



THE ABUSE OF THE SOIL,  
VELD AND WATER RESOURCES  
OF SOUTH AFRICA

BY

DR. J. C. FICK

*an Interests Group Publication*

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## PREFACE

(By the SOUTH AFRICAN INTERESTS GROUP)

When the psalmist sang "The Earth is the Lord's and the fulness thereof" he echoed the thanksgiving of a people who had suffered long in the desert. Among the primitive people the direct relationship between the richness of the earth and the well-being of man had not been obscured as it has by the refinements of modern civilization. They knew that their meat, their bread, their milk and their wine were of the soil—and indirectly their clothing too. But they did not know, as we now know, that the very wilderness in which they had wandered had been fertile until, by the ignorance or the indolence of man, it was given over to a waste of sand.

South Africa lives on a layer of soil, the average depth of which is probably not more than eighteen inches in the farm lands and of course much less in the vast mountain tracts. There is no margin for waste. Yet every year and for many years past tons of soil and wide stretches of fertile land have been, and still are, lost through the mistakes or the neglect of those who have most need to conserve it. For long this passed almost unnoticed except by the few who without thought or prospect of personal reward and with a devotion, proof against repeated disappointments, have pointed the danger ahead and sought out its causes and remedies. One of these is Dr. Fick, whose treatise on soil erosion the South African Interests Group is privileged to publish. He and his colleagues in the Department of Agriculture have recently found a powerful ally in the Veld Trust, and at last there is a quickening of interest in South Africa's most vital problem.

If it were feasible by Act of Parliament to prohibit the process by which furrows become ditches and ditches dongas, the problem might be left to the Government to settle. But the most that any Government can do is to make the method known and the means available to combat erosion, and possibly enforce some elementary safeguards by occupiers of land. Nor is this a problem which affects only the farmer as all depend on the soil, all are concerned in its preservation.

The real and effective remedy is a national crusade bringing the truth home so vividly and so personally to every South African that his whole strength will be bent to save earth, the eternal mother, from this continued neglect and injury. Her face is already scarred, her strength sapped, but there is still time to heal and restore, lest we are finally brought to mourn in Milton's words :

“Earth felt the wound ; and Nature from her seat  
Sighing in all her works, gave sign of woe  
That all was lost.”

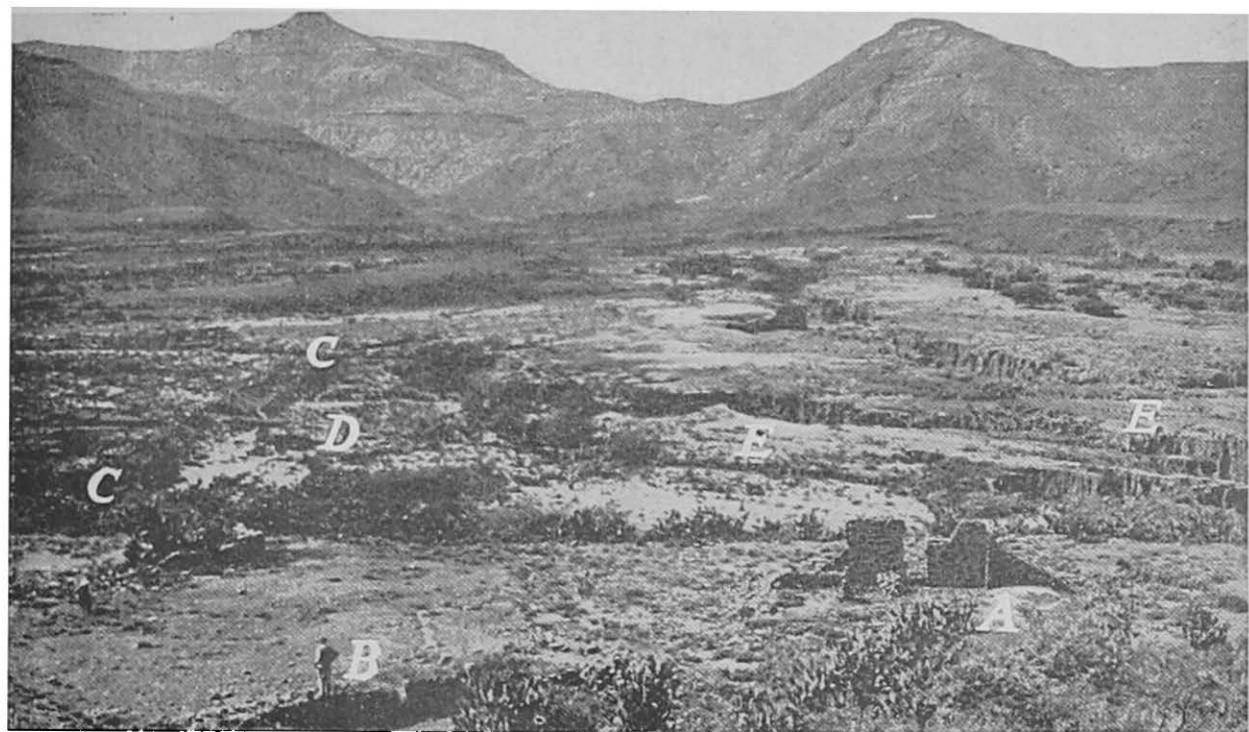
## INTRODUCTION

ON a narrow plateau, against the slope of a hillside, stand the ruins of a one-time farm-house and outbuildings. Before decay and destruction had set in, the proud owner of this farm, which is situated in the Maraisburg district, looked down on a wide fertile valley extending to the foot of the Bamboes mountains. To-day a view of this valley offers the visitor a dismal spectacle of destruction—a fantastic design of parallel and interlacing gaping dongas, some of which are forty feet deep. "Over there," explains Oom Daan Marais, who has seen eighty years of life and farming in this district, "you see the remains of the wall of a big dam. And here, where those deep dongas are, I once saw the best wheat in the district. The wheat on this rich, deep soil was irrigated from that dam and produced excellent crops. The remains of a threshing floor should also be somewhere over there—unless it was swallowed up by a donga. To the right of the dam where you can see the tops of a few thorn trees, a beautiful orchard used to produce a variety of fruit."

On investigation, the remains of the threshing floor were found and on an island between the dongas, where the orchard used to be, a solitary shrivelled-up fig tree and nearby a dead mulberry tree were discovered. A more depressing scene of an abandoned devastated farm would surely be difficult to find. Soil erosion has seldom executed its fiendish destructive work in a more thorough and more spectacular way.

Such is the fate of this farm which, not a long time ago, was a beautiful thickly vegetated valley, which was well irrigated by the rain-water coming down from the slopes and ravines of the Bamboes Mountains and slowly penetrating through the thick vegetation. Later when the natural vegetation had been destroyed by the plough, the fertile alluvial soil yielded excellent crops. This, however, was only a passing phase. To-day the rain-water rushes down from the bare mountain slopes and hillsides and collects in the many dongas along which the muddy water, laden with silt, is carried firstly to the Spitskop spruit and then to the Vlekpoort river, eventually silting up the valuable Lake Arthur. The Maraisburg and Smalfontein irrigation dams,





1. KARROO SCENE. The tragic scene described in the introduction. A—the ruins of the dwelling-house. B—the author standing on the remains of the outbuildings. C-C—the old broken dam wall is still visible. D is the site of the orchard. E-E is where the wheat lands used to be. Note also the bare mountain slopes.

which were built in the Vlekpoort river in about 1916, have for some time been silted up with soil robbed from the above-mentioned farm and other neighbouring farms by a similar process of destruction.

A century ago nobody would have thought of building such dams, neither was there at the time a Vlekpoort river in which the dams could be built. Much less did the need exist for such dams, as the broad swampy vlei with its deep pools had abundant water by which the springs were permanently fed. That was before the hillocks and ridges and the Bamboes mountains (there is to-day no sign of bamboos or other reeds) were deprived of their dense vegetation and sparse Karroo bushes with a little grass here and there remained the only plant growth, before the luxuriant vegetation of the vleis was destroyed by veld fires and before the pools and water caches were gradually more and more eroded and hollowed out, until a great gaping drainage donga was carved out. This donga is to-day known as the Vlekpoort river.

In the course of time tributary furrows, running into the Vlekpoort river, were formed, so that to-day from every ravine in the mountains and hills a great donga, which is again connected with numerous small ones, drains into the Vlekpoort river. In this way a network of sluits was formed on either side of the river, which so thoroughly drains the whole valley, that the majority of springs have either dwindled or completely disappeared. This condition has entailed a serious reduction in the beneficial effect of the rainfall, with the result that old inhabitants maintain that the amount of rainfall has decreased and that its nature has changed. These assertions are made without taking into consideration that a large part of the average annual rainfall of 14 inches, especially that which falls in torrential storms, to-day rushes rapidly over the sparsely vegetated surface, collects in the small and large dongas and is lost, together with the soil held in suspension.

So it happened that the lush well-watered Vlekpoort valley at the foot of the Bamboes mountains is to-day a bare and barren waterless area where surface and donga erosion continue in ever-increasing tempo.

This is unfortunately not a unique case. Areas where veld and lands are destroyed by erosion and denuded of water supplies, and where the conditions are daily becoming more serious, are found throughout the country. Everywhere, through almost every vlei, are deep black dongas where only recently the vlei was covered with waving grass and where the deep pools reflected the surrounding reeds and rushes. In all four provinces of the Union, as well as in the native

territories, ever-increasing erosion manifests itself on previously productive grainlands and on pastures. Shocking evidence of this process of destruction comes from Natal where an accurate survey of an area of 113,177 acres between the Boesmans and Bloukrans rivers reveals the following facts :

	<i>Acres</i>	<i>Percentage</i>
Area completely eroded to rock or shale ...	21,699	19·1
Sheet-eroded and over-grazed hillsides ...	37,465	33·1
Cultivated, badly eroding areas ...	15,251	13·4
Area in fair condition ...	38,762	34·4
	<u>113,177</u>	<u>100·0</u>

(*Vide* Pentz : "Soil Erosion Survey of the Reclamation Area in Natal." *Science Bulletin*, No. 212 of 1940.)

Only one-third of the surveyed area is in a good productive condition, one-fifth has already been totally destroyed and the productivity of the remaining portion is rapidly decreasing and will in due course be destroyed unless the devastating erosion forces are harnessed.

Veld, soil and water supplies are the natural resources on which the farming system of the country is dependent. These three are closely inter-related and if one of them is allowed to deteriorate, the others are adversely affected and the ultimate result is soil erosion with all its accompanying evils.

Soil erosion is usually thought of in terms of dongas. These, however, are the ultimate and most obvious results of a series of inter-related and simultaneously progressing processes which jointly cause increased and accelerated flow of water over the surface and eventually lead to abnormal erosion. As these dongas are the visible, and most generally known form of soil erosion, they will be used as the starting point in discussing some of the destructive results of erosion

## CHAPTER I.

## RAVAGES OF SOIL EROSION

**Surface Destroyed by Dongas**

The total area of the multitudinous large and small dongas in the country comprises many thousands of morgen, which have become useless for pasturage or cultivation. It is a portion of our country simply given away, and the worst is that this area is cheerfully allowed to increase. Study the figures above on the survey in Natal. Compare them with the colossal schemes which were constructed in Holland in order to reclaim land from the sea.

