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SOILS OF THE SOUTH PACIFIC
THEIR CAPABILITIES AND LIMITATIONS

by

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SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME

SOILS OF THE SOUTH PACIFIC - THEIR CAPABILITIES AND LIMITATIONS

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The importance of the soil factor in plant productivity has been long recognised in the South Pacific. The indigenous people of the region recognised the varied kinds of soils they dealt with and were able to match their different crops to certain soils and adapt management practises to suit local conditions so as to obtain sustained yields adequate for their needs.

Early this century soil resource studies and soil surveys were instigated in various countries of the South Pacific to satisfy the expanding cash cropping systems which were introduced. These investigations also served as a basis to increase the basic food, fibre and wood supply for an expanding population and to provide a surplus of cash crops for export.

An analysis of the state and progress made in soil survey and land use studies in the member countries of the South Pacific Commission was given at the Regional Technical Meeting on Soil Science and Land use in Suva in 1976 (South Pacific Commission, 1976). The results of this analysis were tabulated in the report of this meeting and an updated version of this information is given with this paper (Table 1).

Table 1 shows that coverage by soil surveys is extensive and most countries are covered by reconnaissance soil maps at scales up to 1:25 000. Most of the surveys include assessments of the soils for land use.

As a result of this 1976 Suva Conference, some important recommendations were made in regard to soil surveys and land use studies in the South Pacific. However, despite their importance, little positive progress has been made in bringing about their implementation. In view of this some of the more important recommendations are worth reviewing and discussing at this meeting.

1. Soil Survey Coverage

It is recommended that efforts should be made to achieve reconnaissance soil survey coverage of the whole region at a scale of 1:250 000. Complementary to this, there should be a concentration on detailed soil surveys of agricultural research stations throughout the region in order to fully characterise and classify the soils. In this way the results from trial work undertaken on the research stations could be more confidently and widely applied to other regions of similar soils.

2. Use of soil survey information

It was agreed that considerable soil information that has been obtained in the past two decades has not been used effectively by the people such as planners, foresters and agronomists who are responsible for development schemes. This is mainly due to the lack of communication between potential users of soil information and soil scientists; insufficient training for such people as planners and agriculturalists in the use of

soil information; and often the failure of soil scientists to present their work in a form which can be readily understood and used. Conferences like this are valuable in bringing the two groups together, for the soil scientist can discuss the type of things he is doing, while the planners and others can outline problems, and indicate what sort of information they require from the soil scientist.

3. Problems of uniform soil classification

The various nationals involved in soil surveys in the South Pacific have tended to use the soil classification systems of their own country and this has tended to inhibit the transfer of information between countries.

Soil scientists lack a common classification whereby they can compare, group and correlate soils over the region and agronomists find it difficult to transfer information on such things as the results of fertiliser and crop trials between countries.

The Suva Conference recommended that there was a need for updating of earlier surveys to give better characterisation of the soils so that more basic data on soil properties (physical, chemical, mineralogical, agronomic) is available to potential users. Development of a common international soil classification system was also considered necessary in order that soil information and the results of fertiliser and agronomic trials can be more readily shared amongst the different countries. International classification systems which are available are the FAO/Unesco system; the USDA Soil Taxonomy; and the French Soil Classification System. Of these, Soil Taxonomy is now being used the most widely in the South Pacific.

More detailed soil characterisation and reclassification of the South Pacific region could be a long process and it was proposed that initially there should be a concentration on the soils of research stations in the region.

Characterisation and classification of the soils on the more important and representative research stations could enable the establishment of "benchmark" sites. These would enable the results of soil and agronomic studies to be fully shared among the different countries of the region. Ultimately some linkage may be possible with the Soils Benchmark Project administered by the University of Hawaii. Such linkage would tap a vast pool of information that is being derived by the Benchmark Soils Project on the agronomy of tropical soils.

4. Soil interpretation for land use

Related to the under-utilisation of soil maps and soil survey reports is the comparative lack of land-use interpretative classifications or soil suitability ratings derived from the soil maps. In these ratings or classifications, the properties of the soils and the local climate are related to specific uses or crops so that the user can gain an understanding of the limitations and potentials of the soils for the use he is interested in.

The Suva Conference considered that any interpretative system for land use should take the following forms:

1. Broad scale interpretative schemes for general planning and agricultural development.

2. Interpretations at the national level for the promotion of individual crops.

3. Intensive interpretation through detailed soil surveys for special uses such as forestry, agriculture, urban or engineering.

