ATOLL RESEARCH BULLETIN

NO. 333

KIRIBATI AGROFORESTRY:

TREES, PEOPLE AND THE ATOLL ENVIRONMENT

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ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
January 1990

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INTRODUCTION

Agroforestry, the planting and protection of trees and tree-like plants as integral components of a polycultural agricultural system, has always been central to the economic, cultural and ecological stability of the Kiribati society. This paper focuses on Kiribati agroforestry, and on the role trees play as: 1) integral components of polycultural agricultural systems; 2) symbols of stability and cultural wellbeing; 3) sources of a diverse range of subsistence and commercial products, the imported substitutes for which would be either too expensive or unavailable to most people; and 4) ecologically important components of agricultural systems which, if lost, would lead to irreversible environmental degradation and resultant cultural deterioration. Two islands of Kiribati, Tarawa and Abemama serve as case studies of Kiribati village-level agroforestry. The findings are based on a ten-day reconnaissance survey of agroforestry on Tarawa and Abemama in 1984, a subsequent visit in early 1989, and a survey of the available literature.

TREES AS SYMBOLS OF ECOLOGICAL AND CULTURAL STABILITY

Although symbols of ecological and cultural stability, forests and trees are rapidly disappearing from the earthscape. As argued by Thaman and Clarke (1987), the replacement of long-lived trees in diversified mixed stands by shorter-lived trees and other types of plants in monocultural stands or by totally artificial landscapes, although yielding undeniable short-term benefits to mankind, severely deteriorates human habitats on the earth.

DEFORESTATION IN THE PACIFIC ISLANDS

Although economically and ecologically precious tropical forests remain on some of the larger Pacific islands, and small areas of mangrove and ubiquitous strand forest have been preserved on others, deforestation in the Pacific is proceeding at a frightening rate. Forests, both primary and secondary, continue to be transformed into degraded savannas and fern-grasslands, mangroves into housing and industrial estates or other lifeless land-sea interfaces, polycultural tree-studded traditional agroforested gardens into monocultural plantations, and urban areas divested of their remaining trees to make way for industrial, commercial, and residential areas or to fuel the cooking fires or erect the squatter housing of low-income families. The trends are the same from the high continental islands of Melanesia to the smallest atoll islets of Polynesia and Micronesia (Thaman and Clarke, 1987).

Deforestation has led to severe erosion in Wallis and Futuna, the Cook Islands, French Polynesia and Hawaii where most of the indigenous forest has been removed, leaving degraded fernlands and grasslands no longer suitable for agriculture (Kirch, 1982:4). Flenley and King (1984) go as far as suggesting that deforestation was responsible for the collapse of the pre-European megalithic culture on Easter Island,

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a view supported by McCoy (1976 in Kirch, 1982:4), who argues that the "radical reduction of forest, shrub, and grassland communities, following over-exploitation and misuse by man", was responsible for a change from open-field cultivation to protected stone garden enclosures (manavai). Similarly, drastic deforestation of the central plateau on the Hawaiian island of Kaho'olawe, due to shifting cultivation and increasing population pressure between AD 1375 and 1600, reportedly led to a "dramatic population crash" and the total abandonment of the interior of the island by 1700 (Hammon, 1980; Kirch, 1982:4). Although, today, some countries and territories have conservation legislation and forestry ordinances, trees are cleared and forest products continue to be shipped off for a fraction of the world market price, while Japan, South Korea, China, and other countries continue to protect their forest resources and to implement major reforestation efforts (Richardson, 1981).

The situation is perhaps more critical in Kiribati, where land area is severly limited and useful trees have been removed in historical times to make way for the expansion of coconut plantations for the production of copra for export. The widespread removal of coastal strand species and mangroves for fuelwood and other cultural purposes continues in many areas, and "agrodeforestation" (Thaman, 1989ab), the removal, neglect, or the failure to replant trees as integral parts of the Kiribati agricultural system, continues unabated, almost completely unheeded by policy makers in the agricultural and forestry sectors. As Chambers (1983) argues, trees and tree planting as traditional components of agricultural systems have been ignored in institutionalised rural development because they "fall into the gaps" between the traditional sectoral responsibilities of "agriculture" and "forestry".

AGRODEFORESTATION AS AN ISSUE

Although deforestation, as such, has received most attention globally, probably of tantamount importance is "agrodeforestation" in the forms of both declining tree planting and the elimination of trees from agricultural and urban landscapes. Trees that have, for generations, provided food, timber, firewood, medicines and served other important cultural and ecological functions, as integral components of polycultural agricultural systems, are increasingly not being replaced or protected by the present generation. Although some countries have increasingly effective systems of forestry reserves, conservation areas, or national parks, few, if any, have legislation or programmes prohibiting the cutting, or promoting the replanting of important or endangered tree species as part of agricultural or other modern-sector development. Thus, agrodeforestation continues, with little or no official recognition or resistance to it.

The situation is not yet beyond hope as it appears to be in some areas of the world because most traditional agroforestry strategies of the Pacific Islands have been preserved, if only in relict form. Nonetheless, increasing agrodeforestation and the gradual disappearance of time-tested agroforestry systems in the face of monocultural expansion of agriculture and commercial livestock production, rapid population growth, demands for fuel, continued urbanization, and the "commercial imperative" (Tudge, 1977) are the dominant trends that will only be reversed by deliberate planning and action (Thaman and Clarke, 1987).

NATURE OF TRADITIONAL AGROFORESTRY IN THE PACIFIC ISLANDS

In traditional Pacific Island "development", forestry, agriculture, housing, medicine, and the production of a wide range of material goods were not compartmentalized into "sectors"; rather they were generally part of integrated

agroforestry systems or strategies tailored to the environmental and societal needs of each island ecosystem. Trees, of course, were major components of such sustainable agroforestry systems (Thaman and Clarke, 1987).

In terms of composition and spatial organisation, all traditional agroforestry systems, from the highlands of Papua New Guinea to the smallest atoll countries, exhibited a high degree of interspecies diversity, incorporating a wide range of cultivated and protected indigenous and exotic species, ranging from some 75 species commonly encountered on atolls, such as in Kiribati which have among the poorest floras on earth, to over 300 widespread species species in the larger-island agroforestry systems of Fiji, Vanuatu, Solomon Islands, and Papua New Guinea. Species include not only traditional staple tree crops such as coconuts, breadfruit, and bananas or plantains intercropped with ground staples and supplementary ground crops, but also a wide range of fruit and nut trees and other useful trees and plants which are either deliberately planted, encouraged and protected in the regeneration of fallow regrowth, or spared when clearing new garden plots.

Moreover, for most traditional tree cultigens and non-tree understory cultigens, for many recently-introduced cultigens, and for a lesser number of indigenous species found in Pacific island agroforestry systems, there is also a high degree of intraspecies diversity, with a wide range of named, locally differentiable cultivars or varieties. Within a given species, these cultivars have variable yield characteristics and seasonality, thus spreading yield distribution and seasonal surpluses more evenly. Similarly, as has been found true in other parts of the world, different cultivars have differential resistence to pests and diseases and to tropical cyclone damage, saltwater incursion and salt spray and drought; differential ecological tolerance ranges in terms of adaptability to different soil types, shade and hydrological regimes; and differential utility (for example, in Kiribati some coconut cultivars are used purely as drinking nuts, some for the flesh, and some for the large shells or the coir which can be used for vessels or for rope respectively).

Also seen as integral components of the broader village agroforestry systems are: 1) secondary or fallow forest areas, indigenous stands of tropical rainforest, and mangrove or coastal strand forest which border or fall within the matrix of active garden or fallow areas; 2) permanent, often sacred, tree groves of primarily planted useful trees in garden areas or surrounding villages; and 3) trees planted in home gardens in nucleated villages or around isolated dwellings. Together these diverse arboreal resources present an image of agroforestry far different and far more polycultural and utilitarian than the predominant view of "modern" agroforesters which commonly sees "agroforestry" as constituting the intercropping of export cash crops such as cocoa, coconuts, coffee or bananas with selected ground or shade crops; cattle under coconuts; the promotion of fuelwood plantations or wood lots; or the intercropping of exotic forest species with export or subsistence ground crops, with virtually no mention of the hundreds of other useful plants and wild animals that are integral to the traditional systems that they often irreversibly replace.

In terms of the more specific utilitarian attributes of individual Pacific agroforestry systems, Table 1 is an attempt to show the multi-functional nature of these systems as well as the value of the individual arboreal components. Although modern agroforesters and horticulturalists may see native forests; silvicultural tree plantings; coconut, oil palm, cocoa, coffee, or banana plantations; or orange, avocado or macadamia orchards in terms of their economic value, or, possibly, even in terms of their ecological, recreational, or nutritional values, it is clear the Pacific island agroforesters perceived arboreal resources to be far more multi-purposeful.

In terms of the ecological value of trees, shade, for example, is critically important

to humans, plants, and animals, especially in open savanna lands, in highly reflective low-lying coral island and lagoonal environments, and in villages and urban areas; damage from wind, erosion, and flood are increased when forests are removed; and mangrove and coastal strand forests stabilize tidal-zone soils and reduce the impact of storm surge and ocean salt spray.

