FORESTS AND EROSION—WITH SPECIAL REFERENCE TO CEYLON

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ABSTRACT

CONSERVATION of the soil and the conservation of forests are closely related. The history of denudation of forests in tropical and sub-tropical countries is allied to its agricultural history, whether it be the continuation of the primitive practice of shifting cultivation or the introduction of new and permanent forms of agriculture.

Forests exert a direct and important influence on water-supply and stream flow and especially on the control of erosion. The results of scientific investigations conducted by the direct or hydrometric method and the indirect or analytical method demonstrate that forests reduce run-off, regulate stream-flow and provide the most effective cover for the prevention of erosion. The fertility of the soil, as reflected in its physical properties of permeability and air capacity, is higher in forest soils than in comparable arable or grassland soils.

Erosion in Ceylon, with its attendant features of severe floods and landslips, is primarily due to the denudation of forests in the steep montane region and their replacement by permanent agricultural crops. The damage caused by shifting cultivation is less permanent and not specially marked in the montane zone, where the effects of soil erosion are most serious. The firing of grasslands results in soil-deterioration, but seldom in extensive erosion.

Soil conservation measures based on forest practice aim primarily at controlling erosion at its source. Legislation against deforestation and for the maintenance of protection forests requires revision and the organization necessary to implement it. The demarcation and reclamation of the catchments of the principal rivers subject to floods, the protection of stream and river " reservations " and the fixation of unstable hillsides prone to landslips are measures based on forestry which are suggested as immediate and practical steps to control erosion. The regulation of grassland burning and the control of shifting cultivation are also suggested.

INTRODUCTION

Conservation of the soil is intimately bound with the conservation of forests. This fact is often ignored or overlooked in the economic development of a country where forests have to be cleared to make way for agricultural crops. In most tropical and sub-tropical countries, the historical background

for the present condition of the country in relation to its agricultural development provides interesting study. In several tropical regions, the increasing poverty of the land and soil is largely due to the unchecked exploitation of forests. In Ceylon, the historical background is somewhat different from that of other tropical regions, especially India and Africa. Ceylon, with its relatively unexplored resources of forest land, offered scope for the investment of capital in coffee and later in tea and rubber. In Africa and India an important reason for the destruction of the forests was the continuation of the native custom of deforestation either for shifting cultivation or the extension of grazing grounds.

In temperate climates the gradual disappearance of forest and its replacement by agricultural crops did not prove detrimental to the people so long as timber and forest products were readily and cheaply imported. The importance of forests in soil conservation in most temperate countries of the old world is certainly not so obvious. With the moderate and evenly distributed rainfall in temperate climates, systems of agriculture have been evolved in the course of centuries in keeping with the climate and have not seriously disturbed the balance of nature. In tropical and sub-tropical countries the destruction of forests, on the other hand, has been attended with serious and far-reaching consequences.

THE INFLUENCE OF FORESTS

The effects of forests on the conservation of moisture, the regulation of stream-flow and the conservation of the soil are generally known but seldom given the full importance they deserve. Experimental data are not readily available from tropical countries. The experimental work done in temperate countries gives us, however, an insight into the whole question. Scientific proof of the effect of forests on water supply and stream-flow has been obtained by, (*a*) the direct or hydrometric method and (*b*) the indirect or analytical method. The best known examples of the former are the investigations of Engler (1) in the Emmental, Switzerland, and Bates and Henry (2) in Colorado. This method has, however, not proved wholly satisfactory. "Within their limitations, however, the investigations so far carried out tend to show that forests reduce run-off and regulate stream flow, causing a stronger flow in dry weather, and the water discharged from forest tracts contains less sediment than that discharged from bare tracts" (3). The chief results of the indirect or analytical method may be summarized (3) as follows :—

> " (i) the total loss of water by interception, evaporation and transpiration is more or less similar for forests and field crops, though much depends on the kind of forest and crop ; it is somewhat in excess of the loss by evaporation from bare ground in the open ;
>
> (ii) In mountainous country, run-off is the factor most affected by the presence or absence of vegetative cover, and by the nature of the cover ; closed forest—particularly with litter-covered ground—is on the whole the most effective cover for the prevention of run-off, though other closed

vegetation such as Bermuda grass pasture or *Lespedeza*, is also very useful; both are much more effective than ploughed land, open crops like cotton, or abandoned fallow land;

(iii.) removal of forest litter or low vegetation by burning greatly increases run-off; this points to the economic superiority of protected forest over pasture land for catchment areas, since forest can be regularly worked, whereas pasture land would be subject to drastic grazing restrictions and would thus lose much of its economic value;

(iv) forest litter has a filtering effect, which prevents the clogging-up of the surface soil that takes place with the impact of rain on bare ground".

