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A Review of Uses and Status of Trees and Forests in Land-use Systems in Samoa, Tonga, Kiribati and Tuvalu with Recommendations for Future Action

R.R. Thaman and W.A. Whistler

INTRODUCTION

Trees and forests have always been important to Pacific societies. They are a life support system, not only for humans, but also for wild and domesticated plants and animals. Trees and forests protect the land from erosion. They protect homes, farms, and coastlines from strong winds and waves. They make soils fertile, keep air, streams and lagoons clean and clear, and provide habitats and food for animals. Trees also provide us with food and countless other products that would either be too expensive to buy or impossible to import from overseas.

Because of the importance of trees, Pacific Islanders have always planted and protected trees or protected forests as a part of their land use systems and have always been willing to accept new trees that can make their life and island better.

Unfortunately, most urban people and many modern agriculturalists and foresters who are concerned more with maximising production of a single species seem to have forgotten the importance of trees and forests for supporting life. Instead of being protected, trees and forests are increasingly destroyed in the name of development. Even modern forestry and agroforestry programs, which have as their main objective the planting of trees, often lead to the destruction of traditional forestry and agroforestry systems and their multi-purpose trees. We may find that this destruction of our trees and forests is one of the most serious environmental, economic and cultural obstacles to sustainable development; perhaps more serious, in the long run, than other issues of such international concern such as global warming and AIDS. There is, thus, a critical need for the protection, re-establishment and planting of forests and appropriate trees in agricultural areas and other appropriate areas to reverse the serious trends of deforestation, forest degradation and agrodeforestation.

NATURE OF THE REVIEW

This review attempts to provide information on: 1) the status of existing "agroforestry systems" in Western Samoa, Tonga, Kiribati and Tuvalu; 2) related programmes and activities; 3) the trees and plants that constitute these agroforestry systems or are currently of high priority or have shown promise in ongoing programs of research and plant introduction.

On the basis of the findings of the review, recommendations are made on priorities and programs that could be part of an "Agroforestry Strategy" to promote tree planting and protection of trees, both inside and outside agricultural systems in the Pacific islands.

The information provided is based on: 1) reconnaissance surveys of trees in agricultural areas, forests, houseyard gardens and experimental sites in Western Samoa, Tonga, Kiribati and Tuvalu between June and September 1993; 2) discussions with personnel responsible for ongoing forestry and agroforestry programs and projects; and, 3) the cumulative knowledge from over 50 years combined experience of both authors in studying the flora, vegetation, agricultural and agroforestry systems, and ethnobotanies of Samoa, Tonga, Kiribati, Tuvalu and other areas of Polynesia, Micronesia and the Pacific Islands.

The Review and, in particular, the reconnaissance visits were conducted in cooperation with the Forestry Department of the Ministry of Agriculture in Samoa; the Forestry and Agricultural Divisions of the Ministry

of Agriculture and Forestry (M.A.F.) of the Kingdom of Tonga; the Division of' Agriculture of' the Ministry of Natural Resources Development and Environment of the Republic of Kiribati; and the Department of Agriculture of the Ministry of Natural Resources Development and Environment of Tuvalu. These were the official contact agencies in each of these countries. Other relevant agencies, institutions and individuals with knowledge or working in the areas of forestry and agroforestry research and development in each country were also consulted.

In all of the Review countries information was gathered on ongoing forestry and agroforestry activities and tree species that have been the focus of experimental and operational programs. Reconnaissance surveys of existing "indigenous" agroforestry systems were conducted in both rural and urban areas. Reconnaissance surveys of all major vegetation associations were also conducted to assess the relative importance of and threats to important tree and perennial species. Interviews were conducted with villagers and development workers to supplement the authors' knowledge on the cultural importance, husbandry and ethnobotany of trees and perennial species, and with other relevant people to gather their opinions on the types of trees and agroforestry and forestry programs and activities that should receive priority in future development.

Drafts of the Review report were submitted to the relevant authorities in the countries studied and to FOA and UNDO personnel for review before final publication.

The review is targeted mainly at national and regional agencies working in agroforestry, forestry and agricultural development. It is hoped that it will also be of value to individual foresters, agroforesters, donors, volunteers and all other persons concerned with sustainable rural development.

The report consists of two parts: Part I which includes background information and descriptions of agroforestry in the review countries and the proposed agroforestry development strategy, and Part II which is a list and analysis of important Pacific Island agroforestry species.

The Terms of reference of the review are in Appendix I.