**The Fate of the Soil which is Washed Away**

Apart from the direct loss of the soil which is carried away along the dongas, some of it is deposited in areas where it is not desired. It often happens that good cultivated land as well as pastures are covered with inferior material. Only recently the Government had to create special loan facilities for wine farmers along the Bree river, where sand had to be removed from their vineyards. The river flooded its banks. The fine, valuable soil was mostly swept away, while the sand was deposited in the vineyards, in some places to a depth of five feet and often completely burying the wire fencing. This vineyard land is valued up to £300 per morgen. The owners suddenly found themselves in the distressing position of having been robbed overnight of their livelihood. Along the Elands river similar damage was done recently and along many other rivers and spruits good soil has often been buried under the inferior type. When the Orange river was in flood in December, 1943, silt was deposited on lucerne and other lands. Occasionally silt of good quality may be quite useful, but in South Africa, unfortunately, it is generally harmful.

Damage of this description is frequently caused on a smaller scale. It is often noticed that coarse sand covers good vlei pasture. The water from the higher regions rushes down on to the vlei, where the speed is decreased and the coarse material is deposited. This phenomenon may often be seen at the foot of sloping lands.

Veld has been and is still being impoverished by a fine purple silt which originates from the weathering of slate up against the hillsides. After the plant-covering has been destroyed and the soil has been washed away, the slate, being exposed, is rapidly converted into a very fine powder. The latter is washed down and a thin deposit of this silt on the lower regions is sufficient to destroy the veld. The silt is not poisonous, as is often maintained, but it covers up the soil to such an extent, that air and water penetration are handicapped and the plants are literally smothered and starved. These purple-red areas of poor or dead veld are often seen in the Karoo and in some parts of the Free State.

Many farm dams, small and large irrigation works, are to-day silted up and useless for their original purpose. Others are in the process of becoming useless. A farm dam, irrigating a few morgen of lucerne or other crop, is a particularly great asset. In the low rainfall areas such a dam is practically an indispensable factor in successful farming. The silting up of such dams is therefore a great disaster to the farmer. Larger irrigation dams built by private or Government enterprise are also affected. Some of the smaller dams costing up to £20,000 are already totally useless. Larger State-owned dams costing up to a million pounds and more are not safe from this danger either. It is reported that some of these dams are already half full of silt. The existence of farmers dependent on these irrigation dams is threatened.

It would appear a safer and wiser investment of the tax-payer's money if another few hundred thousand pounds were spent on combating the erosion in the catchment area of a million-pound dam in order to prevent the silting up of such a dam and in order to stabilize farming below as well as above such a dam.

The water supply schemes of towns and cities are also subject to this danger. Some of the towns are already faced with serious water problems, as a result of the silting up of their dams. There are cases where new taxes have to be levied to raise funds for new dams, while those that are being silted up have not yet been fully paid for. Even the cities with their magnificent water supply schemes cannot consider themselves safe, unless soil erosion is not taking place in the catchment areas. But soil erosion does take place and, as long as that is the case, the dams are in danger.

At the coast there are also specific problems with silt. Soil which is washed into harbours has to be removed continually, costing a great deal of money in the long run. The case of a certain pleasure resort at the coast is enlightening. This town has its water pumped from just above the river

mouth. Twenty years ago no town councillor would have imagined that the town would ever have to face a water problem, as the supply seemed inexhaustible. The pump had been placed on an extensive water surface, fourteen feet deep. To-day the town councillors have good reason to be alarmed, as the river mouth has silted up to such an extent that the depth of the water has decreased to four feet. The soil causing the difficulties in this case originates from advanced erosion which is taking place a hundred miles or more up the course of the river.

At river mouths the sea is often muddy for miles out. This happens when the river comes down in flood, and is especially noticeable during the first summer floods. When the Orange river was in flood in December, 1943, an aerial view showed muddy discolouration for miles out to sea. This could only have been caused by an enormous quantity of soil. Such a condition not only spoils the swimming and fishing of many a holiday-maker, but also adversely affects the fishing industry.

### Floods

The danger of floods is increased if the overflow of rain-water pours into the rivers and spruits too quickly. Over densely vegetated hillsides and veld the water flows more slowly and thus reaches the spruits and rivers more gradually, so that it is carried away in a more even and quiet manner. A large percentage of the water will penetrate the plant-covered soil and therefore less water will reach the river. But when the surface is sparsely vegetated, when large areas are totally denuded, also, when numerous sluits lead to the regular water-ways, more water reaches the river in a shorter period and the possibilities of disastrous floods are created. The sluits therefore act as drainage canals which feed the rivers too rapidly.

The colossal damage caused by the floods along the Bree river in 1942 would not have taken place if the mountains in the catchment area had still been well covered and the water thus been prevented from rushing down at a terrific rate, and if there had not been so many sluits, which could carry the water to the river, accumulating it so rapidly that a flood was inevitable. If the catchment area had still been in a good condition and not ravaged by soil erosion, the water would not have carried away so much sand and soil. Thus, even if the heavy rains had inevitably caused a flood, the damage would have been less as in this case the greatest damage was caused by the deposit of sand on the vineyards. The same applies to other rivers, viz., that the dangers of floods are increased by the rapid conveyance of

water along erosion dongas in the catchment area. The December, 1943, floods near the lower end of the Orange river were aggravated, if not altogether caused, by the erosion and numerous dongas in the catchment area. A large number of these dongas are many miles from Upington, but they pour their water into unknown spruits, which on their part feed the rivers and these eventually caused the Orange river to overflow.

### Damage to Public Works

The increased drainage along erosion sluits often leads to local wash-aways, which are not reported in the papers but which always cause some damage. The roads and railways are often accused of causing erosion. Although many sluits could be attributed to them, the other side of the question, viz., that roads and railways often suffer because adjoining farm owners allow and encourage erosion, is often overlooked. The fact remains that soil erosion is responsible for regular expenditure on the repair of roads, bridges, railways and telegraph poles damaged by wash-aways.



2. KARROO SCENE. The large main dongas with numerous smaller tributaries form a perfect drainage system for the area, resulting in little water soaking into the soil between the dongas, to keep plants alive. An enormous amount of soil has been washed away here.

### The Depletion of Water Resources

When the present owner of Finkelfontein bought the farm in 1920, his neighbour called and welcomed him to the district. The neighbour explained that Finkelfontein was an outstandingly good sheep farm, but that the water question was a great problem. Previous owners had to trek with their stock long before the district was seriously afflicted with drought. The new owner wondered why the farm had been named "Finkelfontein"—there was no sign of a spring. He started off by sinking more and deeper boreholes, but its water problem remained acute. All boreholes, except for the dependable one in the vlei, failed before the drought had properly set in. In the course of time he realized that he should try to conserve the rain-water. This farm is situated at the top end of a wide basin, leading into a vlei which stretches up to and beyond the neighbouring farm. So the farmer constructed a series of dams, not large irrigation works but ordinary farm dams, some of which were quite small. He also made contour and diversion walls against the slopes in order to check the flow of water, so that more could penetrate the soil. The system of walls and furrows was such that surplus water was carried



3. A close-up view of the dongas seen in No. 2. Note the excellent deep soil that is being washed away.



to the dams. The veld, which had been overstocked and impoverished, he controlled by suitable rotational grazing systems as a result of which the veld improved and the growth became thicker, on its part helping to regulate the overflow of rain-water.

Ultimately very little water was lost from Finkelfontein and sufficient water was retained to produce wonderful results. After all the work was completed and the dams were full, a certain area near the farm buildings remained moist long after the rainy season. When the next season's rains came and the dams, including those that had been built during the second dry season, were full, a strong stream of water began to flow from this spot. To-day there is a strong spring here which is without doubt the spring after which the farm was originally named. With the aid of this dam sufficient wheat is grown to provide 800 lamb ewes with green winter grazing and to rear the lambs without any difficulty. In addition 300 bags of grain are harvested from this land.

Finkelfontein is no longer an arid farm, but has an abundance of water. The boreholes which used to give in so readily are to-day more stable. The most dependable borehole in the vlei has also developed into a strongly-flowing spring.

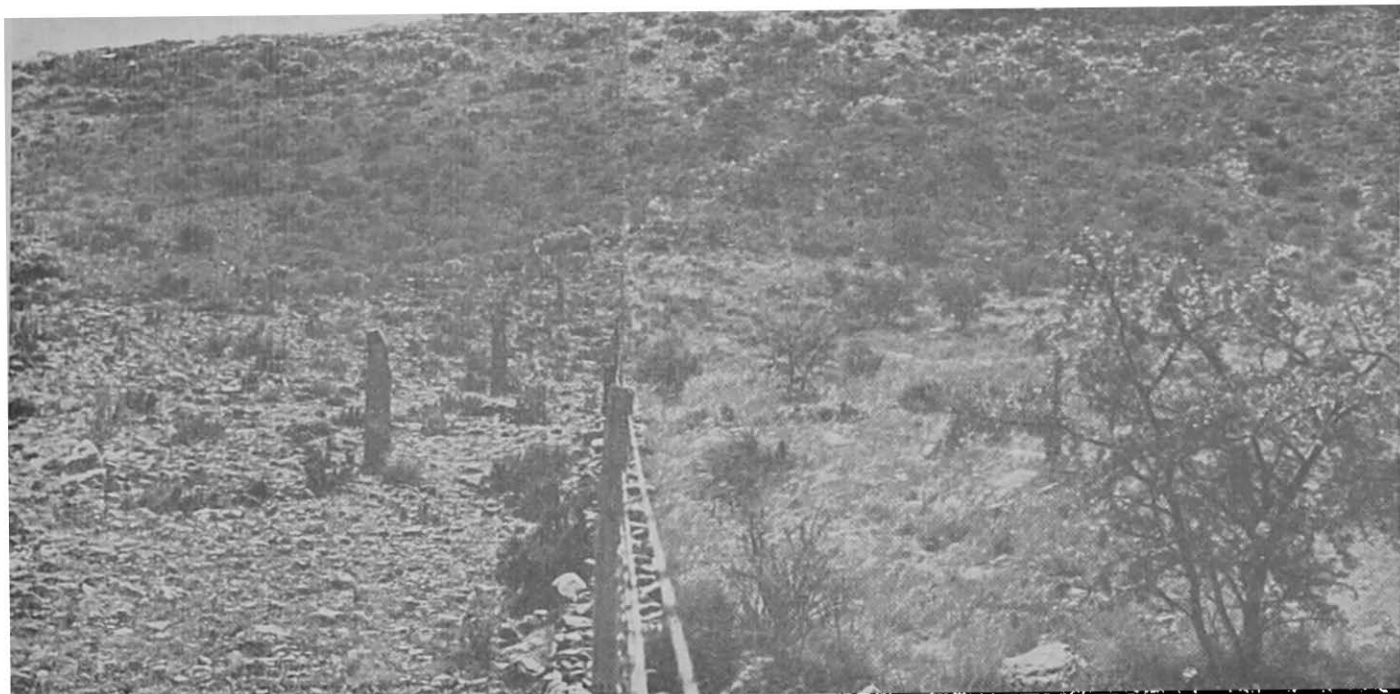
This is the true and actual story of the recovery of the veld and water resources on this farm situated about halfway between Hanover and Richmond, and there are many similar cases. Unfortunately, however, there are numerous farms on which the water resources have dwindled or completely disappeared and where nothing is done towards their recovery. The plaint "South Africa is drying up" is often heard. This statement is not unfounded. To substantiate this, reference need only be made to the weakening and disappearance of springs and permanent streams, the lowering of the subterranean water-levels, as shown in many boreholes and wells and to the increasing severity of droughts. The reason for these disconcerting phenomena is easily found. The water flows down the thinly vegetated mountains more easily and rapidly and drains away quickly along the erosion furrows. A large portion of the water that should have penetrated into the soil to strengthen the subterranean water flows off uselessly and causes erosion damage on its way.