Soil improvement is another area where trees are of critical importance, especially given the high cost of fossil-fuel-dependent inorganic fertilizers and recent concern as to the detrimental impact on soil of long-term use of such fertilizers. In the case of Kiribati, with among the poorest soils on earth, in terms of both available soil nutrients and organic material, this function takes on much greater importance. The value of forests and trees as habitats for plants and animals, many of which are of considerable subsistence and commercial value, cannot be overstated (Thaman and Clarke, 1987).

There is no need to examine the importance of timber, except to emphasize that trees are of critical importance in the informal sector in most countries for house construction, fencing, boatbuilding, toolmaking, weaponry, making containers, fishing gear, cooking equipment, and handicrafts (Table 1).

Foods from trees are of immense value, whether as staples, supplementary sources, or occasional snacks and famine foods. The nutritional importance of dominant staple tree crops, such as coconut, breadfruit, bananas and plantains, sago palm, and Pandanus spp. and the wide range of fruit and nut trees found throughout the Pacific have been widely stressed elsewhere and need no further mention (Parkinson, 1982; Coyne, 1984; Thaman, 1979, 1982ab, 1983, 1985, Yen, 1980ab). Supplementary foods and snacks are described by Thaman (1976, 1976/77, 1982ab) for Tonga and Fiji and other Pacific Islands and by Clarke (1965, 1977) for a highland Papua New Guinean community. Powell (1976) provides a comprehensive coverage of wild-food use and other important aspects of ethnobotany for the entire island of New Guinea.

Table 1. Ecological and cultural functions and uses of trees in agroforestry systems in the Pacific islands, based on fieldwork in Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Tonga, Western Samoa, Kiribati, and Nauru.

ECOLOGICAL

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

CULTURAL/ECONOMIC

Timber(commercial)	Broom	Prop or Nurse Plants
Timber(subsistence)	Parcelisation/Wrapping	Staple foods
Fuelwood	Abrasive	Supplementary Foods
Boatbuilding(canoes)	Illumination/Torches	Wild/Snack/Emergency Foods
Sails	Insulation	
Tools	Decoration	Spices/Sauces
Weapons/Hunting	Body Ornamention	Teas/Coffee
Containers	Cordage/Lashing	Non-alcoholicBeverages
Woodcarving	Glues/Adhesives	Alcoholic Beverages
Handicrafts	Caulking	Stimulants
Fishing Equipment	Fibre/Fabric	Narcotics
Floats	Dyes	Masticants

Toys	Plaited Ware	Meat Tenderizer
Switch for Children/ Discipline	Hats	Preservatives
	Mats	Medicines
Brush/Paint Brush	Baskets	Aphrodisiacs
Musical Instruments	Commercial/Export Products	Fertility Control
Cages/Roosts		Abortificants
Tannin	Ritual Exchange	Scents/Perfumes
Rubber	Poisons	Recreation
Oils	Insect Repellents	Magico-religious
Toothbrush	Deodorants	Totems
Toilet Paper	Embalming Corpses	Subjects of Mythology
Fire Making	Dancing Grounds	Secret Meeting Sites

Source: Adapted from Thaman and Clarke, 1987.

It is important to stress, however, that although many tree foods are energy-rich in carbohydrates and/or vegetable fats, it is in other nutritional essentials such as vitamins and minerals and fibre that they often excel in comparison with the ubiquitous root-crop staples and other annual non-arboreal plants. For example mango, papaya, and some Pandanus spp. are excellent sources of provitamin A; Canarium spp., Inocarpus fagifer, and avocado (Persea americana) of B-complex vitamins; guava, mango, papaya, and Citrus spp. and other lesser known species, such as beach mulberry (Morinda citrifolia) and bush hibiscus spinach (Hibiscus manihot), of vitamin C and/or iron; and most seeds or green leaves (for instance, from Ficus spp., Gnetum gnemon, which also provides edible seeds, and Moringa oleifera) are good sources of plant protein and a range of other micronutrients necessary for optimum health (Thaman and Clarke, 1987; Thaman, 1983). Spices and sauces from tree products can also be of great nutritional importance.

Wild food and other valuable products are also lost to subsistence communities when the diversity of plants and animals that supplied them disappear along with the forest that served as their habitats (Clarke, 1965; 1977; Thaman 1982a). Deforestation has severely restricted the habitats for wallabies and the valued cassowary bird of Papua New Guinea, and a great number of vertebrate and non-vertebrate wild animal foods and an even greater range of wild plant foods that contribute significantly to the dietary well-being of many Pacific islanders, particularly in the interior of large continental islands. The destruction of mangrove forests is of particular concern for coastal and atoll communities because of their importance in marine and estuarine food chains as well as being favoured habitats or nurseries for a wide range of fin-fish, molluscs, and crustaceans (Thaman, 1982a). The removal of trees such as Pisonia grandis, the favored nesting or rookery species of the black noddy tern (Anous tenuirostris), a delicacy reserved for important feasts in Kiribati and Nauru, also impoverishes traditional food systems.

Trees are also important sources of food and fodder for domesticated animals. Pisonia grandis leaves for example, are used as pig feed; Leucaena leucocephala leaves and pods are used widely for goats, pigs, and cattle; and coconuts and papaya are abundant and important animal foods throughout the Pacific.

In terms of other uses, the arboreal pharmacopoeia is widely known and valued by modern science and industry as well as by local inhabitants, with all parts of the Pacific possessing medicine-producing trees and associated plants. Wrapping materials includes coconut leaves, leaves of Artocarpus altilis, Musa cultivars, Hibiscus tiliaceus and Macaranga spp. Other leaves, notably Ficus spp., serve as effective abrasives. Dyes are derived from many sources, e.g., Bischofia javanica (a major red-brown dye for

tapa), Bruguiera spp. and Aleurites moluccana (black), Morinda citrifolia (yellow), and Bixa orellana (red)(Thaman and Clarke, 1987).

Perfumes or scents such as sandalwood are well known outside of the Pacific, while less cosmopolitan fragrances are derived from Cananga odorata and other scenting agents that are put into coconut oil from trees such as Pimenta, Plumeria, Pandanus and Gardenia spp., Parinari glaberrima, Aglaia saltatorum, Fagraea berteriana, and Calophyllum inophyllum (Thaman and Clarke, 1987). In Tonga, for example, there are over 50 species of sacred or fragrant plants, known as 'akau kakala, which are central to the spiritual and economic fabric of Tongan society and which are planted or protected as integral components of Tongan agroforestry (Thaman, 1986, 1987a). Plants have similar spiritual value in Kiribati, with many featuring in Kiribati legends and cosmogeny and being used for scenting coconut oil and ceremonial body ornamentation (See Table 2).

These few examples from Table 1, show the utilitarian diversity and the economic and cultural value derived from trees and agroforestry in the Pacific, values that are rarely acknowledged in planning or project documents, but that would be extremely difficult or impossible to replace with imported substitutes. The elimination of such utilitarian and cultural diversity can only serve to lock Pacific societies more tightly into the vicious circle of economic and cultural dependency.

KIRIBATI AGROFORESTRY

The non-urban Pacific island agroforestry systems that operate under the most severe environmental constraints and population pressure are found on atolls. Atolls may, in fact, be the most intensively agroforested island type in the Pacific in terms of the relative importance of trees to non-trees within the system.

An excellent example of atoll-agroforestry is that practiced in Kiribati, where a wide range of cultivated and protected wild trees and a more limited number of non-tree plants and livestock are raised within a relatively dense and homogeneous matrix of coconut palms. Population pressure is high especially on the main island of Tarawa, where 17,921 people inhabit an area of only 920 ha, with the population density of the most populated islet, Betio, expected to reach densities rivaling Singapore by the year 1990 (Carter, 1984:231). Population densities on Abemama and other outer islands are significantly lower. The only agricultural export from Kiribati is copra, of which 5,682 tonnes valued at $A3,074,536 were exported in 1979 (Pargeter et al., 1984).

Environmentally, the atolls and table-reef islands of Kiribati are rarely more than 3 metres in elevation above high-tide level, with the true atolls surrounding large central lagoons. Their highly alkaline calcareous and rocky soils are among the most infertile on earth, with very low water-holding capacity, little organic material, few available soil macro- and micro-nutrients, apart from calcium, sodium, and magnesium, and restricted availability of iron and other micro-nutrients because of the high pH. Rainfall is extremely variable, with extended periods of drought being common. Ground water is brackish to slightly salty and subject to saltwater incursion. The islands, where one is never more than 0.5 kilometres from the sea, are susceptible to inundation by storm surge and tsunamis (seismic sea waves) and the constant effect of humid salt-spray-laden winds. As stressed by Small (1972:5): "all this adds up to a very difficult environment for plants, and produces problems for animals and man."

In terms of floristic diversity, as a result of small island size, distance from the Asian continent, relatively young geologic age of the islands, and harsh environmental conditions, there are estimated to be only 66 indigenous plant species, found in

Kiribati, none of which are endemic, and just under 300 total species, including exotics, mostly ornamentals and weeds, which have ever been reported to grow there (Fosberg and Sachet, 1987; Fosberg et al., 1979, 1982; Thaman, 1987b).

