SOIL EROSION*

ROLAND V. NORRIS

In the past few years restriction and other economic difficulties have given rise to many new problems in regard to the maintenance of estates. It is desirable, however, that preoccupation with such difficulties should not lead us to lose sight of the long-standing question of soil erosion.

It will not be disputed that the soil is the chief asset of any agricultural enterprise and the preservation intact of this asset must, therefore, be regarded as of fundamental importance.

Unfortunately this principle does not always receive adequate recognition and, though the process of erosion may be a gradual one, it is apt to be overlooked that the effect is cumulative and that in the course of time — and a shorter time than many people imagine —vast capital losses may be incurred.

Moreover, it has to be remembered that those in charge of land, in addition to protecting their own interests, have a duty to the community as a whole since, as I shall show, the evils of erosion are by no means confined to the land on which such erosion occurs. At present in all countries where erosion is a serious problem public funds on a very large scale have to be expended in making good the remoter damage caused. It is unlikely, however, that the authorities will continue indefinitely to provide such funds without questioning the responsibility of those primarily concerned, and it seems fairly certain that sooner or later legislation will be introduced making it incumbent upon owners to take all reasonable anti-erosion measures.

* Address given at Badulla, 7th. November, 1936.

So far as Ceylon is concerned the importance of erosion has been stressed for a considerable number of years — certainly for more than thirty years, and as long ago as 1909 in a report made by Mr. W. L. Strange an officer deputed from India, recommendations were made which indicated quite clearly and accurately the steps that should be taken.

In 1916 another visitor from India wrote on the situation as follows: "In the hill tracts of Ceylon, an area which is now covered with the tea gardens, the original forest canopy was removed to make room for coffee which later gave place to tea. Little or no provision was made at the time to retain *in situ* the fine soil of the original forest and in consequence the loss of soil has been enormous and is still going on. The water-retaining power and fertility of the tea soils of the hill regions of Ceylon have fallen off on account of the loss of fine particles and large sums are spent annually in adding green and other manures to the land. The Agricultural Capital of the Island has been allowed to run to waste and can never be replaced by any system of manuring."

Numerous other individuals and Committees have referred to the problem in similar terms and their views will be found summarised in the "Report of the Committee on Soil Erosion" issued in 1931 as Sessional Paper No. III of 1931.

In this same report also will be found very clearly stated the measures which this Committee considered should be taken to meet the problem.

Recently the Executive Committee of the Board of Agriculture has taken steps to ascertain how far these recommendations have been carried out, and though unfortunately the answers to the questionnaire sent out were very incomplete, it is quite clear that the action taken has fallen far short of what might reasonably have been expected. Many estates did not reply at all to the questionnaire. It is probably fair to assume that the majority of such estates have not taken anti-erosion measures and hence the position cannot but be regarded as most disappointing.

The reason generally given for this inaction is the economic conditions of the past few years and it is only fair to admit that such conditions have naturally been a bar to rapid progress. But it is equally cogent to stress that money has been spent and continues to be spent on work which not only does nothing to check erosion, but on the contrary, encourages this.

Much good work has been done on individual estates but it is clear that there is still a considerable body of persons who either still fail to appreciate the seriousness of the position or else remain unconvinced of the efficacy and practicability of the anti-erosion measures proposed.

Ceylon is by no means alone in this respect. In the United States and in Africa neglect of the problem and failure to take anti-erosion steps in adequate time have led to enormous damage to cultivated areas and equally serious damage of an indirect nature. Some reference to affairs in these countries may serve to make clear the conditions to which soil erosion may lead.

In the United States continuous cropping of large areas under improper conditions of cultivation has destroyed the tilth of the soil and led to erosion on the largest scale both by water and wind. Official figures issued by the Soil Erosion Service of the U.S.A. show that in the past seventy-five years some 35 million acres, or approximately ten per cent of the cultivated area in the States, have been permanently ruined by soil erosion and it is estimated that each year erosion removes twenty times as much plant food as is consumed by the crops grown.

As a consequence of erosion floods have followed. The river beds are gradually silting up and have proved incapable of dealing with the enormous volumes of water which suddenly reach them as the result of surface run-off after heavy rains. The Mississippi is a case in point. The navigable reach of this river has been noticeably curtailed in recent years and the serious flooding which took place in 1927 is estimated to have caused damage to the extent of more than three hundred million dollars. Further the increase in surface

run-off at the expense of percolation *through* the soil has resulted in many areas in a permanent fall in the water-table and led to considerable difficulties in maintaining the water supplies of certain districts.