DEFINITION OF TERMS

A widely accepted definition of agroforestry, developed at the International Council for Research in Agroforestry (ICRAF) is:

Agroforestry is a collective name for land-use systems and practices in which woody perennials are deliberately grown on the same land-management units as agricultural crops and/or animals. This can be either in some forms of spatial arrangement or in a time sequence. To qualify as agroforestry, a given land use system or practice must permit significant economic and ecological interactions between the woody and non-woody components.(Lundgren 1987:48).

Other definitions (King and Chandler 1978, Thaman and Clarke 1993), which stress both the planting and protection of the trees in the agricultural systems as well as the cultural utility/acceptability, and the ecological stability of the systems are relevant to this study to describe the great diversity and functional utility of existing agroforestry systems in the South Pacific.

"Deforestation" (FAO, 1990) refers to changes of land use which lead to a depletion of tree crown to less than 10% (this definition relates to the definition of forests as ecosystems with a minimum 10% cover of trees). In this paper deforestation is more widely intended as the deliberate and accidental destruction or removal of forests through the use of fire, felling for timber and fuel, overgrazing, clearance or destruction for agricultural and urban-industrial expansion, and other human activities.

"Forest degradation" is defined as: the degradation or impoverishment of forests, measured in terms of loss of biodiversity (which includes genetic, species and ecosystem diversity) and economic, cultural and ecological utility and stability, resulting from the selective removal of trees or other forest plant and animal species or the degradation of forest environments, through processes such as destructive logging, burning, or invasion of disturbed habitats by weedy or less useful exotic species.

And, "agrodeforestation" (Thaman, 1988bc, 1989b) is defined as: "The removal of trees or the failure to protect or replant trees in existing agroecosystems.

These rather unrestrictive and functional definitions, of both agroforestry and deforestation, forest degradation and agrodeforestation, have been selected to cater for the great diversity and functional utility of existing Pacific lsland agroforestry systems, which range from dooryard or houseyard and squatter -garden agroforestry in both urban and rural are as to deliberate intercropping and the protection of trees and tree-like perennials in garden areas and the planting of woodlots and protection of inland and coastal forest stands (which are seen as part of integrated agroecosystems) in sparsely populated rural areas.

TRADITIONAL PACIFIC ISLAND AGROFORESTRY

In traditional Pacific Island societies, activities such as forestry, agriculture, housing, health and nutrition, education, and trade and industry were not compartmentalised into economic sectors as they are in modern development. They were all components of an integrated production system adapted to the environmental, economic and cultural needs of the communities of the islands. The traditional Pacific Islands agricultural systems were really agroforestry systems, where trees were planted and/or protected because of the great variety of their functions as a contribution to the whole system (Clarke and Thaman 1993).

The agroforestry systems found in the region differ considerably in response to the different ecological and socio-economic conditions of each country. The various systems and their characteristics are described separately for each country in the following chapters. Here an overview of the species composition and the role played by trees in production systems in the South Pacific is presented.

Tree Species of Major Importance

Tree or tree-like species of major importance that are found in the agroforestry systems of Western Samoa, Tonga, Kiribati and Tuvalu include:

- food or fruit
- handicraft plants
- other cultivated or protected multipurpose species
- fast-growing pioneer species
- ornamental or shade species
- plants used in living fencing or for hedges or animal pens
- inland or coastal forest species that are protected in, or adjacent to, active agricultural lands.

These species are listed in alphabetical order by their scientific or Latin names and described in detail in Part II of this report.

Food or Fruit Trees

Food or fruit trees are the most common tree or tree-like species found in villages and houseyard gardens, in permanent village tree groves and as protected or deliberately planted intercrops in food gardens. They include: coconut palms, a wide range of banana and plantain cultivars (*Musa* species and

cultivars), breadfruit (*Artocarpus* spp.), edible pandanus (*Pandanus* spp.) varieties, especially in the atolls countries; common fruit trees, such as Malay or mountain apple (*Svzvgium malaccense*), oceanic lychee (*Pometia pinnata*), Polynesian vi-apple (*Spondias dulcis*), mango (*Mangifera indica*), guava (*Psidium guava),* papaya (*Carica papaya*) and native fig (*Ficus tinctoria*); a range of common citrus trees, including sweet orange, mandarin orange, rough lemon, lime, sour orange, pomelo or shaddock, and calamondin orange; a range of nut or seed trees (trees with edible seeds), such as canarium almonds (*Canarium* spp.), Tahitian chestnut (*Inocarpus fagifer*), tropical almond (*terminalia catappa*) and the red-bead tree (*Adenanthera pavonina*); and kava (*Piper methysticum*), the traditional alkaloid social beverage plant in Samoa and Tonga and most of Polynesia, in Vanuatu and other areas of Melanesia, and in Pohnpei in Mocronesia.

