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INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

LAND RECLAMATION IN THE TROPICS

WITH

SPECIAL REFERENCE TO INDIA

January 21, 1952

Economic Department
Prepared by: E. deVries
Land reclamation in the tropics with special reference to India

1. Introduction

At the FAO Conference in Rome last November, I discussed the subject of land reclamation in the Tropics with Mr. Dodd, with the officers of the Land-Use Section of the Division of Agriculture of FAO, as well as with some delegates, and with the Hon. Mr. K. N. Munshi, Minister of Agriculture of India.

Both Mr. Dodd and I had received some material on the subject from Dr. G. F. van der Meulen of Wadung (Indonesia). We were particularly interested in this information because a great part of the future expansion of food and agricultural production in the world will have to come from the tropics. Also, the LRD has entered the field of land reclamation with its loan to India end, therefore, the bank is greatly interested in the best way to proceed with this type of project.

2. Reasons for low yields in the tropics

On the average, yields on the tropical soils are rather low and any improvement would help economic development in those areas. For many crops, including such tropical crops as rice, average yields rise with the distance from the equator. One of the reasons, which cannot be changed, is the length of daylight in the growing season. This is especially important for short-lived crops, less so for sugarcane and cassava which remain a year or more in the field and thereby profit from an all-year-round 13-hour day. This same factor is also the basic reason for the success of tree crops in the tropics, e.g. rubber, coffee, tea, oilpalm, cacao, coconuts, etc.

Another reason for low yields is the generally low level of technique in tropical areas. This can be overcome gradually through technical assistance and investments. A third important reason is the lack of mineral nutrients for crops in most tropical soils. Heavy rains often cause leaching and erosion of the top soil and chemically-rich soils are rarely found. The quantity of phosphates especially is often inadequate to give a good yield annually.

Shifting cultivation, if done judiciously with long periods of rest, restores the fertility of the top soil mainly because the trees which are permitted to grow on the previously cultivated land draw the needed mineral elements from the subsoil through their roots. The decaying leaves then transmit the minerals to the topsoil. When the density of population becomes too heavy, there is no time for such long periods of fallow and the land deteriorates. This maximum of density of population depends on soil and rainfall, but under optimum conditions it is not above 50 people per square kilometer of potential farmland. Without adequate periods of fallow, shifting cultivation
becomes a curse, because ashes from the frequently burnt vegetation are easily blown away or leached and the loss become permanent.

Where the top soil is completely exhausted, the people of tropical countries find it no longer pays to cultivate the soil. The land is then left to noxious grasses, which require little mineral food and have deep rootstocks capable of surviving the uncontrolled fires which are often started for the purpose of obtaining young sprouts for livestock during the dry season (often also for hunting). Everywhere in the tropics one finds wasteland areas covered with poor shrubs and noxious grasses; these lands once yielded good crops.

The local farmers are mostly unable to do much about this deterioration of the soil. Over-grazing, the appearance of bad grasses, and erosion are the visible phenomena of a process which they cannot stop effectively. Where irrigation is possible, the water often supplements the necessary elements; in some cases (rubber in Malaya and Indonesia) a tree crop can be found which establishes its own equilibrium of plant food and growth. In most cases, however, the land finally is deserted because the low yield does not warrant any more the use of labor and equipment.

In view of the need for higher food production, it becomes increasingly important to make such land fit for agriculture by means of modern techniques.

3. Mechanical land-clearing as a possible solution

There are regions where land is waste for reasons other than depletion of the soil. In some places war or civil unrest have made people move out. Other areas are too swampy or too dry, or are infested with tsetse fly or malaria. In all such cases land reclamation with modern heavy equipment is fully justified, and tractors and bulldozers are being increasingly utilized. In some places plant hormones are being used to kill the trees in order to facilitate future clearing (e.g., Surinam). Stumps may also be dynamited. Special equipment to cut the very deep rhizomes of kaus-grass (Secchium spontaneum) has been developed.