Thousands of formerly moist vleis are to-day arid and disfigured by dongas. These vleis were covered with luxuriant vlei grass and underbrush. Here and there were clear water pools surrounded by reeds. Some of the vleis were marshy. All of them contained an abundance of water in the deep porous soil and between the lush plant-growth. This water

gradually filtered through the soil and appeared elsewhere, sometimes miles away, in the form of a spring. These vleis also fed the larger permanent streams as well as boreholes and wells. To-day, however, the majority of vleis are drained by a network of dongas with their tributary furrows. The water pools have disappeared. Against the walls of the dongas may be seen the deep, black fertile soil, dried out to such an extent that the luxuriant plant-growth which it could have sustained, is absent, owing to lack of essential moisture.

On the farm Pinekloof, on the road from Ladybrand to Maseru, is a beautiful reclaimed vlei. At the time of a visit in 1929 the owner was busy with the construction of a series of walls to control the water. Previously the water coming down from the kloof in the mountain was evenly dispersed over the vlei. Later on a sluit was formed with fingers spreading into different directions, so that the water flowed away in these sluits and was lost and dry veld took the place of the fertile vlei. Where the water fell into the dongas it carved away the soil, so that the dongas became wider, deeper and longer. This process would have continued until no veld remained, had the owner not realized that something must be done. He designed a well-thought-out system of walls, which again disperses the water over the vlei and which allows the furrows between the walls to hold water. In this way the water no longer falls into the dongas and neither do the dongas drain the vlei. The result is a fertile vlei where a large quantity of nutritious hay is cut. The donga has been converted into a series of valuable pools of water surrounded by reeds and benefiting the springs lower down. This was indeed a great task. Where the last wall was built across the largest donga, the latter was so deep that the wall had to be thirty feet high. But this vlei is saved. Others have also been saved as in the Karroo, where in recent years a number of vleis have been treated in a similar way and excellent results have been obtained. However, there are still thousands of vleis where erosion is progressing and which must be saved. In most cases it will not be possible to reconstruct as good a vlei as the original one, as erosion has advanced too far. Further destruction can nevertheless be prevented and the eroded areas can be turned into useful veld which holds abundant water and yields good pastures.

The layman may consider it strange that mountains could be of any importance in the conservation of a large quantity of water, as one surmises that the rain-water would in any case flow rapidly down the steep inclines. This is indeed the case to-day on our burnt, denuded and bare mountains, but in the natural course of events this is not the case. The



4. THE MIXED KARROO VELD. A striking example of soil conservation and destruction. On the right of the farm boundary the grazing is controlled, and the hillside is consequently well covered, yields good grazing, and no abnormal erosion takes place. On the left the hillside has been overgrazed and destroyed for so long that the grass cover has practically disappeared, the carrying capacity seriously lowered, and bad surface erosion is taking place.

densely vegetated mountains, as they were not so long ago, serve as immense water reservoirs which feed and maintain the springs, mountain streams and subterranean water. A good deal of this water was conserved in marshy vleis, or in sponges or on plateaux against the slopes or on the top of the mountains. Many of these sponges have been artificially drained to make room for cultivated lands on the humus-rich soil. Others have been destroyed as a result of veld fires or overstocking. We still have beautiful luxuriant mountains and wonderful mountain streams and springs, but unfortunately there are many that are arid, their streams seriously weakened or dried up. The remains of many a small irrigation scheme, which was dependent on mountain water, gives proof of the weakening of water resources.

South Africa is drying up as a result of the maltreatment she receives. There are no dark unknown reasons for the deterioration of mountain streams and springs—it is the result of soil erosion. The mountains are burnt, trampled and denuded of trees, shrubs and grass and the water sponges are destroyed. The rain-water is not conserved, but rushes rapidly down the inclines and washes away more and more soil. All this can have only one result, viz., accelerated drying up of the mountains, the weakening and complete disappearance of mountain waters and other subterranean streams which are fed from the mountain.

### **Decline of the Productivity of Agricultural Land**

The area suitable for crop production is strictly limited. At the most one-tenth of South Africa is suitable for the purpose. It is therefore a serious matter if the ability of agricultural soils to produce crops is not at least maintained. One would rather discuss the increase in productivity of our agricultural soil, but soil erosion is busy ruining so much of it that the burning question at the moment is to maintain what we still have, and to reclaim what has not yet been lost irrevocably.

Travellers along the railways and roads through our agricultural districts will observe little sluits washing through the lands situated against slopes. The soil that has been washed out by these sluits is the fertile top-soil that sustains the crop. It is important to realize that the top-soil is of limited depth, and must therefore be protected. Apart from alluvial soil in vleis and along spruits and rivers, top-soil to the depth of eighteen inches is considered remarkably good. If therefore this thin layer of top-soil should be lost, any attempt to grow a crop on the dead subsoil may be abandoned. The top-soil has been built up through the centuries making it suitable for ploughing and the production of crops

Its structure is such that it absorbs water readily, that it facilitates the circulation of air, and that conditions for root formation are favourable. It is there that the roots of plants find their indispensable nutriment. Top-soil contains the essential humus that is chiefly responsible for the good physical and chemical condition of soil. It swarms with micro-organisms which transform organic matter into humus, at the same time assisting in the preparation of certain plant foods into a condition rendering them easily assimilable. These micro-organisms therefore play an important part in the creation of favourable physical and chemical conditions in the soil.

The top-soil is the living, proper habitation, both of natural veld and agriculturally grown plants. Remove the top-soil and the sub-soil is exposed. This is clayey, compact, unfriable, impervious to water and air, is difficult to cultivate, and contains only small quantities of assimilable plant foods, humus and bacterial life. The sub-soil is therefore totally incapable of yielding the same crops as the original top-soil. The eroded furrows and sluits so often seen in lands indicate, therefore, that the productive portion of the soil is being lost. This is a serious matter. Every little sluit washed into a land lessens its productive capacity. The farmer often regards these little sluits more as a nuisance, because they make his ploughing difficult. After the land has been more or less re-levelled by ploughing, harrowing and planting, he forgets his lost capital: the soil that has been washed away. These losses are allowed to take place year after year, until at last the farmer wakes up to the fact that his harvests have declined to such an extent that it no longer pays him to cultivate his lands, notwithstanding the application of fertilizers, using better varieties of crops, good seed, and trying whatever other expedients he can think of.

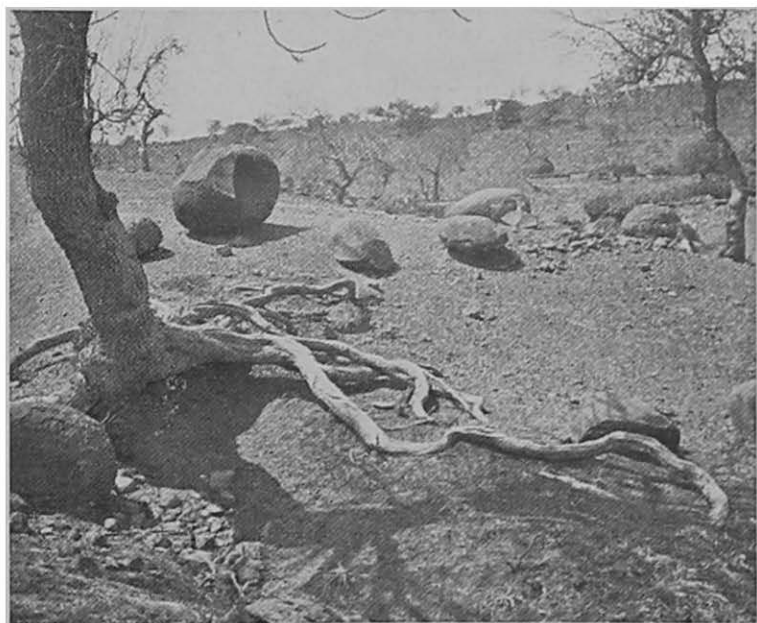
Eventually he must abandon the eroded lands. These soon become the prey of further accelerated erosion, because when once the top-soil has gone, the more easily erodable sub-soil soon goes, and the dongas become deeper and wider. Some of the deepest and worst dongas are to be found where once good crops were harvested. Unfortunately there is no lack of such cultivated lands, now practically lost beyond reclaim. There are many others rapidly going the same way to total destruction. The need for the application of soil and fertility conserving methods is very great. On the other hand, there are also similarly eroded lands, which, with the application of reclamation measures, have been rescued from total destruction, and are again yielding good crops.

The correct methods are known. All that is needed is their application.

There are cases, particularly applying to the wheat lands of the winter rainfall area, where sluit erosion is seldom observed, and yet the productivity of the lands has declined seriously. It is often disputed that this is also a result of soil erosion, since the washing of the lands is not apparent to the eye. It is true that sluits and rills are not often seen, but the collodial soil constituents containing its fertility have gradually been dislodged and washed away. In the course of time the soil therefore becomes more sandy, more compact, is more difficult to cultivate, and becomes more impervious to water. Its productivity is declining.

### Wind Erosion

Thus far the damage caused by water has chiefly been dealt with. Wind erosion, however, is also the cause of soil losses. It often accompanies erosion by water. In the Karroo for instance, wind erosion often plays an important part, in conjunction with surface erosion. As the veld becomes sparse, and water begins to wash away the top-soil, wind erosion comes into play and assists in the process. Once a bare patch has been created the grains of sand on it are



5. NATAL. The roots of this tree once grew and developed in good soil.

easily blown by the wind, and they then bombard the surrounding vegetation to such an extent that it is weakened and eventually killed. In this way the bare patch increases in size. As the surface becomes more sparse and bare so conditions become more favourable to water erosion.

Certain portions of the country, notably the North-Western Cape, have suffered enormously from wind erosion. The cause here was the ploughing of good sweet veld for wheat. For a period good harvests were reaped from the sandy soil. The price of land increased as a result. The soil and climatic conditions, however, were not suitable for cultivation, and consequently the soil started blowing away. To-day a scene of sandy desolation characterises portions of this region of former wheat-lands. Even sand dunes are in evidence. Wheat no longer grows, and the pastures have also been destroyed.

Other parts of the country, particularly the Western Free State and Transvaal also suffer from wind erosion on ploughed lands. It is a sad sight to see wind-driven sand destroy a stand of mealies. The pellets of sand strike the plants immediately above the surface, injuring them to such an extent that sooner or later they die. In some lands heaps and dunes of wind-driven sand have made an appearance.