Most of these species, with the exception of mango, most of the citrus trees, red-bead tree, guava and papaya, are either aboriginal introductions (plants introduced by the original inhabitants before European contact) or in some cases indigenous species. Recently introduced banana varieties are also growing along with the traditional aboriginally introduced cultivars, and in some areas are now more common.

In most coast areas and on atolls, the coconut is ubiquitous within gardens and areas under short-term fallow. In more mature fallow areas, the coconut is also often dominant, with other useful trees scattered amongst coconut palms in poorly maintained copra plantations. Whereas in modern plantations, the palms tend to be evenly spaced and of a similar age-class, the palms in food gardens, fallow areas and poorly maintained plantations on atolls tend to be scattered, of different age classes and often crowded and in need of thinning.

Handicraft Plants

Apart from the coconut palm, which is used in the production of a wide range of plaited ware and other handicrafts, the handicraft plants of most widespread importance are:

1. Pandanus species or cultivars (*Pandanus spp*.), commonly planted exclusively for their leaves which are used in the production of fine and rough mats, thatching, baskets and a wide range of other plaited ware, and which are of particular importance on atolls where pandanus timber is also used in house construction; and,

2. Paper mulberry (*Broussonetia papyrifera*), which provides the fibrous inner bark that is used in the manufacture of bark cloth (tapa cloth) and other handicrafts in Samoa and Tonga.

Both pandanus and paper mulberry are deliberately cultivated in monospecific stands or intercropped both systematically and randomly within other crops and allowed to merge into the fallow vegetation, where they can still be harvested. The shrub-like pandanus cultivars, some of which are quite ornamental, are also commonly planted along the boundaries of garden or as utilitarian borders or hedging in houseyard gardens. Wild, uncultivated pandanus from coastal areas and fallow areas is also commonly used for handicraft production and other purposes.

Other Cultivated or Protected Plants

All traditional agroforestry systems include a range of other multipurpose tree species that are either cultivated or protected in agricultural areas because of their cultural utility. In Samoa and Tonga these include trees such as *Erythrina variegata* , *Bischofia javanica*, *Alteurites moluccana*, *Cananga odorata*, *Atuna racemosa*, *Hernandia moerenhoutiana*, *Garcinia sessilis*, *Aglaia saltatorum* and *Glochidion ramiflorum.*

Species commonly planted or protected on atolls include *Guettarda speciosa*, *Tournefortia argentea*, *Terminalia samoensis*, *Premna serratifolia* and *Morinda citrifolia* (See Part II for detailed descriptions).

Fast-Growing Pioneer Species

Fast-growing pioneer species are often encouraged through selective weeding. These species, which play a major role in fallow cycles and soil nutrient recycling and have a cultural uses, include *Macaranga harveyana*, *Kleinhovia hospita,Hibiscus tiliaceus*, *Omalanthus nutans,Morinda citrifolia*, *Pipturus argenteus* , *Melochia aristata*, *Trema cannabina*, *Grewia crenata* and *Adenanthera pavonnia*. Species that become more dominant in mature secondary forest include *Rhus taitensis*, *Alphitoniazizyphoides* and *Elattostachys falcata*.

Important secondary species on atolls, that dominate abandoned coconut plantation undergrowth and abandoned giant swamp taro (*Cyrtosperma chamissonis*) garden areas, include *Acalvpha grandis*, *Guettarda speciosa*, *Premna serratifolia*, *Morinda citrifolia*, *Pipturus argenteus* and *Scaevola taccada*.

Ornamental or Shade Species

A range of ornamental and shade trees of considerable cultural value are particularly well-adapted to houseyard gardens, roadsides and institutional plantings. Among the more important species are frangipani (*Plumeria rubra* and *P. obtusa*) and poinciana or flame tree (*Delonix regia*), which grow well in Samoa, Tonga and on the atolls. Other ornamental trees of importance in Samoa and/or Tonga include the rain tree (*Samanea saman*), a range of cassias or shower trees (*Cassia* spp. and *Senna* spp.), African tulip tree (*Spathodea campanulata)*, bauhinia or orchid trees (*Bauhinia spp*.) introduced banyans (*Ficusbenjamina* and *F. benghalensis*), tropical almond (*Terminalia catappa*) and tamarind (*Tamarindus indicus*).

Living Fencing and Hedges

Also important, particularly in areas near villages and around fenced pastures, are species planted as living fences, hedges, windbreaks, boundary markers or pig pens. The most common species include *Erythrina variegata*, *Hibiscus tiliaceus*, *Ceiba pentandra*, *Spathodea campanulata*, *Garuga floribunda*, *Casuarina equisetifolia*, *Aleurites moluccana*, *Gyrocarpus americana* and *Jatropha curcas*. Common hedge plants include *Hibiscus rosa-sinensis*, *Polyscias* spp., *Acalypha amentacea* (*wilkesiana*), *Codiaeumvariegatum* and *Breynia nivosa*.