However, it is clear that these mechanical improvements are no solution to the problems of an exhausted top soil. After cultivation, one or more crops may be raised, but yields will soon decline for lack of mineral plant food in the soil, and after a short time it will no longer pay to cultivate that soil. Bad grasses will once more invade the area and the total process may prove an economic loss.

Where leaching and erosion are the main problems, very often the top soil of these wastelands is more depleted than the subsoil. On the other hand, the subsoil often develops a hardpan and is not easily penetrated by roots. In all reclamation projects it is of utmost importance to have topsoil and subsoil analyzed and compared, because of lack of humus (and therefore nitrogen) and physical conditions of the subsoil, deep ploughing often does more harm than good, and this is an additional danger of purely mechanical reclamation.
4. Experiments in Indonesia in 1925/1941

A number of experiments have been made, aimed at the enrichment of the topsoil by the use of deep-rooted leguminous plants. Some species are able to penetrate deep into the subsoil (note) up to 15 feet and they pump mineral nutrients from the deep layers into their stems and leaves to build up a thick and luxurious growth. Later on these dense masses of material can be cut and worked into the topsoil and thereby the topsoil is enriched by chemical fertilizers from the subsoil. Thus, the reclamation is not only mechanical, but chemical and biological as well.

I have seen these experiments carried out and had told Mr. Rucinski and Mr. Koer of their results in August or September 1950 (when I had just entered the service of the Bank) in relation to the kens grass program in India. However, at that time I had no evidence that the records were saved through war and occupation and had no material on hand to compare effect and cost of different methods. Recently, however, my old friend Mr. G. F. van der Heulen had sent me details on these experiments with original photographs which had been stored away during the war. A summary of the results is given in the following paragraphs.

5. Effects of deep-rooted cover crops

A number of leguminous plants have the capacity to penetrate deep in the subsoil and to bring up nutritive chemicals along with water, thereby assuring a dense growth of intertwining vines and leaves, which remains green through a rather prolonged dry season and smothers kens grass and other weeds. Under favorable circumstances and using the right types of plants (see attached note) this green cover reaches to men's height and produces 60-80 tons of green organic material per hectare, i.e. 15-20 tons of dry matter. An analysis in the Experiment Station in Buitenzorg, Java, established that a one season's growth of Centrosema pubercesus (excluding the roots) contained per hectare the equivalent of:

- 300 kg. ammonium sulphate
- 60 kg. double super phosphate
- 120 kg. potassium chloride
- 80 kg. lime
- 600 kg. chemical fertilizers

The value of these elements is at present about U.S.$20 ($8 per acre) but it is an additional savings that these fertilizers would need no transport, and their application would cost nothing, as they are produced from the subsoil itself. It can easily be calculated that on the immense areas of cultivable land in the tropics, a general use of this method would be of great economic importance. In India alone, there are 80 million hectares under cereals every year, and the total cultivated area in the tropics is easily twice that acreage.

In experiments in West Java, Dr. van der Heulen got 50% increase in yield of non-irrigated rice and kenef (Hibiscus sabdariffa) and succeeded in planting
very good rubber gardens on soils which were considered completely useless, following years of careless shifting cultivation. Kens grass and other noxious grasses grew there up to 7 feet high. (I saw these gardens myself in 1935/1940).

Next to the chemical effect, these leguminous plants have other beneficial results. Very often the subsoil is too hard for the roots of cultivated plants, but the decaying roots of the legumes allow the penetration of the subsoil. This means not only an additional source of phosphates and potassium, but also a much better water supply for the crops in the dry season, and a permeability in the rainy season. The losses by run-off water are reduced and in the dry season, or in dry spells during the wet monsoon, there is an apparent difference in resistance against drought. Also, the bacterial activity in the soil is greatly improved.

If this treatment were given every five or six years, a progressive improvement of the soil would be attained instead of a progressive depletion, as is now mostly the case.

6. Mechanical cultivation of pre-cured soil

There is an apparent technical problem which confronts the man who wants to prepare this land for crops. The 3-7 ft. high mass of strong vines is a great obstacle for even the strongest caterpillar tractors. It happened on Java time and time again that 150 H.P. caterpillars had to be freed from an intertwining vine by 'labrers' and therefore the work did not proceed satisfactorily.