The causes of wind erosion are the same as those of water erosion, i.e., over-grazing and destruction of the veld, and exhaustion and structural collapse of cultivated lands.

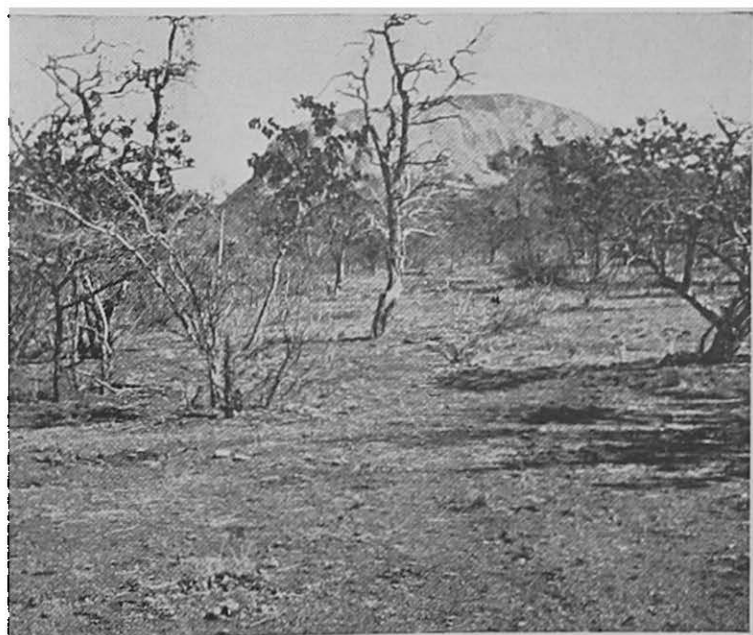
### **Vandalism of Natural Beauty**

The poet, who sang of gathering wild flowers and stealing kisses in the vlei, where the birds sing happy and gay, will, should he re-visit the vlei that inspired his song, receive a nasty shock. So did the writer when he recently for the first time re-visited the farm where he lived and played the first eleven years of his life. The happiest memories of childhood's years on the farm are related to the vlei. Its natural swimming pools were the delight of all the children of the neighbourhood, including the native picannins. The attempts to snare red, yellow and longtail-finches afforded much pleasure to the children. Pig or Arum lilies were gathered to win the favour of their teacher. It was a bitter disappointment to find that the cool pools of water had disappeared, that the longtail and other finches had sought pastures new, and no lilies were to be seen among the parched, ugly dongas. This former scene of beauty had turned into such a nightmare of ugliness that it seemed that childhood's memories existed in imagination only, and yet, we did swim in those crystal clear pools, did try to trap

those gaily coloured birds, and did pick flowers for the schoolmistress.

Soil erosion is everywhere busy spoiling the beauty of nature. A sea of grass, particularly "rooi grass" (*Themeda*), is a beautiful sight, and more so when the wind ripples it into waves, and sleek cattle graze contentedly. All too often, these days, we have to use our imagination to form some picture of what a certain hideously eroded or wind-blown piece of ground used to look like. Many travellers pass Naauwpoort either by road or rail. A traveller of the early days has described how beautiful that part of the country used to be, with its green pastures, marshy vleis and streams of water. When next you journey past there, have a look for yourself and try to find those former scenes of beauty.

Those magnificent mountain views, green slopes and bush-grown kloofs, with their rippling streams of water, are now also gone. To-day they are bare and dismal sights, and an easy prey to the ravages of erosion. Fortunately they are still beautiful in the high rainfall areas, but where the rainfall is low many mountains stand to-day stripped naked, and unpleasant manifestations of human destructiveness.



6. NORTHERN TRANSVAAL. The veld is trampled out and destroyed. Most of the rain water runs off and washes away the top soil with it. Even the trees are dying. Dongas will soon appear.



Water, apart from its usefulness, is always fascinating. There is always something attractive about a place where there is water, even if it is only the croaking of frogs. But our waters are disappearing together with the fairness of scene that usually goes with them.

We are busy distorting the face of South Africa into an unfriendly, forbidding and frowning countenance, to mutilate the fair prospect of Karroo plains, the waving grasslands and majestic mountains, and to silence the songs of birds, and the evening chorus of the frogs.

### **Extent of Erosion Damage**

From a reliable source it has been recorded recently that erosion has already lowered the potential productivity of South Africa by twenty-five (25) per cent. This does not mean that we cannot produce more than we do at present. If we practice better farming systems we can increase our production of farm products, and establish it on a more stable basis. This disturbing assertion does mean, however, that if we were to extend our productive capacity to the maximum, we would only be able to produce three-quarters as much as we could have done if our soil, veld and water resources had been to-day in the same condition they were a hundred years ago. In other words, a hundred years ago our agricultural resources were such that if the productive capacity were extended to the utmost, the country could have supported a considerably larger population than it can to-day. It is shameful admission, but nevertheless true, that the agricultural resources of the country have been so misused that the population it can support, is decreasing in numbers.

This assertion has been questioned. Various arguments have been raised to prove that we can produce much more than we do at present. It is not denied that the present methods of production can be improved upon, and that it is possible to produce much more, but at the same time there is no doubt about it that the natural resources of portions of the country have been destroyed to such an extent that they are no longer capable of producing anything, and that those portions are therefore potentially lost.

A short summary of the soil erosion damages mentioned above will indicate that the potential loss in productivity of 25 per cent. has not been exaggerated. The productive, top-soil of our lands is being washed away—as witness observe the rills, sluits and dongas. Lands which have been so washed away that they can no longer be cultivated confirm the evidence. The former fertile, well-covered veld, which over large stretches has been replaced by dongas,

surface erosion, poor and sparsely grown patches, prove that the productive capacity for animal products has declined alarmingly. The evidence of silted dams that no longer hold water to nurture a crop is irrefutable, and points to the doom that awaits lands dependent upon water from dams that are rapidly silting up. The relics of smaller irrigation schemes which depended upon mountain streams and other former streams of water and springs, tell the story of water resources of the past that have now disappeared, and is a warning of what is still to come.

The simple fact boils down to this : that we have misused and continue misusing our natural agricultural resources, soil, veld and water, with the result that about a quarter has been lost, and another quarter is rapidly going downhill. If we wish to safeguard our own existence here, and that of our descendants, drastic measures will have to be taken immediately to get the destructive forces of erosion under control once more.



7. NORTHERN TRANSVAAL. Bare veld similar to No. 6, now reclaimed and made useful once more. Food has again been provided for animals. The rain-water soaks in where it falls. The soil no longer washes away.

## CHAPTER II.

## NATURAL BALANCES.

THE pioneers, as they spread over South Africa, and tamed and made habitable one part of the country after the other, did not find unchained forces of erosion busy destroying various areas. As they trekked through the country they discovered a great diversity of soil and veld types associated with changing landscapes and water sources, and of climatic and rainfall conditions. Notwithstanding this great diversity, however, conditions were everywhere stable; the soil, vegetation and water supply were in harmonious relation with one another, and with the topography and prevailing climatic conditions.

A certain pioneer came to the conclusion that he had reached his destination when upon a day he outspanned alongside a spring where the surroundings particularly pleased him. The range of mountains formed a wide semi-circle and embraced the environment of his camp with wide-open arms. The piece of land extending from the foot of the mountains did not slope uniformly and was not a regular terrain. Dotted about in the basin were smaller hills, koppies, and rises, and in between these were both small and larger vleis, which at their upper levels merged with the mountain kloofs, and at the lower expanded into the broad vlei below. This vlei in turn emptied into a water-course which conveyed the surplus water to the nearest river. Beyond the vlei stretched an undulating landscape of rises and ridges.

This piece of South Africa that charmed the pioneer, and where as stock farmer and agriculturist he found everything his heart desired, did not just happen to be there one fine day. Thousands of years had passed before it had evolved to that stage. The infinitely slow soil-forming, weathering processes had gradually ground the rocks and stones into soil. The first particles of rock which broke from the slopes were washed down to the lowest level where they gradually built up the first thin layer of soil. Here plants began to take root and helped to catch up more soil-forming particles. Centuries passed and the vegetation and soil not only increased, but both underwent radical changes. The finely ground rock

was increasingly changed into the soil we know to-day, and the plants evolved from simple forms to the grasses, shrubs, trees and flowers the pioneer found when he arrived on the scene. Through the centuries Nature had worked for this pioneer, covering mountain slopes with soil, gravel and stones, so that they were suitable for the growth of trees, shrubs and grass, which covered and bound the surface. More luxurious and denser bush, shrubs and grass grew in the kloofs, which were all moist, and in some spring water began to flow.

The soil against the hills and koppies is more or less of the same nature as against the mountain slopes. It is shallow in most places, but there is sufficient of it to provide for a dense short grass cover, with a tree or shrub here and there.

The soil in vleis is mostly of a black colour, fertile and deep; it can absorb and retain much water for the use of plants growing there. This valuable vlei-soil was washed down and collected over many centuries. It contains the accumulated fertility of centuries and it is for this reason that in such soil grasses and rushes grow so well. The main vlei is thickly overgrown, with luxuriant reeds around the pools of water, and on most marshy ground.

The soil of the undulating country beyond the mountain slopes is of a different nature. For a depth of twelve to eighteen inches it consists of a sandy, porous loam, but below that is a tough, clayey, unfertile subsoil. This undulating country, however, is thickly covered with beautiful sweet grasses, which even in winter provide good feed for animals.

There is an abundance of water everywhere, such as the crystal clear springs, and the natural ponds. Should it be necessary, there are also excellent sites for dams, which would be filled, not with mud, but clean water.

Shortly after the pioneer had camped here it began to rain incessantly for days. Soon the soil could no longer absorb all the water. The marshy sponges on the mountains and the pools were all filled. Much surplus water had to flow away, but it did so gently. The water flowed down the slopes to the vleis, and from there into the big vlei, where, spread out, it meandered to the watercourse and eventually as clean water reached the river. The vegetation against the slopes and in the vleis regulated the flow and guarded the soil against erosion.

It was of course necessary for the formation of the landscape, the soil and the vegetation, that soil particles had to move. When the pioneer arrived this soil movement was still going on, but nature controlled the process. The gradual shifting of soil material by wind and water is a natural

process that has always been going on, and that will continue indefinitely. This is the process of normal or geological erosion. Under undisturbed natural conditions this normal erosion is such a gradual process that no serious losses occur. At the same time soil building processes are taking place that more than compensate for the losses. The soil material conveyed by normal erosion is again deposited at the lower levels. Here it gradually accumulated and built up our valuable vlei and alluvial soils along water courses and rivers. These alluvial soils are of the most productive we have, since much of it is irrigable.

Normal erosion is therefore an extremely gradual, natural and useful process. It is also responsible for the sculpturing of our landscapes and the lovely variety of natural beauty, ranging from rocky mountains and kloofs to wide, open plains.