It is under these harsh conditions and a paucity of flora to choose from, that the I-Kiribati (people of Kiribati) have evolved their distinctive agroforestry system, which incorporates into a matrix of the superdominant coconut palm (Cocos nucifera): 1) indigenous species (almost exclusively ubiquitous pan-Pacific or pan-tropical, ocean-dispersed species); 2) selected aboriginally-introduced food plants, such as the staple giant swamp taro or babai (Cyrtosperma chamissonis) and pandanus or te kaina (Pandanus tectorius); 3) some recently-introduced exotics; and 4) settlements or villages and other urban features (Table 2).

Scattered throughout the matrix of the superdominant coconut or te ni (Cocos nucifera) are pandanus or te kaina (Pandanus tectorius), breadfruit or te mai (Artocarpus altilis), and the native fig or te bero (Ficus tinctoria), along with a wide number of pantropical strand species, such as Scaevola sericea, Tournefortia argentea, Guettarda speciosa, and Pemphis acidula.

Coconut Palms

Almost all coconut palms seem to have been planted either deliberately or accidentally by the I-Kiribati. The resultant agroforested landscape takes the form of a real forest, rather than an orderly plantation, because a great proportion of the trees are spontaneous occurrences of different heights and age-classes, rather than deliberately planted, equally-spaced trees of a single age class. On both the seaward and lagoon-side, coconuts lean outward interspersed with pan-tropical strand species, whereas in the higher central portions of the islands they generally form thick stands, with young coconut seedlings and other plants in various stages of growth often forming an almost impenetrable jungle that extends almost from the beach ramparts on the ocean side towards the centre of the islands. In many areas, plants suffer from excessive density, although towards the lagoon side, where most of the settlements and giant taro (babai) pits are found, the "forest" begins to thin out (Catala, 1957:22; Watters and Banibati, 1977:33). Moul (1957:1), however, found concentrations to be denser along lagoon shores and interspersed with young palms and pandanus on Onotoa atoll in southern Kiribati.

Sixteen locally recognized coconut cultivars are divided into two main categories according to whether the mesosperm is edible (te bunia) or non-edible (te ni), the latter term also applying to coconuts in general. Some are favoured for their juicy flesh, the quality and sweetness of their toddy and some for the quality of their fronds, coir from the husk, or wood for use as handicrafts and building materials (Catala, 1957:25-27).

Catala (1957:30-34) stressed the "extraordinary resistance of the palm" in Kiribati to prolonged drought and its ability to continue to produce inflorescences, which although incapable of producing commercial value copra, still produced the nutritionally essential toddy. The ability to withstand prolonged drought depends on the nature of soils, the degree of salinity of groundwater, the nature of tides during droughts, and the sporadic occurrence of fire during drought periods. Despite this incredible resistance to drought and increasing salinity, the production of most palms, most notably copra production, is severely affected by drought, although palms around village sites, beside babai pits or in abandoned babai pits, and around inland ponds seem to be affected only minimally by drought because of proximity to the freshwater lens or the presence of greater domestic and organic waste near villages and babai pits. Watters and Banibati (1977:33) reported that, after a prolonged drought in the early

1970s, only 44.2% of mature coconut palms surveyed on Abemama were bearing in 1972.

In the terms of tree density, a transect across Bikenibeu islet, Tarawa contained 138 irregularly spaced palms in an area of 5,950 m^2, a very high density of 231 per ha (a fully stocked regularly spaced copra plantation in Tonga would have a density of only 157 per ha). In this same area, 11 pandanus trees, most of them concentrated in the mid-island portion or toward the lagoon and village end of the transect, were also inventoried. Nearer to village sites, the density was considerably lower, with fourteen surveys giving an average density of only 155 palms per ha, not counting other important trees. For example, one village, covering an area of some 10,750 m^2 had only 100 coconuts, a density of 93 per ha, as well as 36 breadfruit trees. For village areas, the average density ranged from 80 to 150, whereas densities were from 200 to 350 in bush garden areas.

The overall estimated density of coconut coverage for the estimated 2,000 ha area of Tarawa Atoll (1,600 ha, after deducting 20% for uncultivated areas under mangrove, swamp, roads, etc.), was 231 in the mid-1950s, thus giving an estimated 369,600 palms for the productive area. Subtracting two trees for every five people (955 trees) for toddy production left a total of 368,645 nut-producing trees, which produced an estimated 23.1 nuts per year, or 8,517,000 nuts available for consumption by humans, animals, for copra production, and for other uses such as making perfume and oil. The estimated annual per capita consumption at the time was four nuts per day for humans and three for pigs (Catala, 1957:40-45).

A more recent study by Watters and Banibati (1977:35) suggests that density of coconut palms on rural Abemama was even higher at 321 palms per ha, with densities of bearing palms being 151.8 (given a figure of 47.3% bearing palms). The estimates of nuts per bearing tree of 17.8 was somewhat lower than Catala's, possibly because the survey was conducted after an extended drought.

For toddy (karewe) production, which perhaps nowhere has such fundamental importance as in the harsh environment of Kiribati, the flower spathes of selected trees are cut and bound and tapped twice a day, once in the morning and once in the afternoon, yielding approximately two coconut shells of liquid per day. A dietary staple for most I-Kiribati households, especially in times of severe drought when palms produce few fruit, fresh toddy is drunk daily by most I-Kiribati. Toddy is also fermented to make a vitamin B-rich (one-third the level found in brewer's yeast) drink (te maning) of varying alcoholic content, a boiled-down syrup (kamaimai), which can be kept without fermenting, and a solid caramelised form (kareberebe)(Catala, 1957:44-46).

In rural areas, in particular, coconut flesh is the major source of dietary fat and a major source of calories, as well a contributing some iron, fibre, and other nutrients, and is prepared and consumed in countless ways. Toddy is particularly rich in energy and vitamin C and has significant amounts of vitamin B and iron (Pargeter et al., 1984:10-15). Bayliss-Smith's (1982:62) study of Ontong Java atoll in Solomon Islands, stresses the dietary importance of coconut, which contributed 21% of all calories directly, as well as the copra, which provided the cash to purchase another 25% of the total calories consumed. In addition to its critical dietary importance, the coconut palm is used in a myriad of other ways to produce products of economic and cultural importance, the imported substitutes for which would either be too costly or unobtainable for most I-Kiribati (Table 2).

Pandanus

After the coconut, the pandanus or te kaina (Pandanus tectorius) is the most

important tree of Kiribati agroforestry systems, with almost two hundred different recognized cultivars, many of which may be exclusive to a given village or family (Overy et al., 1982; Luomala, 1953). Catala (1957:51) reports, however, that only 16 names were widely recognised on Tarawa.

Because pandanus will grow in very poor or thin soils, it can be found growing almost anywhere on atoll islets. In ecological surveys of pandanus, Catala (1957:52) found that for Tarawa atoll there was an equal density of pandanus, whether it was on the ocean or lagoon side, or, in the interior, although it grew more successfully where coconut density was lower, particularly in marshy areas or along the lagoon edge where pandanus seems to have a definite advantage over the coconut. Moul (1957) also found pandanus present in most vegetation associations on Onotoa atoll.

Although natural stands commonly occur in swampy areas, in coastal littoral forests and bush plantations which have been neglected for extended periods, the majority of pandanus in garden lands or around villages or residences are planted and owned by individuals (Luomala, 1953:83). Because pandanus propogated from seeds will rarely reproduce desired characteristics, almost all planted pandanus are started from cuttings, ideally cuttings which already bear the beginnings of adventitious roots. At times, new trees will be mulched with leaves of Guettarda speciosa or other plants, and coverered with black topsoil, as well as receiving compost or attention. Frequent tamping around young plants, even after they are fully established, is carried out to obtain low, easy-to-harvest high-yielding trees. Given optimum light availability and care, trees near villages can bear as soon as tens months after planting, whereas they may take up to more than a year in bush gardens (Catala, 1957:53-54).

The fruit of pandanus is a very important part of the I-Kiribati diet; the tree also provides raw material for a wide range of plaited ware, construction materials medicines, decorations, parcelisation, perfumes, and other uses, as well as being the I-Kiribati ancestral tree, from which, according to mythology, the progenitors of the I-Kiribati came (Luomala, 1953:83).

The fleshy parts or drupes of the ripe fruits are consumed raw, as well as being prepared or included in other dishes in a variety of ways. Some of the commonest preparations are te tangauri, te tuae, and te karababa. Te tangauri, a paste made from a mixture of a puree of the fresh fruit and grated coconut, can be eaten fresh or dried in the sun. Te tuae, is prepared by cooking the fruit, removing most of the fibre, and making a paste, which is then spread on leaves and dried in the sun. The dried paste, which is then cut into pieces for further desiccation, will keep for years, constituting a food reserve which can be used on long voyages or prepared at a later time by softening in and/or prepared with coconut milk or grated coconut. Te karababa is prepared by cooking the drupes, mashing them and mixing them with grated coconut. The resultant product is then eaten after being spread in the sun for further desiccation, or is further processed into te kabubu by toasting and grinding into flour, which keeps for long periods and which may be eaten straight or prepared as an ingredient in a range of dishes, including te korokoro, in which te kabubu is mixed with kamaimai (toddy molasses)(Catala, 1957:56-58).

