LAND USE AND SOIL AND WATER RELATIONS WITH REFERENCE TO COCONUT CULTIVATION

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Introduction

Of the three plantation crops of Ceylon, coconut covers the largest extent—a little over one million acres. Land use and soil water relationships involved in the cultivation of the coconut palm are therefore of significant importance to the agricultural prosperity of Ceylon.

Unlike tea and rubber which are restricted to limited climatic, rainfall and soil types, the coconut palm by its distribution is almost ubiquitous, except of course at the higher altitudes. It is grown over an extensive range of soils ranging from *halophytic* conditions extending from the Kalpitiya Peninsula to Hambantota on the West Coast, and from Mullaitivu to Arugam Bay and the Jaffna Peninsula on the East Coast ; the alluvial lands of the North-Western and Western Provinces, mostly on the river valleys of the Ma Oya, Deduru Oya and the Mee Oya ; the lateritic lands of the wet-zone of the Western and Central Provinces and even on the hilly and undulating lands of the Kurunegala, Matale and Kandy Districts, and the silted up estuaries such as those of Madampe and Mundel lakes, where palms grow under water logged *mesophytic* conditions. Under such an array of soil, rainfall and topographic conditions land use and soil and water problems and their interrelated aspects are varied and manifold.

Similarly there is a variety of social and economic conditions under which the coconut palm is cultivated, which determines its land use patterns, some of which are considered below. Under the conditions varying from village gardens, small holdings and large coconut estates, there are certain cultivation patterns which determine in particular the water regime of the coconut palm and its ultimate yield.

Opening and Development of Jungles for Planting Coconuts

In view of the fact that today there is a considerable and perhaps extensive tempo of development and opening of both crown and private jungles for planting coconuts, it is appropriate to commence with this primary aspect of land development in relation to the subject under discussion.

Particularly in the latter part of the last century, and the early part of the 20th century, between 1885 and 1915, coconut development on an extensive scale was mainly restricted to the Chilaw, Puttalam and Kurunegala Districts of the North-Western Province and also of the Colombo District of the Western Province.

Opening up of coconut lands was then largely by the *Goiya System* which briefly consisted of the following operations : Clearing and burning the jungle, digging of planting holes, and the actual planting being done by the ' Goiya ' or the cultivator. Simultaneously with or immediately preceding the planting of coconuts, the cultivator or share cropper sowed his catch crops of cereals and legumes, invariably mung or green gram in the Yala or South-West Monsoon season, and Kurakkan (*Eleusine coracana*) in the Maha or North-East Monsoon, together with a variety of other catch crops such as pumpkins, chillies, gingelly, amaranthus, maize.

Manioc was also planted in between the coconuts and lasted at least one year on the ground, while plantains which remained on the land for nearly three years was invariably planted by the owner of the land. Depending on the usage of the district, the owner normally got 1/3 or 1/4 of the catch crops, except plantains the entire income of which accrued to him. In fact this method was the traditional ' Chena System ' imposed on the development of coconuts.

Catch Cropping : Advantages

Although in theory catch cropping, particularly of root crops such as manioc are alleged to compete with the young palms and retarded its development and early bearing, in actual practice it had essentially practical advantages, among them the following :—

(*a*) The problem of weeding between the palms, where a heavy under-growth follows clearing and planting of the seedlings is economically solved by the incidental weeding that is associated with the root crop manioc which has to be weeded at least twice in the early stages. Subsequently when the manioc develops, the well developed bush shades the ground adequately so that weeds are completely smothered.

(*b*) Normal hand weeding has to be carried out if the land is not under catch crops, as the stumps are not removed until the 3rd or 4th year. Therefore mechanised weeding even with simple buffalo drawn disc harrows is not possible. If hand weeding of the ground space between the palms is done, soil exposure to scorching effects of tropical sun and the beating action of monsoonal rains would be fatal to the soil, so that from this point catch cropping which cover the ground is essentially an advantage.