The variations in the hardness and weatherability of various geological layers and formations have played an important part in the sculpturing of the landscape by nature, forming slopes with different degrees of fall, undulations and valleys, as they are to-day. To quote but one instance, the dolorite layers so often found in softer formations, often determine the plane along which the slope of a valley or vlei



8. O.F.S. This was once a wheat field in the Orange Free State. To-day it is a patch of sand dunes.

is built up. Should this dolorite layer be blown away with dynamite, for instance, abnormal erosion will take place above it, because the topography will have to be reformed to adjust itself to the lowered buttress.

So through the ages our soil, with its rich variety of vegetation, has been built up, and the water resources fitted into the scheme. Our agricultural resources, soil, veld and water, were prepared for us in advance. All we had to do was take possession. They evolved side by side, are mutually dependent upon one another, and if something goes wrong with one the others suffer as a result.

It is most important to realize that the soil and veld types found in a particular region are the natural result of a gradual evolution under the prevailing climatic conditions, included in which is the quantity and nature of the rainfall. The prevailing climate was instrumental in evolving simultaneously the soil and the vegetation, and the one influenced the other. According to established laws of nature, static balanced conditions and stability were created in the course of time, as between slopes, soil type, vegetation and climate. For instance Bushman-grass veld became the natural cover of regions with a very low rainfall and so long as this vegetal cover can be maintained no difficulties will arise. In other regions with a high rainfall Tambuti grass for instance became dominant, because the compound of natural factors required this veld type for the creation of a stable equilibrium in that environment.

The variety and nature of the vegetation are not only a result of the particular soil and climatic conditions, but are at the same time an expression or revelation of the nature of that special soil and climatic environment. The different factors are mutually and inseparably related. The constituents of the soil have developed under the influence of the prevailing climate and of the indigenous vegetation; the vegetation has developed under the influence of the climate and soil type. They cannot be divorced from one another. For this reason you would not expect to find "rooi" grass in Bushmanland, or Karroo veld in the fifty-inch rainfall mist belt along the Drakensberg mountains. But if something is done to bring about a drastic change in one of the ruling factors then the others are also affected. The encroachment of Karroo veld serves as a practical example. The Karroo has gradually penetrated into the adjoining grass veld for the reason that the grass has been over-grazed and tramped out to such an extent that the run-off has increased, and less water absorbed by the soil. The usefulness of the rainfall has thus diminished, which simply means that too little water penetrates the soil to maintain a covering

of grass. Consequently the grass has given way to Karroo bush which can do with less water. This, however, is not all. The topography and the soil had originally developed with and under the influence of a grass covering. Where the grass had now been replaced by a more sparse Karroo veld, the equilibrium had been disturbed; more water runs off more rapidly, and the soil, no longer protected by grass, washes away.

### The Hydrologic Cycle in Nature

A study of the hydrologic cycle in nature presents the matter in a clearer light. What happens to the water falling from the clouds? With the assistance of the sketch given at the end of this pamphlet we will follow the hydrologic cycle:

- (1) A portion of the falling raindrops evaporate again and return to the atmosphere before it reaches the earth's surface.
- (2) Further evaporation takes place from the leaves and stems of plants before the rain reaches the soil.
- (3) Of the water reaching the ground a portion sinks in :
  - (a) A portion of this is of vital importance to the plants that grow in that soil, because it is used in the assimilation process in which the carbon dioxide, that the leaves absorb from the air, and the water that the roots take from the soil under the influence of the sun's heat and light are converted into plant material; in this way the materials that constitute the plant body are collectively formed in the process of growth. In this process of growth most of the water taken up by the roots is again released through the leaves in the form of vapour. This is the transpiration process which takes place simultaneously with the assimilation process. A very small portion of the water taken up is used in building the body of the plant, where it may be retained for a time, but eventually, when the plant decomposes, is again released into the atmosphere as water vapour.
  - (b) A portion of the water absorbed by the soil evaporates again directly, even before it sinks to deeper levels or is absorbed by the roots of plants. The volume that in this way returns unused into the atmosphere depends on how much is used by the roots of plants, the temperature of the soil and of the air immediately above it, and on the physical structure of the soil. Much water can be lost from the soil in this way.

- (c) Some of the water sinking into the soil penetrates to a good depth, below the reach of roots and of direct evaporation. This feeds the underground water supplies, and reappears on the surface at various distances in the form of springs. Spring water may evaporate directly into the atmosphere, or some of it may seep again into the top-soil, from which it may evaporate or be used by plants, to pass into the atmosphere eventually as transpiration water. The underground water is also pumped out of wells and boreholes and brought to the surface for the use of animals and plants, and through which, or by direct evaporation, it again reaches the atmosphere.
- (d) Lastly, it sometimes happens that the water that sinks deep into the soil reaches underground streams that do not lead back to the surface, but direct to the ocean, from which it again evaporates.
- (4) When the rain reaches the soil surface, a portion of it does not evaporate immediately but flows away over the surface. It fills depressions, pools, marshes and dams, and after this the surplus flows down dongas, watercourses and rivers to the sea. While on its way, and from the pools and dams, some of the water also evaporates, and eventually after it has reached the sea it evaporates to supplement the water-vapour in the atmosphere.
- (5) Some of the water impounded in pools, marshes and dams penetrates into the soil and nourishes the surrounding plants, or sinks deeper into the earth, to strengthen the underground water supply. Along these channels it eventually reaches the atmosphere once more.
- (6) The use of water by the animal kingdom must not be forgotten. What happens in the case of plants is duplicated in animals. The major portion of water used as such by animals, or that enters their bodies, contained in the organic matter they consume, is transpired in the form of perspiration or breath, and thus re-enters the atmosphere as water vapour. A smaller quantity is separated in liquid form, but this also eventually reaches the atmosphere. Still a smaller quantity is used in building the body, the decomposition of which, however, eventually releases the water.

The fact therefore emerges that there is a perpetual hydrologic cycle in nature. Under certain conditions the vapour in the air gathers together in the form of clouds,



from which it falls to the earth as rain. On reaching its destination, rain-water performs a variety of functions, and travels along many different channels, but is eventually re-absorbed as vapour by the sun's energy, to take part in the formation of clouds.

Under natural conditions all this takes place in an orderly manner and according to plan. Plants grow because sufficient water is absorbed by the soil to feed them. Springs and streams flow constantly because they are constantly being replenished. The fall of sloping land is such because the soil and the vegetal cover have evolved in such a manner that a stable condition is reached which protects them against the force of running water, of which the manner and speed of run-off is again regulated by the grade, density and nature of the vegetal cover. Everything is in a state of harmonious equilibrium. A disturbance of but one of the controlling factors may throw this harmony out of balance, with disastrous results. For instance, the important factor that determined the slope  $A-B$  as  $X\%$  (vide sketch) was the fact that at  $A-A$  a hard dolerite reef is situated which through the centuries has served as a buttress, against which the soil and vegetation built up along the slope  $A-B$ , and which under certain conditions brought about the particular slope of  $X\%$ . After maintaining its position for centuries, this reef eventually succumbs to the weathering process, it crumbles and disintegrates. Imagine that the reef were to crumble and wash out to a depth of ten feet. The buttress of the slope  $A-B$  has now disappeared. The speed of run-off water is increased with the result that from  $A$  a donga ten feet deep begins to eat its way up to  $B$ . There is nothing unnatural about this. It is simply the re-adjustment of a new balance at a lower level, to conform with the new lowered buttress at  $A$ . The slope above  $A-A$  becomes eroded into dongas, and the veld is destroyed. But if we could afford to wait sufficiently long, perhaps some centuries, a new state of equilibrium will have been created, at a 10-foot lower level than originally, and the soil will support good veld once more. If, however, we had repaired the reef with concrete when it broke, the original conditions would have been maintained.

In passing it might be mentioned that there are thousands of such broken key point buttresses in South Africa that should be repaired. Unless this is done, dongas will be washed upstream from such points, and will multiply until new planes have been formed in conformity with the lowered levels of the faults. All other supporting measures, such as the fencing in and revegetating of the dongas, and building small barricades in them will decelerate the desiccation to

the new level, but stable conditions will not be reached until the new plane and slopes have been established.

Now let us consider the more common form of disturbance of the natural equilibrium, i.e., the derangement of the plant cover. As already mentioned, the soil and veld types evolved simultaneously. Now imagine that by some means or other the plant-life has suddenly been exterminated. This will immediately disturb the normal course of the hydrologic cycle. More water will run off at an accelerated speed. The underground supply will be deprived of its rightful portion, and at the same time soil will be washed away.

This sudden extermination of the vegetal cover actually takes place when a piece of land is ploughed over. Special measures should therefore be taken to protect the exposed soil against erosion. A gradual weakening and destruction of the veld takes place as the result of injudicious veld utilization methods. The ultimate result is the same: the disturbance of the hydrologic cycle with its inevitably harmful effects.

### Water in Motion

In the hydrologic cycle it is that portion which flows over the surface that under certain circumstances cause damaging erosion. In order to understand the way in which the erosive force of run-off water can be increased, and the measures to be adopted, to combat this, it is necessary to have some knowledge of certain elementary principles and laws connected with water in motion.

I. *The quantity of matter conveyed by running water depends upon (a) the nature of the surface over which it flows and (b) the speed of the flow.*

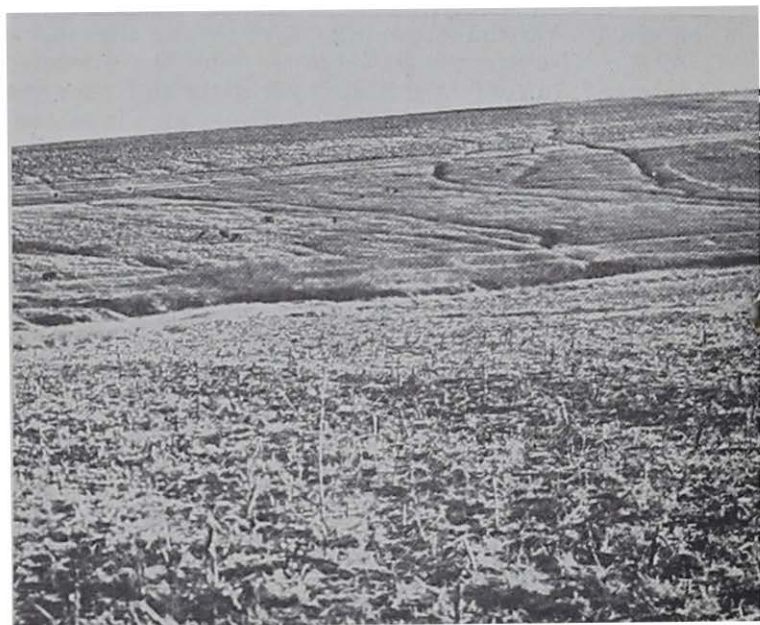
#### a) THE NATURE OF THE SURFACE.

Water flowing rapidly over a hard rock surface will remain clean, because the cohesion of rock particles is strong enough to withstand disintegration by the force of the water. The power of resistance of the rock against water is great. If the same flow of water were to cross a ploughed field, small soil particles would be suspended in the water and carried along, and bigger loose detritus might be rolled along as well. Soil particles do not adhere together as strongly as rock particles. Their cohesion is weaker. The resistance of soil against the water erosion is much less.