The meeting considered that general land capability classifications were inadequate, especially in planning for specific crops as potential erodibility of the soil is given too much weight and the classifications do not highlight the positive features of the soil which may be important in assessing the potential of plants which could be suited to the local environment.

Most interpretative classifications which have been put forward are based on the type and degree of soil limitations for various uses and a generalised use suitability may be derived from this. These can be at various levels; for example, general broad suitability for pastoral, cropping, forestry or urban use; for groups of crops with common soil and climatic requirements such as cash crops or tree crops; or they can be for specific crops such as bananas, cocoa, citrus etc.

Of necessity most of these interpretative classifications are somewhat subjective because, in many cases, the information on basic soil characteristics, climatic parameters, and the agronomy of the crop is incomplete. The soil scientist alone cannot provide all this necessary information and major improvements in land use suitability classifications will only come about if there is more active co-operation between soil scientists, climatologists, agronomists, agriculturalists and foresters.

Other recommendations from the Suva Conference were that there was a need for more basic data on climatic parameters which are important in crop growth; and that there is a need for greater co-operation between countries in the region in co-ordination of soil and land use studies and in the transference of the results of fertiliser trials and agronomic work amongst the member countries. It was felt that the South Pacific Commission would be an appropriate body to initiate and administer this co-operative work.

Progress in Soil Surveys and Land-use Studies

To describe the wide spectrum of soils in the South Pacific and to detail their limitations and potentials would be a mammoth undertaking well beyond the scope of a report like this. Instead the following section outlines the progress and status of soil and land use studies in some of the individual countries and uses these as examples of the methodologies used, the progress made, the range of soils present, and their problems and potentials.

COOK ISLANDS

A reconnaissance soil survey of the Southern Group of the Cook Islands was completed by New Zealand Soil Bureau during 1950. The results were published in the Soil Bureau Bulletin series (Grange and Fox, 1953) with accompanying soil maps at 1:31 680 scale.

In 1974 Soil Bureau was asked to upgrade this earlier work through a more detailed soil survey and land use study for the Southern Group of Islands. This programme was conducted in three phases (Leslie, 1977) and operated as part of New Zealand's Bilateral Aid Programme to the Cook Islands. The three phases were as follows:

Phase I - Detailed soil survey and land resource evaluation. This included soil surveys at scales of 1:10 000 (Rarotonga) and 1:15 000 (Aitutaki, Mauke, Atiu, Mitiaro, and Mangaia). The field work was accompanied by morphological, chemical and physical characterisation of the main soils. This work was undertaken at Soil Bureau's laboratories in Lower Hutt.

Phase II - comprised pot and field fertiliser trials; soil classification; land use rating; education; and publication of data.

The pot and field trials indicated likely fertiliser responses on the various soils; classification included the USDA Soil Taxonomy, New Zealand and FAO/Unesco systems; and land use interpretations related the soils according to the type and degree of soil limitations for subsistence dryland tuber crop production, ground cash crops, and tree or tree-like crops. The educative aspects included a land-use seminar held in Rarotonga in 1975 (Soil Bureau, 1975), at which the interim results, and their significance to land-use, were discussed with growers, agriculturalists and planners. Soil Survey Reports with an accompanying soil map are being published for each island and a popular, lay-orientated booklet describing the soils and their use, has been published (Soil Bureau and Cook Islands Ministry of Agriculture and Fisheries, 1979) and distributed to schools, villages etc.

Some aspects of this second phase are ongoing. Soil moisture studies are being carried out on the main cropping soils; an irrigated/no irrigation monitoring trial under citrus is continuing, and citrus fertiliser trials are being conducted.

Phase III - Production and implementation. This phase is designed to make use of the very large amounts of land resource information that is now available from many sources in assisting in land use management and planning. This phase includes a study of social factors involved in increasing production. It is a continuing one and is still in a somewhat experimental stage. To make it work, the information gathered in the first two phases will need to be used effectively and cooperation and involvement by a wide spectrum of disciplines will be necessary (Leslie, 1977).

