

Changes in Traditional Agroforestry Systems in the Kingdom of Tonga

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General Background

Introduction

The Kingdom of Tonga, located in the central southwest portion of the Pacific Ocean, consists of three groups of small islands, with the total land of less than 750 square kilometers. Monthly mean temperature ranges from 17 to 30 degrees centigrade, with annual average rainfall of approximately 2,700mm, of which roughly 2/3 falls during the wet season, November to April (Thompson 1986).

An ethnically homogenous population with a single language has inhabited in Tonga for over 3,000 years. Its social structure has long been hierarchical, with three typical levels: commoners, chiefs or nobles, and a supreme authority. Tonga's economy is based mainly on agriculture and tourism. Its GNP was estimated at US\$239 million in 1996, or GNP per capita amounts to US\$1,720. The major cash crops are squash, coconuts, watermelon, bananas, vanilla beans, yams, taro, cassava, peanuts, corn, and pineapples. Tonga's export is very dependent on squash, which amounts about the half of the total Tongan exports (Trade New Zealand 2001). Pigs, horses, cattle, goats, and chicken are raised locally. Fish is abundant in the surrounding ocean.

Although Tonga was completely forested before, Tonga's remaining natural forests are confined to small areas. The largest portion of natural forest in Tonga is found on the steep east coast of 'Eua and plantation forests are only found on the islands of 'Eua and Vava'u.

Land Tenure System

Land tenure system in Tonga is distinctive: all land in Tonga is the property of the King and Royal family. And every Tongan male over sixteen years old is entitled to 8.25 acres of agricultural land and a small town allotment to build his house. It is unlawful for anyone to sell any land but they may lease it in accordance with the *Land Act*.

However, changes in social factors, such as population growth, many Tongan people live overseas and/or hold works in the city, affect this land ownership. The lands within convenient distance became scarce and less than 30% of lands are farmed by landowner themselves and the other lands are leased to relatives or other farmers (Sione 1994). This influences the intensity and care of agricultural land use. The leased lands tend to be farmed for cash cropping. Cash crops such as squash, watermelon, sweet potato and tomato are grown as monoculture after mechanical land clearing.

Livestock

Pigs are the most important livestock as food source in Tongan society. However, pigs walk freely around the owner's house, and house properties and farmlands are fenced to protect from pig damage. Pig damage on farmland became more problematic these days because of the absence of animal management. The owner feed pigs daily with root crops/coconuts/fodder that are brought from his farmland.

Other livestock such as horses, cattle, goats are small in numbers. They are usually tied in the field and moved around once a while where there is no crop. Chickens are not kept in a cage and walk around in the village. Run-away livestock damages farmlands and people always hunt them.

Trees

Tongan people use a wide variety of forest products, including non-timber forest products, from diverse tree species for fruits, foods, fodder, weaving material, timber, perfume, medicines, firewood, handicrafts, canoe construction and so on. 26 fruits trees and at least 67 other non-food and non-timber forest product tree species were recognized (Thaman 1976). Table 1 shows some example of tree species and its use in Tongan agroforestry system.

Interesting to note that usually trees, except coconut trees, were not intentionally planted by farmers, but they regenerated naturally and were left without removing due to its values. The number of trees in the farmlands is decreasing due to mainly the expansion of commercial monoculture and the increasing use of agricultural machineries.

Table 1. The Common Tree Species in Tongan Agroforestry

Scientific Name	Tongan Name	English Name	Use
<i>Cocos nucifera</i>	Niu	Coconuts Tree	Fruits, foods, aliment for animals, timber, weaving material, oil,
<i>Carica papaya</i>	Lesi	Papaya	Fruits, aliment for animals, fodder
<i>Artocarpus altilis</i>	Mei	Breadfruit	Fruits,
<i>Bischofia javanica</i>	Koka		Dye
<i>Mangifera Indica</i>	Mango	Mango	Fruits
<i>Citrus sinensis</i>	Moli	Orange	Fruits, tea
<i>Inocarpus fagifer</i>	ifi	Tahitian Chestnut	Fruits
<i>Santalum album</i>	Ahi'	Sandalwood	Perfume
<i>Psidium guajava</i>	Kuava	Guava	Fruits,
<i>Aleurites moluccan</i>	Tuitui	Candlenut	Soap, fence
<i>Pometia pinnata</i>	Tava		Medicine, fruits
<i>Morinda citrifolia</i>	Nonu		Medicine, fruits
<i>Pandanus spp.</i>	Lou'akau		Weaving material
<i>Rhus taitensis</i>	Tavahi		Medicine, firewood,
<i>Macaranga harveyana</i>	Loupata		Timber, firewood, medicine

Coconuts

Coconuts are vital for Tongan life. And also, coconuts are the most common component of the agroforestry system due to small canopy shade, long economic life, provide daily needs for Tongan and/or cash return, no need to intensive care.

