UNESCO/UNFPA Fiji ISLAND REPORTS No. 5 (Canberra, ANU for UNESCO), 1979

5.6 LAND RESOURCE POTENTIAL

M. Latham
(ORSTOM, Noumea, New Caledonia)

Page

LIST OF TABLES

LIST OF FIGURES

I - INTRODUCTION AND METHOD

INTRODUCTION

In a paper for the second general report of the project (Latham and Denis, 1979), a method for the evaluation of land resources was presented, and illustrated by the particular case of Lakeba. The present paper makes reference to the methodology described in that paper, but does not re-present it in detail. The Lakeba material is, however, re-presented and expanded, since this is necessary for the purpose of the present Island Report.

Apart from some tiny potential reserves of manganese, the land resources of Lakeba are composed only of the soil and water of the island; crops, livestock and trees are the only potential products. Copra, food crops and yaqona are the present products, together with some locally-used timber from the forest remnants; a much larger output of timber from the new *Pinus caribaea* plantations will be added to this range in the future. Virtually all the cultivable land in the island is used, or has been used in the past, and while the recent trend has been one of contraction of food-crop production from certain areas it is possible that extensive cultivation of cassava and yaqona may be increasing (M. Brookfield, this volume). Population is virtually static, and there is no immediate indication of heavy new demands on the island's resources. None the less, a potentially more important role can be envisaged for the quasi-town of Tubou, and the pine scheme may ultimately generate some industrial employment if its problems can be solved (UNESCO/UNFPA Project, 1977, p. 375-380; M. Brookfield, this volume).

This exercise undertaken here does not assume these changes or rely on them. The purpose is to explore the production capacity of the island given available crops and technology. In a sense, therefore, this is a paper concerned with hypothetical possibilities rather than with likely developments. None the less, the exploration of these possibilities provides a benchmark against which the present and future utilization of the island's resources may be evaluated.

METHOD

In the method described in greater detail elsewhere (Latham and Denis, 1979), it is argued that three sets of possibilities and limitations must be evaluated in order to attain an estimate of land capability. These are edaphic, concerned with the soil and the availability of water and nutrients; morphodynamic, concerned with erosion and flooding; technical, concerned with land management. It is first necessary to define 'ecological units' within which these constraints and possibilities may be examined, then, having determined the basic agrological qualities of each such unit, to define land potential in terms of types of crop and land use technique available, and the chances of success of each type. In what follows, the landscape of Lakeba is evaluated along these lines. Ecological units are taken as the soil types described earlier in this Island Report (Latham, this volume), refined by topography and the availability of water.

Edaphic conditions

The extent of soil penetration by roots, the availability of water and the availability of nutrients are the critical variables. Lakeba soils are of very varying depth, but shallow soils predominate. The natural forest is on shallow soils (Humic Cambisols), but the roots penetrate the weathered rock; the roots of *Pinus caribaea* may also be able to penetrate the compact weathering horizon of the Ferralic Cambisols. However, field crops are less adaptable to shallow soils, and poor drainage is a barrier to all unadapted plants. Table 6.1 provides further data on soil depth, and on other conditions discussed in this section.

There is also great variability in soil-water retention. The range is from 50-70 mm in the Ferralic Cambisols to 140-160 mm in the Eutric Fluvisols. In a drought-prone climate, soils of low water-retention capacity dry out quickly, resulting in wilting of moisture-demanding plants. The talasiga soils are the first to be affected by drought, but water availability is a limitation to cropping in most of the soils of the island. Particular importance therefore attaches to those sites where supplies are available from the water table, and especially to land below spring sites where shallow-rooted annual crops can normally obtain water even in long dry spells.

Nutrient availability is subject to a complexity of factors, including texture, structural instability, amounts of carbon and nitrogen, phosphorus reserves, exchangeable calcium and potassium, pH, cation exchange capacity and base saturation. The relevant data for the humiferous horizons of the Lakeba soils are presented in Table 6.1. There is a broad correlation between vegetation cover and the amounts of organic matter and major nutrients. Soils under talasiga are poor to very poor in organic matter, and deficient in nitrogen, potassium and phosphorus. This is rather well summed up by the 'index of biological activity', being the emission of carbon dioxide per square metre per hour (Bachelier, 1968), obtained by methods discussed elsewhere (Latham and Denis, 1979). On the talasiga-bearing soils (Acric Ferralsols, Ferralic Cambisols and Chromic Luvisols) this index is generally below 50 $mg/m^2/hr$, whereas on soils under forest (Humic Cambisols, Eutric Fluvisols, Humic Gleysols) emissions higher than 100 $mg/m^2/hr$ were measured.

Soil deficiences are less readily evaluated. The only general deficiency of Lakeba soils is in nitrogen, but potassium is also low when it is considered that root crops are large consumers of this element. Phosphorus reserves are high, but assimilability of this element is uncertain. A more detailed study might reveal deficiencies in micro-nutrients which could be of considerable importance; the Institut de Rečherche des Huiles et Oléagineux in the New Hebrides found the addition of such micro-nutrients to have a major effect on coconut production, and it is possible that this is a Pacific-wide problem, as similar results have also been reported from Papua New Guinea and the Solomon Islands.

In general, it can be concluded that edaphic constraints are least on the alluvial and coastal plains, in the swamps and on steep slopes under forest; though generally deficient in nitrogen and potassium, these are the soils least liable to drought. The talasiga areas, which cover some 40 per cent of the island have, on the other hand, an extremely low fertility.