The erodability of the various soil types also differs. For example, the tough, claylike soil of many Karroo depressions, usually termed "brak leegtes" by farmers, is very susceptible

to erosion. Should the protecting plant-cover be destroyed and the thin top-soil layer begin to wash, erosion is accelerated and the whole vicinity becomes a maze of dongas with brackish soil exposed. In contrast to the above, the black vlei soils are less susceptible. This soil has a better crumb structure, and is not so easily suspended in water, and thus easily washed away. If dongas are allowed to develop in the black vlei soils they will also multiply, but not at such a rapid rate in all directions as is the case in the brackish depressions.

The physical and chemical constituents of the soil and the thickness of the various layers determine the erodability of that particular soil. It is important to realize that these constituents and consequently the erodability of the soil is influenced by the treatment the soil receives. For instance, a heavy thunderstorm falls on an evenly sloping bult covered with the same type of soil. A portion of this land is still covered with a good mat of grass, a second portion has just been burnt, and a third has been ploughed over. The grass covered portion will withstand the forces of water erosion better than the burnt portion, and the ploughed piece of land will be most vulnerable to erosion.



9. ORANGE FREE STATE SCENE. Cultivated lands on sloping ground through which dongas have been washed. If proper measures are not taken these lands will be altogether useless within a few years.

Wrong agricultural methods influence the physical and chemical qualities of soil to the extent that its erodability eventually increases. When a piece of loamy soil is ploughed for the first time its structural condition is such that it is comparatively erosion-proof against run-off water. In the course of time, however, as the humus becomes exhausted, and the structure degenerates, the soil particles are more easily suspended in water, i.e., its erodability increases. This is not unavoidable. If methods of utilization are used that preserve a good structure, the erodability will not increase.

#### *b*) THE SPEED OF RUN-OFF WATER.

With an erodable material like soil the quantity of fine material that is conveyed in suspension, and the coarser that is rolled along, are determined by the speed and volume of the running water. If the volume remains uniformly constant the speed is the chief deciding factor.

As a general rule it holds good that an increase of speed means an increase of the quantity of material that can be conveyed; and, *vice versa*, if the speed of flow of a fully laden stream decreases, some of the matter in suspension will be deposited. This is a basic principle which is applied when soil conservation works are erected.

II. *The speed of flowing water is determined by a number of factors, of which the following are the most important, in regard to combating soil erosion:*

(a) The steeper the slope the faster water will flow.

The energy that motivates the flow of water from point *A* to a lower point *B* is determined by the vertical fall between the two points. Say, for instance, the vertical fall between *A* and *B* is ten feet. If the distance between *A* and *B* in one case is 1,000 feet and in another only one hundred feet, then the slope of the latter will be much steeper and the water will flow much faster than in the case of the former. The vertical fall between *A* and *B*, however, is the same in both cases, and the water movement begins at *A* in both cases, with the same amount of energy to make it flow. The conclusion arrived at is therefore that the longer the distance the water has to flow to pass down the same vertical fall, i.e., to use the same amount of energy, the slower it will run. This principle is also used in combating erosion.

(b) The smoother the surface and the less obstacles, the less resistance there will be against the flow of water and the faster it will run.

- (c) A given volume of water, when collected together, e.g., in a donga, flows faster than when spread out over a wide surface; the narrower and deeper the donga the more rapidly the water will flow.
- (d) In similar dongas greater volumes of water will flow faster than smaller.

With regard to (b), (c) and (d) it will therefore be understood that in proportion to the number of obstructions in the way of the water, so will the energy necessary to overcome them be consumed, and the less energy there will remain to increase the speed. Furthermore, the greater the surface over which the water is spread and not allowed to accumulate in defined courses, the less speed with which it will flow. In this way the opportunity is afforded the soil to absorb more of the slowly flowing water. The volume that runs off is lessened in this way, as well as its speed.

III. *The speed of flowing water is most important so far as soil erosion is concerned, as will appear from the following :*

- (a) If the speed of water is increased, its capacity to transport soil is increased, because—
- (b) the capacity of water varies approximately as the second power of the speed of flow, i.e., if the speed of a stream is doubled its capacity to convey soil is increased  $2^2=4$  times, or if the speed is trebled the stream's carrying capacity is increased by  $3^2=9$  times.
- (c) the size of particles of the same material which can be conveyed by a stream of water varies as the sixth power of the speed of flow, i.e., if the speed is doubled it gives the water the power to carry particles  $2^6=64$  times larger.

It is, therefore, clear from (b) and (c) that the increase of the speed of run-off water intensifies the danger of erosion considerably.

IV. *In connection with soil erosion combating measure: one therefore aims at :*

- (a) An increase in the cohesion and resistance of the soil against the water flowing over it. This can be attained by maintaining the humus content and good structure of the soil, and by keeping the vegetation growing on it in a healthy, luxuriant and dense condition.
- (b) A reduction of the speed of run-off water—
- (i) by an increase in the number of obstructions, so that energy may be expended in overcoming them,
  - (ii) by increasing the length of the flow,
  - (iii) by inducing the water to flow in numerous small

streams and to prevent them from converging into larger streams along distinct courses.

In a nutshell, all this demands a healthy, dense vegetation, and, in the case of ploughed land, the surface must be irregular and ploughed on the contour.

The surface of an undulation well covered with vegetation is usually irregular, and the plants, as well as the decayed vegetation, form numerous obstructions. The water must find its way through the tufts of grass and other plants and thus remains divided in numerous small streams which by devious ways reach the foot of the bult. In this way the speed of the water is decreased, but should the bult be maltreated by burning, over-grazing and tramping out, the speed restricting factors are weakened and the more bare the piece of land becomes, the more quickly will the water run off, and the more will it also tend to collect in defined courses, where dongas will begin to form.

V. Where a donga has actually been formed, water falling in its catchment area will flow with increasing speed. The erosive force of the water in that area is therefore increased tremendously and promotes the rapid eating back and extension of the donga.



10. NORTHERN TRANSVAAL. This field is cultivated on the contour, and the potatoes are also planted on the contour. Strips of Napier fodder planted at regular intervals further protect the soil. Here soil erosion is no problem.

## CHAPTER III.

## THE CAUSES OF SOIL EROSION.

THE discussions in the previous chapters have shewn where the causes of accelerated and destructive erosion are to be sought. It is still necessary, however, to discuss the matter more comprehensively here, even at the risk of repeating certain points.

**Misuse of the Veld — the Basic Cause of Erosion on Unploughed Land**

The primary cause of soil erosion on the veld, including the slopes of mountains, must be attributed to such disturbances in the nature and density of the natural vegetal cover as inevitably lead to the increased and accelerated run-off of rainwater. Such changes, or rather deterioration of the veld have actually taken place, and the process is continuing over vast stretches of our country. When the natural balances have been disturbed to such an extent that more than the normal run-off rain-water occurs and abnormal erosion commences, a further weakening of the vegetation is induced, because less water is absorbed by the soil for the use of plants. A vicious circle is created in this way, by which one evil plays into the hands of another, and bad is followed by worse.

Imagine again that we are inspecting one of our numerous bults, thickly overgrown with "rooi" grass. The good living top-soil on which the veld grows luxuriantly consists as a rule of a comparatively thin layer, seldom more than eighteen inches in depth. This top-soil rests on a more compact, clayey, dead sub-soil, incapable in itself of affording habitation to a luxuriant growth of vegetation. The top-soil readily absorbs rain-water. The surplus water flows comparatively slowly over and between the grass without causing any erosion damage.

Then comes the winter, when, as so often happens, the grass is burnt. Even the dead decaying grass that forms a sponge-like layer around the tufts, and that facilitates and hastens infiltration of water into the ground, is burnt. The ash containing the mineral plant-foods obtained from the soil is blown away by the wind and what remains is later washed away.

The first early rains of summer now begin to fall. As usual they are sharp downpours. The raindrops strike directly on the bare spots between the burnt tufts of grass and bombard them so intensely that the thin toplayer of soil is churned up to such an extent that some of the soil particles are suspended in the water. It is now also easier for the water to find a way down the bare hillside, in this way increasing the volume and speed of water flowing away, carrying with it soil in suspension. Less water is also therefore absorbed by the soil, thus the grass receives less for its use, less pasture is produced and more soil is eroded away.

Added to this, the piece of land is overgrazed ; too many cattle are put to graze on it. The veld is thus kept short, and since the cattle cannot find sufficient to eat, they wander from place to place looking for food and trample out the veld, loosening the top-soil, and injuring the grass, particularly the young tender plants. The habits of growth of summer grasses are such that during the summer growing period the plants store reserve food-supplies in their roots, in order that the plants may be capable of developing strongly the following spring, as soon as there is sufficient moisture and heat in the ground, until enough green leaves have developed to enable the plant to grow further actively. If the veld is therefore overgrazed during the summer, the plants do not have this opportunity of gathering sufficient reserves, with the result that they enter the next period of growth with a diminished power of growth. This in itself may adversely affect the possible production for that season.

At the commencement the increase in water losses and erosion that accompany the first decrease in plant-cover and water absorption may be slight, so trifling that it is not noticed ; nevertheless it is the beginning of the evil, which progressively grows worse, and soon the veld vegetation will be struggling to exist. Above ground the plants are misused while below ground their water and food supplies dwindle, as more and more water and top-soil washes away. Plants begin to die. Less and less seed is propagated and the conditions for its germination become more unfavourable. Seedlings that do manage to appear have little hope of developing fully. And so the bare patches between plants become bigger and bigger. A real vicious circle rules supreme.

At this stage sheet or surface erosion sets in. Top-soil over the entire surface is lost. Soon dongas will begin to appear. Run-off water concentrates along defined channels, like foot-paths, and the first sluits are born. When once the top-soil has been eaten away, the sluits rapidly become deeper and wider, because as a rule the erodability of the



sub-soil is greater than that of the top-soil. As the sluits and their tributaries expand, the drainage of our piece of land is increased. As a result the efficacy of the rainfall diminishes rapidly, and the plants suffer more and more from drought.

This is the usual course of events, but it does not always happen exactly as sketched above. The trouble need not necessarily start with a veld fire. Overgrazing during a dry season, for instance, may set the ball rolling. In some cases the time that elapses between the weakening of the veld and the appearance generally of sheet erosion and then dongas will be short, but in other cases it may be quite a time. This will depend upon the extent of overgrazing, veld trampling and destruction of the topography, the nature of the soil and veld, and the quantity and incidence of the rainfall, and also of the class of stock farmed with.

It has often happened that owing to a bad system of farming, cattle-veld has been allowed to be grazed so short by cattle that they could no longer exist on it. After that sheep are placed on the veld. These animals, which can subsist on shorter pastures, then accelerate the deterioration already begun. For some considerable time, however, the sheep manage quite well; together with goats they can maintain a living on the degenerating veld. Small stock remain in good condition and the farmer labours under the misapprehension that he is practising the correct farming system. Should he observe that his veld is becoming more sparse, and the run-off water more muddy, as erosion increases, he takes little notice, because the condition of his stock tells him that everything is still in order. The method of "taming" the veld with cattle so that it will be suitable for sheep is often practised deliberately. It was certainly never realized that this "taming" of the veld was in reality a veld-destruction and erosion-promoting process. As regards topography, it is obvious that, if other factors are equal, the danger of erosion is greater in proportion to the increasing degree of the slope.

