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Land Reclamation Methods—*Sequelae* to Soil Erosion *

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Introduction. In the agricultural countries of the Old World, farming for several centuries has not significantly reduced the productive capacity of the land, because Nature-induced erosion was always kept under control, through *conservation* farming, as opposed to *exploitative* farming which is the primary cause of man-induced erosion In the words of Sir Daniel Hall, "the methods practised by the pioneers in the development of a new country are rarely those of sound agriculture... ". To capture the international trade in agricultural commodities, all opportunities, as they arose in the last World War, were harnessed and soil fertility was bartered away for the precious metal, as so much produce exported is so much soil fertility driven out of the land. Deforestation, to meet the needs of wood for fuel, cellulose, explosives, newspaper, books, rayon, match sticks, paints, varnishes &c. and to bring more land under the plough, for agricultural produce, brought in its wake, floods, erosion and the desert. Forty million acres were worked in this way, in the U S A. (Africa is no better) and were abandoned during the World Economic Depression, from the erosion that resulted through faulty land utilisation, mainly mono-culture Wild floods are unknown in areas not tampered by man. The cities, railways, roads, hydro-electricity, water supply schemes, irrigation and navigation projects, all secured through forced production converted to astronomical bank balances, are shaken in their very foundations, by erosion induced by man, through deforestation and floods. To quote Jacks and Whyte, "more soil was lost from the world between 1914 and 1934 than in the whole of previous human history." The combined effects of boom, slump and drought produced a catastrophic biological and physical deterioration of whole regions, culminating in dust storms and floods which threatened to become fixed events in the calendar of North America.

The toll of erosion. The uneven surface of the land, the incapacity of the soil to permit of percolation of rainwater as quickly as it is received, the annual uneven distribution of rainfall and the whole of it finishing off in a few downpours are the familiar causes of soil erosion. In the stupendous quantities of soil let down annually, fabulous losses in nitrogen, potash, lime and humus occur, when compared to the normal intake of plant foods, in such soils. The muddy water of rivers, laden with the eroded soil, silts up the spawning beds. Turning into the up-country, the soil originally teeming with life, is rendered lifeless. None can gainsay Nature's decree. Land is never restored to its original state, but is reclaimed to some extent, by some of the methods given below.

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Methods of Reclamation. All reclamation methods of eroded land go under four broad groups. They are (i) Mechanical, (ii) Agronomical, (iii) Biological and (iv) Socio-economic.

(i) **Mechanical Methods of Reclamation.** The slow but persistent removal of the final fractions of valuable soil under ' sheet erosion ', the wash out with squally violence in ' gully erosion ', the dune and desert formations from ' wind erosion ' and the engulfing of productive land by ' sea erosion ' may all be arrested, by adopting suitable courses of action, individually, communally or regionally, by resorting to minor works such as contour terracing ; contour hedging ; contour trenching ; contour ridging ; tilling across the field gradient ; damming ravines ; throwing embankments across 'dongas'; erecting dikes; arranging 'pockets and spill ' ways and providing storm water drains.

Individual. The use of these methods to counter-act erosion, are known to the Indian pesantry, from time immemorial. All agriculture on the slopes of the Ghats have been rendered possible, by a knowledge of the above. In the slack periods the peasantry annually mend the havoc of past denudation and attend to necessary work to prevent future erosion. The thousands of small seed bed tanks and ponds spread over the vast Godavary Western delta are no more than the " pockets and spill ways " that are suggested on the subject to control erosion. Quite apart from the various measures cited above, there is nothing to equal the will of the farmer in averting on his holding, a distant catastrophe of whatever magnitude, by the timely close up of the imps that tend to gnaw the entrails of the soil. The orchards, in the villages of Nandarada and Dosakayalapalle of Rajamundry taluq, are some of the best that deserve mention in this connection, notwithstanding the erosive nature of the light soils on which they are raised.

Communal. In the Godavary Western delta, a number of Joint Stock companies are working in projects like the Losari- Gultlapadu, Vemuladeevi, and Kalipatnam, in reclaiming lands, from a number of evils, of which erosion is one. The soil of these projects rendered into a syrup, by the floods overflowing the embankments of the drains, is transported bodily. In some of the States in America, the Soil Conservation District Laws give scope to farmers to co-operate and undertake demonstration projects, of soil conservancy. ' Badava ' lands all along the sea-board, in which paddy and finger-millet are cultivated, are periodically overrun by tidal action. Such lands in the villages of Komaragiri and Neman of East Godavary are protected by bunding against the sea-flow.