Pandanus leaves are used in the production of thatching, roofing, a range of fine and everyday mats, hats, sails (in the past), cigarette wrappings, food wrappers, caulking material, and baskets for babai compost. The trunk and adventitious roots are used in house and general construction, with particular cultivars being best for different uses (Luomala, 1953; Catala, 1957; Overy et al., 1982)(Table 2).

Breadfruit

The next most important cultivated plant is the breadfruit or te mai, of which there are two distinct species, the common breadfruit (Artocarpus altilis) and the Mariannas breadfruit (A. mariannensis), plus a hybrid of the two (Fosberg et al., 1979; Fosberg and Sachet, 1987; Thaman, 1987b). Although well-adapted to the atoll environment, its distribution seems to be directly related to the salinity of groundwater, being planted primarily in villages or their immediate vicinity, and occasionally along roadsides, particularly on the more protected lagoon side of the islands. Moul (1957:11) reported that it was very common along village streets on Onotoa, and the canopy of one of the most extensive breadfruit groves on Tarawa almost covers the main road through the chiefly village of Eita.

Although much less common, breadfruit rivals pandanus in subsistence importance in some areas. Whereas pandanus is an important component of the "bush" flora, often forming pure stands, breadfruit is rarely found in the heart of the bush (Catala, 1957:61), but forms a major, often dominant component of the vegetation around villages such as Eita and Betio on Tarawa. In one village on Tarawa, with a population of 115 (22 families), Catala (1957:64) counted 93 trees, all of which belonged to the person or household who planted them, even if the planter moved to another village. The number of trees per household varied from 0 to 11, with the mode being 4 (Catala, 1957:Table X).

Like pandanus, breadfruit are almost always deliberately planted in holes, or circular well-like structures, filled with waste, including the dead leaves of coconut and breadfruit and the leaves of te mao (Scaevola sericea), te ren (Tournefortia argentea), te uri (Guettarda speciosa), and te non (Morinda citrifolia), and often topped with black topsoil found under Guettarda speciosa (Catala, 1957:64; Moul, 1957; Small, 1972). Under favourable conditions, trees may reach over 20 metres in height, with trunks almost two metres in circumference, although under less favourable conditions, trees may only reach 8 to 10 metres and one metre in circumference (Catala, 1957:64).

Of the major economic plants, the breadfruit seems to have the least resistance to prolonged drought. Sabatier (1939 in Catala, 1957:61)), says that breadfruit trees survive with difficulty in the drier southern islands and "are practically exterminated every ten years." Moul (1957:11) reports that a significant proportion died during the prolonged drought of 1949-50. It generally bears for the nine months from May to January, during which time fruit is often very abundant, being eaten ripe, both raw and cooked, depending on the variety, as well as being cooked, crushed and preserved by drying as te kabuibui ni mai or te tuae n-te mai.

Young leaves and buds of breadfruit are used medicinally to cure ear infections and conjunctivitis respectively, the leaves for food parcelisation and fertiliser or compost for babai and other plants, and the wood for outrigger canoe hulls and fishing floats (Catala, 1957:65-66).

Other Cultivated Fruit Trees

Other commonly cultivated fruit trees are papaya, te mwemmweara or te babaia, banana and plantain cultivars or te banana, the native fig or te bero (Ficus tinctoria), the common fig or te biku (Ficus carica), and the lime or te raim (Citrus aurantiifolia). Occasionally lemon trees or te remen (Citrus limon) are found, and guava and mango have been introduced but are rare, and, in the case of mango, survive with difficulty (Table 2).

Papayas are particularly common in villages, and, where well cared for and mulched, are healthy and produce good fruit, which is eaten raw when ripe, especially

by children, and cooked green with coconut milk. In a village of 23 households, with a population of 115, Catala (1957:Table X) found 111 papayas, amounting to just under one tree per person, although the age and productivity of individual trees were not indicated.

Bananas and plantains, of which there seem to be two main and two less common cultivars (Table 2), are occasional to common, although much more common on wetter islands in north Kiribati, such as Makin and Butaritari, and in southern Tuvalu, where the main island of Funafuti (meaning the "place of the banana") is renown for its extensive banana plantings. Bananas are commonly grown around houses in villages and occasionally planted in abandoned babai pits or in specially dug banana pits, a common practice at mission settlements and boarding schools. Although most commonly grown in pits, bananas and plantains, are normally not planted in flooded soil, as is babai, but in slightly higher parts of pits or in pits which have been partially filled.

Where well looked after, bananas grow well and are a favoured staple when eaten green or as a fruit when ripe. If grown as a "pit plantation", it is usually necessary to dig a rather deep trench around the pit to keep coconut roots out. A layer of dark soil collected from under Guettarda and Scaevola is added along with composting and rusted tin cans to provide iron (Catala, 1957; Small, 1972). Although there seems to be considerable scope for an expansion of banana and plantain pit cultivation, the taro beetle (Papuana sp.) may have caused widespread damage to plants grown in "pit plantations". When grown in villages, close to the lagoon side, mulching with organic material, coconut husks in particular, results in good yields.

The native fig or te bero (Ficus tinctoria) is commonly cultivated around villages and occasionally in plantation areas. Moul (1957:12) reported it as common around abandoned babai pits and present in small thickets in rich soils around Pisonia grandis groves on Onotoa atoll in southern Kiribati. It is propogated vegetatively by planting branch cuttings, its fruits being an important staple in the drier southern islands. The fruit are picked when ripe and sometimes when green, cooked, crushed in a mortar into a puree which can be eaten after being sweetened with toddy molasses (kamaimai) or sugar and grated coconut or preserved by drying in the sun on Guettarda speciosa leaves. It reportedly bears many times throughout the year, and has wide cultural utility (Table Z)(Luomala, 1953; Catala, 1957; Small, 1972).

The common fig or te biku, reportedly introduced by missionaries, seems to be very well adapted to the atoll environment and is occasionally found propogated by cuttings in village home gardens.

The lime (Citrus aurantiifolia) is by far the most common citrus fruit grown in Kiribati, but is found only occasionally in villages. The fruit is highly sought after for squeezing on fish and other foods and for making drinks. Lemon trees are present on the agricultural experiment farm at Bikenibeu, but rare elsewhere.

Other Cultivated Food Plants

Other cultivated but minor tree-like food plants include sugarcane (Saccharum officinarum) and hibiscus spinach (Hibiscus manihot), which are both found only occasionally in villages around homes. Although sugarcane grows poorly in some localities, it shows promise where well mulched. Hibiscus spinach, a very nutritious green vegetable, reportedly introduced by contract workers returning from the phosphate mines on Banaba (Ocean Island), grows particularly well and shows little or no evidence of the insect or disease damage so characteristic in Fiji.

Giant Swamp Taro or Te Babai (Cyrtosperma chamissonis)

The major understory non-tree food plant in Kiribati is the ceremonially important staple, giant swamp taro or te babai (Cyrtosperma chamissonis), which is cultivated in pits excavated to the freshwater lens, using a very labour-intensive system of mulching. About 20 named cutivars are recognized (Small, 1982). Te babai is not a woody species, but because of the very sophisticated system of mulching and fertilization with leaves from numerous tree species, and because the babai pits are found within a matrix of coconut palms and other trees, te babai must be seen as an integral component of the Kiribati agroforestry system.

Te babai was probably more extensively cultivated in the past, as evidenced by the numerous abandoned pits, some of which have been overrun with coconut seedling and weeds. Although pits are often abandoned due to increasing brackishness, many were obviously abandoned long ago, with most pits being very ancient, the inhabitants having no recollection of their origin (Catala, 1957:68). On Abemama, for example, Watters and Banibati (1977:37) found, in a survey of 16 households, that whereas the mean number of pits in use was only 4.2, the mean number of empty pits per household was 23.4, with only 7.7 still containing the water necessary to produce te babai. Moreover, few of the productive pits were fully stocked, thus "reflecting more basically the changing food preferences and habits and growing reliance on the cash component of a household's total income" (Watters and Banibati, 1977:38). On Onotoa, Moul (1957:5) found that as many as ten individuals had separate plots in single pits ranging from 25 to 30 feet long and 10 to 20 feet wide.

As a result, te babai has become almost a luxury in many areas, reserved almost exclusively for ceremonial purposes, rather than constituting a staple food (Catala, 1957:67). Nevertheless, te babai cultivation continues to be surrounded with tradition, and there has been some recent rehabilitation of abandoned pits on both Tarawa and Abemama. As Catala (1957:67) relates: "pulling up a babai in order to offer the tuber to a distinguished guest is considered the greatest honour that can be paid to him."

Te babai pits must be excavated through as much as 1.5m of hard conglomerate and limestone to reach the freshwater lens, with Moul (1957:5) reporting pits up to 15 feet deep. The young shoots are planted in holes about 0.3m (2 feet) deep in the bottom of the pit and mulched and fertilized with black topsoil (te bon, te iarauri, or te ianuri) from stands of Guettarda speciosa, Scaevola sericea, and other plants and a variety of leaves, some of which are specially prepared for the purpose, using techniques generally not divulged. Baskets of pandanus or coconut leaves are commonly made, into which the shoot is planted or in which the fertilizer or mulch is administered to the plants in the pit.