The erodability of soils also differs. Some kinds of soil and veld types are more vulnerable than others. In this respect the climate and rainfall plays an important part. The natural balances are more sensitive in the low-rainfall sweet-veld than in the high-rainfall, thickly-covered sour-veld regions. Sheet, donga and wind erosion in the sour veld is therefore less serious in comparison with the extent with which the sweet veld and Karroo are threatened. It is for this reason that the perennial grasses of many Karroo farms have almost entirely disappeared, and the more sparse shrubs have encouraged surface erosion over vast areas.

On many farms this has advanced to such an extent that large bare patches are to be seen, and networks of large and small dongas are in evidence. Many of the hills and mountains, formerly well protected by grass, are now bare and barren, others are going the same way, and the rain-water rushes down their slopes, laden with soil.

It is quite true that the Karroo bushes make good grazing for sheep, and the assertion of many farmers that it pays to overstock grass veld, and to treat, or rather maltreat, it in such a way that it becomes bush veld is probably also true. Nevertheless it is a short-sighted policy, and even though it may pay, and pay well, the person who practises it, it creates difficulties for those who follow him, when the soil erosion he has set in motion has advanced to such an extent that even sheep farming will no longer be easy, and it will be found that the productive capacity of the farm has diminished considerably, although the capital invested in the farm remains the same or higher than it was originally. To-day many farmers are already reaping the bitter fruits of these rapacious farming practices.

This does not mean that the aim should be to replace the nutritious Karroo bushes by grass. The two should be coupled together. The management of the veld should be such that at least those portions that are most susceptible to erosion, i.e., the slopes, the hills and the mountain sides, and some of the vleis should be well covered with grass. This is quite possible in practice, particularly in the artificially created Karroo regions, namely, those parts that were grass country a century ago.

The tentacles of the Karroo are stretching out wider and wider. In the course of time the grasslands bordering on the Karroo proper have been largely exterminated and the Karroo shrubs have taken their place. This process is continuing and is definitely a sign of danger. The natural balances have been severely disturbed here, and accelerated erosion is robbing these regions of soil. Sheet erosion as well as desiccation is taking place. Such unstable conditions have been created in these parts that it is not surprising that some of the most extended and ghastly donga erosion is to be found there.

In mixed-veld grass regions, and particularly in the sour veld, the misuse of the vegetation has not had the same result of aggravated erosion. The veld has certainly changed as a result of wrong methods of utilization, and grasses of better quality have and continue to be exterminated; but fortunately they are generally being replaced by plants of inferior quality, with the result that, although the quality of the veld is diminishing, the soil remains covered and is

protected against sheet erosion. In passing it might be mentioned that as the result of wrong grazing practices "renoster-bush" (*Elytropsus rhinocerotis*), "harpuis"-bush (*Europs tenuissimus*) and helichrysums have invaded such large areas of veld that its value for grazing has been lost, or has seriously diminished. In the sweet thornveld regions the encroachment of thornbush has also become a serious problem. The bush has become so dense in places that it has to be eradicated at considerable expense before useful grazing on the veld can again be obtained.

The expression "overgrazing" used here signifies much more than simply having too many stock grazing on a particular area. Often actually the reverse of too many head of stock may yet result in overgrazing, simply because a suitable veld management system is not being practised. Instead of first studying the physiography of the farm, taking into consideration the veld and soil types, and then systematically dividing it into camps, and following a suitable rotational grazing system, the stock wander about at will over the entire farm, or in camps that are too large. Even if the farm has been divided into camps, these are often placed wrongly, for instance if a piece of good palatable sweet veld is included in the same camp with a less palatable piece of veld. The stock will then concentrate on the former, which consequently becomes badly overgrazed and trampled. If camps are too large they also encourage selective grazing, in other words, the stock seek out the better grasses, and prevent them from thriving and producing seed; thus they dwindle in numbers, and what replaces them is usually unpalatable grasses of lesser value.

The available veld must therefore be judiciously divided into camps, and a suitable grazing system must be followed by which each camp must have a chance to grow properly and to produce seed. If the condition of the veld is considered thoroughly, with the resolve that veld deterioration will not be allowed to take place, then the veld management system that is being followed will be such that care will be taken not to overstock, and everything relevant, namely soil, veld, animal and farmer, will benefit by it.

Only too often it happens that sufficient provision is not made for watering stock, which means that the animals have to walk to and fro, and in this way trample out the veld, making footpaths, a large proportion of which sooner or later become dongas.

The absence of a suitable veld management system is often coupled with the absence of sufficient provision of reserve fodder for droughts and periods of scarcity. It would appear that our optimistic farmers simply refuse to acknow-

ledge the precariousness of our rainfall as a proven fact. As soon as one drought that has caused them heavy losses has passed, they apparently believe that this is the last drought they are ever likely to experience, and so they continue in the same old way, without providing reserve feed for the next drought, than the coming of which nothing is more certain. The poor animals wander hither and thither, looking for a morsel to eat, and in this way destroy the veld even more, and trample the thin top-layer of soil into dust, thus conditioning it nicely for blowing away with the wind or washing away with the first rain.

By far the greatest portion, in fact more than 90 per cent., of the country is suitable for stock farming only. Stock farming is dependent on the veld. The veld is and must be the most important source of food for our livestock. It is therefore an imperative necessity that the veld should not be misused and mismanaged. The sins of the past can still be forgiven because the sinners sinned unknowingly and unconsciously of the consequences. Those consequences are now, however, staring us in the face. We are challenged to repair thousands upon thousands of dongas, to reclaim our eroded veld and lands, to prevent the shameful death from hunger and thirst of large numbers of livestock, and to save this country from turning into a desert (as it is rapidly becoming under present conditions); to maintain the heritage left us by our forefathers who civilized this country by the great sacrifices they made for us; to ensure that here in South Africa a great well-provided population shall exist for all time.

Fortunately it is no longer necessary to grope about in the dark. The pasture research work in relation to the various soil, veld and climatic regions has yielded a mass of information bearing on the reclamation of deteriorated veld, and of such utilization methods of veld as will prevent destruction, and be an asset to both animal and pasture. The pasture research stations of the Department of Agriculture and Forestry study the basic principles of the utilization of the various types of veld, the supplementation of deficiencies that occur from time to time, and the application of the research findings in practice, in order that they may fit in with suitable farming systems for particular regions and individual farms. The programme of research and multitude of findings that can be applied advantageously in practice, are too numerous to discuss in detail here. It need only be mentioned that in broad outline the programme of activities may be summarized as follows:

- (a) The development of systems and methods of utilization and management of natural veld, by which the

veld and soil will be conserved and the grazing animal reap benefit, while veld deterioration, weed encroachment and soil erosion will simultaneously be prevented.

- (b) The making and use of veld hay in conjunction with the veld utilization systems.
- (c) The use of grazing and fodder provisions of old exhausted lands that are practically useless, and are highly susceptible to erosion.
- (d) The reclamation of veld that has been destroyed, which includes methods of restoring the vegetal cover, controlling erosion, and in other cases to replace less valuable plants that have become established, by more valuable ones.
- (e) The study of indigenous and exotic grasses and other perennial fodder plants, in regard to seed production, propagation, methods of utilization for grazing, hay and silage.
- (f) The role and function of grass in rotational systems for the improvement and maintenance of the soil structure and fertility.
- (g) The improvement of grasses by breeding and selection, and the investigation of problems in connection with the supply of grass seed.
- (h) The study of fodder trees, bushes and shrubs.
- (i) The provision of fodder reserves for times of scarcity, in order that the veld may not be trampled unnecessarily.
- (j) The use of surplus dead grass and all organic farm refuse for making compost, and the best utilization thereof.

A mass of useful information has already been obtained. The great difficulty is to rouse interest amongst those who use the veld, and to convert them to the practice of veld reclamation and conservation methods. These methods are at the same time payable. They ensure higher and more stable income. The Department of Agriculture and Forestry will gladly furnish the necessary details to enquirers.

Veld utilization methods that fit in with the soil and veld types and the prevailing climatic conditions is the most important preventative against soil erosion on the uncultivated parts of the country.

### Soil Erosion on Cultivated Lands

When the soil is ploughed over to establish a cultivated field, a violent disturbance of the natural balance takes place. In one fell swoop the protecting vegetation is destroyed and the top-soil is torn asunder. It is obvious that conditions have now been created that are conducive

to abnormal soil erosion, and that special measures have to be taken to prevent this.

The new field is usually highly productive and possesses the inherent ability of resisting erosion, by both wind and water, comparatively well. The chief concern should be to maintain the ploughed field in a state of permanent stability. This can only be done if the top-soil is not allowed to wash or blow away gradually, and its productivity is maintained. In order to accomplish this the soil must be kept where it was, the humus content and structure must be maintained, and provision should be made for a satisfactory supply of mineral plant foods.

The maintenance of the soil's structure is interdependent with the humus factor. In virgin soil there exists a natural balance between the creation and decay of organic matter, with the result that the humus-content remains constant and comparatively high. As long as this is the case the soil also maintains a good structure which enables rain-water to be absorbed well and rapidly. As long as the relationship between humus-content and soil structure is favourable the soil also retains its powers of resistance against erosion so much better. With the ploughing over of the soil, however, the natural cycle of organic matter from and back to the soil is broken. The improved aeration following on cultivation also promotes the rapid decomposition of the soil-humus. Coupled with this there is the deterioration of the soil structure, followed by increased water run off. After years of continual cultivation the erodability of the soil increases.

The decrease of the humus-content, the deterioration of the soil-structure, increasing soil erosion, and dwindling productivity are not matters of being prevented.

The entire process is the result of wrong soil utilization methods. There is no doubt that the stability of the soil can be maintained if cropping systems are followed that provide adequately for the maintenance of the humus in the soil, the structure, and plant-food content. This can be achieved by the adoption of suitable rotational cropping systems, and the application of farm manure or compost and artificial fertilizers. At the same time attention must be paid to suitable methods of soil cultivation.

### **Contour Cultivation**

Further measures should be taken to protect lands situated against steep slopes. The first step should be to plough and plant on the contour, and not up and down hill, otherwise numerous rills will be formed along which the water, instead of being absorbed by the soil, will flow, taking

with it the fine top-soil. This is particularly the case with row crops, like mealies, where the cultivator's parallel excavations facilitate the formation of excellent run-off canals.

Contour-ploughing in itself will contribute considerably to the saving of soil and water, but alone is not quite enough. The land is not yet sufficiently protected against heavy downpours. A further step is necessary: the erection of contour walls and furrows. The underlying principle with this is to interrupt the long sloping falls and to divide them into shorter slopes, each of which will only have to cope with the water falling on it, and not have to contend with water coming from higher up as well. The interruption of the long slope is accomplished by erecting contour walls at specified distances from each other. These so-called contour walls should, however, not be strictly level, but should have a slight fall. The soil required for building the wall is taken from the upper side, so that a furrow or canal is formed, along which the surplus water gravitates from the land and is released at a suitable point. With the occurrence of heavy downpours, when furrows are usually washed through sloping lands, and much soil is carried away in this manner, it is of considerable value if the water, which would ordinarily have rushed down the entire slope, can be diverted in this way, and the flood broken and led from the land at a lesser speed along these canals. The possibility of a gradual loss of the top-soil is in this manner almost eliminated.