Species of particular importance on the atolls include *Polyscias* spp., *Pseuderanthemum* spp., *Graptophyllum pictum* and *Clerodendrum inerme*. Other species that are increasingly common, particularly in Kiribati and Tuvalu, are Casuarina and the native *Pisonia grandis*. *Premna serratifolia* is also used occasionally for living fence poles and garden stakes.

Staple Food Crops, Ground Crops and Animal Food

In all of the Review countries the diverse mix of trees, staple tuber crops and fruit- or leaf-bearing groundcrops provides a fairly good diet. This is complemented by domesticated pigs and fowl, birds, fruit, bats and (in case of Samoa and Tonga), a limited range of wild plant such as nuts, fruits, and greens from the surrounding forests, fallow areas, ruderal sites, rivers, and swamps. In coastal areas, and particularly on the atolls where terrestrial food resources are more restricted, reef gleaning and a wide array of fishing techniques provide an abundance of protein, including finfish, shellfish, crabs, lobsters, echinoderms (e.g., sea urchins and sea cucumbers or beche-de-mer) turtles and octopus.

The dominant staple ground crops in Samoa and Tonga are taro (*Colocasia esculenta*), yams, (*Dioscorea* spp.), banana and plantain (*Musa*) cultivars, sweet potato (*Ipomoea batatas*), cassava or manioc (*Manihot esculenta*), tannia, cocoyam or American taro (*Xanthosoma* spp.) and giant taro (*Alocasiamacrorrhiza*). There is also a diversity of other ground crops including sugar cane (*Saccharum*

officinarum), bush hibiscus spinach (*Hibiscus manihot/Abelmoschus manihot*), pumpkins (*Curcurbita* spp.), pineapple (*Ananas comosus*), maize (*Zea mays),* chilli peppers (*Capsicum* spp.), cabbages (*Brassica* spp.), beans (*Phaseolus* and *Vigna* spp.), and non-food species such as kava, *Pandanus* spp. and paper mulberry. Colocasia taro, by far the most important traditional staple and recently the most important export crop in Samoa, has recently been devastated by established tara leaf blight (*Phytophthora colocasiae*).

Fallow and Protected Forests

District areas of primary or relatively undisturbed secondary forest and old-growth fallow forest, as well as sections of coastal strand or mangrove forest are found in all the Review countries, although areas of inland forest area more common in Samoa.

These areas, that serve as hunting reserves and sources of medicines and other products, are also integral components of overall land use and agroforestry strategies and play a vital role because of their ecological and cultural importance to sustainable agricultural land use systems.

Land Clearance and Fallow Forests

The basic stragegy for clearing a piece of land for gardening, in areas of shiftiing agriculture (e.g., in Samoa and Tonga), consists of burning the base, felling, or ringbarking some or all trees and clearing the underbrush, usually through burning, from a section of fallow land. This practice is often referred to as slash-and-burn agriculture. At the same time selected tree species may be protected. These species will remain or be allowed to regenerate along with deliberately planted short-term and long-term ground and tree crops.

Trees that have been preserved, usually slow-growth forest, fruit or nut trees, and trees of medicinal or other cultural importance such as citrus trees, oceanic lychee (*Pometia pinnata*) or *Bischofia javania* are often pruned, pollarded or coppiced. This opens garden areas to sunlight, adds additional organic material or nutrients to the soil (if burned or allowed to rot in place), or provides firewood or trellising for climbing or crawling plants, such as yams.

Selective weeding during the life of gardens also protects important medicinal and wild food plants and pioneer tree species, which will dominate early stages of the fallow vegetation.

As a form of "enrichment planting", domesticated or indigenous trees often deliberately or accidentally (e.g., from cast-off mango or citrus seeds) planted, so that, as gardens return to fallow, valuable trees are scattered throughout fallow areas. If left for several decades, the planted trees merge back into mature secondary fallow forests, which again become available for clearing for new gardens. In Samoa, for example, *Erythrina variegata* and *Erythrina subumbrans*, both nitrogen-fixing trees, are commonly planted in, or as fencing around, shifting taro gardens.

These "fallow forests", if not re-cleared for gardening, provide an enriched and sustained supply of fruits, nuts, wild plant and animal foods, medicines and other materials. These forests, in some ways, constitute the supermarket, pharmacy, and hardware store of the people (Clarke and Thaman 1993).