(*c*) Yet more the question of soil erosion would be a major problem on lands without catch crops. It was the former practice to cut drains later in the 3rd or 4th year after the stumps are removed, by which time major damage would have been done to the soil had there been no ground cover such as the catch crop provides.

It is even popularly believed in the low rainfall, one-monsoon areas such as the Puttalam District, that the shading of the ground by manioc conserves soil moisture and actually helps the developing young palms and more than compensates for the loss of plant food removed by catch crops. These are points which should be experimentally investigated.

Loss of Nutrients

On the alleged drain of nutrients by various catch crops we have little, if any, scientific data. It is alleged that manioc in particular is a gross feeder of plant nutrients and causes a setback to the palms in the lapse of a few years compared to the normal dates of flowering of the young palms.

Similarly the over planting of plantains, five bushes to a square (one in the centre of the square, and four along the rows of palms), however beneficial from the point of view of shading the ground and conserving soil moisture, would undoubtedly cause a setback to the palms, as the plantains are known to be a heavy potash feeder—and potash is the main requirement of the developing young palms themselves. A better practice, now recommended by us, is to have only one plantain bush per square, and that at the centre of the square, particularly on the poor soils deficient in potash.

This advice is of course often a counsel of perfection, as plantains form the main catch crop which covers the cost of maintenance of a long term crop such as coconuts which may come into bearing on virgin lands in 7 years and into full bearing in not less than 10 to 15 years.

There is little doubt that the system of catch cropping inherent in the *Goiya System* should be modified to suit a more scientific basis planned at the conservation of the soil and moisture and of the inherent fertility of the land. Economic considerations today suggest that such crops as chillies, mustard and even onions which the country demands should be grown between the young palms.

Highland Development Schemes

Often ' Pilot Schemes ', where the provision of soil and water conservation methods is done *post hoc* and even the statutory conditions of the Soil Conservation Act are ignored where clearing of jungle and the reservation of jungle strips near water courses is concerned, are the chief culprits.

When we come to the large scale Highland Development Schemes under coconuts, consisting of units of 3,000 or more acres under the Land Development Ordinance as Middle Class, Peasant or ' Pilot Schemes ', planned development based on scientific land use planning should be possible. In this connection, based on my recent experience of such schemes already developed, and yet more schemes contemplated I should submit the following for the consideration of the Government :—

(*a*) Instead of fragmented holdings, be it 25 acres for middle class or 5 acres for peasants, development should be in *collectivised* large units, on the co-operative system, and not as individual units. The Land Development Ordinance should be accordingly amended.

(*b*) Detailed Soil Surveys should be carried out and not the Reconnaissance Surveys on which land on a broad basis has been so far recommended. Reconnaissance Surveys are insufficient for efficient land use planning.

(*c*) Corridors of 10 to 12 yards of jungle should be left for every 1,000 acres as wind belts and as sanctuaries for bird life.

(*d*) That a scientific study should be made on a long term basis of (i) the manurial and soil fertility aspects of catch cropping under the traditional system of coconut cultivation and modified systems; (ii) the actual drain of fertility by the catch crops taken off the land ; (iii) how best this drain, if recovered by the sale of economic crops can be replaced by the addition of manures.

For the use of mechanised implements (and this is inevitable due to shortage of labour for intensive clearing of land during short seasons and the field operations

involved in planting both the catch crops and the coconuts) early stumping should be done as soon as clearing and burning are over, and this should be followed by the provision of contour drains. The use of cultivation implements would be then much easier and a lot of work that is done by hand, can be done by simple buffalo drawn implements such as simple types of ' cultivators ' and the disc harrow. On larger extents under plantation conditions the use of tractors are equally possible.

(*e*) Soil and water conservation measures should be adopted from the earliest stages soon after clearing and burning jungle.

(*f*) Catch cropping should be carefully planned and adjusted to meet the economic needs of the country and not haphazard and stereotyped according to the traditional Chena System.

