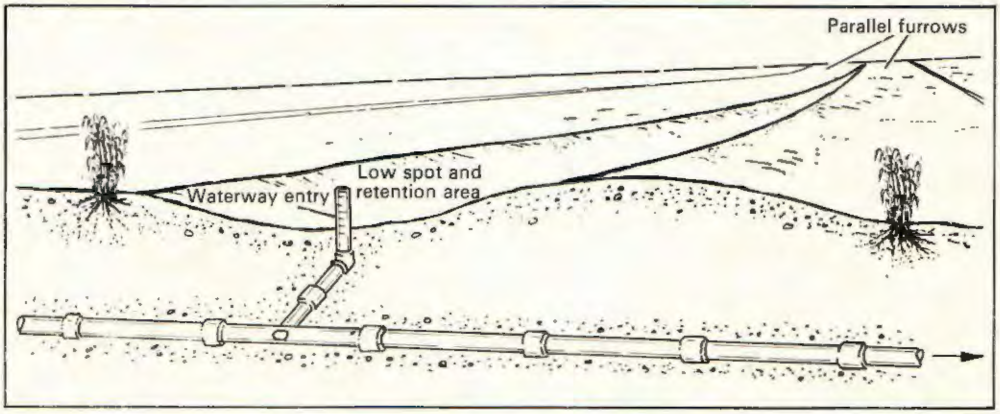


Fig. 9 Underground piped waterway used to conduct water from retention bays in a system of parallel bench terraces



Diversion terraces

Function

Diversion terraces are constructed along the up-slope edges of cultivated land to trap run-off water from areas unprotected by conservation structures. These include hill slopes under bush or used for grazing, and homestead and compound areas. High volumes of run-off can be expected from these areas, especially if they are large or the vegetative cover poor. The water caught in these terraces is conveyed safely to planned waterways, natural watercourses, or other suitable terrain.

Design

Diversion terraces are usually bare or grassed earthen canals, flanked along their lower edges by earthen embankments which should preferably be grassed over. As large volumes of water have to be conveyed, the accent is more on adequate flow space in the canal than on the cross section of the embankment, which can be fairly narrow and steep as it does not have to be traversed by machines.

Construction and maintenance

The easiest way to construct diversion terraces is by road grader or, on steep slopes by using an angled bulldozer blade. The procedures are described in Appendix IV "Construction of conservation terraces using a blade terracer".

As the cultivated area below the diversion terrace relies for its protection entirely on the interception and efficient conveyance of floodwater by the terrace, this functional efficiency must be maintained. Therefore:

(*a*) The terrace channel must be kept free from silt, stones and debris.

(*b*) Grass, where it is grown in the terrace channels must be kept mown short at all times.

(*c*) Embankments should be inspected regularly for signs of settling, erosion or undercutting, and damage must be repaired immediately.

Fig. 1 Cross section of a typical diversion terrace

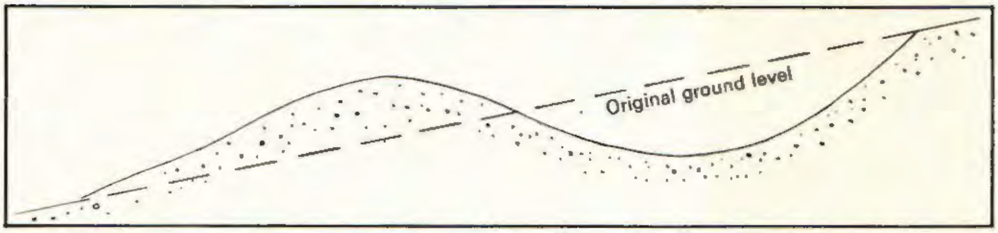
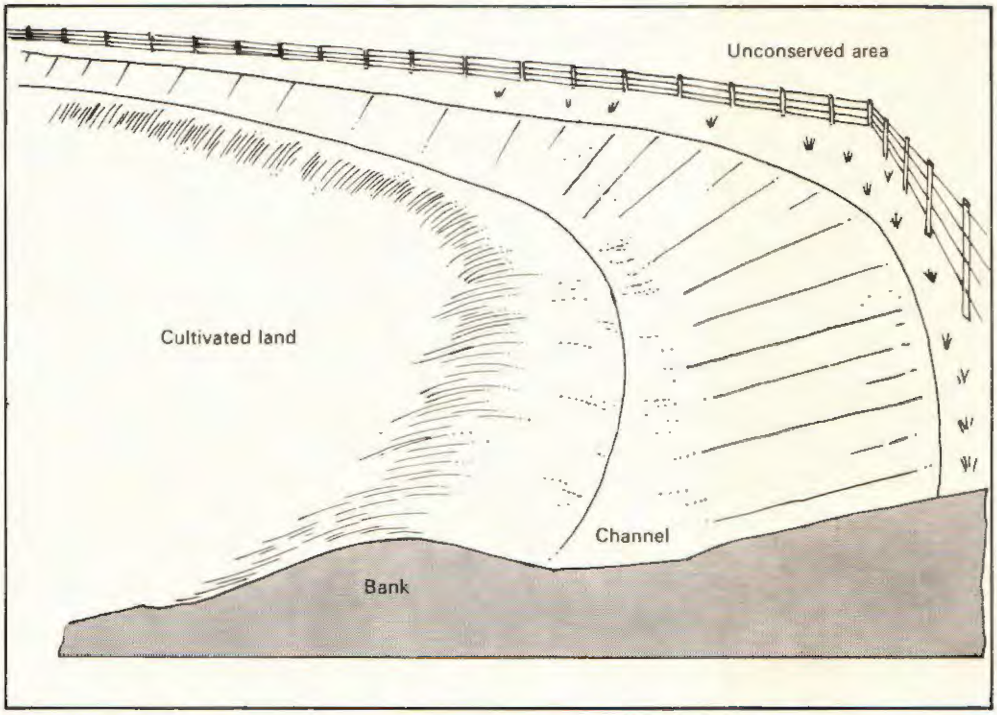


Fig. 2 A diversion terrace, intercepting water flowing off unconserved land



Types

Ideally, farm roads should follow crest lines, contours or terraces, but as this is not always possible (owing to steepness or unsuitable direction) roads of special design, such as steep diagonal, boundary or slope-break roads may have to be constructed to provide access to all parts of the farm. Combinations of some or all of these types are often necessary.

1 **Crest roads.** Crest lines are the best sites for major roads, as they are easily drained, easily constructed, and can be used to provide links with all contour and terrace roads.

It is necessary to camber a crest road so that it lies above the level of the adjacent land and can thereby shed water. Shallow drains should be constructed on either side. Run-off water from these drains can be diverted into adjoining cane fields at each conservation terrace, or between terraces, by locating short drains at regular intervals. (Two drains are usually sufficient between any two adjacent conservation terraces.)

The form of construction is important, as erosion on a crest road is often very difficult to repair. However, if the road is constructed well at the outset it usually needs little maintenance. (See Fig. 1 below).

Crest lines are not always suitable for main extraction roads as they may be too steep. (Maximum grades for gravelled roads should rarely exceed 1 in 8). The direction of crest lines may also be unsuitable for an efficient transport system.