As part of this multidisciplinary approach, the New Zealand Government funded the Totokoitu research station in Rarotonga. The station is administered by the Plant Diseases Division of DSIR and provides a "benchmark" site for the transfer of land use/cropping information, not only within the "Cooks" but to other South Pacific countries with comparable soils and climate. To this end a detailed soil survey of the station has been made and the soils characterised and classified according to Soil Taxonomy (Leamy et al., 1975).

This whole programme from basic soil survey through trial work and publication of data and on to utilisation and incorporation of information and results in the planning stage, has been very successful, and could well be used as a model for applying the results of soil research to increase agricultural production in many of the South Pacific countries.

KINGDOM OF TONGA

A similar three-phase programme has been intiated for Tonga and the main island groups, Tongatapu, 'Eua, Vava'u and Ha'apai have now been covered by reasonably detailed soil maps at a scale of 1:25 000. The main soils on each island have been characterised and classified according to Soil Taxonomy and reports are now being prepared for publication.

Pot and field fertiliser trials are continuing on the main soils of Tongatapu, 'Eua and Vava'u and a land use seminar was held in Nuku'alofa in 1976 at which the interim results were discussed with planners, agriculturalists, and growers (Widdowson, 1977).

The soils of Tonga are mainly formed from thick, relatively young but weathered deposits of volcanic ash overlying coral limestone. Most of these soils are very fertile and this natural fertility has been maintained for many hundreds of years through the type of subsistence agriculture that has been practised. With the pressure of increasing population on the land requiring the shortening of the bush-fallow period, and the expansion of cash cropping, problems of declining soil fertility, structure deterioration and soil erosion could become more apparent. Providing these can be adequately dealt with, the soils of Tonga have a high potential for a wide range of crops.

As with many other countries in the South Pacific, the drift of the rural population to the major urban areas is creating problems. In planning for the expansion of urban areas the soil factor needs to be taken into account to avoid urban expansion on to land which has a high potential for agricultural production or which has severe limitations for urban use, such as periodic flooding or high water tables.

FIJI

Soil investigations in Fiji started in the early 1900's but the most comprehensive study was that of Twyford and Wright in the 1950's (Twyford and Wright, 1965).

The results of this survey were published as a monograph which included soil maps at 1:126 720 scale of the islands in the Fiji group except for Rotuma Island.* These soil maps have a matching series of land classification maps.

The Twyford and Wright survey has proved useful as a source of basic data on the soils of Fiji but for many areas more detailed soil maps are required and characterisation and classification of the more important agricultural soils require up-dating. Interpretative classifications of

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* Rotuma was later surveyed in March/April 1981

the soils for specific crops and other land uses also need to be developed.

More recent surveys in Fiji are those of French soil scientists from ORSTOM of the Lau Group and Taveuni (Latham et al., in prep.), surveys by Soil Bureau of Lakeba (Leslie and Blakemore, 1978) and Vanua Balavu (Leslie, in prep.).

Detailed soil maps have been made of many of the agricultural research stations by staff of the Fijian Ministry of Agriculture and Fisheries and during 1980 Soil Bureau started modern characterisation of the soils on some of these research stations with the view of understanding more about their properties and how they classify according to Soil Taxonomy. Koronivia, Legalega and Nawaicoba stations are completed and three stations on Vanua Levu will be studied this year.

As the soils on the research stations comprise representative soils of the wider region in which the station is located this work will allow for the establishment of "benchmark" sites that can be used to evaluate fertiliser responses, new crops, and management practises covering the main soils of Fiji.

Counterpart training in soil survey is an integral part of this programme so that, in time, Fijians will be able to carry out soil survey and allied research themselves.

SAMOA

Soil survey coverage of the two main islands (Upolo and Savaia) of Samoa was completed in 1956 by A.C.S.Wright. This work is published as a New Zealand Soil Bureau Bulletin (Wright, 1963). As well as soil maps, Land Classification Maps at 1:100 000 were included in the bulletin.

As with many of the early soil surveys in the Pacific, full use has not been made of the results of this survey but under the Samoan Government's Soils and Management Project, further soil analytical work and pot and field trials is being carried out on the soil mapping units of Wright. A start has been made in classification of soils according to Soil Taxonomy but much more work on this is required.

The soils of Samoa are formed mainly from basalts of varying ages with reasonably fertile, but shallow and stony soils on the younger flows and deep, strongly weathered and strongly leached soils on the older flows. Superimposed on this is a leaching regime related to elevation and increasing rainfall so that even the soils on the younger flows at high altitudes are extremely leached of plant nutrients.