Soil Type in Relation to Soil and Water Conservation

As stated earlier coconut soil types show a wide range and variety and soil water relations show a similar range of variation. These are briefly summarised below :—

(i) Along the coastal littoral two or three main types are dominant : (*a*) *Coastal coarse and fine sands*, deep and well drained on which coconuts apparently seem to thrive. Near the sea the water table is high and varies depending on the tide and the rainfall. This coastal fringe does not extend inland more than a quarter mile (or even less) and especially on the wet-zone the soils are very deep ; (*b*) sand dunes and the wind blown sands overlying a lagoon bed—the well known *CINNAMON SANDS* which predominate the Negombo District, from the Ja-ela—Negombo—Pallansena area, quite a few miles inland, and a smaller pocket in the Madampe area, extending inland for about 3 miles from Karukkuwa to a distance along the Madampe, Kuliyapitiya Road, and bounded on the West by the silted up Negombo and Madampe Lagoons; (*c*) in Colombo South —between Moratuwa-Ratmalana and Colombo.

The main characteristics of this important soil type are (i) the poor infertile nature of the top sandy soil and the variability of its depth, as a rule between 3 to 6 feet ; (ii) the seasonal fluctuation of the water table, suddenly rising with the monsoonal rains ; (iii) the subsoil consisting of heavy estuarine clays and (iv) the black iron pan, typical *ortstein* formed by concentration of colloidal iron and organic matter with the sand and clay at depths of 3 to 6 feet. This soil is a typical *Tropical Podsol*.

Poor in fertility, the soils respond to manuring so long as the land is adequately drained to remove the excess water when drainage is possible or by deep drains cut even 4 to 5 feet deep and 4 feet wide, with the soil removed spread round the palms to form raised platforms and lower the water table. These soils respond to cultivation and so long as drainage is adequate yields of 4,000 nuts/acre/annum are obtainable with manuring. Yet more, the nuts are large and are of thick kernel, copra out-turns of 950 to 1,000 nuts per candy being not unusual.

(ii) *The sandy soils of the Puttalam and Batticaloa Districts :* There is a similar sandy soil in the Puttalam District extending from the Kalpitiya Peninsula up to Mundel overlying the silted up estuarine clays of the Mundel and Puttalam Lagoons, and west of the Chilaw-Puttalam Road, subject to severe dry seasons during the rainless non-monsoonal periods, and severe water logging during the North-East Monsoonal rains and similar soils on the East Coast stretching from Vakarai on the Trincomalee-Batticaloa Road down South to Arugam Bay.

Along both these coastal strips the land pattern is characteristically interspersed with lagoons, which debouch into the sea and make a characteristic landscape. Water logged on the lagoon edge, and subject to tidal action the drainage problem is complicated by the nature of the sub-soil which ranges from estuarine clays in the Madurankuli area to recent coral and Miocene arenaceous limestones further north on the west coast and impermeable coral masses close to the surface in Kalkudah in the East Coast, and a variety of sandstones.

Water logging is much more pronounced than on the cinnamon sands of the Western Province and in many cases, adequate drainage of these soils, the *sine-qua-non* of successful cultivation is not possible unless a unified comprehensive statutory Drainage Scheme is established by legislation, compelling estate owners not to block drains, culverts and water courses. A scheme similar to the drainage methods adopted on such soils in Malaya is imperative if these soils are to be rehabilitated.

These lands suffer from excess water when not required and deficiency of water during droughts. Especially in the Puttalam and Batticaloa districts these lands which once were growing coconuts successfully have become derelict and the rehabilitation of the extensive area of such lands extending to about 30,000 acres in the Puttalam District alone some of which borders on marginal conditions is an important national problem.

During droughts, which in the single monsoonal Eastern Province in particular can last 8 months from March to November, when the water table recedes, moisture conservation in the top soil is as much of a problem as the drainage of excess water during the rains. In this connection the burying of coconut husks from the sheet anchor, but unfortunately it is rarely done in the Eastern Province.

Another characteristic of these soils so far as soil and water conservation is concerned is the ease and rapidity with which a mat of surface roots—the so-called *Bissa* is formed.

