Background report for the formulation of a management plan for the forest and tree resources of Tonga

Report T1

SPC/APFNet Project *Capacity Building Towards Effective Implementation of Sustainable Forest Management Practices in Fiji, Tonga and Niue*

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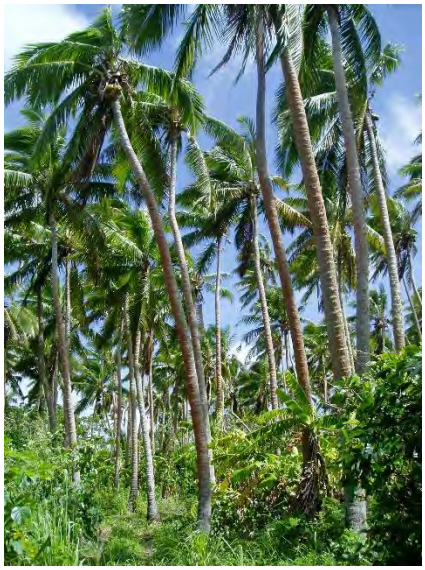

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Abbreviations and acronyms

APFNet	Asia-Pacific Network for Sustainable Forest Management and Rehabilitation
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organisation of the United Nations
FMP	Forest management plan
GDP	Gross Domestic Product
ha	hectare
km	kilometre
m	metre
MAFFF	Ministry of Agriculture, Food, Forests and Fisheries
NGOs	Non-government organizations
SFM	Sustainable forest management
SPC	Pacific Community
TFP	Tonga Forest Products

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Figure 1 – Tonga's landscape is dominated by trees

1. Summary

The landscape of Tonga is dominated by trees. The original forests have been extensively cleared and modified by more than 2,500 years of settlement, resulting in a unique mixture of agroforestry plantings, coconut woodlands and small areas of remnant natural forest and timber plantations. Trees are also an intrinsic part of the agricultural system of land use in Tonga. Overall, more than 85% of Tonga is covered in trees. Much of this tree cover falls outside of the conventional definition of 'forest' used by bodies such as the Food and Agriculture Organisation of the United Nations, which excludes land predominantly used for agriculture. However, a rigid delineation between 'forest' and non-forest' does not provide adequate recognition of the manner in which trees are integrated into the environmental, social and economic fabric of Tonga. A more holistic approach is therefore taken in this report to describe Tonga's diverse tree cover under the broader title of 'forest and tree resources'. This approach is consistent with the National Forest Policy for Tonga, which recognises that 'sustainable forest management' (SFM) includes 'forests' and 'trees outside of forests'.

This report briefly describes Tonga's forest and tree resources and the current institutional arrangements for the management of these resources. It summarises the values and benefits that the forests and trees provide and it identifies some of the threats to the sustainable management of these precious resources. The report ends with a brief summary of potential actions that could be taken to enhance the prospects for sustainable management. These actions are presented to foster further review and discussion with stakeholders as part of the current project for the development of a management plan for Tonga's forest and tree resources.

The forests and trees of Tonga provide a broad range of services and benefits, including-

- Timber
- Non-timber forest products
- Coastal protection
- Catchment protection
- Habitat for biodiversity
- Shade and shelter for crops under agroforestry systems
- Cultural and social values
- Carbon storage and climate mitigation.

The challenges for optimising the economic, environmental and social benefits of sustainable management of Tonga's forest and tree resources include-

1. Lack of inventory
2. Agricultural clearing
3. Coastal development
4. Poor logging practices
5. Unsustainable cutting of sandalwood
6. Tree removals for firewood and other purposes
7. Land tenure
8. Social and economic factors
9. Institutional capacity
10. Lack of knowledge
11. Climatic factors
12. Biological factors
13. Rubbish and pollution

14. Wood processing capacity and infrastructure
15. Markets and certification

The pursuit of sustainable management of Tonga's forest and tree resources will require creative and practical approaches that enhance the capacity and motivation of landholders and communities to manage their resources without undue reliance on the support of governments or funding bodies.

2. Geophysical and climate

The Kingdom of Tonga comprises 172 islands with a total land area of about 750 km^2 within a sea area of about 720,000 km^2 in the South Pacific at latitudes 15 to 24 South, and longitudes 173 to 177 West. The main island groups are Tongatapu, Ha'apai, Vava'u and Niuas.

The geology and soils of the islands are volcanic and coral in origin. The main islands are formed from uplifted limestones to a height ranging from up to 70 m on the low lying islands of Tongatapu and Ha'apai and up to 210 m on Vava'u (Roy, 1990) and 312 m on 'Eua (Wilde, 1983). All islands have well-developed soils principally derived from volcanic ash (tephra) up to 10 m in depth (Roy, 1990). Soils are shallower on ridge tops and sloping ground.

Soils are generally very fertile. The clearing of forest results in a large net loss of soil C and a decline in soil fertility due to deficiencies in minerals such as N and P (Hart, et al., 1981). These effects are mitigated under the traditional system of agroforestry and rotational bush fallow but they may be exacerbated by more intensive forms of agriculture ((Manu, 2014) (Stevens, 1999).