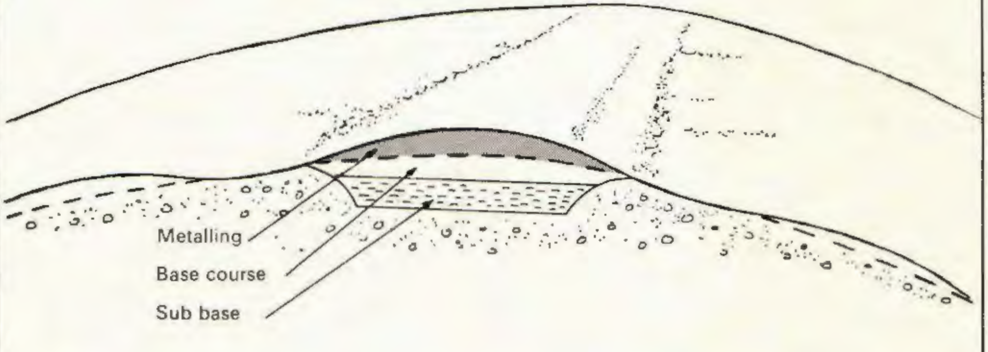
2 **Terrace roads.** Broad-based terraces and bench terraces can be used as roads, and the quality of construction will depend on whether they are classified as primary, secondary or tertiary. Where terrace roads cross waterways, protection should be provided so that the waterway does not erode. This can be done by grassing or paving the road or by constructing pipe or box culverts of adequate capacity under the road.

When constructing this type of road, relatively stable sub-soil is exposed on the inner side of the road, while the outer edge is built up from loose soil (mostly topsoil) excavated during construction. As a result, there is a difference in the degree of compaction and stability between the two sides of the road, and this will mean that the outer edge will tend to settle, altering the designed aspect of the road. To offset this tendency, loose soil built up at the outer edge should be well compacted *and* allowance made in the design for some further settling.

(For cross-sectional illustrations of terraces see Fig. 1, 2, 3 and 4 in Appendix IV.)

3 **Diagonal roads.** These should be designed in the same way as bench terraces but, to overcome the serious drainage hazard peculiar to this type of road, the roadside drain should be paved and frequent diversion bolsters constructed to move water to the lower side. At least two bolsters should be located between adjacent terraces. The channel of the bolster, including the chute on the road embankment, should

Fig. 1 Diagrammatic illustration of how a crest road is constructed



be paved. On primary roads, cross drains of adequate capacity may be used in preference to bolsters. Bolsters from steep diagonal roads should, where possible, discharge into conservation terraces. Intermediate bolsters will discharge directly into the field, in-field erosion being avoided by increasing the number of bolsters as appropriate.

4 **Other roads.** Uncambered cut-off, soil boundary, or slope break roads, are designed so that water is shed across the entire length of the road into the cane fields below. If used as primary or secondary roads, they should be cambered and drained to ensure all-weather access.

Categories

Three categories of roads are recognised — primary, secondary and tertiary.

1 **Primary roads** are used as main haulage or heavy duty roads and should be not less than 5 m wide. They are constructed by removing the topsoil to a firm base course (or by importing sufficient base course material) and providing a durable wearing surface. Design should be as in the cross sections in Fig. 1 and 2.

2 **Secondary roads** are used for field access and cane haulage and should be not less than 4 m wide. They are constructed by removing top soil and shaping the sub-soil to provide a camber, the top of which is higher than the adjacent land. The road is then gravelled to provide a durable surface.

3 **Tertiary roads** are used for in-field access, and they should not be less than 3,5 m wide. They are constructed by shaping so that the top is above the level of the adjacent land and they are then grassed or provided with a light gravel surface. Design should include adequate camber and drainage.

Drainage

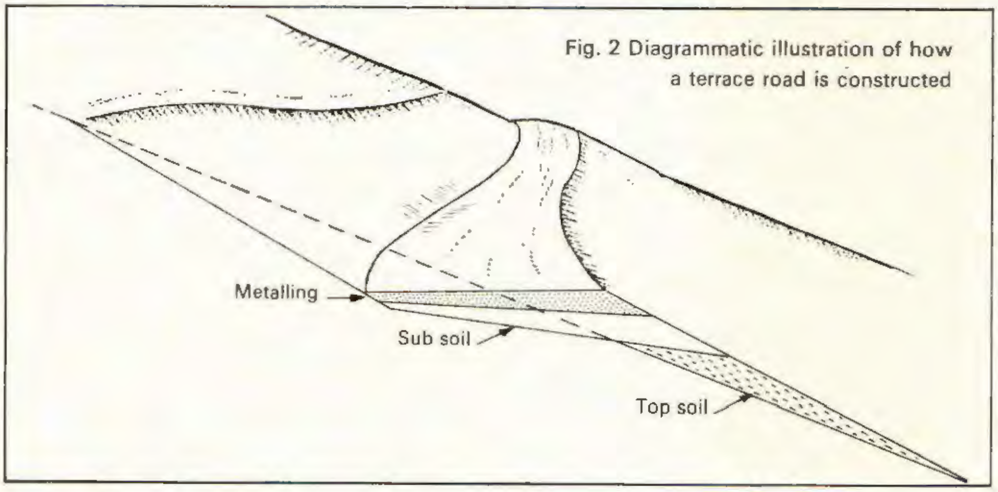
When designing a road system, the major consideration must be drainage. A road automatically creates drainage problems because, to be good, it must have a hard wearing surface. This makes it impervious to water and, as a result, a major source of run-off. Furthermore, failure to provide adequate drainage will result in erosion damage to the road itself. It is very difficult to repair or rebuild erosion-damaged roads.

Maintenance

Road drains should be kept free from silt and debris, particularly during the rainy season. All roads, unless protected by metalling or paving, should be grassed and the grass kept mown. All grass and paving of road drains should be kept in good condition.

Well constructed, well drained, and well maintained roads are an asset. Poor roads are not.

Fig. 2 Diagrammatic illustration of how a terrace road is constructed



Conservation terraces

Function

Conservation terraces are constructed to limit the in-field velocity of run-off water in cultivated fields so that it is reduced to a minimum. Design and spacing are related to particular conditions of soil, climate, slope, crop, and management practices. These terraces are designed to convey the expected run-off water safely from the area immediately above them to suitable discharge points. The danger incurred when the "safe" velocity is exceeded can be gauged from the following expressions:

(*a*) the erosive power of water varies with the second power of its velocity. Thus, when the water velocity is doubled, its erosive power is multiplied by 4,

(*b*) the volume of particles that can be carried in suspension (sediment) varies with the fifth power of the velocity. Thus, when the water velocity is doubled the sediment load can be multiplied by 32,

(*c*) the size of individual particles moved by flowing water varies with the sixth power of its velocity. Thus, when the water velocity is doubled the size of the particles it can carry is multiplied by 64.

Factors affecting design

Soils differ in their qualities of resistance to erosion by water. Resistance is influenced by the texture, structure and depth of a soil.

Climate relates to the pattern and nature of rainfall, its intensity, duration and seasonal incidence. These influence run-off characteristics and velocity of flow.