Morphodynamic conditions

It has already been shown that erosion rates on forested catchments may be as high as on talasiga catchments, and that both are of a high order (Latham, this volume). The fact that forest soils on slopes of 30-60 per cent are very liable to erosion after clearance is amply confirmed by the work of Servant (1974) on comparable slopes in Tahiti; during the wet season, he found erosion

TABLE 6.1: EDAPHIC CHARACTERISTICS OF LAKEBA SOILS

	ACRIC FERRALSOLS	HUMIC FERRALSOLS	FERRALIC CAMBISOLS	CHROMIC LUVISOLS	EUTRIC FLUVISOLS	RENDZINAS	HISTOSOLS	HUMIC GLEYSOLS	EUTRIC CAMBISOLS	HUMIC CAMBISOLS
Natural vegetation	Talasiga	Forest	Talasiga	Talasiga	Coconut Plantation	Coconut Plantation	Grasses	Grasses	Reeds	Forest
Useable average depth in cm	100	40 - 60	20 - 40	100	100	100	Hydro-morphic	Hydro-morphic	30 - 40	30 - 40
Water reserve in mm	80 - 90	120 - 140	50 - 70	120	140 - 160	Water table	Water table	Water table	110	140
Physico-chemical characteristics (Horizon A_1)										
Texture	Loam	Clay	Sandy Loam	Loam	Clay	Sand	-	Clay	Clay	Clay
Structural unstability	0.3	-	0.6	0.6	0.1	0.4	-	-	0.4	0.4
Bulk density	0.65	-	0.70	0.87	0.83	0.86	0.52	0.57	0.82	0.80
Carbon %	3.0	4.3	3.3	2.9	5.7	8.3	13.5	12.7	2.8	6.0
Nitrogen %	6.15	0.3	0.18	0.14	0.42	0.68	0.13	0.35	0.21	0.55
pH	5.3	5.6	4.9	5.3	6.5	7.1	4.4	5.6	5.8	6.0
Exchangeable Ca++ in me/100 g	2.2	6.1	2.2	2.5	24.4	-	14.1	19.6	10.5	9.4
Exchangeable K++ in me/100 g	0.3	0.2	0.55	0.4	0.3	0.5	0.18	0.64	0.76	0.33
Cation exchange capacity in me/100 g	30.7	27.6	22.4	26.0	45.0	-	50	50	29.2	23.7
Base saturation %	16	48.9	29.1	40.4	13	-	50	50	76	75
Total phosphorous (per mille)	1.4	2.0	1.4	2.1	2.4	1.8	1.2	1.3	2.1	0.7
Biological activity in mg of CO_2/m^2/hour (rainy season)	20 - 40	-	15 - 80	35	184	120	240	235	108	138

rates of 1500 tonnes/km^2/month, more than ten times the index calculated by the present author in the forested Waitabu basin of Lakeba. The most vulnerable soils would seem to be the Humic and Eutric Cambisols, which may explain the long fallow periods traditionally used in such situations in Fiji.

Soil structure is almost as important as steepness in determining vulnerability to erosion. The Ferralic Cambisols and Chromic Luvisols are particularly weakly structured, and rapid gullying has been observed on Chromic Luvisols even on gentle slopes. A striking instance is the deep gullying of the drainage ditches alongside the airstrip, which in places reached a depth of nearly five metres in less than four years; rapid runoff and structural instability are the main predisposing causes of this alarming erosion.

Allied to erosion is deposition. The deposition of silt on flat stretches of new forestry roads in the interior of the island is destroying the utility of these roads almost as rapidly as gullying and sheet erosion on the steep pitches. Measurements of the importance and speed of silting in the swamps of the island are reported elsewhere (Latham and Denis, 1979). In view of the small size of the island much silt is carried rapidly into the sea, and the impact of flooding is more apparent in the destruction of taro plants in irrigated plots than in any visible change in the morphology of the plains. It is none the less very probable that aggradation of the plains is a continuing process, and also that there continues to be deposition of colluvium on terraces in valleys draining the talasiga country. There is an important difference in effect according to the source area: material derived from the forest areas may increase fertility in the swamps and on lower slopes, but material derived from the talasiga is likely to reduce rather than enhance the qualities of the soil. Considering the high proportion of talasiga land in most of the catchments, the effect of deposition is probably more often negative than positive in terms of soil fertility in the valleys.

Technical considerations

Even though little use may be made of them at present, there are technical possibilities for the amelioration of constraints, and by no means all of these demand the use of high technology; many are anciently known in Fiji and other parts of the Pacific. Erosion can be controlled and reduced; the depth and texture of the soil can be improved for better root-penetration; the mineral content of the soil can be improved by fertilization; hydromorphic zones can be drained.

In protection against erosion the vegetation cover is of prime importance. Fire prevention is the first step, and where this is accompanied by afforestation, as on Lakeba with pines, the results are likely to be of a dramatic order. In cultivated areas, it is possible to encourage a suitable fallow cover by planting fast-growing ground plants, or trees as in the New Guinea highlands. Use of perennial rather than annual crops on steep slopes is also advantageous. The length of uncovered slopes can be shortened by terracing, the construction of contour ridges, or planting of contour-line hedges of densely-growing plants such as *Cyperaceae* to check runoff. Mulching and manuring improve soil structure and hence resistance to gullying. All these practices are incorporated in the traditional agriculture systems of different Pacific societies.