Crops

For traditional Tongan agriculture, root crops, such as taro, giant taro, cassava and yams, were exclusively cultivated for daily foods. And also Kava (*Piper methysticum*), which is a member of the pepper family is very important component for cash income. Its rootstock is used to prepare the drink, which serves for the very important social life for Tongan male. The drink is also reputed to

be sedative, tonic, stimulant, and addictive. Paper mulberry (*Broussonetia papyrifera*) is cultivated as the source of weaving material

Modern agriculture for cash cropping is expanding rapidly in Tonga. Cash crop species for exporting are squash, watermelon, bananas, etc. And also, cash cropping for domestic markets is growing dramatically due to social changes: more people live in the city and buy foods from markets; and more vegetables became popular among the Tongan diet. In short, demands for commercial crops are increasing for domestic and international markets.

Tongan Agroforestry Systems

Background

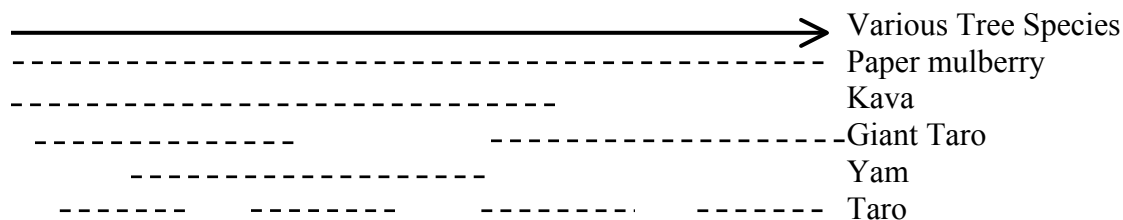
The integration of trees and crops is a traditional Tongan agriculture, presenting ecologically sustainable land use over its long history. Over years, Tongan population has been increasing, modern technology has been introduced, social needs became more diverse, and economic expectation became higher. And traditional farming system developed into several sub-systems. In Tonga, most areas are covered by a mixture of crops and trees at various stages of cultivations of different system. Therefore, it is difficult to describe Tongan agriculture adequately. In this paper the four main systems will be focused, which are the two traditional agroforestry systems, commercial agroforestry, and urban agroforestry

1) Traditional Agroforestry System—Home-garden style

Objectives: Tongan people expect literary everything traditionally they needed for their daily life from this system, e.g. foods, medicines, clothe materials, firewood and so on. This system provides the most diverse forest and agriculture products from the land to meet household needs. Generally cash cropping is not the main purpose of this system but surplus may be brought to local markets.

Temporal arrangement: Interpolated arrangement (space and time-dominant) is used. Trees always exist, and under the tree canopy various crops and useful plants are cultivated. Farmers are able to harvest a couple of different kinds of staple plants through the year and seasonal fruits and other products.

Fig 1. Example of Cropping Cycle for Home-garden System



Tree Species: Very diverse tree species are found, providing all necessity for Tongan social life. Comparing other systems, tree density and number of tree species are higher.

Crop Species: Root crops, such as taro, giant taro, and yams, are growing simultaneously very often kava and/or paper mulberry is mixed. Due to competition for light with tree species, crops are planted sparsely comparing other systems.

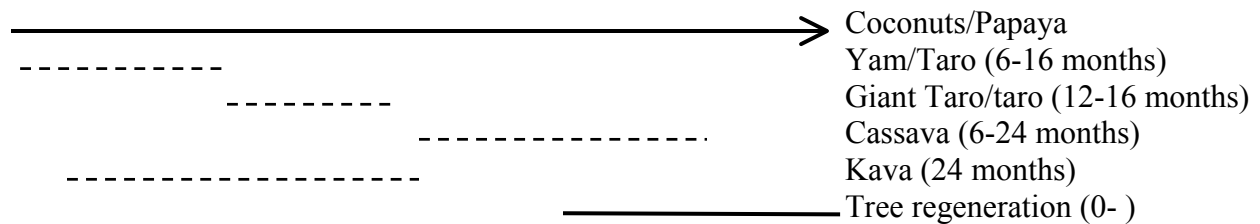
2) Traditional Agroforestry System—Slash and Burn

Objectives: This system is more focused on crop cultivation and less focus on forest products. Farmers grow crops for their house needs and to bring to domestic markets.