Among the several investigations carried out on these lines, a few may be cited as of interest in relation to the conditions in this country:—

(*a*) Observations by Duthie, Hardy and Rodriguez (4) in tropical rain forest in Trinidad showed that the evaporation of water in the open was 3-5 times that in the forest. The actual rainfall for the year of observation was 111 inches.

(*b*) Experiments carried out by Lowdermilk (5) in China demonstrate that with ordinary rainfall the ratio of run-off in the forest to the open increases, *i.e.*, there is a limit to the degree of absorption of water by forest soils. Even with heavy rainfall there is, however, an appreciable difference.

(*c*) Gorrie (6) in the Punjab showed that the degree of run-off was approximately 16 times more for overgrazed and virtually bare land than for eroding land reclaimed by afforestation and construction of bunds.

(*d*) Hornby (7) in Nyasaland found that the destruction of tree-growth in native cultivation had increased run-off from 33 per cent. of the rainfall in forested areas to 69 per cent. in cleared lands.

The physical properties of the soil which most affect plant growth are permeability and air-capacity. Burger's (8) investigations showed that the increasing fertility of Swiss forest soils depends on an increase in their air-capacity and permeability and that both air-capacity and permeability are considerably higher in forest soils than in comparable arable or grassland soils, although the total porosity (air and water capacity) need not be necessarily higher. According to Burger's results, clear cutting lowers the air-capacity of the soil by some 40 per cent. and frequently reduces permeability to a fraction of its previous figure. Even after a period of 10 years, soil left bare after clear-cutting had a permeability roughly 30 times less than a good forest soil. Even where artificial regeneration is established without delay, many decades pass before the soil regains its original structure. The results of clear-cutting

on the structural properties of the different soils are not uniform. The effect varies with the climate and the site conditions. Generally speaking, however, the structural properties of clayey soils are more affected by clear-cutting than sandy soils. The deterioration of the physical properties of the soil may be lessened to a considerable extent if the understorey is left intact or introduced before clear-cutting takes place (9).

SOIL EROSION IN CEYLON

The chief cause of erosion in Ceylon is the denudation of forests; secondly, and only limited in its incidence, is the effect of firing of grasslands (*patanas* and *talawas*). Shifting cultivation in the tropics has been held responsible for the destruction of large tracts of forest, the impoverishment of the soil and the replacement of a tree cover by worthless scrub or grassland. Although shifting cultivation is generally held to be the chief cause of soil erosion in the tropics, as practised in Ceylon it is confined to large tracts in the Dry Zone where, from the comparatively flat nature of the land and poor rainfall, soil erosion never assumes serious proportions. *Chena* cultivation in the montane zone is very limited in its extent. The severity of erosion is to some extent mitigated by the fact that within a few years, the clearings are abandoned and if left undisturbed revert to some form of vegetative cover, even if only scrub. Fire and grazing are the chief causes of the permanent deterioration of the soil and increasing liability to erosion. In Ceylon, however, overgrazing is seldom in evidence and burning is confined to grasslands and savannah forest.

The serious nature of the problem of soil erosion in Ceylon has been recognized for some years. This is especially true of the hilly country of the central and south-west portion of the Island where a large proportion of the pristine forests have been converted into extensive plantations of tea and rubber within a short period of under a century. The initial clearing of these forests in a region of high rainfall with steep slopes predisposing to heavy run-off and erosion, combined with systems of agriculture which not only excluded any form of soil cover but also encouraged the loosening of the surface soil, resulted in serious erosion, the silting of rivers and their increasing liability to floods. Even as early as 1894, the Kelani Ganga in its upper reaches which were navigable at that time were observed to be silting up rapidly; the cause of the silting was held by competent authorities to be the increasing cultivation of tea (10).

The majority of rubber estates, since the early "Twenties" have adopted the maintenance of a ground-cover as general practice, but in tea estates the immediate practical disadvantage of a ground-cover and the traditional importance attached to clean-weeding were more weighty considerations, so that it is only recently that there has been progress towards the establishment of a soft ground-cover.

Although a ground cover is regarded as the most satisfactory individual method of preventing erosion in that it anchors the soil and increases its absorptive capacity, the importance of other soil conservation measures have not been overlooked. From the earliest times large estates have adopted a system of drains but these were usually laid out at relatively steep

gradients. There has been a gradual tendency to convert these into drains on the contour or at a slight slope, but this practice has not yet become universal. More advance has been made in rubber areas where a very effective system of a combination of ground-covers with stone terraces, contour platforms, contour trenches and silt-pits has been reached. In the more remote and inaccessible estates, especially in small holdings, soil conservation measures are still very inadequate.