Regional. The larger interests of a province, or a country can never be served, by a few joint stock companies. State effort in bunding in Belgaum, Dharwar and Bijapur districts, in contour ridging (Watt-bundi) in the Kangra district and in contour trenching in the Punjab and the U. P., has already achieved substantial results.

What is required for this Province is (1) the conduct of a survey of the areas suffering from erosion and needing reclamation ; (2) long-range planning for taking up and finishing the ameliorative operations, by zones and under stated periods of time ; and (3) the inauguration of a minor engineering department, for tank formation and tank restoration. Erosion, in areas of poor soil binding, is a great menace. In such, the preservation of the catchments to be formed with forest reserves and vegetation, and the rivetment of the bunds to be put up, may never make the works 'productive' in the P. W. D. sense. The tank formation and the tank restoration, in the province, may easily cost several times the estimated cost of the Tungabhadra project ; but the resources of the country will be permanently improved in a manner comparable to the State drive in Italy, where a swampy expanse has been metamorphosed into arable land and the scourge of malaria driven out. The Tennessee Valley in America, would be spending to the tune of nearly 400 million dollars, for the ten years ending 1943, in the reclamation projects of eroded lands. In Japan with the " operation of the natural forces of sedimentation, plant succession and re-vegetation " under the check-dams of the Forest Engineer, erosion is checkmated. Japan and Java, " two islands with highly erosive topography and climate and supporting 500 and 680 people per sq. mile ", have erosion under full control.

(ii) **Agronomical Methods of Reclamation.** The free play of sun, wind and rain on bare soil brings about erosion. It is therefore necessary to have 'plant cover' on the land, at least during periods in which erosion is the greatest.

Sound rotations. The rotations to be practised are to be such as would (1) minimise the periods of fallow, (2) produce crops producing a dense stand and a soil binding root system and (3) provide for recuperative crops that give nitrogen to the soil. Unoccupied cultivable waste, when brought under cultivation is first put under horse gram, which is a leguminous recuperative crop producing good plant cover. Cotton, maize and tobacco, that require to be spaced widely, are generally unsuitable as reclaimers and have to be rotated with those which produce a good plant cover. The experience of Mr. Kanitkar, of the Bombay department, of Agriculture cuoted by Dr MacLagan Gorrie, goes to show that sorghum, which figures prominently, in the rotations of the eroded black soil tracts, is a good controller of erosion. The following typical, age-long, dry-land rotation, of the loams and the clay loams of the Telugu districts, is a protector of the soil and affords plant cover for a great part of the year.

1st year :— Mixture of dry paddy and red gram ;
2nd year :— Chillies with rows of cotton at intervals ;
3rd year :— Groundnut followed by coriander ; or Bengal gram, or fodder sorghum, when conditions permit.

Unfortunately such rotations are not regularly practised by the cultivators who are lured away by money crops like chillies which are raised annually, as at Gollaprole in Godavari district. Mono-culture systems as maize in the

corn-belt and cotton in the Southern States of America, and cotton followed by maize in Uganda are said to be the causes of the disastrous erosion, in those countries.

Green manuring. Sometimes in preventing one evil, we may bring about another. Incessant cropping done with the object of securing a plant cover may bring about soil exhaustion. Secondly, with the onset of the monsoons, heavy masses of soil are rolled down streams, breaching embankments. A number of wild streams between Bezwada and Kovvur play havoc on the country, every year, in their traverse to the Kollair lake. Raising green manure crops is a panacea to these evils. The matted root system, binds the soil and prevents to some degree, this scouring of soil by floods.

Mixed Farming. For a country dependent on cattle for its agriculture, mixed farming provides the cattle with diversified feeds, and conserves the land by warding off erosion. A Telugu proverb condemns the practice of raising of pure crops under rainfed conditions. Run off and erosion figures collected for a number of years at the Missouri Experiment Station, Columbia and the observations of Dr. MacLagan Gorrie in this country, indicate that in the order of their importance bare fallow, sound rotation and pasture aid soil conservancy.

Limit of safe productivity. Under the perennial irrigation system of the deltas, raising two or three crops of paddy, in an year or garden crops which are gross feeders on soil fertility may impoverish the soils.

Site of plots and soil blow. The fragmentation and the disintegration of holdings are a blessing in disguise, in lessening erosion. Plots of half to two acres are found to be fairly free from erosion, in the Bombay Presidency. Such divisions of land are a necessity, in the light soils of Anantapur, where the harvest of groundnut with bullock hoes turn the soil to the fineness of flour and render it liable for wind erosion.