Temporal arrangement: Basically separate (time-dominance) but light canopy tree species like coconuts and papaya can be integrated as intermittent (space-dominant). This system starts with yams, which is the most economically valuable crop in Tongan markets, mixed with taro and/or Kava. After yams are harvested giant taro is planted mixed with taro and plantain and/or kava. While these two first stages, the farmlands are intensively cared and maintained weed free. The last crop of the crop cycle is cassava due to its ease of management, low economic value and its ability to thrive on poor soil. The cassava fields are very crowned and hardly weeded, which encourage natural regeneration of tree species while this stage. They harvest cassava, as their needs arrive for mostly family use and for pig’s aliment. After cassava cultivation, they leave the land idle. And then the land is clean up and the new cycle starts.

Roughly one-third of the total agricultural area is under cultivation at any one time, the rest is used under various stage of fallow, from grasslands to secondary forest(Kunzel 1989)

Fig 2. Example of Cropping Cycle for Slash and Burn System



Tree Species: Coconuts and papaya are seen throughout the cycle, but other useful tree species that are very common for home-garden system are absence in order to reduce the competition for light and space. During cassava cultivation, tree species such as guava regenerate. However, all bush are cut and cleaned at the land preparation the next cultivation cycle.

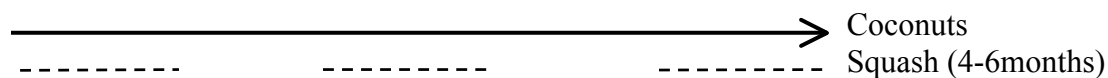
Crop Species: Traditional root crops are dominant throughout the cycle and they generally planted in array and closer. The number of crop species cultivated at the same time is fewer than home-garden system. However, except cassava, most crops are intercropped with others, 1 to 5 species at once (). Recently, many farmers, especially who live close to the cities, started to cultivate introduced vegetable, such as tomatoes, potatoes, eggplants, and cabbages, for domestic markets.

3) Commercial Agroforestry—combination of traditional and modern system

Objectives: Cash cropping is the main purpose of this system. Agricultural machines, such as plow and tractor, and agrochemical, mainly fertilizer, are used. Efficiency in terms of time and money is important. Sub-standard quality products are mainly used for pig aliment and/or consumed by local people.

Temporal arrangement: Intermittent (space-dominant) arrangement is applied: Under Coconuts palms cash crops are planted. Cash crops are cultivated only during the growing season (in case of squash June to October) and the rest of time the land is left idle.

Fig 3. Example of Cropping Cycle for Commercial Agroforestry



Tree Species: Coconuts palms are exclusively preferred tree species to integrate into this system. Coconuts palms are planted in rows in order to facilitate the use of plow. Coconuts fruits are collected for house use, local markets, and for pig’s aliment, and in some case for exportation.

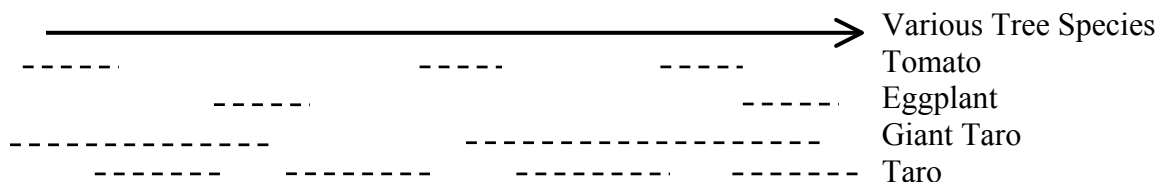
Crop Species: Crop species are chosen according to demands of domestic or international markets. Generally one crop species is planted in the area, mostly squash for international markets or vegetables for domestic markets.

4) Urban Agroforestry— Home-garden style

Objectives: House residents utilize adjacent areas to residences to produce foods for the family and sometimes for local markets. This system is more seen around and in the cities because more people moved into urban area for job while their own farmlands remain in different islands. The fields are fenced by living shrub-like tree species to protect from pig damage and managed intensively.