Trees or plants, such as breadfruit, bananas, pandanus, yams or taro, are reproduced vegetatively from parts of the original parent plant or cultivar. For example, different named varieties of breadfruit in Samoa and Tonga (e.g., **aveloloa**, **'ea** or **kea**, **ma'afala**, **maopo** and **puou**) represent five different "named" vegetative clones that have descended from five distinct original breadfruit cultivars.

More sophisticated techniques such as grafting, budding or marcotting are currently being conducted at experimental farms in Samoa, Tonga and Kiribati to reproduce trees such as citrus or mango.

Species Diversity

As a result of many years of plant selection and introduction, by both indigenous and non-indigenous peoples, there is great diversity in the agroforestry systems in all the Review countries, both in terms of species diversity (the number of different species) and genetic diversity (the number of different varieties, provenances, cultivars or clones of the same species). For example, the great diversity of clones or cultivars of breadfruit in all of the Review countries and the almost bewildering diversity of pandanus cultivars in Kiribati are evidence of this long and intensive selection process and subsequent vegetative propagation and dispersal of desirable cultivars throughout different island groups. Interspecies diversity is, of course, less in the harsh and less-diverse atoll environments of Kiribati and Tuvalu than is Samoa and Tonga.

In the approximate order of their cultural importance or abundance, the types of species found in agroforestry systems include: 1) widely-cultivated or deliberately planted food and non-food species, 2) species that are protected or preserved when clearing garden areas, and, 3) species that are protected upon spontaneous generation.

For some species, both cultivated and wild or feral forms or varieties are recognized. Feral species are domesticated plants (or animals) that have escaped from cultivation and now grow wild or naturally without the help of humans. The more common domesticated species are usually represented by many cultivars (e.g., different named cultivars of coconuts, bananas, breadfruit, pandanus, hams, taro, sugar cane or bush hibiscus spinach). These named cultivars have been selected and cultivated for thousands of years in response to local environmental and cultural needs. This diversity of species, cultivars and clones is now being lost due to increasing emphasis on single species commercial production for export or local sale.

Advantages of Trees

Central to an understanding of the importance of traditional agroforestry and the importance of promoting planting and protection of trees and forests is the utilitarian diversity of the trees of traditional agroforestry systems. Table 1 shows some of the diverse fuctions and traditional uses of trees in the Pacific.

ECOLOGICAL

Shade
Soil Improvement
Animal/Plant Habitat
Erosion Control
Frost Protection
Flood/Runoff Control
Wind Protection
Wild/Animal Food
Weed/Disease Control

CULTURAL/ECONOMIC

Timber (commercial
Timber (subsistence)
Fuelwood
Boatbuilding (canoes)
Sails
Tools
Weapons/Hunting
Containers

Woodcarving
Handicrafts
Fishing Equipment
Floats
Toys
Switch for Children/Discipline
Brush/Paint Brush
Musical instruments
Cages/Roosts
Tannin/Rubber/Oils
Toothbrush
Toilet Paper
Fire Making
Embalming Corpses
Lovemaking Sites
Subject to Mythology
Broom
Parcelisation/Wrapping
Abrasive
Illumination/Torches
Insulation
Decoration
Body Ornamentation
Cordage/Lashing
Glues/Adhesives
Caulking
Fibre/Fabric
Dyes
Plaited Ware
Hats
Mats
Baskets
Commercial/Export Products
Products
Ritual Exchange
Poisons
Insect Repellents
Deodorants
Secret Meeting Sites
Prop or Nurse Plants
Staple foods
Supplementary Foods
Wild/Snack/Emergency
Foods
Spices/Sauces
Teas/Coffee
Non-alcoholic Beverages
Alcoholic Beverages
Stimulants
Narcotics
Masticants
Meat Tenderizer
Preservations
Medicines
Aphrodisiacs
Fertility Control

Abortifacients
Scents/Perfufmes
Recreation
Magico-religious
Totems

Ecological View

Shade is important to humans, plants, and animals, especially in open grasslands, in highly reflective low-lying coral-island and lagoonal environments, and in villages and urban areas. Forests reduce damage from wind, salt spray, erosion, and flood. Cases of accelerated erosion due to deforestation are common in all island groups. Mangrove forests stabilize tidal-zone soil and reduce the impact of wave erosion, storm surge, tsunamis and salt spray.

Studies after Tropical Cyclone Isaac in Tonga in 1982 showed that most indigenous plant species were very little affected by hurricane-force winds and two to three meter storm surge, whereas introduced non-coastal species suffered high mortality due to windfall and the effects of excessive salinity related to both storm surge and severe salt spray. Moreover, areas inland from intact coastal and mangrove forests suffered far less damage and mortality (Thaman 1982).