There is a popular belief that this mat of roots has a deleterious effect on the palms, but on its physiology and ill or good effects we have no data—and therein lies an important line of research—in fact our knowledge of the entire root system of the coconut palm is meagre and there are many popular legends stated in the literature referring to ' Water Roots ' and ' Feeding Roots ' which need debunking.

(iii) *The Terra Rosas :* These red soils which are in scattered pockets and are some of the most fertile coconut soils are of unique interest from the point of view of this soil-water relationships.

Restricted to the North-Western Province—the main pockets are the (*a*) The soils derived from the Dolomitic Limestones of the Kurunegala-Dambulla area, the characteristic coconut soils being those of Beligama Estate on the Kurunegala-Dambulla Road; (*b*) The red soils of the Ma Oya silted up estuary, extending from Pallansena south of the river mouth to Mudukatuwa and Mahawewa on the North; (*c*) The Puttalam triangle extending from a little beyond the town limits along the Anuradhapura and Kurunegala Roads (Sirambiadi Village recently developed as a Middle Class Colonisation Scheme being typical) and (*d*) The extensive area along the West of the Puttalam-Mannar Road, dominant along the Karadipooval-Vannativillu-Karativu belt and bounded on the West by the Kalpitiya Lagoon. These soils extremely deep and fertile are undoubtedly derived from Miocene limestones, outcrops of which are yet seen behind Ambalama Estate fringing the lagoon. These limestones are

wever highly arenaceous compared to the Jaffna Miocene limestones and accounts for their ghter texture.

The water holding capacities of these *terra rosas* are well-known and further studies are eeded in determining their clay type—they may probably contain a certain amount of mont-orillinitic and illitic clay types, and they may therefore be not adequately water stable, and ould be liable to erosion in contrast to the typically kaolonitic soil types.

In spite of the very low rainfall of some of the areas, such as at Karadipooval on the Puttalam-lannar Road, estates where husks have been buried and moisture retained are in fact as heavy ielding as the best in the Chilaw District, though not manured at all, but only cultivated.

Cultivation Operations on Coconut Estates in Relation to Soil and Water Conservation

Cultivation operations on coconut estates (and small-holdings) are partly traditional, ased more on empirical methods of trial and error, and to a considerable extent recent develop-nents resulting from the investigations carried out and propaganda done by the Coconut Research nstitute during the last two decades.

Briefly, between clearing the jungle, planting and catch cropping between the palms and the emoval of the last of the catch crops, bananas, in the third year, the problem of weeding and veed control appears.

Weeds are intimately connected with the moisture regime, particularly in the dry single monsoonal areas. There are three methods of control which have adjusted themselves to chang-ing economic conditions. (i) Hand weeding on land not yet stumped, where implements cannot be used, a slow and expensive operation today; (ii) planting of cover crops such as Calapagonium, Centrosema and Pueraria which however need careful control as rank growth on virgin lands can smother the palms and make the problem of weeding yet more complicated by the infestation of venomous snakes and reptiles, and moisture conservation yet more complicated by the cover crops, competing for moisture with the palms and (iii) where land has been stumped and catch water drains provided, the buffalo-driven Ransom's Eight Disc Harrow is the most economical and effective. This implement does not cut too deep and the dead mulch of weeds if harrowed at the proper time as the drought sets in and before weeds have set seed, effectively conserves moisture.

This has been systematically adopted in the 3×3×3 N-P-K manurial experiment on young palms from the seedling stage at Ratmalagara with considerable success, on a land which was under a thick growth of Illuk (*Imperata cylindrica*) and dense under-growth, with conspicuous success.

Indeed if weeding is not properly controlled illuk, the bugbear of the coconut plantation rears its head. Those of you who may have experienced the insidious onslaughts of this perni-cious stoloniferous grass know what an expensive item illuk control can be. On the other hand, we do not know to what extent a long ley of controlled illuk can conserve moisture. Uncontrolled there need be little doubt that moisture competition can occur. Of course on the other hand for the purpose of soil conservation against run off there can be no plant cover to beat illuk.