Leaves used for fertilization and mulching, in order of importance, are te kaura (Sida fallax), te uri (Guettarda speciosa), te ren (Tournefortia argentea), te mai or breadfruit (Artocarpus spp.), te wao (Boerhavia repens), and to a lesser extent, species such as te kaura ni Banaba (Wollastonia biflora), te kanawa (Cordia subcordata), te kiaou (Triumfetta procumbens), and te kiaiai or te rao (Hibiscus tiliaceus). These leaves, with the exception of Sida fallax, are mixed with other plant waste, particularly old pandanus leaves and coconut refuse, black topsoil, and occasionally ground pumice (te uuan), and applied green or dried to the basket surrounding the plant or placed in the pit near the plant.

In the case of te kaura (Sida fallax), the leaves are rarely placed in the pits before drying, as their fermentation is believed to produce heat which can either kill or harm the te babai. The leaves are generally dried in the sun on mats and then taken to the pits in baskets, commonly mixed with other leaves, black top soil, and sometimes pumice; the mixture is then stirred to inhibit the formation of mould. The most

preferred topsoil is that found under te uri (Guettarda speciosa) trees (Catala, 1957:69-70; Small, 1972:68-69). As can be seen, the leaves of a variety of trees and the black topsoil found under trees are very important in te babai cultivation, and increasing agrodeforestation may be, at least in part, responsible for the decline in its cultivation in Kiribati.

Cultivated Exotic Timber Trees

Two trees deliberately introduced for reforestation purposes are the casuarina (Casuarina equisetifolia) and leucaena (Leucaena leucocephala). Casuarina, in particular, which was rare in the 1950s, has been widely planted on Tarawa as part of government sponsored reforestation programmes to provide windbreaks for recently planted coconut palms on the ocean sides of atoll islets (Overy et al., 1982:14) and to provide firewood. Leucaena was also introduced for reforestation purposes, because of its nitrogen-fixing ability, but is not widely planted.

Cultivated Ornamentals

Commonly cultivated ornamentals, most of which are found in houseyard gardens, mission settlements, schoolgrounds, or in major settlements, include plumeria or frangipani (Plumeria rubra and P. obtusa), hedge panax (Polyscias guilfoylei and P. fruticosa), copperleaf, Jacob's coat or the beefsteak plant (Acalypha amentacea), false eranthemum (Pseuderanthemum carruthersii), golden bells or yellow elder (Tecoma stans), bougainvillea (Bougainvillea spp.), lantana (Lantana camara), hibiscus (Hibiscus rosa-sinensis), dracaena (Dracaena fragrans), ixora (Ixora casei), and the poinciana or flame tree (Delonix regia). Also present in houseyard gardens, but not common, are the Tahitian gardenia (Gardenia taitensis), Acacia farnesiana, Cordyline fruticosa, and the Pacific fan palm (Prichardia pacifica). With the possible exceptions of Dracaena fragrans and Prichardia pacifica, all of these plants constitute important sources of flowers and leaves, which are used along with flowers from native species such as Guettarda speciosa, Sida fallax, and Scaevola sericea, used in the ubiquitous leis and head garlands so important for all social and ceremonial occasions (Table 2).

Important Indigenous Species

Important indigenous trees or tree-like species, which are integral and widespread components of the Kiribati agroforestry system include Scaevola sericea, Guettarda speciosa, Tournefortia argentea, Sida fallax, Morinda citrifolia, Clerodendrum inerme, Premna serratifolia, Pemphis acidula, and Dodonea viscosa (Table 2). Other indigenous trees, which are uncommon to rare in agricultural areas, but sometinmes found in coastal strand forest, houseyard gardens and villages, and as street trees in the main settlements, include Calophyllum inophyllum, Cordia subcordata, Terminalia catappa, Pisonia grandis, Hibiscus tiliaceus, Terminalia samoensis, Barringtonia asiatica, Hernandia nymphaeaefolia, Macaranga carolinensis, and Thespesia populnea. Also of localized importance are the mangrove species Rhizophora mucronata, Bruguiera gymnorhiza, and Lumnitzera littorea. All of these species have important cultural uses, many of which are described below and in Table 2. The information is based on in-the-field surveys and on Luomala (1953), Catala (1957), Moul (1957), and Overy et al., (1982).

Te mao (Scaevola sericea) is the most common shrub and the commonest understroy species and thicket former in Kiribati (Moul, 1957:22). It is found everywhere in coastal littoral forest, is common in plantations, especially where coconut density is low, and occasional in houseyard gardens and in villages and other habitats. It is an important

component of the coastal strand vegetation which provides protection from salt spray to inland plantations and gardens, is an important producer of humus and organic material because of its abundance, and has a wide ranging of cultural utility (Table 2).

Te Uri (Guettarda speciosa), te ren (Tournefortia argentea), and te kaura (Sida fallax), are the most common sources of leaf compost for the cultivation of te babai. Guettarda speciosa, one of the main components of the atoll vegetation, is occasionally cultivated in village gardens and particularly common in the centre of islets, where it is important in the formation of black topsoil te bon (te iarauri, or te ianuri) which is mixed with leaf-compost used in planting babai, pandanus trees and other crops. Its wood is used in general construction, its leaves are one the most important composts or fertilisers for babai, and its flowers are used in the production of garlands and head wreaths. All pastes or preserves are spread on its leaves for sun-drying, it is prominant in I-Kiribati legends, mythology, and is associated with phases of the moon and stations of the sun. It is easily one of the most culturally important plants in Kiribati (Table 2).

Te ren (Tournefortia argentea) is commonly found scattered in groups in plantation areas, occasionally in strips of ocean or lagoon strand forest, and was reported by Moul (1957:20) to be very common on the edges of babai pits on Onotoa. Like Guettarda speciosa, it has wide cultural utility. Its wood was occasionally used as a substitute for Calophyllum inophyllum for canoe bows and y-shaped pieces as spar supports on outrigger canoes. It also provides a favoured fuel, and was used as the bottom piece in making fire by friction in the past. The leaves are reportedly eaten in salads by boat crews, and used medicinally to reduce fever, as a female deodorant, and for magic and scenting coconut oil, as well as being an important ingredient in compost or fertiliser for babai and other plants. Te ren also features in many I-Kiribati legends.

Te kaura (Sida fallax), a small shrub found scattered throughout plantations, is occasionally in villages, and common on lagoon sides and on the inner margins of coastal ramparts of islands. It is a favored species for personal ornamentation, magic, particularly love magic, and is used medicinally. Its flowers and leaves are shredded and dried to produce the "strongest" compost or fertilizer for babai. Also occasional in plantation areas and cultivated as a living hedge or ornamental in home gardens is Clerodendrum inerme. It is reportedly used medicinally and its flowers used in garlands.

Te ngea (Pemphis acidula) is very common on sandy areas inland from mangroves and in clusters in garden areas bordering the ocean coast and on beach ramparts, where it often forms almost pure stands and serves as protection against sea spray. It is important medicinally, and the dense, extremely hard wood has wide utility, because of its resistance to sea water, and is a favoured firewood. Te kaiboia (Dodonea viscosa), indigenous to many Pacific islands, but possibly a recent introduction to Kiribati, locally common near existing villages and in sites of former dwellings and occasionally in garden areas, also has a variety of uses (Table 2).

Te non (Morinda citrifolia) and te ango (Premna serratifolia), two of the most important medicinal and magical plants in Kiribati, are occasional in coastal areas and relatively common in bush gardens and houseyard gardens in villages (Table 2). The pungent ripe fruit of M. citrifolia are occasionally eaten after boiling by old people, as a famine food , and as a stimulant on long fishing trips or ocean voyages, and the consumption of the young leaves has been actively promoted recently as a rich source of vitamin-A to combat outbreaks of vitamin A-deficiency night blindness among children.

Other indigenous species of wide cultural utility occasionally present in the coastal strand forest bordering garden areas, in houseyard gardens, or in settlement areas

include Calophyllum inophyllum, Cordia subcordata, Terminalia catappa, Pisonia grandis, Hibiscus tiliaceus, Terminalia samoensis, Barringtonia asiatica, Hernandia nymphaeaefolia, Macaranga carolinensis, and Thespesia populnea. All of these culturally useful species were more widespread in the past before official government emphasis was placed on clearing indigenous species to extend and rehabilitate coconut plantations and before current high population densities placed such pressure on limited arboreal resources.

Te kanawa (Cordia subcordata) is occasional in coastal forests and in villages, its attractive wood being highly valued for woodwork, and the inner bark, leaves, and attractive orange flowers highly valued for medicine, magic, composts and, garlands. Te kanawa is also featured in Kiribati legends and is the totem of the Karongoa clan.

Te kunikun (Terminalia catappa) and the related species, te ukin (Terminalia samoensis), both useful trees, are occasional in villages and in tree groves in plantations and inland from coastal littoral forest, almost always as individual trees, and sometimes planted as ornamentals. T. catappa is the favourite tree of the ancestral goddess Nei Tituaabane, and its mature seeds from the fruit (te ntarine) are eaten.

Te itai (Calophyllum inophyllum), so important medicinally and for general construction, canoe building and woodworking, is occasional around villages and towns, and was a sacred tree in the past on Tabiteuea.