Strip cropping. Strip cropping with arable crops alternating with 'dense sod crops', is now under practice, all the world over, as a conservancy measure

Selective weeding. This is in vogue in plantation agriculture, for soil conservancy. Obnoxious weeds above are eradicated, while the less harmful are left untouched, in the tea, coffee and rubber estates, in Ceylon and South India.

(iii) Biological Methods of Reclamation.

Regulation of the strength in livestock and controlled grazing. Strangely, the very factors that retard progress in livestock improvement, also assist erosion. Greater destruction of plant cover and heavier indiscriminate trampling arise with the maintenance of a higher proportion of cattle than is justified by the cultivated area. The Vizagapatam district (specially the Vizianagaram taluq) is one of those suffering greatly from soil erosion.

It may be due either to its red loams ; it may also be due to the stock-rearing industry, in that district. The trodden paths of cattle and goats assisted by scouring in rainy periods bring about gully erosion. The village commons and the unreserves thrown open to grazing get greatly eroded, through such indiscriminate trampling. The pasture grasses grazed bare, fail to recover in time, to be economically useful. Controlled grazing and cutting the grasses periodically sound well toward stock improvement as well as the prevention of soil erosion. But to do away with the over-stocking and un-economic herds in a country that is averse to the destruction of life is no easy matter. Are sufficient areas available even for the indispensible tilling cattle, to arrange for grazing by rotation in blocks, for the permanent preservation of pastures ? In the tracts of intensive cultivation, as well as in wetland areas, it is hardly possible to have standing room for the village cattle, especially during the inclement weather. This has been a thorny subject receiving attention for several decades. Educative propaganda and slow state intervention, with caution, would secure the desired object of getting rid of the un-economic herds, over-stocking, promiscuous grazing and the want of organised pastures.

Regulated forestry. The forest policy should not be pursued as a commercial revenue proposition. Forest preservation and controlled grazing are antagonistic to the world's needs of wood and meat, but all the same they are to be helped in the interests of national economy. The very many uses which wood is now put to, may bring in, a time, when forestry may be encouraged and made to encroach on agricultural land. Submarginal exhausted agricultural land may be re-forested, or brought under controlled grazing, as under the Taylor Grazing Act of 1934, in America.

Ecological engineering and re-vegetation. Ecological observations of the flora and the fauna on the land, as also a study of the habits of the communities settling on the land are necessary to practise ecological engineering, for soil conservation. New fauna (from the domesticated) should not be introduced, if they bring in degeneration of the flora *in situ*. Nor should man be permitted to dominate and disturb the balance existing between the land and the flora it is supporting.

Extensive cultivation is going on, in the sandy loams of the coast-wise areas, under *doruvu* wells and along the banks of the rivers Hagari, Pennar &c. that have sand in them and no water flow for a greater part of the year. In both the kinds of tracts, the water bed is fairly high and manure being the only limiting factor of production in them, quite a variety of valuable crops is raised. Unfortunately, the play of strong winds on the coast, as well as in the areas of low rainfall of the said rivers has led to erosion on the wind-ward side and dune formation on the lee-ward side. Wind-breaks and shelter belts in which bare land alternates with crop land are the main ways to deal with. Casurina is widely grown on the coast and to some extent on the afore-mentioned river banks and adjacent to the banks.

Shelter belts are greatly used in the Jutland peninsula, of Denmark and are claimed to give protection to areas "equal to ten to twelve times their height". In addition to the moderating influences on soil temperature, wind, humidity and evaporation, high crop yields up to thirty per cent are also reported.

Soil binding may be effected with re-vegetation by suitable ecological material. The trees that are used for the purpose, in the several countries of the world are Acacias, *Cassia siamea*, casurina, Eucalyptus, Festucas, Pines, poplars, spineless cactii and willows.

The following are the vines, creepers and grasses, in vogue for the purpose, in the various countries.

Botanical name.	Common name.	Country of use.	Remarks.
	Vines and Creepers		
Pueraria thumbergiana	Kudzu vine	U. S. A. and S. Rhodesia	Originally a native of China; propagated from roots and crowns
Bignonia radicans	Trumpet creeper	U. S. A.	
Strophostules helvola	Trailing wild bean	do.	
Lespedeza striata	Lespedeza	do.	
Ipomdea biloba	Sand-binding weed.	India	Used by the railways on the permanent way.
	Grasses		
Eruarta villosa	Pyp grass	Africa	
Cyanodon dactylon	Bermuda grass	India	'Hariali', or lawn grass
Agropyron scabrum	Blue grass	New Zealand	
Aristida pennata	Sand grass	Russia	
Eremochloa ophiuroides	Centepede grass		
Pennisetum clandestinum	Kikuyu grass	India, Africa	
Andropogon halepense	Johnson grass	do.	
Paspalum sp.	The kodo millet group	do.	
Agrostis sp.		do.	