In South and East Africa similar difficulties are being encountered though there the ultimate cause is somewhat different. Particularly in the native reserves, where wealth and social status are largely determined by the number of cattle held, the land has for years been seriously overgrazed. As a result the soil has been completely denuded of cover, erosion has followed with the formation of enormous gullies, the water-table has fallen and large areas of country have been completely ruined.

Though we may not do things in Ceylon on quite the same scale as in the United States, the same progress of events is taking place. The nutrients and organic matter in our soils are being washed away followed by the surface soil itself, our rivers and reservoirs are gradually silting up and the numerous floods to which we are liable are largely due to the sudden accumulation of surface run-off.

The extent of actual soil loss and loss of nutrients is not fully realised since the process is a gradual one. But though gradual it is continuous, and if one considers the long period of time, and the expense incurred, in building up a denuded soil, it would certainly appear the more economical course to endeavour to prevent such loss rather than remedy matters afterwards. Moreover, it must be remembered that loss of nutrients is not the only process taking place. Erosion leads also to a loss of tilth with which fertility is closely associated.

I trust, however, that I have now said enough on this aspect of the question to convince you that erosion can no longer be ignored, and I must pass on to discuss the factors concerned in erosion and the measures which have been suggested to reduce this.

In Ceylon in most areas erosion is mainly due to water and on estates erosion may be considered under two classes, sheet erosion, *i.e.*, erosion taking place slowly and more or less evenly over a large area and gully erosion which is much more localised and leads to the formation of ravines.

The first soil property we must consider is that of particle size. The part of the soil we are most concerned with is the so-called "clay"; this is the finest portion of the soil consisting of particles with a diameter of less than one ten-thousandth-of-an-inch and chemically it is the most active fraction. These fine particles are easily held in suspension in water and settle out very slowly. This latter fact is of importance in considering the efficacy of silt-pits and similar devices.

The behaviour of these particles is, however, modified by the treatment and agricultural condition of the soil. In the presence of adequate supplies of humus or organic matter and with suitable cultivation these fine particles adhere together in crumbs which are less readily taken up in suspension and, conversely are much more rapid in settling out. Such a state of affairs, represented practically by good tilth, considerably reduces the risk of erosion.

The conditions suitable for erosion are those in which the top layer of soil rapidly becomes bathed in sufficient fluid to allow the particles to slip easily over one another. Anything, therefore, which increases porosity and water-holding capacity or facilitates percolation will tend to prevent erosion. Again humus plays an important part. The channels left by decaying organic matter provide both for intake of water and what is equally important, for outlet of air. In addition the moisture-holding capacity of the soil is beneficially effected by organic matter and a soil poor in humus and organic matter more quickly reaches the stage at which a free movement of soil particles take place.

In view of the above considerations the prevention of soil erosion becomes a question of:—

(1) Checking the beating action of rain which churns up the surface soil.

(2) Maintenance of soil porosity which diminishes the very severe loss from normal surface run-off.

(3) Fostering conditions which produce soil flocculation.

(4) Provision of barriers to catch soil unavoidably lost.

Put in another way these measures amount to (a) preservation of tilth (b) ensuring that as much of the water shall pass down *through* the soil instead of running off the surface and (c) steps to recover soil which may still be eroded.

In connexion with the above we must consider the relative parts played by high shade and ground cover. High shade tends to prevent (1) the churning of the soil by heavy rain, and (2) the baking and caking of the top soil which reduces its permeability. Moreover, the leaf-fall and mulch derived from shade enhance this beneficial effect since such litter is in itself highly absorbent and tends to prevent the pores of the soil becoming clogged. But, unless a really heavy mulch is produced, high shade does little to prevent surface run-off and *it cannot be too strongly stressed that it is the latter which is the most potent factor in producing erosion.*

The efficiency of ground cover is much greater. The mechanical resistance it offers to soil movement, the increased porosity derived from a fine root system and the better distribution of organic matter entailed, all combine to give ground cover a special value. We may say then that the first and main line of defence against erosion is the provision of a soil cover.

As against this we must stress the present practice of clean weeding and, more particularly, the method by which such weeding is usually carried out, namely the use of scrapers. The replies received to the questionnaire recently issued by the Board of Agriculture indicate that the vast majority of estates still employ scrapers and little real progress can be expected while this practice continues. As distinct from deeper cultivation, scraping merely loosens the soil surface to a degree sufficient to hasten the washing out of the finer particles without effecting any improvement in porosity. The surface water almost at once finds an impermeable layer and takes in its stride the loosened surface. On each occasion the same process is renewed and from this point of view clean weeding as usually carried out clearly stands condemned, a fact which every Committee which has considered the question has stressed.