Te buka (Pisonia grandis), the favoured nesting tree for the black noddy, an important food resource, is uncommon to occasional as isolated individuals or small groups, and has been recently planted in villages and at the hospital in Bikenibeu for its edible leaves, which are rich in vitamin A. It was probably more common in the past as a dominant in the indigenous climax forest. There reportedly remains a large traditional Pisonia reserve on the island of Onotoa in south Kiribati, which is surrounded by extensive guano deposits and the most luxuriant vegetation seen on the atoll (Moul, 1957:4).

The remaining species, te kiaiai or te rao (Hibiscus tiliaceus), te baireati (Barringtonia asiatica), te nimareburebu (Hernandia nymphaeaefolia), te nimatore (Macaranga carolinensis), and te bingiging (?)(Thespesia populnea) are all uncommon to rare in coastal strand forests, plantation areas, and villages on Tarawa and Abemama, despite their widespread cultural importance, often as babai compost. This, as suggested above, is probably the result of their widespread removal from coastal strand forests and the expansion of coconut monoculture in inland plantation and garden areas, coupled with the declining importance of the subsistence economy (Table 2).

The mangrove species serve as habitats and/or an important food supply for a majority of the important edible fish species. They also have an important role in coastal stability, land reclamation, and the protection of gardens from saltwater spray at the interface between the lagoon and agricultural areas. On Onotoa, they reportedly encircle nutritionally important fishponds (Moul, 1957:5). Mangroves are also used in construction and in the production of medicines, dyes and garlands (Table 2). They must, consequently, be considered integral components of agroforestry systems, particularly in land-scarce areas such as Kiribati. Te tongo (Rhizophora mucronata) is the most common species, forming very dense stands on swampy lagoon shores as well as being found on the the windward ocean coast at Bairiki, Tarawa. Te tongo or te buangi (Bruguiera gymnorhiza), is common to occasional in mangrove areas, and te aitoa (Lumnitzera littorea), although rare on Tarawa and possibly absent on Abemama, with only one large tree seen in Eita Village Tarawa, is reportedly more common on Butaritari.

POLYCULTURAL AGROFORESTRY AS AS BASIS FOR INNOVATION AND STABILITY

In summary, the 56 trees or tree-like species found in the agroforestry systems of Tarawa and Abemama represent a resource of enormous economic, cultural and ecological importance. These species, which along with the many other non-tree species have been preserved as part of the integral agroforestry system for generations, are now almost totally neglected by most agricultural developers and researchers. Consequently, although the agroforestry systems of Kiribati remain relatively in-tact on some islands, the push to encourage cash cropping of coconuts and small-scale commercial livestock production, and increasing urbanization have led to increasing agrodeforestation and neglect of many of these important tree species by a new generation of I-Kiribati who have become increasingly cash-oriented, and less tree-oriented, having not been educated to see the long-term utility of trees. Many young Kiribati, in fact, no longer know the local names nor the uses of these resources which made their ancestors self-sufficient.

As argued by Thaman and Clarke (1987), trees are both a symbol and a basis of stability in agroecosystems and will continue to be a precondition for sustainable development in the Pacific. Their very disadvantages as seen by modern developers (e.g., taking up space, lag-time between planting and maturity, perceived slow growth rates, etc.), which have often led to their domination or replacement by more immediately productive annuals, should be seen as advantageous in a world where biological stability is increasingly precarious. The "frozen" quality of trees - once established they are awkward to replace with other species - and the related lack of a quick turnover of product or landuse provide a permanence in ecosystems that slows misuse and provides a wide range of ecological benefits: diversity of habitat, diversity of species, prevention of accelerated erosion, maintenance of soil fertility and arable soil structure, flood retardation or prevention, and wind protection.

The culinary, nutritional, and medicinal value of trees and their contribution to dietary diversity and sustainable food, nutrition, and health-oriented development must be stressed in the light of the rapidly declining quality of nutrition and nutrition-related human health in the Pacific, a decline that has been widely documented, and which has led to very high incidences of nutritional disorders such as iron-deficiency anaemia, obesity, and general micro-nutrient deficiency and of nutrition-related non-communicable diseases such as cardiovascular disease, hypertension, diabetes, various forms of cancer, hyperuricaemia and gout, dental disease, and alcoholism (Coyne, 1984; Thaman, 1979, 1982b, 1983, 1985). Trends are similar in Kiribati and seem to be directly related to a decline in the consumption of traditional foods, which derive from the existing agroforestry system, such as toddy, coconut, breadfruit, pandanus, giant swamp taro and fish and a corresponding increase in the consumption of nutrient and fibre-depleted highly-processed imported foods (Wilmott, 1968; Pargeter et al., 1984).

With increasing population and urbanization and the almost exclusive official emphasis on monocultural production for export, and the associated growing neglect of traditional agroforestry-based food systems, there is also increasing food scarcity, both physical and economic (in terms of high prices), especially for the highly nutritious local staple food crops, fruit, and vegetables, and animal and fish protein, not to mention, dangerously high, and increasing levels of food dependency. Moreover, further agrodeforestation can only serve to create other destabilising dependencies on foreign sources for fuel, fertilizer, medicines, perfumes, and other material goods currently produced by existing agroecosystems. Similarly, ingenious and time-tested strategies for wild food acquisition, food processing, storage, and preservation have been all but

forgotten by many of today's youth and are in danger of disappearing (Massal and Barrau, 1956; Barrau, 1958, 1961; Yen, 1980ab; Klee, 1980; Parkinson, 1982; Thaman, 1982b, 1985).

In addition to their immense cultural and economic value, trees also provide the benefits of: 1) low labour requirements for maintenance compared with annuals, 2) provision of the "insurance" of a reserve food supply, should annuals fail, and 3) in combination with annuals in a two-story structure, which constitutes a more intensified utilization of space, aggregate yields greater than many monocultures of annuals (Thaman and Clarke 1987).

Given their many advantages, in terms of ecological and cultural utility, nutritional diversity and sustainability, economic self-reliance, and ecosystem and cultural maintenance, polycultural agroforestry systems, such as those found in Kiribati, would seem to offer ideal bases for further development and innovation, rather than being ignored as anachronisms or obstacles to "modern" development. It has even been suggested that the promotion of "urban agroforestry" may be one of the most cost-effective means of solving problems associated with increasing urbanisation in the Pacific islands (Thaman, 1987a).

Although there is a continuing need for innovation and modification of existing systems based on both internally and externally-induced or inspired changes or the incorporation of new species and agroforestry strategies, such innovation has already taken place, and continues to take place in response to changing ecological conditions, increasing population pressure, changing societal aspirations, and exposure to new plant species and agroforestry technologies, both prior to and after the time of European contact. The polycultural systems that exist today <u>are</u> the evidence of the continued willingness of Pacific island agroforesters to make rational decisions to adapt their systems to changing environmental and social conditions and technological options (Thaman and Clarke, 1987). It is critical, however, that today's development planners and managerial elite recognise the need to <u>base</u> modern agricultural and forestry development on such proven traditional Pacific island agroforestry systems, and, as suggested before, to see that the planting and preservation of trees within the matrix of existing agricultural systems is of tantamount importance to the promotion of the more monocultural agricultural and forestry development currently fostered in Kiribati and elsewhere in the Pacific islands. Rather than encouraging thoughtless agrodeforestation and associated helplessness, dependency, and the destruction of a significant part of the Kiribati cultural heritage in the name of short-term national economic development objectives, it might be possible, using a more balanced polycultural agroforestry approach, to foster development and innovation which would protect trees, people and their agroforestry traditions and to promote economic self-reliance and cultural and ecological stability in the atoll nation of Kiribati.

Table 2. Important tree and tree-like species of agroforestry systems of Kiribati, based on 1984 field research on the islands of Tarawa and Abemama. Notes: 1) under "Vernacular Names", the first name(s) listed are the Kiribati name (s) and the second the English or other common non-Kiribati vernacular names; 2) the article <u>te</u>, which is almost always used before a noun, is seen as being an integral part of the name and is found before almost all plant names except those named after people, eg. <u>neikarairai</u> or in some cases where the name is a direct "Kiribatization" of a non-Kiribati name, e.g., <u>nambere</u> from the Fijian <u>na bele</u>; 3) the vowels are generally pronounced: a as in father; e as in a in fate, although sometimes as the e in ten; i as ee in see; o as o in note, or sometimes as o in Bonny or aw in awful; u as oo in boot; 4) consonants such as ng are pronounced as the ng in sing; b sometimes like an English b, sometimes like an English p, often a sound in between both, or even like a sound between a b and v; k is

pronounced hard, often sounding more like a g (e.g. Kiribati sounds more as if it should be spelled Giribas in English); r as an unrolled English r; t like a normal t before the vowels a, e, and o, with ti being pronounced si or tsi, and tu being pronounced too, soo, or tsoo (e.g. Kiritimati is pronounced like Christmas in English and katuru is pronounced as it it were kasooroo in English; and w like a w in English, but also as a bilabial in some cases.