Temporal arrangement: Interpolated arrangement (space and time-dominant) is applied to this system. Under various useful tree species, several food and non-food plants are intercropped.

Fig 4. Example of Cropping Cycle for Urban Agroforestry



Tree Species: A wide variety of tree species are found in this system. And, people often deliberately plant tees in this system, such as medical plants, sacred

Crop Species: Beside traditional Tongan root crops, a wide range of recently introduced crops, including temperate vegetable, such as tomato, potato, eggplant, etc. are cultivated under this system. And also, ornamentals, medicinal plants, and other non-food plants are planted.

Comparison of Different Agroforestry Systems

Farmers' Type and Farm Locations

Applied agroforestry systems to the lands correspond with not only lands' conditions but also farmers' social situations. Fig 5 and Table 2 illustrate an example of Tonga community and farmlands. There are three major types of households, Household 1-3. Household1, who represent rich and big farmers, have own land (Farm2) and lease other lands from relative (Farm5) and the government (Farm6). Household2, who represent general farmers, have own land (Farm3) and lease other lands from relative (Farm4) and work as a labor for Fram6. Household3, who work in the city, have no farmland in the same island, instead they do urban agroforestry in their residential area (Farm1). On the own lands, Farmland2 and 3, farmers conduct both traditional agroforestry systems, home-garden and slash and burn, dividing the lands spatially. On the leased land, Farmlands 4 and 5, if farmers can invest for high-input agriculture, they go for commercial agriculture. And if not, they do commercial agroforestry, which needs less investment at the beginning. The leased lands from the government, Farm6, used for huge commercial agriculture. On the residential or adjacent area, Farm1, urban agroforestry—home-garden style, is found.

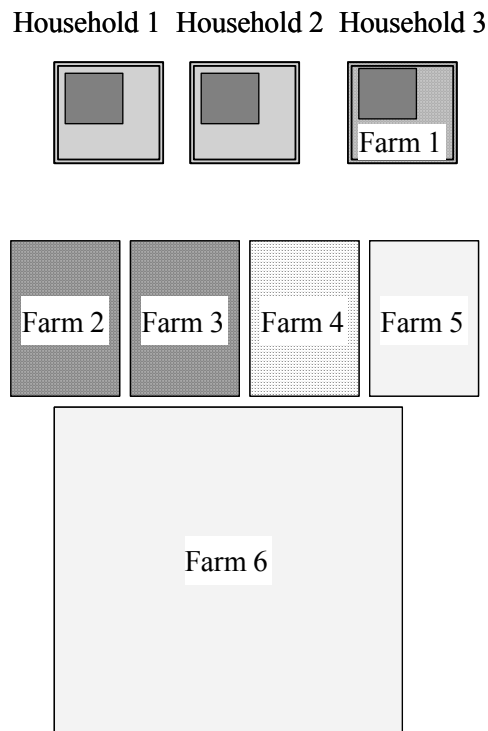


Fig 5. Tongan Community

Table 2. Applied Systems by Farmers' Type and Ownership

Household	Farmland	Ownership	Applied system	Farmers' Situation
1	2	Own	Traditional Agroforestry (Home-garden + Slash and burn)	Substantial income from commercial agriculture
	5	Rent from relative	Commercial Agriculture	
	6	Rent from the government	Commercial Agriculture	
2	3	Own	Traditional Agroforestry (Home-garden + Slash and burn)	Not enough income and do labor work for additional income
	4	Rent from relative	Commercial Agroforestry	
3	1	Own	Urban Agroforestry(Home-garden)	Work in the city

Comparison of Four Agroforestry Systems

Farmers apply each agroforestry system according to their needs, purposes and land conditions. Table 3 shows the comparison of different agroforestry systems. As of area, traditional home-garden system is applied to small acreage, 2-3 acres; slash and burn system is applied to medium size, 8 acres; commercial agroforestry is for bigger areas; and the urban agroforestry is applied to very small land, 0.5-1acre. Home-garden styles, both traditional and urban one, are found in the lands where the landowners by themselves conduct farming. Slash and burn system is seen in owned and leased lands. Commercial agroforestry, from which farmers' expectations for economic income is very high, is found in leased lands. There is a difference for the labor type among systems also. For traditional and urban home-garden styles, the landowners or their family members do most of work. For slash and burn system, landowners get paid labors for some special occasions, such as at planting, weeding and harvesting periods. For commercial agroforestry, landowners get paid labors for the intensive and short time agricultural activities. Plant components are more diverse in home-garden system and very simple in commercial agroforestry system (Thaman 1976; Kunzel 1989; Raynor 1992; Thaman 1993).