TABLE 6.2: EVALUATION OF THE AGROLOGICAL QUALITY OF LAKEBA SOILS

SOILS UNITS	EDAPHIC LIMITATIONS	MORPHODYNAMIC LIMITATIONS	INVESTMENT REQUIRED	LAND CLASS
Eutric Fluvisols	Possible hydromorphy	-	Mechanization and irrigation	A
Humic Gleysols	Hydromorphy	-	Drainage	A
Histosols	Hydromorphy; low fertility; high acidity	-	Drainage; addition of large amounts of fertilizer	B
Rendzinas	Calcareous sandy texture	Susceptible to marine erosion	Mechanization	B
Humic Ferralsols	Clayey texture	Susceptible to erosion	Contour cultivation	B
Chromic Fluvisols	Low fertility	Susceptible to erosion	Controlled mechanization; heavy fertilization; protection from fire	C
Humic Cambisols	Very shallow	Very susceptible to erosion	Contour cultivation; protection against fire	C
Eutric Cambisols	Very shallow	Very susceptible to erosion	Contour cultivation; protection against fire	C
Acric Ferralsols	Very low fertility	-	Protection against fire	D
Rhodic Ferralsols	Low fertility	Susceptible to erosion	Protection against fire	D
Ferralic Cambisols	Very low fertility	Very susceptible to erosion	Protection against fire	D
Lithosols	Shallow, low fertility	Very susceptible to erosion	-	E
Thionic Fluvisols (Mangroves)	Hydromorphy; salinity	-	-	E

One technical skill is still employed on Lakeba -- drainage of the swamps for taro cultivation. However, so many areas of formerly-drained land have now been lost that it would probably require major works to re-establish cultivation in some of the larger swamps.

Possibilities for technical introduction

There is as yet very little use of imported energy in the agriculture of Lakeba, but given the relatively low population density it would seem that no large extension of cultivation is likely without it. The coastal plains and colluvio-alluvial terraces could grow maize, sorghum or other crops given use of mechanization; the sowing of improved pastures is necessary for expansion in stock-rearing. For such enterprises to be initiated on any scale, the use of tractor-drawn ploughs and harrows would seem essential, and is entirely feasible on the plains with their light soils.

At present very limited use is made of mineral fertilizer, in some food gardens and in the pine nursery. The widespread deficiencies in nitrogen and potassium would suggest that the wider use of imported fertilizer might be attended by considerable improvements in yield. However, both the use of green manure and more careful fallow management are viable alternative or supplementary paths whose specific object is to increase the level of organic matter in the soil. Recently *Centrosema pubescens*, locally called 'centro', has been introduced for this purpose; as a legume it also has the advantage of fixing nitrogen in the soil.

II - EVALUATION OF LAND RESOURCES

THE CLASSIFICATION OF LAND

On the basis of agrological quality, five land classes are recognized on Lakeba. Details are set out in Table 6.2. The classes are as follows:

A. Good land without major limitations and with soil of sufficiently high fertility for a range of crops. Mechanized cultivation would be feasible on this land. The soil types involved are the Eutric Fluvisols and Humic Gleysols of the alluvial and coastal plains, now mainly under coconuts.

B. Land of moderate potential, with some limitations but capable of improvement. These soils either have lower fertility than those in the first group (Histosols; Rendzinas), or have marked liability to erosion (Humic Ferralsols).

C. Land of low potential for cultivation, with major limitations. Most soils are susceptible to erosion, and some (e.g. the Chromic Luvisols) are of low fertility. None the less, these soils could be improved by measures to reduce erosion, such as the cultivation of perennials, or by the addition of fertilizers and planting of legumes to improve fertility. Though difficult to work, these soils have agricultural potential.

D. Land of very low potential for cultivation, with low natural fertility and serious liability to erosion. These are the true talasiga soils (Ferralic Cambisols; Rhodic Ferralsols) which are of such low cropping potential that their only worthwhile use is under trees. This is the land on which reafforestation work should mainly be concentrated.

E. Land of no productive value. Soils in these areas exhibit from one to several major constraints to cultivation, and the land should best be conserved in its natural state and protected from fire.

The wide range of land quality in Lakeba has in the past enabled farmers to employ the potential of different ecological units so as to spread the risk of natural events such as drought and cyclone. In the future it would be possible to make use of this variety to obtain a better balance between cash and subsistence crops within a more varied and more productive agricultural system. It must be stressed that the agricultural and forestry potential of the island as a whole must be classed as quite good. Notwithstanding the large area under talasiga, the agricultural potential of Lakeba gives the island a favoured position among the Lau islands, and this fact has historical importance in that it was the basis for the political dominance achieved by Lakeba in the pre-colonial period.

PRESENT AND POTENTIAL CROPS

The range of crops presently grown in Lakeba is limited, notwithstanding some efforts at new introduction by the agricultural extension service. Coconuts and food crops have been augmented by pines, and are now being further augmented by the creation of pasture. However greater diversification is possible, together with some re-allocation of land between uses, and a discussion of some land-use possibilities that might be available in a more intensively-developed Lakeba now follows.

Annual crops

A range of crops quite outside the present inventory is entirely suitable for Lakeba, though large-scale production would require some degree of mechanization. The list includes maize, sorghum, dry rice, and especially ground nuts and soya beans. These crops, almost unknown on Lakeba at present, require fairly fertile and deep sandy-clay to clay soils. They could readily be established on the clay soils of the alluvial and coastal plains, and on the Chromic Luvisols of the colluvial areas with heavier addition of fertilizer, in rotation with a legume to provide green manure and increase the organic matter content of the soil. Such crops could be used to feed stock, either locally or elsewhere in Fiji. Cassava could also be cultivated on a larger scale, to supply food for pigs.

Irrigated crops

Irrigated taro is already the most distinctive of Lakeba's food crops, even though it may have taken second place to yams in a bygone time. The system of taro cultivation is intensive, and varied, and is described elsewhere by M. Brookfield (this volume). Wet rice has been introduced on a trial basis in the past, but abandoned, and the bunded padi plots now returned to taro. It could, however, be tried again, and it might be noted that islanders on Kadavu have turned their taro beds into rice padi plots with success. In view of the large local consumption of rice, and the possibility that problems experienced by taro cultivators through disease elsewhere in the region may strike Lakeba, it seems wise to sustain experimentation with rice.