Steepness and length of slope strongly influence the intensity of run-off and in consequence, velocity. Steepness also determines the type of structure.

The crop and cropping cycle. Different crops have different flow retarding characteristics, but as cropping cycles cause soil to be exposed at different times of the year, run-off velocities will vary accordingly.

Mechanization creates specific demands in terms of terrace design. As labour becomes scarcer and more costly it will increasingly be replaced by relatively expensive machines, including those which apply valuable chemicals such as fertilizer or herbicides. Accurate operation and application will be necessary to avoid waste, and this demands smoothness of travel which can only be achieved by gradual transitions in slope, gentle curves, and an even surface. Mechanical harvesters, for instance, have limited ground clearance so if they are to traverse broad-based terraces, the lateral dimensions of these will have to be increased.

Types of terraces

Broad-based terraces are of convenient design, as their banks can be planted with cane or used as roads. Furthermore, under certain conditions, they may be traversed by machines without damage being caused.

A retention-type broad-based terrace is illustrated in Fig. 1 opposite. This design is usually recommended for slopes of up to 10%. It is constructed by ploughing soil inwards from both sides.

An entrenched-type broad-based terrace, is illustrated in Fig. 2. This design is recommended for slopes of 10 to 15%. It is constructed by ploughing only from the upper side.

Bench terraces, of ordinary or improved design, are recommended for use on all sugarcane land of more than 15% slope, as on such steep land it is impractical to construct broad-based terraces. However, exceptional considerations relating to total mechanization may change this concept.

Ordinary bench terraces are cut into the hillside leaving steep banks on both sides so that they are inaccessible to tractors and other machines from field areas above or below them. Fig. 3 illustrates this type of terrace.

Improved bench terraces are constructed with topsoil borrowed from the field area above. These terraces are accessible from the upslope side. Despite the fact that they are constructed almost entirely of topsoil, the advantages they offer in terms of ease of mechanization and reduction in silting make their construction worthwhile. This type of terrace is illustrated in Fig. 4.

Fig. 1 Retention-type broad based terrace (slope: up to 10%)

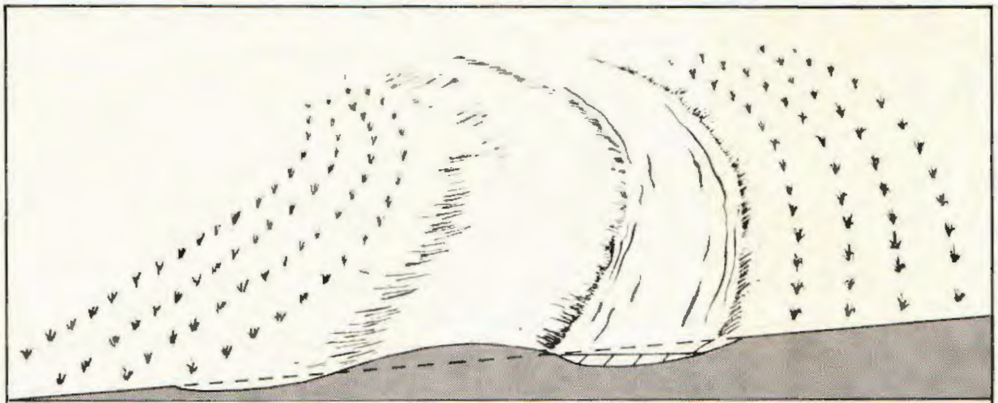


Fig. 2 Entrenched-type broad based terrace (slope: 10 to 15%)

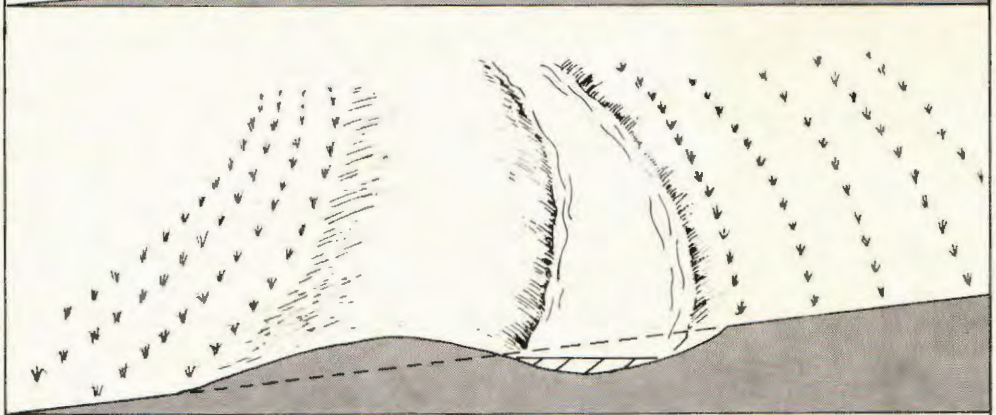


Fig. 3 Ordinary bench terrace (slope: more than 15%)

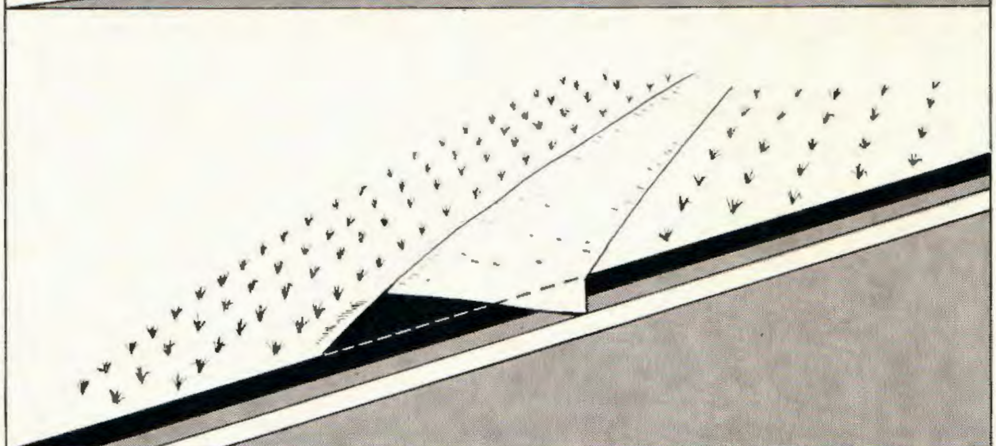
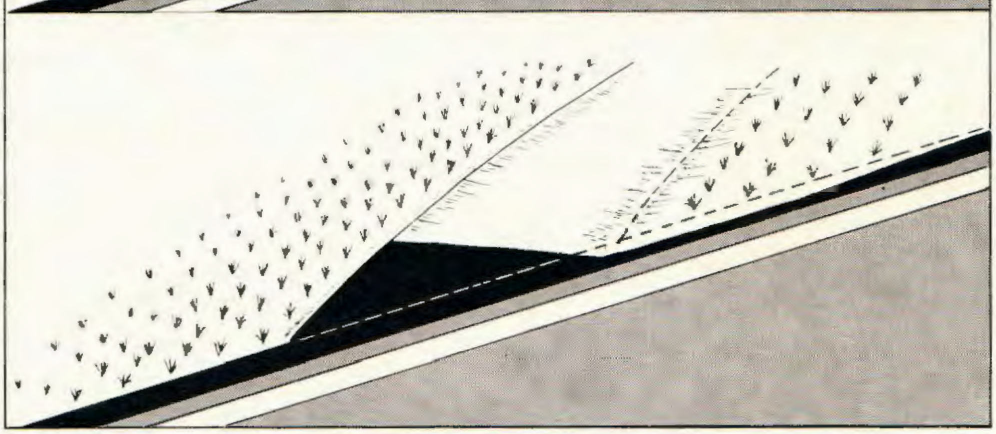