As the young palms come into bearing and the fronds are out of reach from cattle, and safe from consequent damage, the land reverts to a mixed pasture, which is normally kept weed-free by cattle, which graze between the palms.

Fifty to sixty years ago clean weeding between the palms was the practice, until in later years the problems of soil erosion consequent on weeding were realized. However today except for a very few estates that have adopted creeping cover crops, a closely grazed sward of mixed pasture is the general rule, and no doubt plays a significant part in the conservation of the soil.

Cattle Keeping and Conservation Problems

The general type of cattle kept on both estates and small holdings is the indigenous so-called *Sinhala* cattle of small build, primarily for keeping the land weed-free and at the same time for the purpose of manuring of the palms by the established practice of tethering to the palms at night usually a pair for a week to ten nights.

This has got established as a general practice, but in view of the interest in the National Milk problem and impetus given by the establishment of the Milk Board by the Government and the drive for more and cheap milk particularly for the cities, the integration of milk cattle and coconuts on estates and small holdings must be anticipated as a progressive development. The soil and water conservation relationship involved in any new agronomic practices that can be expected to arise must be carefully considered as also the soil fertility practices arising therefrom. The rest of the paper briefly touches some of the points arising therefrom.

The usual practices on coconut estates in this connection may be briefly summarised :—

The grass legume mixture that develops as a climax resulting from the intensive uncontrolled grazing is a mixture of indigenous grasses—mostly *Digitaria Marginata* mixed with the common legume *Desmodium triflorium* (Sinhalese—Undupiyali).

Little attempt has been made at any type of scientific pasture management or the introduction of improved strains except, spasmodic interest by the Department of Agriculture, first with *Brachiaria distachya*, then *Brachiaria miliformis* (both local grasses) and now the centre of interest has shifted to the introduced African drought resistant grass *Brachiaria brizantha*.

New Developments

The Coconut Research Institute with the establishment of a division of Agrostology commenced an integrated programme of research on problems of pasture and animal husbandry on coconut estates.

Pasture studies on coconut estates have to harmonise the nutrient and soil fertility needs of both the coconut palms and the pasture and that of the cattle in order to get a maximum economic return per acre. It is hoped that, though this will have to be worked out for a range of climatic and soil types and is a matter of long range research, the work of the Coconut Research Institute will make significant advances in the not too distant future.

Reference should be made to the small extent of fodder pasture such as Napier and Guinea grass grown on estates for cattle. It may be mentioned here that, as recorded in a very early edition of the Coconut Planters' manual by Ferguson, in the late eighties of the last century, the sowing of Guinea grass seeds and establishment of Guinea grass stands between the palms soon after planting and the end of catch cropping was attempted with success, and that on such lands herds of good dairy cattle and cart bulls were successfully bred.

Inter-cultivation

Other practices in general that involve soil disturbances favourable to erosion are the usual biennial (or annual in alternate rows) ploughing of the land between the palms, simultaneously with manuring and the newer practice, though adopted on a very small scale as a labour saving policy—broadcasting and ploughing and disc harrowing in manure.

To what extent the frequency of such cultivation should be carried out, particularly on the lighter sandy soils where excessive soil disturbance leads to destruction of organic matter and soil structure with the consequent loss of moisture retention and water stability of soils, are points that need further careful investigation. There is a general traditional belief that ploughing and soil cultivation is necessary and except for the $3 \times 2 \times 2$ manurial $\times$ cultivation experiment at Ratmalagara Estate where in addition to two manurial treatments, the effects of ploughing versus no ploughing is also superimposed, there are no critical experiments.

It should be mentioned that on the subject of soil cultivation, and in particular the changes brought about by the introduction of mechanised implements there has been a tendency to indulge in armchair criticism and rather wild statements based on analogies on other perennial horticultural crops in sub-tropical countries—from the results of which it is dangerous to make deductions applicable to local conditions.