Of the efficacy of ground covers in reducing erosion there can no longer be any manner of doubt. It is a matter of common observation. Actual data have also recently been published in *The Tea Quarterly* derived from an experiment in East Africa. In this experiment plots on a uniform slope of 1 in 6 were used and the erosion on clean-weeded plots compared with similar plots with a cover-crop. The observations extended over a period of four months during which the rainfall amounted to 58 inches. While the erosion on the clean-weeded plots in this period amounted to a maximum of eighteen tons of soil lost per acre, the loss from the plots carrying a cover-crop in no case exceeded one-sixth of a ton per acre, *i.e.*, the cover-crop reduced the soil loss more than a hundredfold.

Various objections have, however, been raised from time to time against cover-crops. Those most commonly heard are that (1) they compete with the major crop in regard to moisture and food supplies (2) they harbour noxious weeds (3) they get into the tea bushes and the plucking table (4) they lead to increased cost of working (5) they harbour snakes and leeches (6) the ideal cover crop has not been found (7) they look untidy and (8) their use is contrary to custom.

Of this list the last two items are probably in their practical result as important as any. I do not, however, propose to take up your time in arguing as to their value but must say a word about the more serious items first mentioned:—

(1) *Competition.*—In regard to moisture, results obtained at Peradeniya have shewn that soils under *Indigofera* have preserved a higher moisture content than clean-weeded plots. In dry areas it is possible some competition may be felt but this might be offset by the use of varieties which die back to some extent in the hot weather.

Competition with food supplies leading to loss in yield of the major crop, if this occurs, is likely to be of a temporary nature only. Most cover-crops derive their food supply from a different soil level than the tea. In any case the cover-crop will eventually be incorporated in the soil and any nutrient originally removed thereby

returned. Such temporary immobilisation of nitrogen may actually be of advantage moreover, in preventing leaching of excess nitrogen from the soil. In the case of leguminous covers there is every probability that the nitrogen supplies of the soil will be increased by their use.

(2) *Harbouring of Weeds.*—There seems to be a considerable difference of opinion on this point and fuller details are required. Any difficulty experienced will probably chiefly occur before the cover is fully established. After that the mere fact of competition should tend to repress other weeds.

(3) *Interference with the Plucking Table.*—Admittedly cover-crops require control and climbing varieties should not be used. Experience has shewn that control is neither difficult nor costly.

(4) *Increased Cost of Working.*—Experience with *Indigofera* and other covers has shewn that this has little real foundation. The initial cost of establishment has to be met, but weeding costs are not increased and expenditure on cleaning out of drains is reduced. In any case it would appear worth while to spend reasonable sums on saving soil rather than expend possibly a rather smaller amount in promoting soil loss.

(5) *Snakes and Leeches.*—These admittedly cause difficulties in some areas and may limit the use of covers there until suitable repellents can be discovered.

(6) *The Ideal Cover.*—It will be admitted by the advocates of cover-crops that it has proved a matter of difficulty to find ideal species. The requirements of different districts vary widely and the burden of searching for and testing out covers suitable for all conditions must be a co-operative effort between Estates, the Research Institutes and the Department of Agriculture if progress is to be made. Many trials have undoubtedly been carried out on estates but unfortunately in most cases the results of such work do not become widely known. What is required is a clearing house for

such information. In this way unnecessary work on species known to be unsuitable could be avoided and more extensive tests of promising varieties carried out.

In this connexion I would suggest that attention has perhaps been focussed too closely on leguminous species. Naturally a leguminous variety is to be preferred, if available, in view of its ability to enrich the soil but, for the moment, the line of least resistance is perhaps to be preferred on the ground that from the point of view of erosion almost any cover is better than no cover.

In recent years successful results have been obtained on many estates with non-leguminous covers such as *Oxalis* for example. Formerly this was universally regarded as a noxious weed and large sums were spent in trying to eradicate it. During the depression estates did not always find it possible to maintain the unequal struggle, and possibly to their surprise, have found that no evil results have occurred while erosion has much reduced. If this be the case with *Oxalis* why not with other so-called weeds ? In other words, has the time not come for a change of policy in regard to "clean-weeding" and for a systematic and extensive trial of "selective weeding". Such a trial has been started at St. Coombs but requires to be carried out by as many estates as possible so that information in regard to the effect of such a policy may rapidly be accumulated and details as to cost and management obtained. I do not doubt that such work would lead to the discovery of many "weeds" which could safely be used as covers and in due course the scraper might possibly be forgotten.