From his study, Wright concluded that areas of land with a potential for cropping which were not being utilised were limited and any large-scale increase in agricultural production would have to come from improved methods of farming on land already being used. Major soil limitations for cropping are largely related to soil fertility and to the rockiness or shallowness of the younger soils which effects cultivation and the supply of soil moisture during dry periods.

Scarcity of adequate water supplies for stock and for irrigation is a serious limitation to agricultural development in many areas.

NIUE

A soil survey and land use study of Niue was made by A.C.S.Wright in 1949 (Wright and Van Westerndorp, 1965). The soil maps accompanying this bulletin are at a scale of 1:63 360 and an extended legend gave the present and potential uses of the individual soils.

Considerable follow-up agronomic work was undertaken by J.P.Widdowson (1966) of Soil Bureau, on Niue. This research, which included pot and field trials, recognised a zinc deficiency in Niuean soils and treatment of this allowed commercial development of passionfruit and limes and improved pasture for cattle grazing.

In 1978, D.M. Leslie of Soil Bureau re-examined the soils of the island to obtain more modern characterisation data on the soils and to determine their classification according to Soil Taxonomy. Work is continuing on the trace element content on the soils and the unique Niue situation of high soil radioactivity.

Information on this survey and the agronomic work has been written up as an interim report (Blakemore, Widdowson, Leslie 1979) and was reported back to the Niueans at a seminar in 1979 (Miller, 1980).

The soils of Niue are mostly shallow with variable thicknesses of "old" weathered ash overlying coral limestone. While pockets of deeper soil exist, a large proportion of the land is not suitable for arable crop production but the potential for tree crops is significant.

SOLOMON ISLANDS

An extensive land use study has recently been made of the Solomon Islands by the Land Resources Development Centre of the Ministry of Overseas Development, Great Britain (Hansell and Wall, 1976-79, Wall et al., 1979). This is a very comprehensive survey covering geology, climate, topography, soils, vegetation and land use.

In this survey, the land system approach, pioneered by the Australians in New Guinea, was used to cover the major groups of islands. Because of the lack of detailed data on climate and soils, no land use capability classification was possible. Instead, a series of maps at 1:100 000 showing Agricultural Opportunity Areas were produced.

Agricultural Opportunity Areas are defined as areas of low population density in which a considerable area of unused land with above average agricultural potential exists. The aim in this was to provide a land inventory with a simple interpretation indicating where further work should be concentrated and where opportunities for agricultural development seem to lie.

General recommendations from this land use study of the Solomon Islands included:

1. The customary land tenure system is a major obstacle to development in many areas and a system of land registration is necessary.

2. Soil erosion, both on agricultural and forestry land is widespread and severe and the development of soil conservation measures should be given high priority.

3. There is a need for more research on the main soils of the development areas in relation to possible cash crops.

4. Training of planners and extension workers in the use of the report is necessary.

Although specific to the Solomon Islands these recommendations could equally well apply to many other South Pacific countries.

FRENCH PACIFIC TERRITORIES

Soil and land use studies in the French Pacific Territories have been concentrated on New Caledonia where soil and land capability maps have been produced at 1:1 000 000 by ORSTOM. The current programme is aimed at soil survey coverage at 1:200 000 with "windows" in key areas at 1:50 000. The soil legend is based on the French system of classification with correlation with the FAO/Unesco soil classification and with Soil Taxonomy. The legends of the land capability maps are based on the FAO scheme for land evaluation.

In French Polynesia formal soil surveys have only recently been started since the establishment of an ORSTOM soils office in Tahiti in 1978. These surveys are being carried out by a team from ORSTOM of the high islands at a scale of 1:40 000. As with the surveys in New Caledonia, the French system of soil classification is being used.

The soil pattern of New Caledonia is diverse. On the wetter, eastern and central part of the island the soils are strongly leached and of low natural fertility. Their fertility status has been worsened by the practises of cultivation and burning and this has also led to serious erosion where cultivation has been extended on to steeper slopes.

On the drier western side of the island, the soils are lress leached and include extensive areas of soils from alluvium which mainly have a good potential for agriculture.

About one third of the territory is covered with soils from ultra-basic rocks. These soils are low in phosphorus and contain excessive amounts of magnesium and other elements such as nickel, cobalt and chromium, which are toxic to plants. The potential of these soils for agriculture or forestry is low.