Fig. 4 Improved bench terrace (slope: more than 15%)

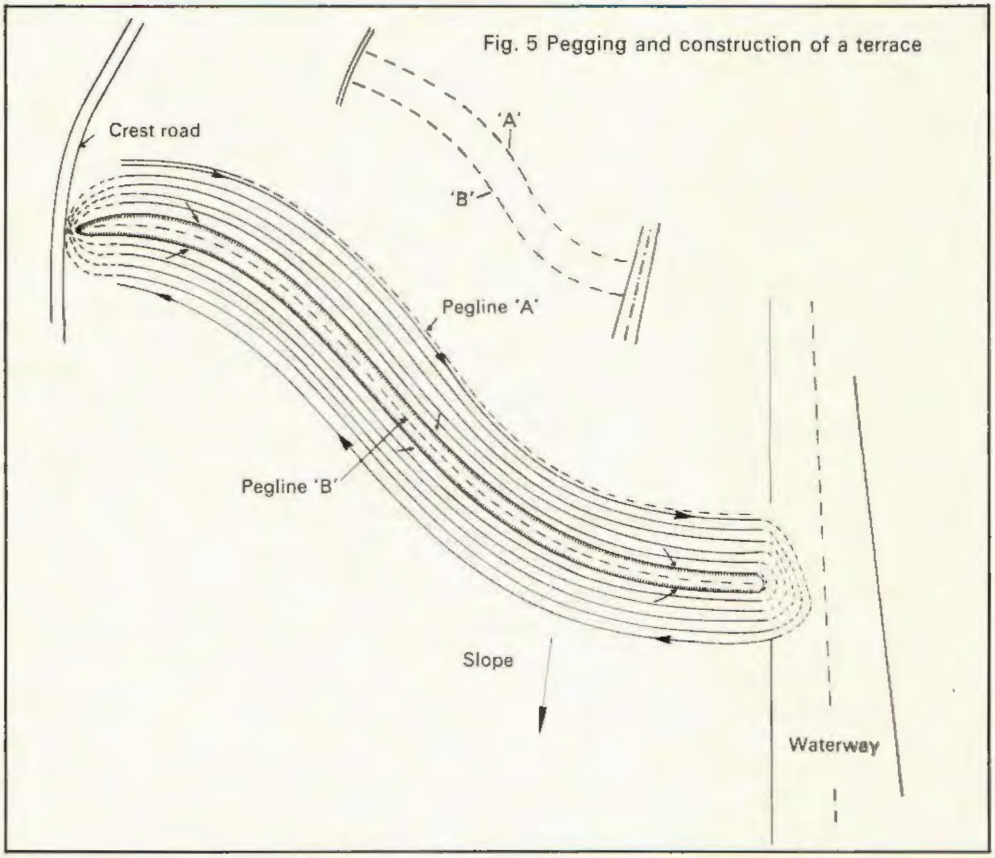


Construction

The following is a guide to the construction of terraces and stormwater drains, using implements commonly found on sugarcane farms. The examples outlined are well-tried methods but they can be adapted by growers to suit their own conditions.

Pegging a grade line ("A" in Fig. 5). This is an essential prerequisite for terrace construction. In one construction method an additional line "B" is pegged parallel to "A", 3 metres *down* the slope (for structures on slopes of up to 15%) and 2,3 to 3 metres *up* the slope for bench terraces on steeper slopes. In the latter case the terrace doubles as a road, and the line "A" marks the centre of the roadway, not the channel.

Fig. 5 Pegging and construction of a terrace



Slopes of up to 15%

Using a 3-furrow disc plough

Phase 1 (Fig. 6)

1 Start ploughing on grade line "A", moving soil down the slope (Fig. 5 and 6).

2 Plough the first return cut steering just below the additional line "B", moving the soil up the slope onto the pegs.

3 The second outward cut is taken into the soil turned over by the first outward cut, while straddling it. The soil is again moved downhill.

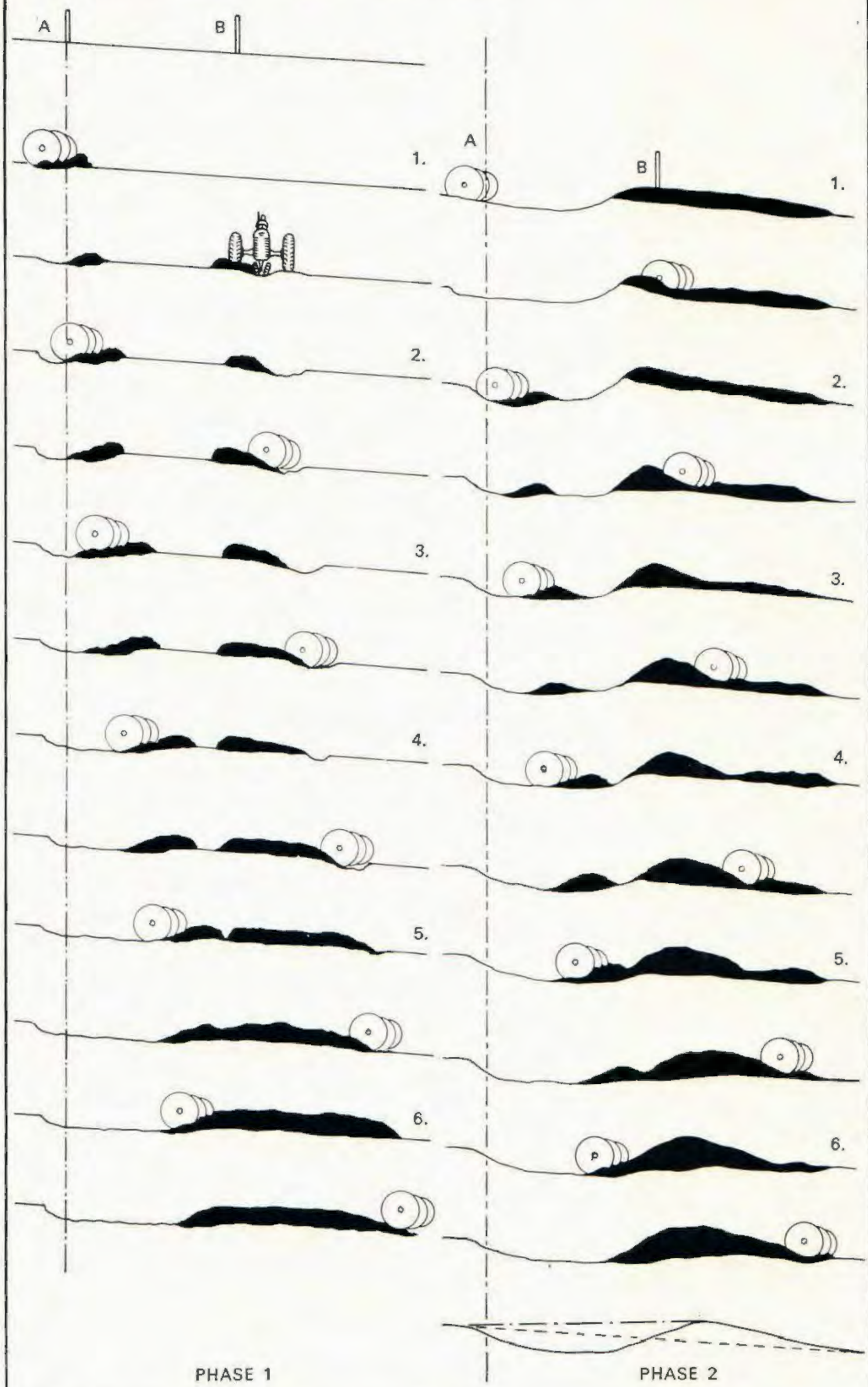
4 The second return cut is taken below the first, as with normal ploughing and still moving the soil up the slope.