The role of coastal plants in soil stabilization is critical to the success of land reclamation and other low-cost coast engineering works. Species already used for land reclamation in various areas of Asia and the Pacific include *Bruguiera gymnorrhiza*, *Calophyllum inophyllum*, *Casuarina equisetifolia*, *Cocos nucifera*, *Hibiscus tiliaceus*, *Lumnitzera littorea*, *Rhizophora* spp. *Scaevola taccada*, *Sonneratia alba*, *Terminalia catappa* , and *Tournefortia argentea* (Yao 1986). Many of the coastal herbs, grasses and sedges, vines and shrubs would undoubtedly be of considerable importance for coastal stabilization and land reclamation. In Kiribati, species of particular importance for the stabilization of the extensive reclaimed Temaiku milkfish ponds on Tarawa are *Scaevola taccada* and *Tournefortia argentea*.

One of the most important ecological roles played by coastal plants is the protection of inland agricultural areas, non-coastal vegetation and fauna, settlements, and water supplies from saltwater spray and storm surge. Because of their tolerance to high levels of salinity, plants with particularly high tolerance to salt spray and saline soils, such as coconut, pandanus *, Tournefortia argentea*, *Scaevola taccada*, and *Guettarda speciosa*, followed by *Cordia subcordata*, *Clerodendrum inerme*, *Terminalia litoralis*, *Premna serratifolia, Morinda citrifolia*, and *Calophyllum inophyllum* (Soucie 1983) can be particular value in this respect. Farmers, throughout the Pacific purposely leave strand or mangrove forest intact to the seaside of their gardens, as they know that to remove it would make farming problematic. In Kiribati, stands of *Pemphis acidula* are left seaward of agricultural areas to provide protection from salt spray and *Casuarina equisetifolia* has been planted to protect newly planted coconuts (Thuman 1990b). Most recently, over 20,000 salt-tolerant coastal trees, representing over 15 different species, have been planted along 2 km of coastline on the windward blowholes coast of Tongatapu to rehabilitate inland deforested agricultural areas and to protect villages from salt spray (Thaman *et al*., 1995).

Soil improvement and provision of organic material is of particular importance to the success of agriculture and plant growth in nutritionally poor and highly permeable coastal soils, particularly atoll soils, which are among the least fertile in the world. Organic material increases soil water holding capacity, reduces soil pH to more favourable levels at which minerals become more available to plants, reduces runoff and water and wind erosion, and reduces water loss due to evaporation.

The value of forests and trees as habitats for plants and animals cannot be overstated. Bird extinctions have been common on Pacific islands and seem to be primarily the result of habitat destruction through deforestation.

Of particular environmental and economic importance are mangrove ecosystems. Their contribution to the nutritional requirements of a high proportion of marine food species, and the negative effects on fisheries yields linked to their destruction and reclamation are widely documented. (Watling 1985, Lal et al. 1983, Khoo 1976, and Baines 1979).

Cultural and Economic Utility

There is no need to stress the importance of timber, except to note that commercial timber operations supply local construction needs as well as generating foreign exchange. Trees are also used for house construction, fencing, boatbuilding, toolmaking, weaponry, making containers and fishing gear, and for many other purposes. The coconut palm is a storehouse of materials for house building, mat making, containers, fish traps (roots), and an endless array of handicrafts; the breadfruit for canoe making; bamboo for fishing poles, housing, and rafts; and many species for handicrafts. Many of these species such as *Intsia bijuga*, *Cordia subcordata* and *Thespesia populnea* are favoured for woodcraving but, where they are found, are now in short supply or endangered in the Review countries due to overexploitation.

Of critical importance is the role of trees in providing a renewable source of fuel (firewood). This is a growing concern in all the Review Countries, especially on Tongatapu and in South Tarawa and Funafuti. Here the situation is particularly serious, because of rapid deforestation, the rapidly increasing cost of kerosene and other imported fossil fuels and the increasing fossil fuel dependency (Kiribati and Tuvalu pay more for imported fossil fuel than the total value of all the agricultural exports).

Foods from trees are of immense value; whether as staples, supplementary foods, occasional snacks, or famine foods. The nutritional importance of dominant staple tree crops, such as coconut, breadfruit, and bananas and plantains, and the wide range of fruit and nut trees is critical to the nutritional wellbeing of Pacific island peoples. The replacement of these foods by highly-processed and imported foods has led to some of the highest or most rapidly increasing incidence of malnutrition and nutrition-related non-communicable diseases in the world in all of the Review Countries (Coyne 1984; Thaman 1982a, 1983, 1988d).

Spices and sauces from tree products can also be a great nutritional importance. Coconut cream or milk is used very widely in cooking and many other tree products are used to improve the taste of food. Trees are also important sources of food and fodder for domesticated animals. Wild food and other valuable products are lost to subsistence communities when the plants and animals that supply them disappear along with the forest and trees that served as their habitats.