Dry-land subsistence crops

The wide present range of dry-land subsistence crops is well suited to the natural resources of the island. Some concern should be expressed at the recent extension of yaqona cultivation on Humic Cambisols in the forest patches, but as this is a long-term crop the principal consideration is the management of the fallow period. The 'less-demanding' subsistence crops -- cassava and sweet potatoes -- are the dominant crops on the poorer soils of the Chromic Luvisols of the colluvial terraces and of the Eutric Cambisols under reed thicket; with care, the use of these soils could be extended.

Improved pasture

The recent increase in cattle numbers has raised the possibility of creating improved pasture under coconuts. Animals are generally pastured in fenced areas of natural grassland on the plains, and sometimes in uncultivated swamps. The native grassland flora is poor in fodder, and successful trials have been made with Koronivia grass (*Brachiaria humidicola*), with the leguminous 'centro' (*Centrosema pubescens*) discussed above in another context, and with 'stylo' (*Stylosanthes gracilis*), but the systematic creation of pasture has not yet been essayed in Lakeba. Experience elsewhere has shown that it is entirely possible to create good pasture under coconuts, given mechanical cultivation and the addition of fertilizer.

Attention may also be called to experiments on the Nausori Highlands in Viti Levu, where some areas in forestry plantations have been fenced off for stock breeding. Without the introduction of fodder species results might be disappointing, and would certainly be so in Lakeba where the talasiga vegetation includes no grass flora comparable with that in the Nausori Highlands. Trial introductions of Koronivia grass, 'stylo' and Nadi Bluegrass (*Dicanthium caricosum*) have been made under pines in a lowland talasiga site near Tubou. These trials need to be extended, and consideration given to possible conflict between the forestry requirement of a closely-spaced stand of trees and the pastoral requirement of wide spacing to permit light to reach the soil.

Tree and shrub plantations

Coconuts presently cover about 20 per cent of the land area of Lakeba, occupying especially the Eutric Fluvisols and Rendzinas. Though the trees are old yields still averaged 0.54 t/ha in the early 1970s (UNESCO/UNFPA Project, 1977). When the question of replanting arises it will be necessary -- or desirable -- to make a rational decision between continuing the monoculture of copra, mixing coconuts with cattle or field crops, or replacing some areas of coconuts with new field crops discussed above. The spacing of trees, and the varieties that might be planted, depend on the choices made.

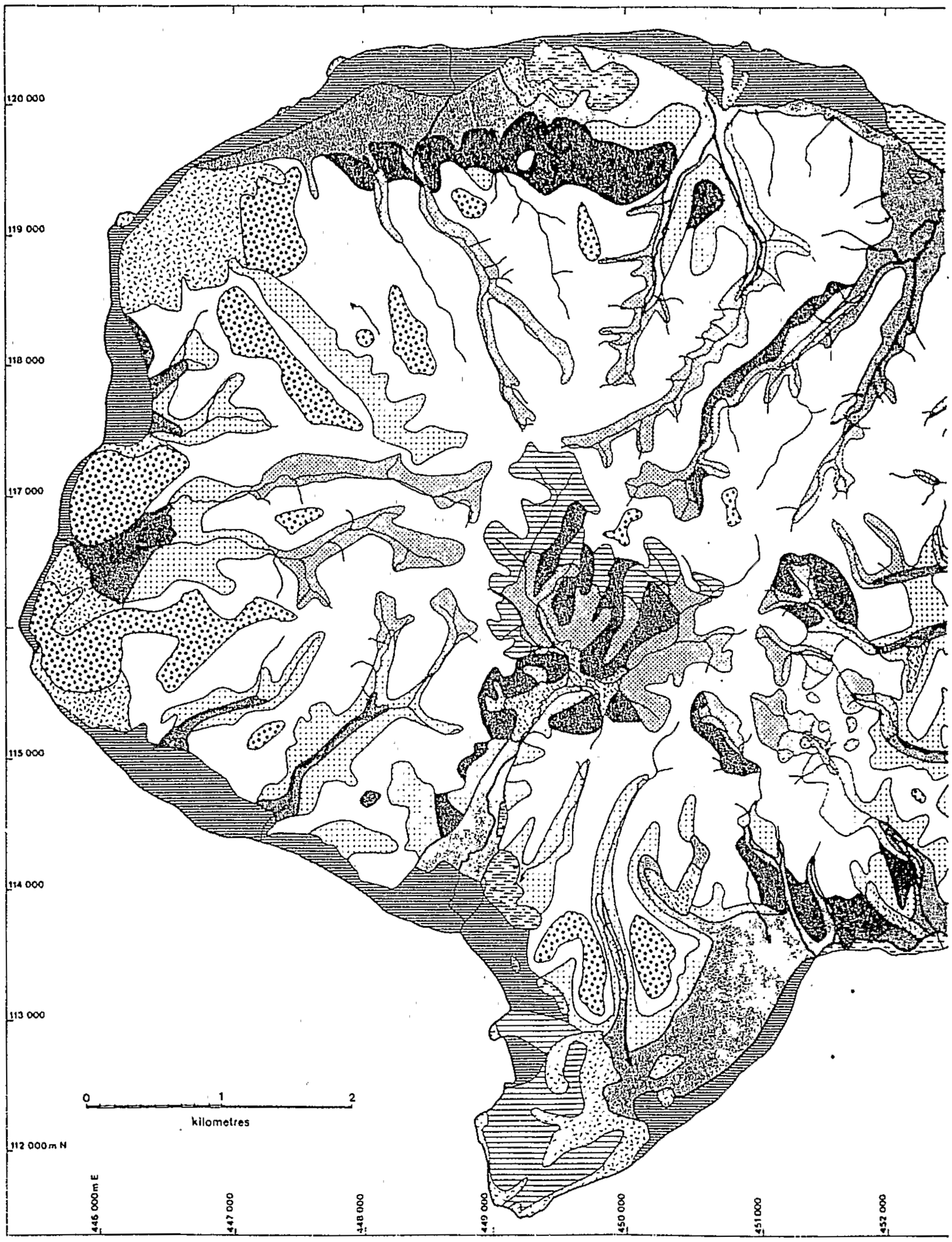
Mention may be made of the possibility of establishing coffee on Lakeba. Though this crop was virtually abandoned in Fiji after the introduction of leaf-rust (*Hemeleia vastatrix*) (Twyford and Wright, 1965), Robusta coffee is hardly affected by this fungus, and its establishment would help diversify the cash base. The relatively dry climate of Lakeba would be of advantage.