This process is continued until the outward cuts from line "A" have reached the line "B", three metres down the slope. This is achieved in 6 passes in both directions, the object being to build up a bank of soil along the additional line "B".

Phase 2 (Fig. 6)

This is a repetition of the sequence in Phase 1, with the first cut again being taken on the position of grade line "A". Return cuts are, however, made into ploughed soil.

Fig. 6 Terrace construction using a 3-furrow disc plough



Using a blade terracer (Fig. 7a)

1 Position the blade so that its down-slope corner is on line "B", angling it so that the up-slope half of its edge only cuts into the soil above this line. The cut soil is expelled to form a ridge below line "B".

2 The second or return cut is taken closer to the grade line pegs with the blade angled in the opposite direction but again set to deposit the cut soil adjacent to the first ridge.

3 For the third cut the blade is tilted in the opposite direction and the sharp bank left by the second cut is removed, the soil being left in a ridge just beyond the down-slope corner of the blade.

4 For the fourth cut the blade is set as for cut number 2 but tilted more steeply. The ridge left by cut 3 is moved next to the ridge left by cut 2 and the channel deepened by further cutting.

5 This cut removes the bank left by cut 4 and the soil is heaped into the cut made by 4.

6 Cut 6 moves the ridge left by cut 5 close to and partially onto that left by cut 4, at the same time deepening the channel. Note that the edges of cuts 2, 4, and 6 have moved steadily up the slope until the up-slope edge of 6 corresponds with the pegged grade line "A".

7 Cut 7 removes the banks left by cuts 5 and 6 and heaps the soil into the cut left by 6. The down-slope corner of the blade now follows the line "A".

8 Cut 8 now moves the ridge left by cut 7 onto the bank created by the accumulation of soil from cuts 1, 2, 4, and 6.

9 If the bank is to be used as a road it will probably need smoothing. In heavy soil it may be necessary to plough beforehand as the blade terracer is unable to penetrate hard soil. This would not be necessary when a bulldozer is used.

Slopes steeper than 15%

Using a blade terracer (Fig. 7b)

1 The first cut is taken with the blade tilted into the slope and its up-slope corner on line "B" which is up-slope from the pegged grade line "A". Soil is thrown down the slope.

2 For cut 2, the blade is tilted so that it removes the bank left by 1 and dumps the loose soil into the cut made.

3 Cut 3 moves soil heaped by cut 1 further down the slope and deepens the channel.

4 Cut 4 moves the soil heaped by cut 2 down-slope into the cut left by 3.

5 Cut 5 moves the heap left by cut 4 onto the previous heaps.

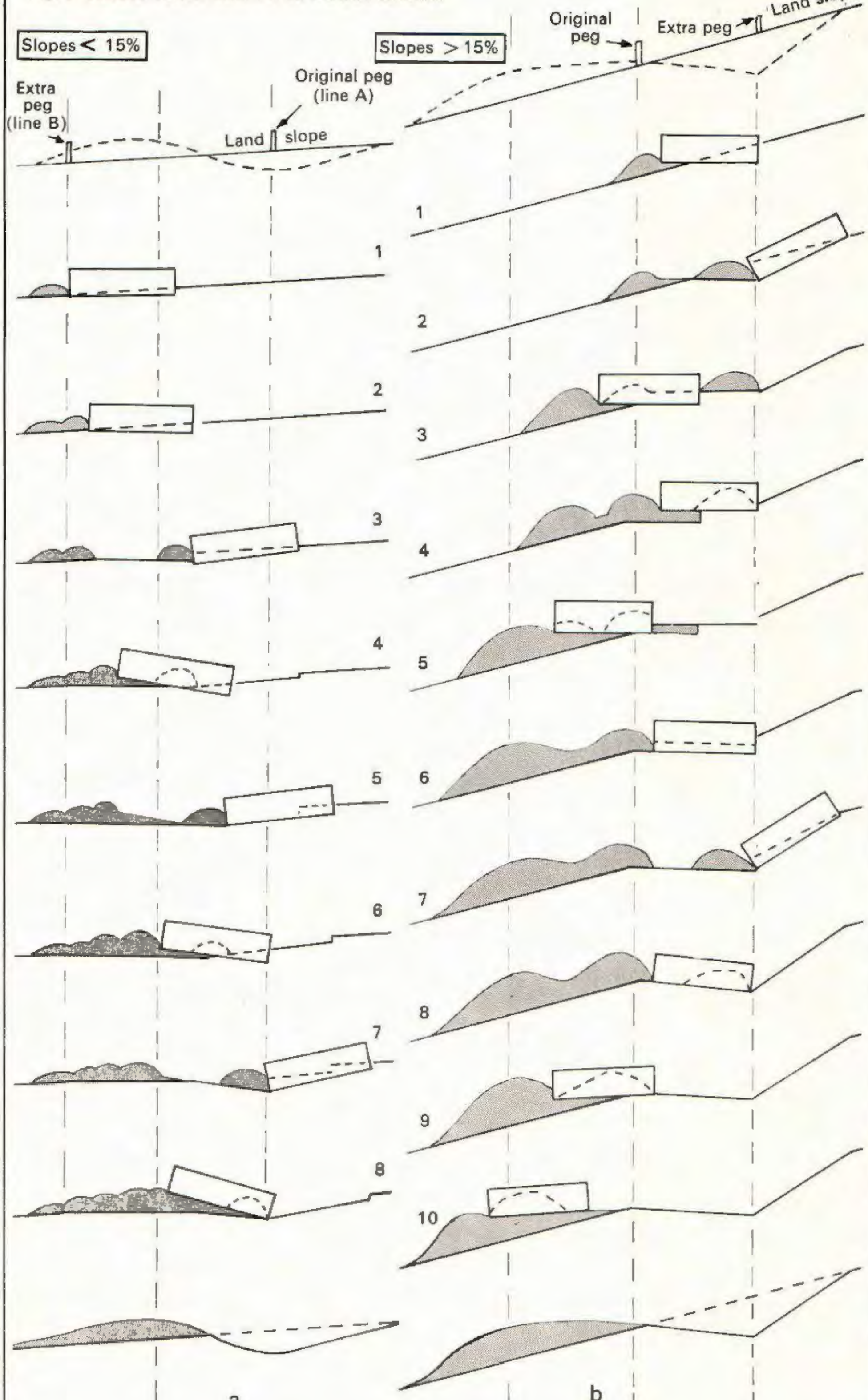
6 Cut 6 deepens the channel, forming a heap of loose earth down-slope from the blade. The blade is tilted so that the base of the channel is angled into the slope slightly.