In French Polynesia, the soils are mainly ferrallitic soils (Oxisols) on the high volcanic islands and rendzinas from coral limestone and sand on the coral atolls. Utilisable areas on the high islands are limited essentially to the coastal plains with hydromorphic soils from alluvium. Some cropping of the steeper slopes of the islands is carried out but this has led to severe erosion and depletion of the natural fertility of the soils.

On the coral atolls, the soils are used mainly for coconut growing and the potential for cropping is low.

Similar soil and land use studies have been carried out on Vanuatua by French soil scientists from ORSTOM (Quantin, 1973).

PAPUA-NEW GUINEA

Soil surveys of Papua-New Guinea commenced in the early 1950's and were conducted at two distinct levels: the reconnaissance surveys at 1:250 000 by the Land Use Research Division of the Australian CSIRO; and semi-detailed surveys by the Soil Survey Section of the Administration Department of Agriculture. The bulk of departmental reports are unpublished although some recent ones such as Research Bulletin 10 on the land resources and agricultural potential of the Markham Valley (Knight, 1973) is a published example of a very detailed and comprehensive soils and land-use study.

All CSIRO reports have now been published. Classification of soils on a country basis has been undertaken by Haantjens (Haantjens et al., 1967) and by Bleeker (1974) using the Soil Taxonomy.

Since self-government, CSIRO, in consultation with departmental soil surveyors, have produced maps at 1:1 000 000 covering the whole country showing vegetation, geomorphology, and land limitation and agricultural land use potential.

SUMMARY

Overall this review has shown that there is a great deal of information available on the soils and land resources of the South Pacific and that work in this field is actively continuing. However, there is a need for greater cooperation between soil scientists and potential users so that more effective use is made of the information already available. As part of this, improved land use classifications need to be devised and included as part of any soil survey or land use project. Again active co-operation will be necessary between soil scientists and agronomists, growers, foresters and engineers in arriving at these classifications.

The soils of the South Pacific are varied but many groups of soils can be matched between countries, a factor which can be used in the transfer of soils and land use information within the region and from other tropical areas. To do this effectively, better and more detailed characterisation of the main soils in each country is required and they need to be classified in a recognised international classification system. In this way technical communication is possible and comparisons can be made between similar soils within the region and outside.

Coordination of this work within the region is essential and the South Pacific Commission would appear to be the appropriate organisation or "umbrella" to fulfil this role.

It would be a difficult and involved task to detail the full range of soils throughout the South Pacific and to list their limitations and potentials. However, most of the countries have common sets of problems which limit the full potential productivity or use of their soils. A few of the more important are:

1. Land tenure

Although the system of land tenure varies greatly from country to country, land tenure is often one of the most important limiting factors. This problem is beyond the scope of this review but needs to be resolved by each country in their own way.

2. Deterioration of soil fertility

Under former systems of subsistence farming which involved a rotation of crops followed by a bush fallow, the fertility of the soils was largely maintained. With increasing population pressure and a consequent shortening of the bush fallow period, and the trend to increase areas under a single crop system, soil fertility is more difficult to maintain. This can be partially overcome with the use of adequate and balanced fertilisers and realistic management of the soil resource. However problems of depletion of organic matter and deterioration of soil structure will still remain and methods such as mulching, suitable crop rotations, and the use of shade trees require to be investigated.

3. Erosion

Parallel with the decline in soil fertility levels is the severe erosion which is occurring where cropping has been carried out on over-steep slopes. Soil erosion is also a serious problem in some areas which are being used for the extraction of timber. If these lands are to be preserved for future use adequate soil conservation techniques will have to be developed and applied.

These problems are not unsurmountable and information from soil surveys and land use studies indicate that in most countries there are sufficient areas of land with moderate to high potential for agriculture and forestry which are under-utilised at present, to satisfy the needs of the country.

Much of the information necessary for improved land use is already available but, in most areas, more soil and agronomic work needs to be done. Some individual countries may not have the resources for this but with greater cooperation between the member countries, the active co-ordination of the work, and improved dissemination of the information, all countries will be able to share and use the wide pool of information that is available to increase the level of agricultural production and to improve land use.