Forestry plantations

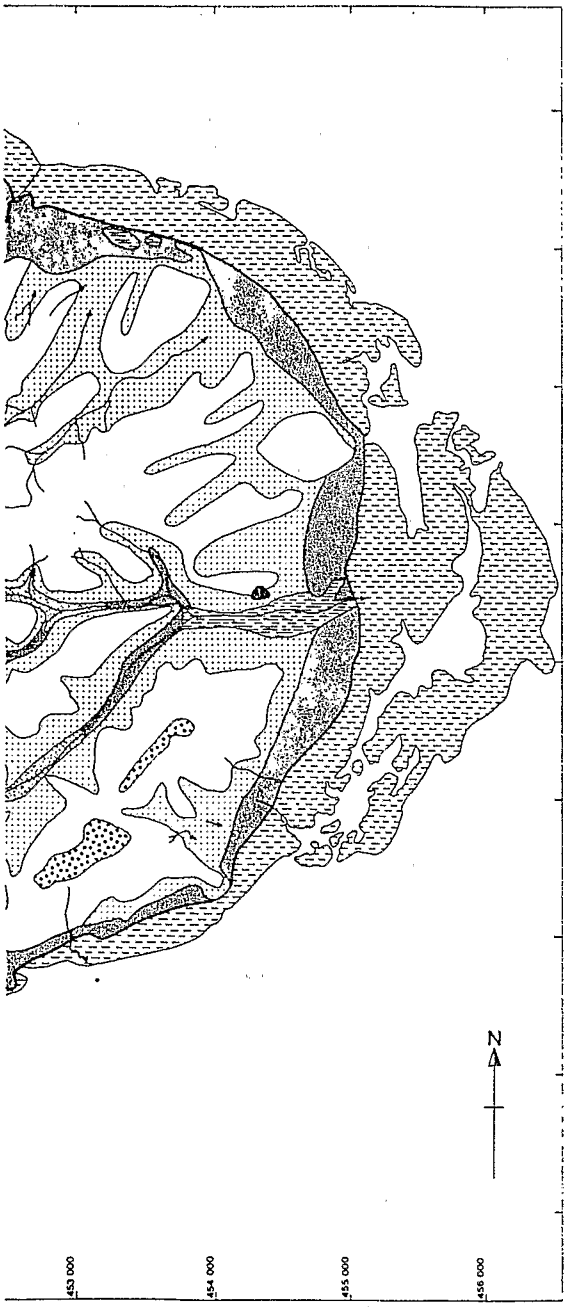
Pinus caribaea was first planted in Lakeba more than a decade ago, and the planting programme envisages the almost complete coverage of the present talasiga country with pines. The edaphic requirements of *Pinus caribaea* are modest, and the trees grow satisfactorily on these soils. The best growth is achieved on the Acric Ferralsols and Chromic Luvisols, but results are

Figure 6.1

LAKEBA
FIJI



LAND SUITABILITY FOR AGRICULTURE AND FORESTRY



LEGEND

LAND UNITS \ LAND POTENTIAL		MECHANIZABLE ANNUAL CROPS	IRRIGATED CROPS	SUBSISTENCE CROPS	LOW DEMAND SUBSISTENCE CROPS	IMPROVED PASTURES	TREE AND SHRUB CROPS	FOREST PLANTATION
LANDS OF GOOD POTENTIAL								
WITH LOW SUSCEPTIBILITY TO EROSION								
	ALLUVIAL AND COASTAL PLAINS EUTRIC FLUVISOLS. UNDER COCONUTS	✪	—	✪	—	✪	✪	—
	SWAMPS. HUMIC GLEYSOLS. UNDER HERBACEOUS VEGETATION. REGULARLY CULTIVATED IN TARO.	—	✪	—	—	—	—	—
LANDS OF MEDIUM POTENTIAL								
WITH LOW SUSCEPTIBILITY TO EROSION								
	COASTAL PLAINS. RENDZINAS. UNDER COCONUTS	—	—	—	◉	◉	✪	—
	SWAMPS. HISTOSOLS AND GLEYSOLS UNDER HERBACEOUS VEGETATION	—	◉	—	—	—	—	—
WITH MODERATE SUSCEPTIBILITY TO EROSION								
	SUMMIT ZONES WITH MODERATE SLOPES. HUMIC FERRALSOLS. UNDER FOREST	—	—	◉	◉	—	◉	◉
LANDS OF LOW POTENTIAL								
WITH MODERATE SUSCEPTIBILITY TO EROSION								
	COLLUVIO-ALLUVIAL TERRACES CHROMIC LUVISOLS. UNDER TALASIGA	◉	—	—	◉	•	•	✪
WITH VERY SEVERE SUSCEPTIBILITY TO EROSION								
	STEEP SLOPES. HUMIC CAMBISOLS UNDER FOREST.	—	—	◉	◉	—	•	—
	LOWER PARTS OF STEEP SLOPES. EUTRIC CAMBISOLS. UNDER REEDS	—	—	—	◉	—	•	—
LANDS OF VERY LOW POTENTIAL								
WITH LOW SUSCEPTIBILITY TO EROSION								
	PLATEAUX. ACRIC FERRALSOLS. UNDER TALASIGA	—	—	—	•	•	•	✪
WITH SEVERE SUSCEPTIBILITY TO EROSION								
	HILLS WITH MODERATE SLOPES. FERRALIC CAMBISOLS AND RHODIC FERRALSOLS UNDER TALASIGA	—	—	—	—	•	—	◉
UNCULTIVABLE LANDS								
WITH LOW SUSCEPTIBILITY TO EROSION								
	MANGROVES. THIONIC FLUVISOLS UNDER FOREST	—	—	—	—	—	—	—
WITH VERY SEVERE SUSCEPTIBILITY TO EROSION								
	BROKEN LANDFORM. HUMIC CAMBISOLS AND LITHOSOLS. UNDER FOREST	—	—	—	—	—	—	—