Besides possessing the property of soil or sand binding, the material chosen should be drought resistant, rhizomiferous, stoloniferous and of the seeding kind, for rapid establishment. It should as far as possible be unpalatable (e. g, rabbit menace in S. Australia and locusts in Kenya), hardy in withstanding soil and sand blow and as far as possible indigenous. Turfs and sods serve the purpose quicker than vegetation through seed propagation.

(iv) Socio-Economic Methods of Reclamation.

Restriction of international trade in soil fertility. The soil is a mine from which fertility is drawn and transported across the seas, in the name of

produce. The high tariff wall built by U. S. A., against the import of agricultural commodities, after the last World War and its non-acceptance of payments of war debts in goods, assisted soil conservation and thus arrested erosion in a measure, though countries solely dependent on agriculture under the falling prices, following the boom had to resort to over-production, to make both ends meet.

The higher the standard of living of the ryots, the greater is the erosion. The impact of western civilisation, on the agricultural populations of the East, raised the standard of living of the latter, during the last three or four decades. The agriculturists of Egypt and India, for centuries adjusted their mode of living to the productive capacity of the soil. Better living enjoins over-production and therefore erosion ultimately. Present rural uplift work should countermand this evil, by necessary propaganda.

Capitalist farmers and industrial magnates. Capitalist farmers emulate industrial magnates, in the possession of wealth and style of living. Agriculture is not organised, in the same way as Industry. Agricultural produce cannot be preserved, nor can it be held over, for years, to regulate prices, as industrial goods. Where the capitalist farmers ape the industrial magnates in the bank balances and style of living, there it is at the expense of the soil, degradation and denudation coming in much quicker in this capitalist farming than under any other system.

The Agricultural Adjustment Act, in America, restricts agricultral production, by the allotment of areas, to the limits of the local and reasonable foreign demand, based on a sound national economy. The co-operation necessary for the working of the Act is secured by compensating for the reduced production.

Agricultural prices to be on a par with the industrial. For an agricultural country like India, agricultural prices must, at least, be set at par with those in Industry, marshalling all the resources of economics, so as to keep the soil fertility intact. The soil of the country, the capital legacy of past generations should be handed down to posterity, by the present generation, without consuming any part of its capital.

Society and the Soil. A stable soil keeps a civilisation stable and free from social unrest. The society that settles on the soil should be symbiotic in its nature and its habits, with the farming system the soil is capable of. In this vast agricultural country, each soil type can have its counterpart in society, be it aboriginal, tribal, *ryotwari*, or any other. The Soil Physicist and the Agronomist are the councillors, to determine the type of Federation that is best suited to perpetuate agricultural India.

Imposition of quotas. In the national economy of the country imposition of quotas on cultivation and production may, when necessary, be introduced, to avoid the burning of wheat and the leaving of the cotton crop un-picked. The creation of an economic bureau, for sound economic nationalism, would go a great way, to stem the tide of soil erosion.

Urbanisation promotes soil erosion. As urban prosperity is at the expense of the rural agriculturist, the burden of taxation should be shifted from the country to the town and from Agriculture to industry.

Land tenures. The system of tenures, on which land is held by communities, is responsible in some measure, for soil erosion. Southern Rhodesia has been a victim to it. Russia passed from Feudalism, Communal Field Farming, Capitalism and Collectivism, to Socialism. How far the last survives the earlier systems, on the steppes of Russia is yet to be seen.

The holdings of owner-cultivators are less liable for erosion than those under tenants. With the ease-loving habit of man, the strength of the owner-workers is falling and that of tenants increasing. Short term tenancy is a result of rack-renting and lands under this system are the worst liable for erosion The systems of tenures that should prevail, between land-lords and tenants, for soil conservancy and doing away with erosion are also subjects for the bureau of economic suggested for creation.

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Tenants' Needs and Departmental Limitations.*

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Introduction. This paper is based on my study of a few holdings in Malabar with regard to the economics of paddy cultivation. It has been my experience in the course of the investigation, which is being conducted under the auspices of the Madras University, to find the people mostly indifferent and sometimes critical about the doings of the Agricultural Department. The causes of such indifference, as I see them, are presented in this article.

General. Earnings in Agriculture may be generally poor but the level is particularly low in the conditions existing in the Malabar district. With no mixed cropping or rotation in crops, paddy is grown in wet lands year after year with the success of the crop depending largely on the south-west and north-east monsoon rains. The cultivation is further complicated by the

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