7 Cut 7 removes the high bank left by cuts 4 and 6.

8 Cut 8 commences with the upper edge of the blade running along line "B" and, followed by cuts 9 and 10, moves soil heaped by cuts 5, 6 and 7 progressively down the slope to form a cambered road.

9 On very steep slopes it may be necessary to work downhill at first, due to excessive crabbing of the tractor. This results in an improved bench terrace, construction of which, using a bulldozer, is depicted in Fig. 8a and 8b. A shallow layer of soil is borrowed from the field up to 17 metres above the road line and moved downhill onto the road line pegs. This provides a bank on which the tractor can work across the slope to shape the road and channel.

Fig. 7 Terrace construction with a blade terracer



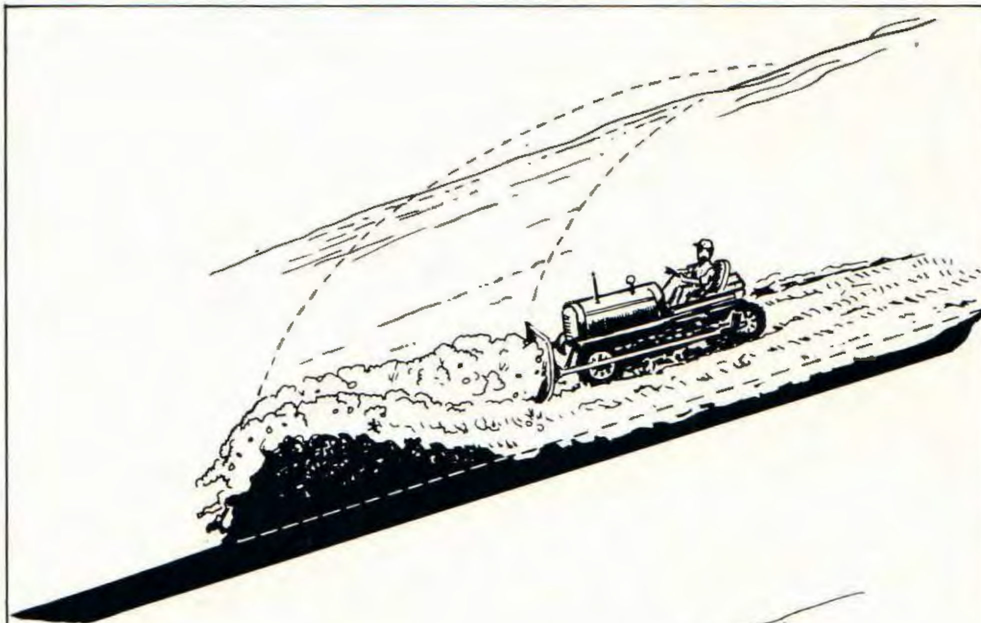


Fig. 8a Soil being pushed down the slope to create an improved bench terrace

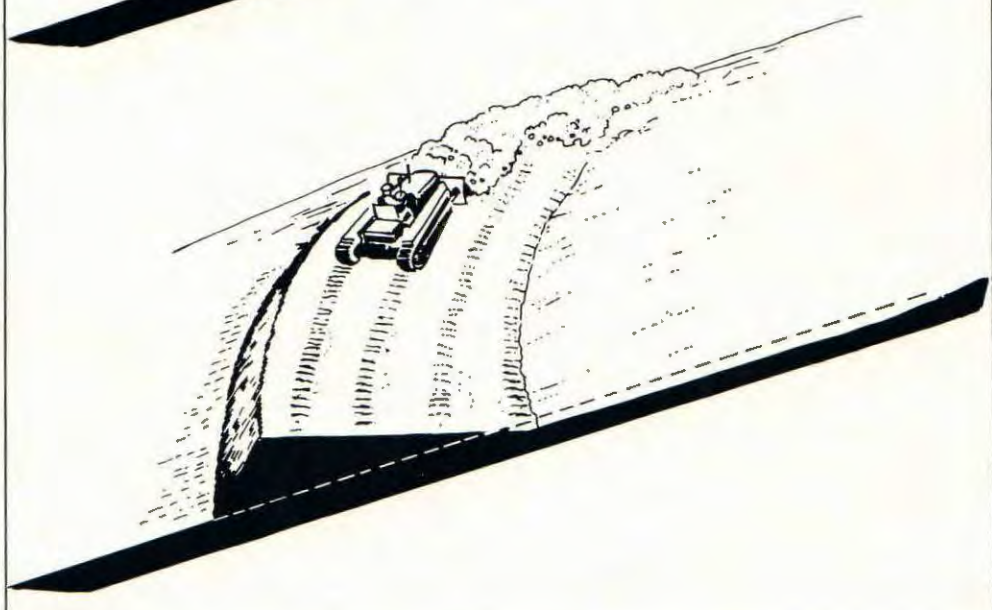


Fig. 8b Constructing the terrace road using the soil pushed down the slope

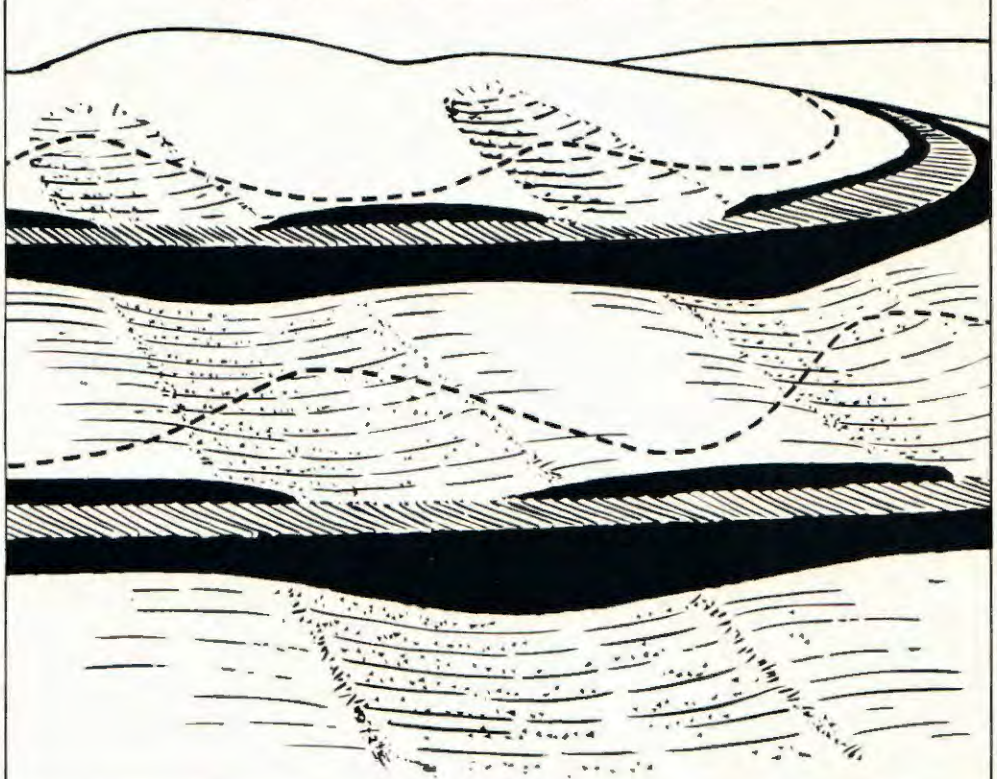
Planting and harvesting a conservation lay-out