Latin Name	Vernacular Names	Notes
Cocos nucifera	te ni; coconut palm	Very abundant throughout the islands along lagoons, around villages, in garden and copra plantation areas, and in littoral strand vegetation on ocean coasts; apart

from isolated large emergent trees, the superdominant upper story vegetation under which all agroforestry activities are practiced; the most important plant in Kiribati; a number of cultivars recognised; a major and perhaps the major staple food source in terms of calories in most areas, the mature endosperm being prepared in a myriad of ways, the juice of green nuts being an important beverage, and the vitamin and mineral- and energy-rich sap from the flower spathe, toddy (karewe), an important daily dietary item, a syrup made from boiled toddy (kamaimai), carmelized toddy (kareberebe), and fermented alcoholic toddy (te manging); mesocarp and male and female flowers used to cure infantile diarrhoea and gingivitis respectively; wood, fronds, husks, and shells the major source of fuel in the fuel-scarce atoll environment; the trunk provides useful timber for all types of construction from small coconut storage houses (te okai) to large meeting houses (maneaba) for posts and thatch; husks used as mulching; fibres of the husk provide string and matting; leaflets used for thatching, baskets, hats, binding and decoration; midribs of leaflets used in brooms; shells used for toddy containers, cups, spoons and bottles; oil used for soap, skin oil, perfume, and cosmetics; most parts of the tree extremely useful, some other uses including medicines, sorcery, general construction and a range of other functions; copra the only source of agricultural export income on most islands is made from mature nuts.

Artocarpus altilis	te mai, te bukiraro;	Commonly planted around villages and breadfruit residences, along roads, and occasionally in inland plantations amongst coconut palms and carefully looked after,

mulched, and fertilized with tin cans, ground pumice to provide iron and other micronutrients; reportedly scarce on more arid southern islands, but common to abundant, especially on Butaritari in the north; reportedy introduced in pre-European-cantact times form either Polynesia or the Marshall Islands; very important seasonal staple eaten in a variety of ways; important shade tree in villages; overripe fruit fed to pigs; seeds cooked and eaten; timber sometimes used in construction and canoe making; sap chewed as gum; juice of leaves used for earaches and the buds chewed and spat into sore eyes; shoots used as treatment for fish poisoning; leaves used for composting; a number of cultivars recognized, including te mai kora and te moti ni wae.

Artocarpus mariannensis	te mai, te maitarika; Marianas breadfruit	Occasional to common in breadfruit groves around villages; uses as for A. altilis

Artocarpus altilis x mariannensis	te mai, te keang, te ang ni Makin, hybrid breadfruit	Occasional in breadfruit groves around villages; uses same as for A. altilis

Pandanus tectorius	te kaina; pandanus, screwpine	Abundant on all islands, where important cultivars are planted near villages and in plantations, with wild varieties found, primarily in coastal strand vegetation; the ancestral tree, from which, according to mythology, the progenitors of the I-Kiribati came; cultivated trees individually owned and well looked after, with each village having its own named cultivars; there are reportedly almost 200 recognised cultivars; extremely useful plant; a very important staple food, the ripe fruit of which is eaten raw and prepared in many forms, the most important being a desiccated cake for long storage (te tuae), a coarse flour from the pounded fruit (te kabubu); timber and stilt roots used in house construction, for digging sticks, and play things; adventitious root tips used in treating boils and sores and as an anti-pyretic; leaves after treating, used in production of fine mats, baskets, hats, skirts, good quality thatch, and, in the past, sails; leaves also used to thatch baskets into which ceremonial giant swamp taro (babai) are planted and composted; old leaves used in composting; leaves also used as bandages, swaps, tobacco or cigarette wrappers, whistles, and ornamentation; flowers and fruit used in garlands and the male flower (te taba) for scenting coconut oil; roots provide floats for fishing nets, red dye and fibre

Scaevola sericea	te mao; native salt bush	The most abundant shrub in Kiribati; found everywhere in coastal littoral forest, common in plantations, especially where coconut density is low, and occasional in villages and other habititats; important component of the coastal strand vegetation which provides protection from salt water spray to inland plantations and gardens; important producer of humus and organic material because of its abundance; branches sometimes used for roofing strips; leaves boiled with women's grass skirts (riri) to make them durable; pith of large trees cut into strips and made into paper-like garlands or necklaces; flowers used in garlands; fruits used medicinally and in magic

Guettarda speciosa	te uri	Very common tree, one of the main components of the atoll vegetation and particularly common in the centre of islets, where it is important in the formation of black topsoil (te iarauri or te ianuri) which is mixed with leaf-compost used in planting babai, pandanus trees and other crops; wood used as rafters and wall frames in housing, for canoe hulls and ribs, and formerly for firemaking by friction; leaves used alone and with other leaves as one of the most important composts or fertilisers for babai and other important plants; all pastes or preserves spread on te uri leaves for sun-drying; very important in I-Kiribati legends and mythology; names of the leaf and the plant asoociated with phases of the moon and stations of the sun; flowers among the most popular for garlands and head wreaths

Tournefortia argentea	te ren; beach heliotrope	Very common tree as scattered groups of trees and occasionally in strips of ocean or lagoon strand forest; wood occasionally used as a substitue for Calophyllum inophyllum for

canoe bows and y-shaped pieces as spar supports on outrigger canoes; wood a favoured fuel and used as the bottom piece in making fire by friction; leaves reportedly eaten in salads by boat crews and used medicinally to reduce fever and as a female deodourant, for magic and scenting coconut oil, and magic; leaves important ingredient in compost or fertiliser for babai and other plants; tree featured in I-Kiribati legends

Sida fallax — te kaura, 'ilima (Hawaii) — Common shrub found throughout plantations and occasionally in villages, especially on lagoon sides of islands; flowers and leaves shredded and dried to produce the "strongest" compost or fertilizer for te babai; often used as fresh green compost on Arorae in the south of Kiribati; flowers very important for garlands and personal ornamentation, formerly reserved for persons of high rank; parts of the plant used medicinally, the juice of the stem for headaches and stomach aches, crushed leaves with coconut oil as a treatment for tropical ulcers, herpes, and mouth sores; flowers used in magic, particularly love magic

Carica papaya — te mwemweara, te babaia, papaya, pawpaw — Very common in villages, where they receive little care; when well-cared-for, produce fruits of very good flavour; hollow leaf stalks used by children as pea shooters and as siphons; juice from shoots applied to corneal ulcers and latex applied to sores and wounds; fruit one of only readily available sources of vitamins A and C and commonly eaten, especially by children and the elderly; also cooked green in coconut cream; occasionally sold to passing ships for twist tobacco in the past

Ficus tinctoria — te bero; native fig, Dyer's fig — Commonly cultivated and propogated vegetatively by planting branch cuttings around villages and occasionally in plantation areas; branches sometimes used in house construction, especially in roof framing; fibrous twigs used for cleaning teeth; roots used as scoopnet frames; leaves fed to pigs and sometimes used as babai compost; fruits an important staple in the drier southern islands being picked when ripe and sometimes when green, cooked, crushed in a pestle into a puree which can be eaten after being sweetened with toddy molasses (kamaimai) or sugar and grated coconut or preverved by drying in the sun on Guettarda speciosa leaves; reportedly bears many times throughout the year; considered a pauper's or famine food in many areas; fruit formerly used to dye hats, mats, etc.; young leaves used in treating boils and watery inner bark used in treating sore eyes

Morinda citrifolia — te non; beach mulberry — Occasional in coastal areas and relatively common in bush gardens and in villages; wood of larger trees occasionally used in house construction, particularly for roofing; red dye for colouring mats and plaited ware prepared with the inner root mixed with ash; small leaves used to treat measles, the over-ripe fruit for warts, the juice from the leaf for boils, the ripe and unripe fruit to relieve coughing, and the root with toddy as a mouthwash; pungent ripe fruit occasionally eaten after boiling by old people, as a famine food, and as a stimulant on long fishing trips or ocean voyages; fruit also use in magic for love and fishing; young leaves used recently as a rich source of vitamin-A to combat outbreaks of vitamin A-difficiency-induced night blindness among children

Pemphis acidula	te ngea	Very common on rocky substrates, inland from mangroves and in clusters in garden areas bordering the ocean coast, where it serves as protection against sea spray; the dense extremely hard wood used for house frames, the tops of canoe masts, pestles, coconut huskers, axe handles, smoking pipes, war clubs, combs, moray eel traps, to attach the outrigger to canoes, and , in the past, fish hooks, because of its resistence to sea water; as firewood, it makes the hottest flame; rotting wood added to coconut oil as a cosmetic, young leaves said to have antiscorbutic properties, the roots, scraped in water to make a hemostatic drink for women to stop post-childbirth hemorrhaging and to treat sores; small fruits sometimes eaten
Premna serratifolia	te ango	Occasional on the lagoon sides of islands and in villages; wood used in house construction and for making fire by friction; straight saplings or branches used for fishing poles; roots used to perfume coconut oil; leaves used medicinally to cure post-childbirth hemorrhage, sinusitis, severe headaches, and as a poulstice for painful limbs; leaves also used for arousing love; mixture of bark and coconut milk used to banish fear in marriage and with te kaura flowers (Sida fallax) to promote true love
Rhizophora mucronata	te tongo; mangrove	Common, forming very dense stands on swampy lagoon var. stylosa shores and reportedly also found on the the windward ocean coast at Bairiki, Tarawa; one of the main components of mangrove forest, serving as protection for villages and gardens against coastal erosion and salt water spray; dense and extremely hard wood used in house construction, for threading coconut shells for shark rattles, making scoop nets, and as stakes for fish traps because it resists salt water and shipworm damage; red dye obtained from the roots; bark used to prefume coconut oil; parts used medicinally to treat sore throat and gums; caulking paste made in the past from boiled fruits
Bruguiera gymnorhiza	te tongo, te buangi; mangrove	Common to occasional in mangrove areas; wood used in house construction; red dye from bark used to preserve and colour canoe sails; bright red flowers used in garlands
Dodonea viscosa	te kaiboia; native hopbush	Locally common near existing villages and in sites of former dwellings and occasionally in garden areas; stems make good fishing rods and frames for scoopnets; fruit used in garlands; young leaves used to scent coconut oil
Plumeria rubra	te meria; frangipani, plumeria	Commonly cultivated ornamental in villages and around homes; flowers used in garlands for ceremonies and everyday use; sap from flower mixed with coconut oil and water to treat sores and sore eyes, leaves used to treat stomach disorders in children