In situations, where floodwaters reach cultivated lands from a higher catchment area, the water must also be diverted by means of walls, before reaching the lands.

The spacing of the contour walls from each other is mainly dependent upon the fall or slope and the type of soil. On surveying a layout of contour banks it is usual to have a six-foot vertical fall between successive contours. It is, however, impossible to discuss here all the details of layout, size of banks, width of furrows, manner of construction and implements used. This information may be obtained from the Department of Agriculture and Forestry, who will even send an official to survey the contours and to advise the farmer on relevant points.

### **Grass Strips between Lands**

When a piece of virgin soil is ploughed over, future trouble and damage can be avoided if the acres (beds) are immediately laid out on the contour, while strips of veld, 9 to 15 feet wide, are left unploughed between the acres. The strips of grass serve the purpose of breaking the force of the water,

and more so since the grass cannot be grazed short during the rainy season, while the crops are coming on, and will therefore grow luxuriantly. Water will actually be diverted by the strips of grass. In the course of time, as these grass strips catch up soil, the surface will be raised and thus natural banks will be formed.

An excellent plan, also, is to plant strips of grass on the contour, on lands already ploughed in one piece. Outstanding results have been obtained with Elephant grass (Napier fodder). In parts of the country where this or similar grasses grow well, such planting may be done in preference to contour walls.

On badly eroded lands in such an advanced stage that sluits have actually been washed, contour banks or walls will be a necessity. Grass may then be planted on the walls. It is in any case advisable to plant grass on the walls and thus consolidate them.

Once the land has been laid out on the contour it will no longer be washed away. All that has to be ensured now is the maintenance of the fertility and structure by a suitable rotational system between the contours, with due regard to the soil's requirements of manure and artificial fertilizers. The rotation of crops must provide for the establishment of some perennial grass, to regenerate the structure of the soil.

### Soil that Must Not be Ploughed

Many cultivated lands are ploughed on slopes so steep that the loose soil cannot possibly remain in position, even should much organic matter be added, and contour rotational cropping practised. The following American research statistics will give some idea how rapidly erosion increases with an increase of slope :

Type of soil ... ..	Sandy loam.
Rainfall ... ..	1 inch per hour.
<i>Slope (fall)</i> —	<i>Soil lost in pounds per acre—</i>
4 ft. in 100 ft. ...	200
8 ft. in 100 ft. ...	1,000
16 ft. in 100 ft. ...	25,000

It is obvious therefore that steep slopes should be left under a cover of grass. If ploughed, so much soil will be lost that it will be impossible to grow grass well again at a future date.

The slope of lands should not exceed 4 per cent. Towards 8 per cent. much difficulty will be experienced, and over 10 per cent. will result in disaster. Some soils may last longer than others, but in the end the result will be the same.

Ploughing has and is still being done in districts where



the soil and climatic conditions are such that ploughing should not be allowed. Great areas of sandy soil in the North-Western Cape, on which good veld used to grow at one time, yielded good harvests of wheat for a short while, but are to-day wind-blown deserts. In the Western Free State and Western Transvaal the same thing is happening. The sandy soils, if covered with grass, are safe, but, if ploughed, conditions are created that make them an easy prey to wind-erosion.

In the rainfall areas, even in the Karroo, pieces of "bult" soil are often ploughed, in a futile attempt to reap mealies or something. Now and then there may be a small harvest but the eventual fate of that piece of land is destruction by wind or water erosion.

### Other Causes of Erosion

Apart from the more common forms of erosion as a consequence of veld misuse and wrong cropping systems, there are other factors sometimes causing bad erosion.

**ROADS.** Many an old road that has become unusable is a huge donga to-day. Often several such old-road dongas lie parallel to one another. As the old road became unserviceable, so another track was chosen next to it, only to be abandoned later for yet another. One after another the abandoned roads have washed out and become dongas.

The drainage system of the main roads is also often responsible for the erosion of adjoining ground. The water must be diverted from the roads, and where it is let through large or small culverts a donga often results.

Often water collects in footpaths, where it washes out the soil until they become dongas, even if the surrounding veld is still good and well covered. It often also happens that footpaths are trodden from one water-hole to another in the vleis, and these are the beginnings of the dongas that eventually drain the vleis dry.

If immediate action is taken to correct the roads and footpaths, it will be a trifling matter in comparison with the strenuous efforts that will have to be undertaken at a later date to reclaim the dongas.

**RAILWAYS.** The draining of water, away from the rail-road tracks, often has the same result as the drainage of roads.

It must be pointed out, however, that the roads and railways are there of necessity, and the combating of erosion along them should be undertaken by the administration concerned, in co-operation with the adjoining landowners.

### Farming Affairs Generally

It would appear from the foregoing discussion that the general causes of erosion are to be found in the farming malpractices, which consist of farming methods being followed that do not harmonise ecologically with the soil, veld, climate, and water supplies. Nobody can be blamed for this. It came to pass during the rapid development of a big and young country, with a large diversity of soil and veld, and precarious climatic conditions. It was almost inevitable that things should have gone wrong at first in many directions, in order that the lesson might be learnt how things should not be done.

The overstocking and destruction of the veld, and the exhaustion of agricultural land was in many cases the result of economic circumstances and pressure. Uncertain climatic conditions and income from animal and crop production, together with unstable and varying market demands and prices for products, had gradually brought farmers into financial difficulties. Two financial depressions were a severe blow to the farming industry, that one in particular which synchronised with the great drought of 1932-33. Problems were aggravated and the mortgage burden became heavier. All this resulted in farmers being forced to punish their farms, i.e., to exploit their veld and soil, in order to produce as much as possible to enable them to meet their obligations.

People who are inclined to blame farmers for the burden of debt on their farms should remember that most farms were undeveloped, and that the owners had to embark upon extensive improvement programmes. Think of the thousands of miles of jackal-proof and other fences that had to be erected, and the sheds, dams, silos, houses, etc., that had to be built. These were essential improvements which this and the former generation had to carry out, all without the assistance of steady rains or stable markets. At the same time speculative prices of land aggravated the farmers' difficulties. All this played into the hands of overcapitalisation of the farming industry.

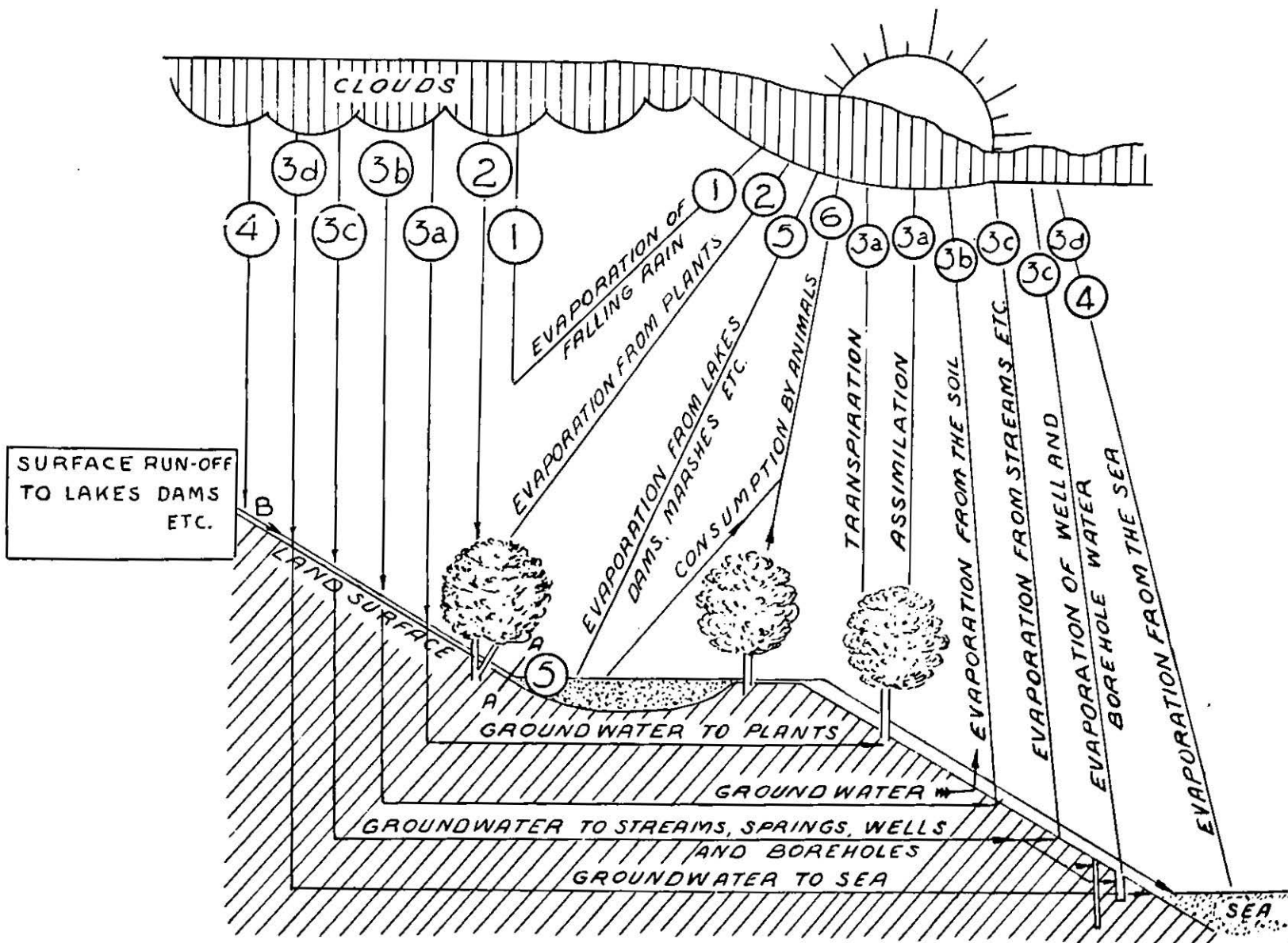
In the course of time another evil developed. This was the subdivision of many farms into units too small to be economically stable. There are various reasons for this. The consequences are, however, the same in every case. In attempting to eke out an existence on these small farms, unsuitable farming systems are carried on, the strength of the soil and veld is overtaxed, with soil erosion the inevitable result.

It has become obvious that the reclamation and conservation of agricultural resources can be reached, within a

measurable space of time, only if drastic steps are taken to remove the contributory causes of soil and veld retrogression and erosion. This can be accomplished only by means of a complete reconstruction of farming in South Africa. The system envisaged will have to be adapted to the natural soil, veld and water resources, and the creation of markets and marketing measures that will ensure the permanent economic stability of the farming industry.

Let no one suppose that the rescue of South Africa's soil can be effected by Acts of Parliament, on the research of experts alone. Success demands the active aid of every farmer ; the collaboration of teachers and children in learning and spreading the doctrine of soil conservation ; and the support of every citizen for an economy which puts the protection of the earth asset first.

— THE HYDROLOGIC CYCLE —



AFTER "LITTLE WATERS" BY H. S. PERSON.

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