Medicinal plants are an important economic and cultural resource, given the extremely high, and rapidly increasing cost, not to mention unavailability, misuse, and doubtful effectiveness of some imported medicines. In Suva, for example, 40% (73) of 183 medicinal plants used by Fijians are found in home gardens. The totals would undoubtedly be much higher if data on Indian medicinal plants were also available (Thaman 1987; 1988c).

Other uses of tree products include wrapping material, perfumes, and garlands. In Tonga, there are over 50 species of sacred or fragrant plants, known as *akau kakala* , which are of great spiritual and economic importance to Tongan society.

A study of coastal trees commonly found in all of the Review Countries and throughout the Pacific showed that there was an average of 9.2 uses per plant, ranging from two reported uses per species to as many as 121 for the coconut. These did not include ecological functions, such as shade, protection from wind, sand and salt spray, erosion and flood control, coastal reclamation, animal and plant habitats, and soil improvement (Thaman 1989a; 1990b).

URBAN AGROFORESTRY

Urban agroforestry is a very common practice in all Pacific Island towns, even in the most highly urbanized areas.

Urban agroforestry is practiced in two main ways: the urbanized home gardens adjacent to residences and agroforestry on undeveloped land within urban areas.

Homegardens are a common feature in the Pacific Islands urban landscape. In these gardens, a great variety of food trees, non-tree staples and supplementary food plants and non food species (see above) are mixed together.

Trees from urban gardens are an important economic and nutritional resource particularly on atolls where, apart from giant taro; which is often reserved for special occasions, the main staples are all tree crops: coconut, breadfruit, bananas and plantains, pandanus and the native fig.

Urban gardens are also sources of medicinal plants. On the small densely populated islands like Tongatapu, Tonga and South Tarawa, Kiribati, where only limited natural vegetation remains, approximately 75% of all reported medicinal plants are found cultivated or protected in home gardens. Sacred or perfumed plants are other very important products of urban gardens and represent a significant economic resource.

Cultivation and protection of trees on idle urban land is also a widespread practice, but less so in Tonga, Kiribati and Tuvalu where there is little or no open urban land, although in some cases Tongans planted entire adjacent unoccupied town allotments to food crops usually under coconuts, bananas and other trees.

The most common species found in urban agroforestry are staple root crops, coconuts, bananas and plantains, papaya, mango, a rangeof fruit trees, ornamental trees and shrubs, and a range of pioneer non-food species.

Living fences of fruit trees or other species are pollarded, pruned, grazed, harvested and are a source of food, fodder, firewood, medicines and flowers.

Animal husbandry on a small scale is also important. Apart from kitchen waste, the main feed for pigs and chickens is coconut. In Tonga, pigs and goats are fed on the leaves of Leucaena, *Pisonia grandis, Gyrocarpus americanus,* and living pens for poultry and pigs are made of the same species plus *Hibiscus tiliaceus, Erythrina variegara* and *Polyscias* spp. all of which are easily pruned or pollarded.

Despite the importance of the agroforestry practices on undeveloped, urban and peri-urban lands, because of the insecurity of land tenure and undefined land ownership, such areas are most severely affected by deforestation for fuel gathering and agricultural clearance (Clarke and Thaman 1993).

The significance of urban agroforestry lies particularly in its:

Nutritional importance: Because of rapid increases in nutritional disorders and nutrition-related non-communicable disease, the dangerous levels of food dependency (dependence on imported foods), and the increasing food scarcity, the contribution of urban agroforestry to dietary diversity and sustainable local food production becomes increasingly important.

Technical importance: Given access to land, urban agroforestry is technically within the means of even the poorest families, since it depends on inexpensive and readily available local technologies.

Economic importance: "Real incomes" of urban gardeners are increased considerably by agroforestry activities. Economic benefits are realized also through the cultivation of non-food trees and fragrant or

sacred trees, as well as subsistence production of various goods. Tree foods, apart from being nutritionally important, constitute important low-capital input, low-risk seasonally-abundant cash crops;

Social importance: The contribution of trees to the quality of life and protection of cultural values in significant.

INSTITUTIONALISED AGROFORESTRY

Agroforestry activities are increasingly carried out and promoted by government agencies. These "institutionalised" agroforestry activities have focused primarily on the planting of exotic timber and nitrogen-fixing species to generate employment and increased local cash incomes and export earnings, to meet demands for forest products, increase agricultural and forestry productivity; and to reduce the negative environmental effects of deforestation.