Polyscias guilfoylei	te toara; hedge panax	Commonly cultivated as a living hedge and ornamental in villages and around dwellings; fagrant leaves used in garlands; cooked young leaves reportedly fed to children as a source of vitamin A to inhibit the recent spread of vitamin A-deficiency-induced night blindness among children
Acalypha amentacea vars.	te aronga; copperleaf, beefsteak plant	Commonly cultivated ornamental in villages; planted as a hedge or living fence; leaves used in garlands
Musa ABB Group	te banana, te umuumu, plantain, cooking banana	Occasional in villages and in pits and reportedly more common on Butaritari in the north; planted and fertilised or composted with black soil form under Scaevola sericea and Guettarda speciosa trees in pits dug down to the water table and occasionally planted on the surface and heavily mulched and composted with leaves, tin cans, and coconut husks; fruit cooked as a supplementary staple; reportedly very susceptible to damage by the taro beetle (Papuana sp.)
Musa AAB Group	te banana, te oraora, lady's-finger banana	Occasional in villages and in pits and reportedly more common on Butaritari; planted as the above cultivar; ripe fruit eaten raw; reportedly susceptible to damage by the taro beetle (Papuana sp.)
Pseuderanthemum carruthersii vars.	te iaro; false eranthemum	Commonly cultivated ornamental in villages; branches used for fishing rods for small fish; flowers and leaves used in garlands
Tecoma stans	neikarairai; yellow elder, yellow bells	Commonly cultivated ornamental in villages; bright yellow flowers used in garlands
Bougainvillea spp.	te akanta; bougainvillea	Moderately common cultivated ornamental in villages; flowers used in garlands
Clerodendrum inerme	te inato	Commonly planted as a hedge or ornamental plant and occasional in plantations; leaves, bark and sap used medicinally; flowers used in garlands
Lantana camara	te kaibuaka; lantana	Occasionally cultivated ornamental in villages; flowers used in garlands and in hair; flowers reportedly used to treat infantile diarrhoea; ripe fruit reportedly eaten by children

Hibiscus rosa-sinensis	te roti; hibiscus	Occasionally cultivated in villages; flowers used for decoration in hair
Citrus aurantiifolia	te raim; lime	Occasionally planted in villages and home gardens; seems to grow well in the atoll environment; ripe fruit highly desired for marinating fish, squeezing on food, and for making drinks
Saccharum officinarum	te kai tioka; sugar	Occasionally cultivated in villages and in home gardens; seems to grow reasonably well in some areas; stem chewed as a snack food
Hibiscus manihot	nabere; hibiscus spinach	Occasionally cultivated around houses in villages; leaves cooked as a vitamin- and protein-rich spinach; grows particularly vigourously and disease-free in Betio, where it was supposedly introduced by contract workers returning fom Banaba (Ocean Island)
Ixora casei	te katiru, te katuru; ixora	Occasionally cultivated in villages; bright red flowers used in garlands
Cordia subcordata	te kanawa; sea trumpet	Occasional in coastal forests and in villages; reportedly more common in past in interior before coconut plantings were extended; attractive wood highly valued for canoes, especially for the key pieces of the bow and stern, for fishnet floats, tobacco pipes, and smaller saplings for fishing poles; inner bark used as pregnant woman's girdle to give magical protection; dry bark used in making fire; innerstem used medicinally as an astringent and cure for diarrhoea when mixed with rainwater, leaves used in treating fever and stomach disorder; leaves added to babai compost; attractive orange flowers highly valued for garlands; the te kanawa is the totem of the Karongoa clan and features in Kiribati legends
Terminalia catappa	te kunikun, te tarin, beach almond	Occasional in villages and in tree groves in plantations and inland from coastal littoral forest, almost always as individual trees; sometimes planted as an ornamental; reportedly very abundant on Banaba (Ocean Island) and formerly more abundant on Tarawa; wood used in house construction and for other purposes; mature seeds from fruit (te ntarine) eaten; leaves used for wrapping food for cooking in the earthen oven; desiccated pith of fruit used to rub corpses; favorite tree of the ancestral goddess Nei Tituaabane
Acacia farnesiana	te kai bakoa; klu	Occasionally cultivated ornamental in villages; fragrant aroma flowers used in garlands

Calophyllum inophyllum	te itai; Alexandrian laurel	Occasional around villages and towns, reportedly much more common in the past; a sacred tree in the past on Tabiteuea; wood used for bow pieces and ribs of canoes, canoe paddles, diving goggles, and in house construction; stems for scoopnet frames; tissues inside nut are crushed for the oil which is spread on sores; juice from the roots used to cure headaches; fruit also used medicinally for morning sickness, chicken-pox, and conjunctivitis; skin and outer flesh of fruit eaten; fragrant flowers used in garlands and to scent coconut oil
Ficus carica	te biku; common fig	Occasionally cultived and thriving in villages and around mission gardens; ripe fruit eaten
Pisonia grandis	te buka	Uncommon to occasional as isolated individuals or small groups, and, recently, planted in villages and at the hospital in Bikenibeu; probably more common in the past, as a dominant in the indigenous climax forest, and removed to make room for expansion of coconut plantings; planted as living bath house post providing shade and privacy; reportedly common in a native forest reserve in northern Onotoa and common in the bush and in villages in other islands; favoured nesting area for noddy terns, the black noddy being an important food resource; the soft wood used for canoe outriggers, for which it was highly valued, and the bottom piece in the fire plough to make fire by friction
Hibiscus tiliaceus	te kiaiai, te rau; beach hibiscus tree, beach mallow	Occasional around villages; probably more abundant in the past; wood used as the bottom stick in making fire by friction; branches sometimes used for outrigger booms; sprouts, when straight, make good fishing rods; fibres from inner bark sometimes uses to make skirts (riri); leaves used for compost and for wrapping food and for treating neurological disease
Casuarina equisetifolia	te katurina, te burukam; casuarina, ironwood, she oak	Increasingly common in villages and in reclaimed areas; introduced as a potential source of timber and fuelwood; occasionally used as fuelwood; useful as a windbreak on ocean side of islets to protect newly planted coconuts
Leucaena leucocephala	te kaitetua; leucaena	Occasional around government buildings and in settlements; introduced for reforestation as a leguminous plant for soil enrichment and firewood; not well established
Plumeria obtusa	te meria; frangipani, plumeria	Occasionally cultivated ornamental in villages and around homes; flowers used in garlands

Delonix regia	te tua; flame tree, poinciana	Occasionally cultivated ornamental in villages, especially in Betio; excellent shade tree; flowers used in garlands
Terminalia samoensis	te ukin	Uncommon in plantation tree groves and in villages; root used for treating mouth sores, part of plant used for treating coughing of blood; red fruit reportedly eaten by children and used in garlands
Barringtonia asiatica	te baireati; fish poison tree	Uncommon in villages, possibly planted from drift seeds; evidentally more common in the past; seed used as a fish supificant or poison
Hernandia nymphaeae-folia	te nimareburebu; lantern tree	Uncommon on the lagoon side of islands and occasionally around villages; wood used in house construction and for outrigger floats; possibly planted from drift seeds
Lumnitzera littorea	te aitoa	Uncommon large tree found in Eita Village Tarawa, but reportedly more common on Butaritari; bright red flowers used in garlands; wood used in house construction and in fish traps becuse of its durability in water; features in songs and legends
Macaranga carolinensis	te nimatore; macaranga	Rare large tree seen near Teorareke; one large tree at King George V school just destroyed; an endangered species in Kiribati
Gardenia taitensis	te tiare; Tahitian gardenia, tiare Tahiti	Uncommon cultivated ornamental in houseyard gardens; fragrant flowers used in garlands
Cordyline fruticosa	te rauti; ti plant	Uncommon cultivated ornamental in villages
Polysicias fruticosa	te kaimamara; hedge	Uncommon cultivated as an ornamental hedge plant in villages; leaves used in garlands
Prichardia pacifica	te bam; Pacific fan palm	Uncommon, but occasionally planted in villages as an ornamental
Psidium guava	te kuava; guava	Rare fruit tree at Bikenibeu; seems to grow welland offers potential for wider utilization; ripe fruit eaten

Thespesia populnea	te bingibing	Rare in coastal strand forest; reported from Butaritari; flowers used in garlands; leaves used in babai composts

Sources: Thaman, 1987; Luomala, 1953; Catala, 1957; Moul, 1957; Small, 1972; Overy et al., 1982; and in-the-field surveys.

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