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Country	Soil Survey completed	Scale	Classification systems	Kinds of Units	Other kinds of maps	Publications	Soil characterisation	Interpretative Classifications	Area
American Samoa	70%	1 000 000	N.Z./Hawaiian	Series	None	Wright, 1963	None	None	76 sq miles 197 km^2
Cook Islands	95%	Atiu, Aitutaki, Mauke, Mangaia, Mitiaro 1:15 000 Rarotonga 1:10 000 Manuae 1:5 000	N.Z., FAO Soil Taxonomy	Series with phases	Interpretative maps for groups of crops in preparation	Grange & Fox, 1953 Leamy et al., 1975 Bruce, 1972 N.Z.Soil Bureau; Cook Islands Ministry of Agric. & Fisheries, 1979 Leslie, 1980 Campbell, in prep. Campbell et al, in prep. Milne, in prep. Bruce, in prep. Bruce, in prep. Wilson, Beecroft, in prep.	Complete chemical, clay mineralogy, some physical micromorphological, biological and fertility work	Ratings for groups of specific crops	93 sq miles 240 km^2
Fiji	100%	1:126 720	Modified NZ/Hawaiian	Series	Land Classification (1:126 720)	Twyford & Wright, 1965	Chemical	Land classification and land use capability	7040 sq mls 18,234 km^2
	1%		Soil Taxonomy	Series with phases		Leslie & Blakemore, 1978 Latham, in prep.	Some clay mineralogy and physical on detailed surveys		
French Polynesia	10%	1:40 000	French, FAO, Soil Taxonomy	Phases of Great Groups			Chemical, mineralogy, physical	General land classification	1544 sq mls 544 km^2
	2%	1:10 000	French	Great Group		Tercinier (1955-1969) ORSTOM, Noumea	Full chemistry and mineralogy		
Guam	100%	1:25 000	Local system	Series	Land Use Capability	Stoneland, 1952	Chemical, some mineralogy	Engineering	212 sq mls 544 km^2
New Caledonia	100%	1:300 000	Local derived from French	Great Groups		Tercinier (1962) Tercinier (1965)	Chemistry		
	10%	1:200 000	French, FAO, Soil Taxonomy	Phases of great groups	Land Capability	Latham (1974) Lathem (1973-75)	Full chemical and mineralogical		
	1%	1:50 000	French, FAO, Soil Taxonomy	Series	Land Capability		Full chemical and mineralogical		

Country	Soil Survey completed	Scale	Classification System	Kinds of Units	Other kinds of maps	Publications	Soil characterisation	Interpretative Classifications	Area
Vanuatu (New Hebrides)	100%	1:500 000	French, FAO	Great Group		Quantin, 1976			
	100%	1:100 000 and 1:50 000	French, FAO Soil Taxonomy	Phases of Great Groups	Vegetation, relief, geology	Quantin, 1972-76	Full chemistry, physical mineralogy, trace elements	Land capability	5676 sq mls 14,700 km^2
Niue	100%	1:100 000	N.Z. Soil Taxonomy	Series with phases	None	Wright & Van Westerndorp, 1965	Complete chemical and clay mineralogy; some physical, biological and fertility		100 sq mls 259 km^2
Papua-New Guinea	40% 60%	1:250 000 Extrapolation	Soil Taxonomy, FAO	Associations, series and phases of series	Various	Various CSIRO and Departmental Publications e.g. Knight, 1973; Haantjens, et.al.1967 Bleeker, 1974	Chemical, physical, clay mineralogy	Ratings for various crops, land use capability ratings for cropping, pasture and tree crops	178,470 sq miles 462,243 km^2
	1%	1:20 000 to 1:50 000	Modified Soil Taxonomy						
Solomon Islands	100%	1:250 000	Soil Taxonomy	Associations	Land systems, physiographic regions, forest types/ vegetation; land use; generalised rainfall. Various scales.	Hansell & Ward 1974-1979 Wall et al. 1979	Chemical, physical, and mineralogical analysis of selected profiles	Delineation of Agricultural Opportunity Areas	11,015 sq. miles 28,530 km^2
Tonga	20% (Tongatapu)	1:100 000	N.Z., FAO Soil Taxonomy	Soil types	None	Gibbs, 1976	Chemical, physical mineralogical	None	270 sq.mls 699 km^2
	90%	1:25 000	N.Z. Soil Taxonomy	Series and phases of series	None	Reports in preparation	Chemical, physical	Ratings for groups of crops, forestry and pasture	
						Orbell, 1971			