It would be detrimental to burn the material in the dry season. Most of the nitrogen would be lost in the atmosphere, and the ashes would easily be blown away with the monsoon wind, or leached away with occasional rains. Dr. van der Meulen therefore developed a mechanical chopping device, which cuts the vines in pieces of 20-30 cm (1/2 - 1 ft.). This cutter can be moved along easily with a 25-30 H.P. tractor. After a few days the soil can be cultivated with a normal disc plow. This should be done at normal 20-25 cm (8-10 inches) depth. It is of no use to plough extremely deep, as the rhizomes of the bad grasses are already starved by lack of assimilation and subsequent weeding is easy. Also, the topsoil is now decidedly more fertile than the subsoil. The dry organic material should be mixed with the topsoil only. Previous chopping of the green cover makes it much more easy to get this mixing evenly done; not much is left above the soil as is the case without cutting the vines.

Of equal importance is the fact that such cultivation is much cheaper. It can be done with medium heavy 50-60 H.P. tractors, which is of great importance not only because the price is lower and fuel less expensive, but also because the very heavy equipment is difficult to get. Furthermore, the medium tractors can be used for more purposes than just cutting the rhizomes of the kens grass.

Mechanical cutting of the green cover and subsequent mechanical cultivation of the soil therefore improves the work and decreases the cost substantially. A rough comparison of these costs is given by Dr. van der Meulen.
He assumes that the present method of reclaiming land in the kens grass project can be done at a cost of around $30 per acre, or $75 per hectare (in three cultivations, two with 150 H.P. caterpillars and a third one with 35 H.P. caterpillars).

The method van der Meulen involves:

a) light disc harrowing with a 25 H.P. tractor and sowing of chemically prepared leguminous seeds ($4 per acre, $10 per hectare);

b) chopping of the cover crop after 5-6 months with a 25 H.P. tractor (at a cost of $4 per acre, $10 per hectare);

c) disc plowing with a 60 H.P. caterpillar (at a cost of $12 per acre or $30 per hectare);

d) The seeds of the leguminous cover crop which will cost another $4 per acre or $10 per hectare.

The total capital investment is less than half that of the 150 H.P. caterpillar with heavy tools to plough the land up till 2 feet deep. Total costs are $24 per acre, or $60 per hectare; i.e., a savings of $6 per acre ($15 per hectare) plus the value of the minerals added to the topsoil of $8 per acre ($20 per hectare). The result is at the same time a much higher yield of the crops, which are subsequently grown.

7. Experience with this method so far

The specific value of deep-rooted legumes is known in the tropics since 1920-1925. Not always, however, has it been directly connected with the "pumping" of chemical fertilizers from the subsoil.

Traditionally, the famous Sumatra tobacco is grown on soils which are cropped two years, and left fallow for six years, during which period a lubricant mixed shrub jungle develops. In later years this jungle has been "enriched" by special legumes and it is hoped that the period of fallow can be shortened. Most rubber, tea, coffee and other plantations with tree crops in the East are now interplanted with leguminous cover crops, partly to prevent surface erosion, partly to enrich the topsoil.

Dr. van der Meulen has been a pioneer in this research between 1918 and 1935. He has applied the methods just described on thousands of hectares with great success, but the war and occupation interrupted his work.

The principle of deep-rooted legumes is also applied in forestry, where young teak forests on the poorest soils are interplanted with Leucaena glauca, a shrub noted for its deep roots and its ability to improve the topsoil.

Between 1935 and 1940, systematic experiments to enrich the natural shrub jungle in Indonesian farmer communities with shifting cultivation in South Sumatra and South Celebes were initiated. Different kinds of legumes were used, both of a creeping and a shrubby nature. Again, the war interrupted this work. It appears that many agricultural experts avoided the use of
rapidly growing creepers, because they knew of no mechanical cheap way to handle the immense mass of vines. Once this device is produced by some big commercial firm, the application of this method will open up a new promising way to put the tropical soils to work for food production.