✪ VERY GOOD POTENTIAL
◉ GOOD POTENTIAL
• LOW POTENTIAL
— USE UNSUITABLE

encouraging even on the Ferralic Cambisols (Table 6.3). Unfortunately, the effect of cyclones on the pine plantations is disastrous. About a quarter of the pines were destroyed by Hurricane Val in 1975, and many others were bent. For this, and other reasons, there would be a case for diversifying the planting programme to include other tolerant species.

TABLE 6.3: GROWTH OF *PINUS CARIBAEA* ACCORDING TO SOIL

SOIL	MEAN HEIGHT	MEAN DIAMETER AT 1.5 m	PERCENTAGE OF TREES LIVING
	m	cm	%
Acric Ferralsols	4.2	26.9	75
Chromic Luvisols	4.7	27.4	76
Ferralic Cambisols	3.5	19.0	76

Note: Measurements were taken on trees four years old, with a sample of 60 individuals for each soil category. Dead trees were not measured.

SUMMARY OF LAND SUITABILITY FOR AGRICULTURE AND FORESTRY

Assessment of the suitability of land for crops and forestry has been made in accordance with the propositions of FAO (1976) which emphasized the importance of evaluating the likelihood of success of a project in relation to the investment necessary to achieve success. The summary presented in Figure 6.1 presents the possibilities for development as a function of the quality of the soil, offering a range of choices rather than a single recommendation.

Four levels of land suitability for productive use are recognized on the map:

1. Land with very high development potential, on which development would have a high chance of success without a large investment. For example, the establishment of pasture or field crops on the alluvial and coastal plains involves no initial investment beyond clearing and planting.

2. Land with high development potential. Here a moderate investment would lead to a good chance of success. Two examples may be cited: the establishment of crops on the Humic Ferralsols with measures to prevent erosion; more intensive cultivation on the Chromic Luvisols, which would require a large addition of mineral and organic fertilizer before cropping could begin.

3. Land with low development potential. On such land a considerable investment would be required for the possibility of only a marginal return. This is the case with cultivation on the Acric Ferralsols, or tree planting on the Eutric Cambisols.

4. Land unsuitable for development. On this land there is either no chance of success, or else the investment needed would be so great that no profitable return could be obtained. Land in this category should be

conserved in its natural state and protected from fire and clearing by man. A possible exception may be made of the mangroves, since while the thin soil covering of Thionic Fluvisols over coral flagstone would rule out successful reclamation for cultivation, there might be a possibility of establishing aquaculture in some sites (UNESCO/UNFPA Project, 1977, p. 92-93). However, the timber resources of the mangroves should be protected, in view of their importance to the marine ecosystem.

Unfortunately, this classification has had to depend heavily on empirical observation, because very few experiments have been made in this part of Fiji. We have taken all observable variables into account, including the characteristics of the soil, the state of the natural vegetation, the environment in general, and the known edaphic requirements of the various crops discussed. A wide range of development possibilities is indicated; only the mangroves and some very steep and rough ground are quite unsuitable for cultivation or planting with existing technical means.

III - TOWARD RURAL DEVELOPMENT ON LAKEBA

Successful rural development needs to take account of two priorities: both an increase in production, and also the protection of the soil -- which is the basis of production -- against degradation and erosion. Three issues are selected for discussion in the light of these twin priorities: the intensification of cultivation on the fertile land of the valleys and the coastal plain; the protection of hillsides under forest and reed thicket; the reafforestation of the talasiga-covered hills.

INTENSIFICATION OF CULTIVATION IN THE VALLEYS AND ON THE COASTAL PLAIN

More intensive development of this good land should be the first stage in planned rural development of Lakeba. Development depends on replanting the ageing coconut stands, on the extension and cultivation of improved pasture on the plain and on the colluvial slopes, and on the introduction of mechanized cultivation with use of mineral and organic fertilizers.

Possibilities for crop diversification are seriously limited by the present extension of coconuts over almost the whole of the fertile flat land on the alluvial and coastal plains. Coconuts can be combined with other types of agricultural production, whether the palms remain as continuous groves or are merely used as boundary markers between fields, as in parts of southeast Asia. The random planting of most of the present stands militates against combination with other activities, including the establishment of improved pasture which would demand mechanical cultivation of the soil. With random planting it is also impossible to reach a balance between the sunshine requirements of other crops and the shading of the coconuts. The present association is unsatisfactory, and prevents maximization of the agronomic potential of a valuable land resource.

The colluvio-alluvial terraces also have a significant agricultural potential. At present these areas are only lightly used for short-lived cassava plots because of their low fertility. There is some planting of *Pinus Caribaea*, in the airstrip valley for example, and as this has been successful further extension is envisaged. However, with the addition of fertilizer and the possible use of mechanized cultivation these soils would be suitable for the establishment of crops such as maize, sorghum or ground-nuts, with a good chance of success. Before the whole area is planted with pines it would be as well to investigate these more rewarding possibilities more thoroughly. Lakeba may not yet be ready for more intensive agriculture, but the time may come, and it is not wise to neutralize potential agricultural resources without taking account of possible future needs.