Row alignment

When all the required conservation works have been constructed, the field can be laid out for planting. The location, alignment, and type of in-field terrace influences the choice of row alignment. Thus, while rows could traverse broad-based terraces quite easily, a similar lay-out could obviously not be adopted in the case of bench terraces. Extension officers should be consulted before a decision is taken.

Parallel terraces. The needs for total mechanization may call for the construction of parallel terraces by extensive land-forming operations or other sophisticated techniques. In such cases row alignment presents no problems.

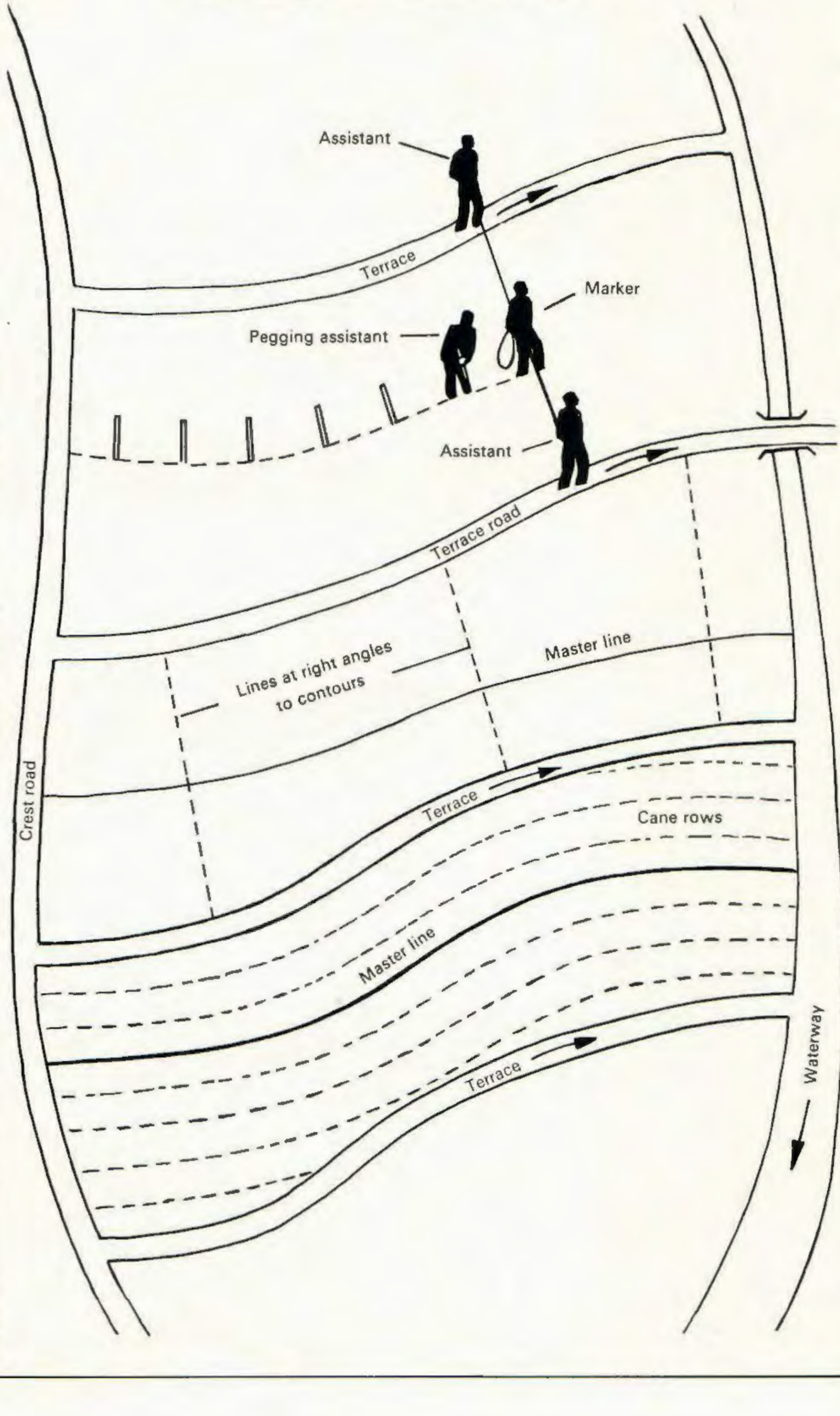
Fig. 1 Parallel terraces constructed by cutting and filling



Master line method. This technique involves planting in the direction of flow of the conservation terraces and is based on the premise that each individual row or inter-row will drain freely into a terrace channel or waterway. It also creates the smallest possible number of short rows, all of which start either from a crest road ending in a terrace channel, or from a terrace bank ending in a waterway. The maximum number of complete rows between terraces is, therefore, obtained by this method.

A master line can be pegged between two terraces by one man and three assistants (Fig. 2). Two assistants, holding the ends of a length of light rope or strong cord walk along adjacent terraces, starting at the crest and moving towards the waterway. The rope in each case stretches to a man walking in the centre of the panel. The assistants on the terraces must ensure that their line is kept at right angles to the contour and reasonably taut. The man in the centre establishing the master line moves between the two men on the terraces. He usually starts close to the upper terrace, if ridging equipment is adjusted to work down the slope, or close to the lower terrace if the reverse is true. As the terraces converge, the man in the middle maintains his

Fig. 2 Pegging a master line between two terraces



distance from the upper terrace by taking in slack line with his lower hand. As they diverge he keeps the lower part of the line taut while paying out line with his upper hand. Pegs are put in by a third assistant, 20 to 30 metres apart along the line followed by the marker. This line of pegs is the "master line" and can easily be followed by the tractor driver when drawing the first planting furrow. All other planting furrows are drawn parallel to this one.

When ridging out planting lines it is beneficial to curve the ridges up the slope when emerging from the field onto a crest road, and down the slope to a waterway. This improves road drainage and avoids ponding between lines at the waterway end. On slopes where construction of broad based terraces is feasible, the "master line" technique may be adapted to facilitate mechanization. This is accomplished by pegging master lines between terraces and then using adjacent master lines to peg a "grand master" line. All planting lines are then drawn parallel to this, so reducing the number of short rows, while planting continues right across the terrace in between.