The cumulative effects of erosion in tea estates, especially in certain districts of the Central Province which contain the main catchments of two principal rivers of the Island, the Mahaweli and Kelani Gangas, have admittedly contributed to recurrent flooding in the lower reaches of these rivers. During the recent floods (August, 1947), landslips were mainly responsible for the great loss of lives, disorganization of communications and loss of property. It is no mere coincidence that the major landslips occurred in regions where tea has almost entirely replaced forest or *patana*. On the steep foot-hills of the Pedro and Adam's Peak ranges, where damage by landslips has been most severe, an interesting phenomenon may be observed where large masses of tea-land have fallen but the forest immediately above has remained intact.

Within recent years, encouraged by the food-drive, small extents of both forest and patana in the montane zone have been brought under temporary cultivation. Although the actual total extent involved is insignificant in comparison with the extent under permanent cultivation, the practice has caused the indiscriminate clearing of protection forest on steep slopes or in stream reservations and will, if unchecked, result in serious erosion. The continuous and repeated firing of the grasslands, especially the extensive montane grasslands or *patanas*, though seldom producing extensive erosion, results in general soil deterioration and incipient erosion.

FORESTRY AND SOIL CONSERVATION

Soil conservation measures based on forest practice aim primarily at controlling erosion at its source. Where erosion is largely due to the devastation of forests, the obvious remedy lies firstly, in prohibiting or controlling deforestation by legislation, and secondly in the reclamation of catchment areas which are now devoid of forest cover.

Under the Forest Ordinance of 1907 various categories of forest are declared reserved forests. Reserved forests in the hill country, from their position on steep slopes and in catchment areas, fulfil a function as protection forests. The earliest regulation of Government was an order prohibiting the alienation of land over 5,000 feet elevation. This was subsequently relaxed in respect of *patana* land. There is, in addition, a General Order prohibiting the alienation of land at any elevation which is required for protecting the sides of ridges and the sources and banks of streams. A more recent order (1940) precludes from cultivation, land with a slope of over 30 degrees and the tops or whole of forest clad hills (11). It is hoped that any Soil Conservation Ordinance contemplated will include more comprehensive legislation for the protection and demarcation of catchment areas, stream and river "reservations" and for the effective protection of climatic or protection

forests. The immediate necessity for the demarcation of unprotected catchment areas of the principal rivers subject to floods, which find their sources in the montane region, should be recognized in any comprehensive scheme of soil conservation for the country. The demarcation of catchment areas can only be done by careful survey and planning. Aerial survey, which is now a recognized means of land-planning, will be the best method of collecting the required data expeditiously and thoroughly. Aerial survey has already been employed for assessing the extent of the damage during the recent floods and for the basis of the new flood-control schemes.

The reclamation of heavily eroded catchment areas, especially in tea estates, can, perhaps, be obtained most quickly and effectively by methods based on natural regeneration. This is very simply achieved by allowing the crop cultivated to grow wild. The natural colonization of grass, herbaceous, and subsequently shrub and tree species, will inevitably follow. The results obtained in the Roehampton Estate catchment area for Diyatalawa show that this method can be adopted with success. The tea there grows rapidly forming a dense understorey with invasion of indigenous shrubs and weeds, while the shade trees of *Grevillea* and dadap form a good over-storey protection with good leaf-litter for restoring soil fertility. In the more severely eroded areas it may be necessary to introduce rapid soil-covering species. For this purpose in the wet montane zone with a rainfall of 100 inches and over, a suitable species would be *Acacia decurrens* which regenerates prolifically from seed, forming a thicket. Simultaneously with the reclamation of catchment areas the protection, and if necessary, the afforestation of unprotected river and stream " reservations " should be taken up.

There is no doubt that a progressive change will have to be adopted in the agricultural practice in the hill country where more comprehensive and efficient soil conservation measures are necessary. These do not properly fall within the scope of forestry and are therefore not dealt with in this paper. In passing, however, the need for the general adoption of a suitable soil cover is worth stressing, in conjunction with simple mechanical methods such as brushwood contour barriers or terraces. Afforestation along with some form of mechanical revetment is also necessary in the fixation of unstable and denuded hillsides where landslips are of frequent occurrence.

The introduction of rotational grazing and controlled burning are necessary to prevent the current, highly destructive practice of indiscriminate patana burning and grazing. Legislation alone cannot achieve this end without educational advancement and effective propaganda. Finally, the control of shifting-cultivation will probably be the most difficult to achieve. The change from this time-immemorial and primitive form of cultivation to systems of permanent agriculture can only be brought about gradually. The more rigid enforcement of the existing legislation regulating the alienation of steep land for cultivation will be the most effective means of controlling shifting cultivation in the montane zone. The introduction of co-operative reafforestation in the Dry Zone has successfully provided a rapid means of re-establishment of a forest cover. This scheme deserves more encouragement and recognition as suitable form of land utilization for the degraded forest types of the Dry Zone.

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