THE PROTECTION OF HILLSIDES AGAINST EROSION

The hillslopes under forest and reed thicket are of some present importance for the cultivation of subsistence crops and yaqona. Shifting cultivation methods are used, and as has been demonstrated many times in many lands, these lead ultimately toward a general impoverishment of the environment. Several modifications of the present utilization of these hillslopes can be suggested.

First is the introduction of perennial crops, which can initially be grown with annuals but in a few years replace them. Coconut stands are sometimes established in this way on Lakeba hillslopes, but there are other possibilities with shrub crops, such as coffee. The growing concept of mixed use of forest is also applicable, following practices long developed in Indonesia and the Philippines. Forest species with useful timber and fruit are planted together with crops, regenerating the forest while augmenting the number of useful trees.

The planting of leguminous cover crops would also assist regeneration, and facilitate the recovery of natural or planted forest. Crops such as *Centrosema pubescens* and *Pueraria phasiloides* could be planted after the cultivation of annuals is finished. Not only would they improve soil fertility, but they are less invasive than the 'mile-a'minute' (*Mikania micrantha*) which, together with species of *Ipomoea*, now occupy the clearings very rapidly and impede natural reafforestation by suffocating young tree growth.

Lastly, the building of terraces and earth ridges along the contour after clearance of the forest and before planting of yams and taro would restrict soil erosion; even cultivation in narrow belts along the contour without earthworks of any kind would have some beneficial effect.

REAFFORESTATION OF THE TALASIGA

The effect of *Pinus caribaea* planting on the talasiga soils has been discussed at some length in an earlier report (UNESCO/UNFPA Project, 1977, p. 61-64). These plantations not only allow the restoration of degraded soils, changing the structure of the A horizon and significantly affecting its chemical characteristics and biological activity; they also encourage the absorbtion of water into the soil, and hence reduce runoff and regulate stream flow. If this second effect is not yet very conspicuous, this is due to the youth and limited size of the plantations, and will become more evident as the pines increase in age and area. Not only is the hydrological regime likely to be modified significantly, but the reduction of erosion from the hills will also reduce the accumulation of infertile material in colluvial zones in the valleys. While we may express some doubts concerning the wisdom of *Pinus caribaea* planting on the valley colluvium, there seems no question of its utility on the hills, and the programme should extend across the whole of the Lakeba uplands as rapidly as possible. Except in so far as some of the talasiga 'para-forest' on the bauxitic plateau areas might be spared to add variety to the landscape and conserve a very distinctive vegetation complex, nothing but good can come of the replacement of talasiga by pines, and perhaps other trees also, throughout the Lakeba hills[1].

A programme on these lines would both permit a major increase in rural production, bringing the larger part of the island into productive use; it would also assist in maintaining the rather delicate ecological balance of the island, and halt the degradation that seems clearly to be continuing at the present time.

CONCLUSION

The land resource potential of Lakeba is large and diverse. Nearly 30 per cent of the island is capable of agricultural or pastoral development, and the diversity of the environment would permit the cultivation of a large variety of crops. However, any programme of intensification would need to take account of the serious morphodynamic constraints which are an integral part of the environment. Erosion of the slopes, and the deposition of infertile material downslope, are the principal ways in which the environment is currently being degraded. It can be argued that some measure of diversification and intensification is necessary for the preservation of the present agricultural environment, as well as for future expansion of agricultural and pastoral production. Such a programme would also improve the resistance of both economy and environment to natural hazard arising from drought and hurricane. Dependence on, and vulnerability to external forces of both human and natural origin, which is so much a characteristic of the present environment and its utilization (McLean, 1979), would certainly be reduced.

ACKNOWLEDGEMENTS

Work in the field on Lakeba was greatly aided by the generous co-operation of Viliami Osborne (Osipani) and Fateake (Fred) Mua of the extension staff of the Agriculture Department. Members of the Division of Mineral Resources in Suva were generous with their own material on the Lakeba environment, and the Ministry of Agriculture were of major help in the analysis of soil samples, and in assisting me to identify plant specimens. The paper was first written in French, and a close translation into English was made in Noumea by Dr Helen Brinon. The editor then prepared a free translation, which appears above, using both these manuscripts.

---

[1] However, see also M. Brookfield (5.7 below) on the question of fire risk. The recommendation here assumes the provision not only of wide fire-breaks, but also of adequate means for fighting fires.

REFERENCES

BACHELIER, G. (1968), Problèmes relatifs a l'atmosphère du sol et l'utilisation possible d'un détecteur de gaz pour la mesure de sa teneur en gaz carbonique. *Cah. ORSTOM Ser. Pedol.*, 6, p. 95-104.

FAO, (1976), *A framework for land evaluation*. Soil Bulletin No. 32, Rome (FAO).

LATHAM, M. and DENIS, B. (1979), The study of land potential: an open-ended inquiry. *MAB Technical Note* 13, Paris (Unesco) in press.

MCLEAN, R.F. (1979), Spatial and temporal variability of external controls on small island ecosystems. *MAB Technical Note* 13, Paris (Unesco) in press.

SERVANT, J. (1974), Un problème de géographie physique en Polynésie Francaise: l'érosion. Exemple de Tahiti. *Cah. ORSTOM Ser. Sci. Hum.*, 11, p. 203-209.

TWYFORD, J.T. and WRIGHT, A.C.S. (1965), *The soil resources of the Fiji islands*, Suva (Government Printer).

UNESCO/UNFPA Project, (1977), *Population, resources and development in the eastern islands of Fiji: information for decision-making*, Canberra (Australian National University for Unesco).