Table 3. Comparison of Different Agroforestry Systems

	Traditional Home-garden	Traditional Slash and Burn	Commercial	Urban (Home-garden)
Area	Small (2-3 acres)	Medium (8 acres)	Large (>8acres)	Small (0.5-1acre)
Land Ownership	Landowner	Landowner /Leased land	Leased land	Landowner
Distance from Residences	Close to village (Up to a couple of hours of walking distance)	Close to village (Up to a couple of hours of walking distance)	Remote from village	Adjacent to residences
Transportation	Walking, horses, vehicles, and bikes	Walking, horses, vehicles, and bikes	Vehicles	Walking
Labor Type	Landowners and family members	Landowners, family members, and sometime paid labors	Paid labors	Landowners and family members
Purposes	Household needs	Household needs and cash income	Cash income	Household needs and cash income
Number of Tree species	Diverse	A few to diverse	1 (Coconuts)	Diverse
Number of crop species	Diverse	A few to diverse	1	Diverse
Species Type	Mostly Native	Native and exotic	Exotic cash crops	Native and exotic

Current Issues in Tongan Agroforestry

Expansion of modern agriculture

Rapid expansion of modern monoculture, without integration of any tree species, is current trends of agricultural land use in Tonga. This intensive, high-input agriculture of plowing, mono-cropping and reliance of agrochemicals is mostly conducted by mostly big, rich farmers. They hire other local farmers to work for the commercial agricultural lands. The lands are repeatedly used over years for the same commercial species, mostly squash for Japanese markets. Recently, squash production for Japanese markets dramatically has expanded, from less than 1% in 1985 to 55.1% of the total exports in 1995 (Ministry of Finance 1997)

Expansion of commercial agriculture has affected Tongan traditional agroforestry as:

- ♦ Labor shortage: Local farmers leave their own farmlands to get economic income by working as labors during the growing season of commercial crops
- ♦ Land shortage: Traditional farmlands with diverse plant components are replaced with monoculture cropland due to its high economic return
- ♦ Watershed protection: Denude lands for monoculture are causing serious problems with the local watershed management (Fielea 2002)
- ♦ Environmental impacts: Introducing use of intensive agrochemicals may damage local ecosystems and reduce the biodiversity

Decline in tree density

90% of farmers are aware of that tree densities are falling in their agroforestry farmlands (Kunzel 1989) due to:

- ♦ General changes in agricultural practices, especially agricultural machine use reduced the number of trees in the lands
- ♦ Social needs have changed: more economic incomes are anticipated encouraging cash cropping and less needs for traditional tree species, such as medical, ceremonial, fiber plants
- ♦ Farmers tend not to appreciate environmental services that trees can provide such as soil protection and/or soil improvement (Kunzel 1989)

Land Ownership

There is difference in farmers' attitudes between farmers using own lands and farmers using leased lands. Farmers using own lands use the area for intensive multiple crop productions for multitude household needs considering long-term stability. In contrast, farmers who use leased lands commonly focus on optimizing economic incomes from the land during the leasing contract term, which tends to be short-term intensive, ecologically unsound agriculture management. In other words farmers change their farming styles according to their purposes: on own land, they operate traditional agroforestry—long-term land use, while on leased land do commercial monoculture—short-term income.

Conclusions

- Tongan traditional agroforestry systems by themselves no longer meet current diverse Tongan social needs.
- The knowledge of Traditional agroforestry systems have developed and/or applied to other land use e.g. commercial agroforestry and urban agroforestry. The idea integrating tree species with other crop productions occurs very naturally as long as trees can directly provide Tongan social needs and have economic value.
- Tree density is declining because traditional agroforestry practices have changed and agriculture lands are expanding.
- Dramatic commercial agriculture expansion has been affecting Tongan society, local ecosystem and Tongan agroforestry systems.
- Tongan traditional knowledge is not appreciated properly by Tongan people, especially by young generations.

Suggestions

- Promoting commercial agroforestry in the monoculture lands may reduce its negative impacts on local ecosystems
- Traditional agroforestry knowledge and techniques should be evaluated adequately and transferred to younger generations
- Land use management with long-term vision should be carried out by the Tongan government

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