Flat cultivation. This implies no deep furrowing or ridging for either the plant rows or inter-rows and involves only the formation of a shallow depression left by the press wheel of the mechanical planter. This technique may be especially desirable in the interests of total mechanization over broad-based terraces. In fields of regular configuration, short rows are eliminated entirely and the terraces alone take care of inter-terrace run-off.

One method of aligning rows is to establish a "grand master" line for the whole field by means of trial pegging and adjustment. Curvature of parallel rows often needs adjustment as well and this may entail changes in gradient.

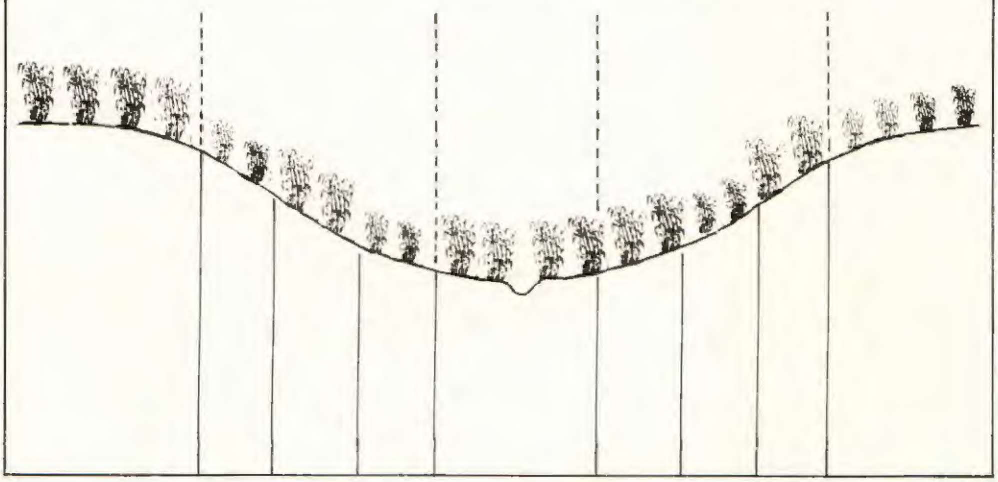
Strip planting and harvesting

Strip cropping can be carried out on hillsides in other than cold areas and this, as the name implies, means developing slopes so that strips of cut or ploughed out cane alternate with standing cane. There should be an age, or stage of growth, difference of at least three months between adjacent strips.

Ideally, trash mulching should be practised, but this is not always possible as burning may be necessary, to permit furrow irrigation or systems of mechanical harvesting. Extension officers should be consulted in connection with specific field layouts and cropping practices.

Fig. 3 represents a cross section through two hilltop areas showing the hill slopes with a valley between, and sugarcane in various stages of growth.

Fig. 3 Cross section of a valley, showing strip cropping of cane



Requirements under the Soil Conservation Act, 1969 (Act 76 of 1969)

APPENDIX VI

OBJECTS OF THE ACT

"The objects of this Act are to make provision for the combating and prevention of soil erosion, and for the conservation, protection and improvement of the soil, the vegetation and the sources and resources of the water supplies of the Republic".

GENERAL PROVISIONS OF THE ACT

The following general notice No. R495 was published by the Department of Agricultural Technical Services on 26 March 1970 and this should be read in conjunction with the guidelines drawn up by local District Soil Conservation Committees.

"General provisions in pursuance of the object of the Soil Conservation Act, 1969. It is hereby notified for general information that, in addition to any direction in terms of section 3 of the Soil Conservation Act, 1969 (Act 76 of 1969), declared by written notice to be applied to an owner or occupier of land in respect of the land referred to in such notice, every owner and occupier of land should observe the general provisions set forth in the Annexure hereto.

Annexure — Laying out and cultivation of lands

1 Virgin soil and land normally not under cultivation, should not be ploughed without the consent of the Minister and otherwise than on the conditions prescribed by him.

2 Existing lands showing signs of water erosion should be effectively protected by mechanical or biological means, for example by one or more of the following, namely stormwater drains, contour banks, water courses or grass ley crops, whichever may be necessary.

3 Existing lands that are subject to damage by wind erosion should be protected with cover crops or crop residues, or by leaving strips uncultivated, whichever may be necessary, and by minimum cultivation during vulnerable periods, except for cultivation for the sole purpose of controlling surface movement of soil particles or establishing windbreaks.

4 Contour cultivation should be applied to lands with an average slope of 2% or more, unless such lands are adequately protected by perennial fodder crops.

The draining of vleis, marshes, water courses and water sponges

5 Vleis, marshes, water courses and water sponges should not be ploughed, cultivated or drained.

6 No land should be ploughed, cultivated or drained within ten (10) metres of the edges or banks of rivers, brooks, springs, vleis, marshes, dongas, water courses or earth channels.

7 No vegetation, excepting proclaimed weeds and other noxious plants should be destroyed within ten (10) metres of the edges or banks of or in rivers, brooks, springs, vleis, marshes, dongas, water courses or earth channels.

8 Within ninety (90) metres of the edges of marshy water sponges, under average rainfall conditions, and twenty (20) metres horizontally and vertically from the edges of water sponges, brooks and rivers, no plantations should be planted or re-established for commercial purposes or regrowth allowed after existing plantations have been thinned out or completely felled.

Protection of soil surface subject to erosion

9 Any soil surface, including bare patches, mountain slopes, apron veld or water courses, which is or may become subject to erosion or denudation of vegetation, shall be fenced off and withdrawn from grazing for at least the full growing season each year until the vegetation has effectively recovered and erosion is checked.

Resting and utilization of pasturage

10 Pasturage that is not treated in accordance with paragraph 9 shall during each cycle of not more than four (4) years be withdrawn from grazing for a full growing season or the equivalent thereof, to rest and to produce seed.

Veld burning 11

Subject to the provisions of the Forest Act, 1968:

(1) sweet grass veld may not be burnt except where this is necessary for the control of invader plants on veld sufficiently rested beforehand;

(2) mixed and sour grass veld types may be burnt only if:—

  (*a*) rested for the full preceding growing season or if a considerable amount of plant material has accumulated there, the moisture content of the soil is sufficient to allow veld growth, and the veld already shows early signs of sprouting; or if

  (*b*) burning is necessary for the control of invader plants on veld sufficiently rested beforehand;

(3) veld in fire protection areas declared in terms of the Soil Conservation Act may be burnt only in accordance with the provisions of the fire protection scheme applicable to such areas; and

(4) macchia (fynbosveld) outside fire protection areas may be burnt only in accordance with such directions as the Minister may from time to time declare applicable on such veld.

Number of stock which may be kept on land 12

The maintenance of pasturage shall not be endangered or the recovery of damaged pasturage prevented by keeping thereon more stock than its long-term carrying capacity justifies.

Private roads 13

Private roads and footpaths shall be protected against erosion and the run-off water from such roads shall be so diverted as not to cause erosion.

Control of invader plants 14

Light infestations and seedlings of trees and shrubs, which in a specific area may harm the more desirable plant cover, shall be so controlled as to prevent heavier infestations from such light infestations or seedlings.

Drift sand 15

Barrier dunes on the coast and other dunes inland on which wind erosion occurs or may occur shall be fenced off and the soil and vegetation so protected as to control or prevent wind erosion".