UNITED NATIONS EDUCATIONAL
SCIENTIFIC AND CULTURAL
ORGANIZATION (UNESCO)

UNITED NATIONS FUND
FOR POPULATION
ACTIVITIES (UNFPA)

THE UNESCO/UNFPA POPULATION AND ENVIRONMENT PROJECT IN THE EASTERN ISLANDS OF FIJI

ISLAND REPORTS

NO. 5

LAKEBA: ENVIRONMENTAL CHANGE, POPULATION DYNAMICS AND RESOURCE USE

H. C. Brookfield
M. Latham
M. Brookfield
B. Salvat
R. F. McLean
R.D. Bedford
P. J. Hughes
G. S. Hope

Editor:
H. C. Brookfield

MAN AND THE BIOSPHERE (MAB) PROGRAMME, PROJECT 7: ECOLOGY AND RATIONAL USE OF ISLAND ECOSYSTEMS

Printed and Published in Australia at
The Australian National University, for
UNESCO, 1979.

H.C. Brookfield, M. Latham,
M. Brookfield, B. Salvat,
R.F. McLean, R.D. Bedford,
P.J. Hughes, G.S. Hope

Printed at:
SOCPAC Printery,
The Research Schools of Social Sciences and
Pacific Studies,
H.C. Coombs Building, Australian National University.

Distributed for UNESCO by:
Professor H.C. Brookfield,
Department of Geography,
University of Melbourne,
Parkville, Victoria, 3052.

© National Library of Australia Card No. and ISBN 0 909596 30 1

GENERAL NOTE

The 'Island Reports' of the UNESCO/UNFPA Population and Environment Project in the Eastern Islands of Fiji are supplementary reports to the General Reports of the Project. Being on specific topics of more restricted scope than the General Reports, they are produced in only a limited edition. Subject to the general approval of the editor they are the responsibility of the authors concerned. The views presented in these Reports are not necessarily those of UNESCO and UNFPA.

The series replaces the 'Project Working Papers', which were preliminary statements published before the General Reports of the project were in draft. One of the Project Working Papers is reproduced in this series, being of a definitive nature; the others, of which only small stocks now remain, are not republished. However, a statement of the formerly-proposed numbers of Project Working Papers, as advertized in our General Report No. 1, is appended to each Report to facilitate cross-reference.

There are five issues of these 'Island Reports', as follows:

1. The hurricane hazard: natural disasters and small populations

2. Koro in the 1970s (reprinted from Project Working Paper No. 7)

3. Land, population and production in Taveuni District

4. The small islands and the reefs

5. Lakeba: environmental change, population dynamics and resource use

The series has been edited in Melbourne, by the former Chief Technical Adviser of the project, assisted by Tyna Charles. It is published for UNESCO at the Socpac Printery, Australian National University, Canberra. The series is not for sale, and is distributed by UNESCO and for UNESCO by the Australian National Commission for UNESCO to individuals and institutions in Fiji and elsewhere. A limited number of additional copies is available from UNESCO, Paris, and from the Department of Geography, University of Melbourne, on payment of a nominal charge to cover handling costs and postage. All enquiries should be addressed either to the Division of Ecological Sciences, UNESCO, or to the Secretary, Department of Geography, University of Melbourne, Parkville, 3052, Australia.

NOTE

In the first general report of the project (*Population, resources and development in the eastern islands of Fiji: information for decision-making*, Canberra (Australian National University, Development Studies Centre, for UNESCO, 1977), the papers in this 'Island Report' are announced as follows:

5.1	(M. Brookfield)	:	Not announced
5.2	(Latham)	:	Project Working Paper No. 17
5.3	(McLean)	:	Project Working Paper No. 17
5.4	(Salvat et al)	:	Not announced
5.5	(Hughes et al)	:	Not announced
5.6	(Latham)	:	Project Working Paper No. 17
5.7	(M. Brookfield)	:	Project Working Paper No. 18 & 19
5.8	(Bedford/Brookfield)	:	Project Working Paper No. 20
5.9	(H. Brookfield)	:	Not announced

Titles also differ from those announced in the General Report.

NOTE

In the first general report of the project (*Population, resources and development in the eastern islands of Fiji: information for decision-making*, Canberra (Australian National University, Development Studies Centre, for UNESCO, 1977), the papers in this 'Island Report' are announced as follows:

5.1	(M. Brookfield)	:	Not announced
5.2	(Latham)	:	Project Working Paper No. 17
5.3	(McLean)	:	Project Working Paper No. 17
5.4	(Salvat et al)	:	Not announced
5.5	(Hughes et al)	:	Not announced
5.6	(Latham)	:	Project Working Paper No. 17
5.7	(M. Brookfield)	:	Project Working Paper No. 18 & 19
5.8	(Bedford/Brookfield)	:	Project Working Paper No. 20
5.9	(H. Brookfield)	:	Not announced

Titles also differ from those announced in the General Report.

LIST OF CONTENTS

A NOTE ON PRONUNCIATION AND SPELLING

The standard Fijian spelling is used through this Island Report as in all reports of the project. It departs from normal English usage in the following:

b is pronounced mb as in lumber
c is pronounced th as in this
d is pronounced nd as in hand
g is pronounced ng as in ring
q is pronounced ngg as in singer (i.e. with greater stress)

There are differences in practice between hard and soft use of these consonants, and the pre-nasalization of 'b' and 'd' ranges from very slight to very strong, but these differences are not reflected in the spelling of the word.

Thus in this report:

LAKEBA	is pronounced	LAKEMBA
TUBOU	is pronounced	TUMBOW
YADRANA	is pronounced	YANDRANA
NASAQALAU	is pronounced	NASANGGALAU
KEDEKEDE	is pronounced	KENDE-KENDE
YAQONA	is pronounced	YANGGONA

The stress in Fijian words of two syllables is either on the first syllable, or equal between both syllables. In longer words it is usually placed on the second syllable.