Institutionalised agroforestry practices currently adopted fall into three basic categories: 1) intercropping of commercial tree crops with ground or tree crops; 2) planting of exotic timber, fuelwood or nitrogen-fixing tree species in existing agricultural systems, as intercrops, "alley crops", rotational crops, or as small-scale monocultures or woodlots; and 3) grazing under commercial tree cropping or silviculture. Details of the programs and projects are given for each country in the next chapters.

PART II

ANNOTATED CHECKLIST OF IMPORTANT AGROFORESTRY SPECIES OF SAMOA, TONGA, KIRIBATI AND TUVALU

SPECIES INCLUDED

Acacia simplex
Acacia spp.
Acalypha wilkesiana
Adenanthera pavonina
Agathis spp.
Agalaia saltatorum
Aleurites moluccana
Alphitonia zizyphoides
Alyxia stellata
Anacardium occidentale
Annona muricata
Annona squamosa
Araucaria spp.
Artocarpus altilis
Atuna racemosa
Averrhoa carambola
Bambusa vulgaris
Barringtonia asiatica
Bischofia javanica
Broussonetia papyrifera
Bruguiera gymnorrhiza
Calliandra calothyrsus
Calophyllum inophyllum
Calophyllum neo-ebudicum
Cananga odorata
Canarium harveyi
Carica papaya

Cassia spp.
Castilla elastica
Casuarina equisetifolia
Cedrella odorata
Ceiba pentandra
Cerbera manghas
Citrus aurantifolia
Citrus aurantium
Citrus hystrix
Citrus limon
Citrus maxima
Citrus mitis
Citrus reticulata
Citrus sinensis
Cocos nucifera
Codiaeum variegatum
Coffea arabica
Cordia aspera
Cordia subcordata
Cordyline fruticosa
Crateva religiosa
Cyathea lunulata
Decaspermum fruticosum
Delonix regia
Dendrolobium umbellatum
Diospyos major
Diospyros samoensis
Dodonaea viscosa
Dysoxylum spp.
Elaeocarpus spp.
Elattostachys falcata
Erythrina variegata
Eucalyptus spp.
Euodia hortensis
Excoecaria agallocha
Fagraea berteroana
Ficus tinctoria
Ficus spp.
Flacourtia rukum
Flueggea flexuosa
Funtumia elastica
Garcinia sessilis
Gardenia taitensis
Garuga floribunda
Gliricidia sepium
Glouchidion ramiflorum
Gmelina arborea
Grewia crenata
Guettarda speciosa
Gyrocarpus americanus
Heliconia laufao
Heritiera littoralis
Hernandia moerenhoutiana
Hernandia nymphaeifolia
Hibiscus manihot
Hibiscus rosa-sinensisHibiscus tiliaceus

Inocarpus fagifer
Intsia bijuga
Jatropha curcas
Kleinhovia hospita
Leucaena leucocephala
Lumnitzera littorea
Macaranga harveyana
Mammea glauca
Mangifera indica
Manilkara spp.
Maniltoa amicorum
Melia azedarach
Melochia aristata
Metroxylon vitiense
Micromelum minutum
Morinda citrifolia
Moringa oleifera
Musa troglodytarum
Musa (AAA Group) "Cavendish″
Musa (AAB Group) "Pisang Rajah"
Musa (AAB Group) "Maia Maoli"
Musa (ABB Group) "Bluggoe" or "Blue Java"
Musa cultivars
Myristica hypargyraea
Neisosperma oppositifolium
Neonauclea forsteri
Omalanthus nutans
Palaquium stehlinii
Pandanus tectorius
Paraserianthes falcataria
Pemphis acidula
Persea americana
Pinus caribaea
Piper methysticum
Pipturus argenteus
Pisonia grandis
Planchonella grayana
Planchonella samoensis
Pleiogynium timoriense
Plumeria rubra
Polvscias spp.
Pometia pinnata
Pritchardia pacifica
Psidium guajava
Pterocarpus indicus
Rhizophora spp.
Rhus taitensis
Saccharum officinarum
Samanea saman
Santalum yasi
Scaevola taccada
Schizostachyum glaucifolium
Sesbania grandiflora
Serianthes melanesica
Sonneratia alba
Spathodea campanulata

Spondias dulcis
Sterculia fanaiho
Swietenia macrophylla
Syzygium corynocarpum
Syzygium cumini
Syzygium malaccense
Syzygium neurocalyx
Syzygium spp.
Tamarindus indica
Tarenna sambucina
Tectona grandis
Terminalia catappa
Terminalia richii
Theobroma cacao
Thespesia populnea
Toona ciliata var. *australis*
Tournefortia argentea
Trema cannabina
Vitex trifolia
Xylocarpus moluccensis
Xylosma spp.
Zanthophyllum pinnatum