8. Procurement of machinery

The equipment used to chop the green masses has been constructed in a few numbers by Dr. van der Meulen. However, owing to the unstable situation in Indonesia he has not managed to get it produced by some big machinery firm. Patents have been applied for in several countries, he writes me.

However, if one of the interested governments or international organizations agree to try his ideas out, he would be willing to give all the technical details for this effort to improve world food production.

Last week I received a letter from Dr. Dion with whom I had discussed these matters. According to this letter (attached), it might be possible experiments without waiting for the development of new tools.

I told Dr. Munshi that Dr. van der Meulen would be available if the Indian Government wants his services, and I am contacting both parties in the hope that India may be the first country to start experiments on a large scale with this promising new method.

I propose also to communicate with Sir Geoffrey Grey, top agricultural adviser in the British Colonial Office, who was present in Rome, and at the Conference advocated the establishment of a network of reclamation and settlement schemes on a group basis in underdeveloped tropical countries. This technique, which involves planned modernized shifting of fields and reclamation on a group basis with mechanical means may be of great importance for parts of Africa.

I personally also think that Centrosema pubescens may be of high value for land reclamation in Brazil, its country of origin.
NOTE:

Selecting the right type of legume

Not all legumes are suited for this job. Those which are mostly used as food crop, fodder or fiber at the same time, are not deep-rooted. These are soybean, peanut, Crotalaria species, i.e. sun hemp, Cajanus indicus and a number of other species.

In the experiments at Buitenzorg, the special value of Centrosema puberaeus, originating in Brazil, was found. This legume is especially suited for hard soils. The Vigna sineusia does well on loose soil.

Experiments in Mauritius by Dr. Bonome showed that the humus of grasses contains 3/4 silica and 1/4 nitrate potassium, phosphorus, calcium and magnesium. The humus of many legumes on the other hand contains 3/4 of last-mentioned chemical elements and only 1/4 of silica.

Centrosema is superior also because it is resistant against both drought and heavy rains. Pueraria javanica, Terannus labialis and krotok from Java also are promising species, which might do well under certain circumstances. In some cases, a mixture of legumes will give the best results. Where these legumes were never grown, the seeds may have to be inoculated with nitrogen-fixing bacteria to have optimum growth, and some seeds are hard-shelled and need chemical or mechanical treatment to achieve good sprouting. These special features of legumes are well known to experts of tropical agriculture.
Dear Dr. deVries:

I am very sorry that, in spite of my plans, I was unable to contact you while in Washington late in December. I ran into difficulty with airline strikes both in Brazil and with Pan American in New York, and was barely able to make my transatlantic connection out of New York. Consequently, I was able to do none of the things in Washington that I had planned on earlier.

I had some discussion with Dr. Mark Baldwin, who is an outstanding soils man, formerly with the U.S.D.A. and now on a consultant basis with FAO in Washington, on the subject of Mr. van der Meulen. Dr. Baldwin agrees wholeheartedly with the basic premise that Mr. van der Meulen is using. He suggests, however, that there are some machines being used at the present time in Latin America and in the sub-tropical parts of the United States, which perhaps do essentially the same operation as Mr. van der Meulen's new machine.

I am writing to Dr. Baldwin to ask whether he can supply me with more definite reference to these machines, and perhaps put me in contact with the manufacturers. This, of course, is only one phase of Mr. van der Meulen's thesis, and it in no way detracts from his value as an exponent of rational management of tropical soils. It merely makes the development of a suitable programme that much easier if it is unnecessary to go through a development stage for new tools.

We have fixed the date of the next meeting of the International Rice Commission for early May, in Bandung. I will be attending this meeting and will definitely see Mr. van der Meulen at that time, if it suits his convenience. Subsequent to that, we can perhaps make some plans to utilize his services in a direct way.

If you wish to contact Dr. Baldwin, or if you have any comment at this stage, I would be very glad if you could keep me informed as to your opinion on the present possibilities.

With kindest personal regards and best wishes for 1952,

Sincerely yours,

s/ H. G. Dion
Land and Water Use Branch
Agriculture Division