In this connexion I am not unmindful that the superintendent of an estate is not usually a free agent. The initiative for such a change of policy must clearly come from above — proprietors, agents, and visiting agents. It is greatly to be hoped, however, that a long view will be taken and permission granted for such work to be carried out. It should not be overlooked that in both India and Java clean-weeding is seldom if ever practised. While it is true that conditions there are very different, have we really sufficient grounds

for concluding that in Ceylon, where soil erosion is so much more a problem than in those two countries, such a policy is really the last word on the subject ?

I have spent so much of my time in stressing the importance of soil cover as the first line of defence against erosion that I can only refer briefly to other measures which, though I would term them secondary defences, are still of much importance. I refer here to drains, hedging and terracing and similar works.

Much has been done to improve drains. It is now widely recognised that the object of drains should *not* be to lead the water off as quickly as possible but rather to hold it up to allow time for the fine silt to be deposited and for percolation to take place. Modern practice is therefore in favour of bunded, lock-and-spill, or reverse slope drains while the gradient should be reduced to the minimum sufficient to avoid lateral flow. By such means not only will the volume of water to be dealt with by the main nethikans be much reduced, but the velocity of flow will also be diminished and less scouring will occur. Needless to say similar precautions should be taken in the nethikans themselves, *i.e.*, the flow should be checked by means of bunds and steps while the edges should also be protected by grassing.

Hedges, *e.g.*, of *Clitoria* or other crops, or even of the tea itself, may also serve a useful purpose in holding up soil, but too much reliance should not be placed on these unless supplemented by other precautions. Gaps are apt to occur to which run-off may be diverted leading to the formation of gullies. In the case of non-permanent hedges, alternate rows should be planted in alternate years so that only half the rows are taken out at one time.

In places where stone is plentiful, terracing can usefully be done. Success depends more on the frequency of the terraces than on their height and provision must be made to avoid spilling of water over the edges.

A word must be said about new clearings, though under the present conditions of restriction this is not perhaps of very great immediate importance. The main object must be to protect the soil from the earliest possible moment and a soil cover or thatch should, therefore, be provided as soon as possible. With proper control there is no reason why this should interfere with the young plants.

In regard to the method of planting, contour planting is generally favoured in other countries. I am not sure that under Ceylon conditions merely planting on the contour will make a very marked difference, though if the tea is planted in continuous lines on the contour it is true an appreciable barrier to wash is set up. Contour planting, however, also facilitates drainage, hedging and terracing.

In speaking to you this afternoon I have had in mind chiefly the problems arising on the larger estates. But the general principles apply equally to small-holdings and there is much scope for improvement on such land. The Institute has two whole-time advisory officers engaged in work on small-holdings in tea, one in the Gampola-Kadugannawa area and the other at Baddegama. By constant visiting, propaganda, organisation of competitions and similar measures, I think we can claim that very effective work is being done and I have been impressed by the excellent efforts many small-holders have made to adopt improved methods of cultivation and soil conservation.

In conclusion, I will only add a few words in regard to the organisation of future work on soil erosion.

On the theoretical side laboratory studies are required on the physical and chemical properties of different soil types in relation to erosion. On the practical side information is mainly needed in regard to the effect of cultivation on erosion. These problems sound perhaps straightforward but their elucidation will require an elaborate technique and much time. In addition the search for suitable covers must continue and propaganda should be intensified so that there may be a wider appreciation of the nature of the problem and

of the available means for dealing with it. The range of the work to be done clearly indicates the necessity for the appointment of a whole-time officer for soil erosion investigations and propaganda. The present staff of the Department of Agriculture or the various Research Institutes can, from the nature of their duties, only devote a part of their time to erosion problems and more intensive work is required. It is satisfactory to know that the Board of Agriculture has unanimously recommended to Government the appointment of such a whole-time officer and there is every reason to believe that the proposal will be sympathetically considered. It would also seem desirable that a small standing technical committee should be appointed to advise on soil erosion work. Proceeding on such lines, and with the full co-operation of planters and others interested in agricultural concerns, there seems no reason why more rapid progress should not be made in the future, particularly as more prosperous times return.