Tonga has a tropical climate with an annual rainfall varying from 2500 mm in the northern islands to 1700 mm in the southern islands with about 60-70% of rain falling during the wet season (November – April) (Tonga Meteorological Service, 2015). Mean annual temperature for Tonga ranges from 23-28^{0}C with a mean humidity of 75%. Daily temperatures are highest in February and coolest in July-August. Winds over Tonga are dominated by the south-east trade winds all year round. Tropical cyclones are confined to the wet season with an average of one to two cyclones per year.

Tonga's climate varies considerably from year to year due to the El Niño-Southern Oscillation. El Niño events tend to bring cooler dry seasons, drier wet seasons, prolonged droughts and a higher frequency of cyclones than normal. The La Niña phase of the Southern Oscillation usually brings wetter than normal conditions (Tonga Meteorological Service, 2015).

3. Forest types and area

The landscape of Tonga is a product of more than 2,500 years of human settlement. More than 90% of the original vegetation has been modified through agricultural practices, which have produced the present day mosaic of crops and trees.

There is currently no forest classification or inventory available for the forest and tree resources of Tonga. Estimates of forest type and area are provided in Table 1. Native forest covers less than 10% of the land mass and it occurs mainly as small remnants in steep, inaccessible or remote areas and coastal strips, swamps and mangroves. A small forestry plantation of 500 ha is situated on 'Eua. Much of Tonga is dominated by coconut woodlands, which form an overstorey of variable density above grassland, shrubland and cropland. Overall, more than 85% of Tonga is covered in trees.

Most of this area is not classified as 'forest' according to the FAO definition of forest[1] because the land is used predominantly for agriculture (FAO, 2012). However, the concepts of 'forest' and 'sustainable forest management' are much broader in Tonga than in other countries as they encompass both areas that are dominated by trees as well as other parts of the landscape where trees are integrated into agricultural and other forms of land use. Tonga's National Forest Policy defines 'forestry' as *the economic, social and environmental interaction of forests, and trees outside of forests, with people*.

In summary, Tonga has a small area of 'forest' but an extensive cover of trees that are an intrinsic part of the landscape (Figure 1).

Table 1– Estimated forest and tree cover in Tonga (hectares)[2]

Land class	area/%	Island Group					Total
		Tongatapu	Vava'u	'Eua	Ha'apai	Niuas	
woodland	ha	619	1,133	1,454	2,450	802	6,458
	%	2	9	17	19	11	9
coconut	ha	22,340	10,079	6,553	8,199	3,924	51,095
	%	82	79	74	63	55	74
forest plantation	ha	0	0	500	0	0	500
	%	0	0	6	0	0	1
mangroves and wetlands	ha	1,319	373	0	0	76	1,768
	%	5	3	0	0	1	3
non-forest	ha	2,809	1,113	300	2,330	2,315	8,867
	%	10	9	3	18	33	13
total area	ha	27,087	12,698	8,807	12,979	7,117	68,688

3.1 Native forests, woodlands and mangroves

The vegetation of Tonga has been classified into 17 communities: herbaceous strand; littoral shrubland; Pandanus scrub; littoral forest; coastal marsh; montane marsh; mangrove forest; coastal forest; lowland forest; montane forest; summit scrub; montane scrub; lowland volcanic scrub; managed land; secondary scrub; secondary forest; and fernland (Whistler, 1992). The communities that are dominated by native tree species are summarised below (Atherton, et al., 2015).

Lowland forest is dominated by species such as *Calophyllum neoebudicum* (tamanu), *Myristica hypargyraea* (kotone), *Planchonella grayana* (kalaka) and *Maniltoa grandiflora* (pekepeka). The

[1] FAO defines 'forest' as land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meters (m) at maturity *in situ*. It excludes land predominantly used for agricultural practices.

[2] from the *National Forest Policy for Tonga 2009* (Government of Tonga, 2009)

largest areas of lowland forests are located in Vava'u and 'Eua. Mature remnants are mainly restricted to remote and inaccessible areas (Figure 2 and Figure 3).

Successional vegetation and secondary growth occurs within allotments that are not being actively managed for agricultural crops (Figure 4). These regrowth stands vary in age from a few years to 20+ years and they may comprise a significant proportion of the land base in some parts of Tonga. Successional vegetation is the first phase of natural regeneration following the cessation of cropping. It occurs from ground-stored seed and seed from neighbouring trees and plants and it initially consists of fast growing and sun-loving 'pioneer' plants which provide shelter for the more slowly growing shade tolerant plants. Trees characteristic of successional vegetation include *Macaranga harveyana* (loupata), *Homalanthus nutans* (fonua mamala) and *Hibiscus tiliaceus* (fau (beach hibiscus).

In the continued absence of burning and clearing successional vegetation will become 'secondary growth forest' (Figure 4). Common secondary growth forest trees include *Rhus taitensis* (tavahi), *Alphitonia zizyphoides* (toi), *Elattostachys apetala* (ngatata), *Grewia crenata* (fo'ui) and *Glochidion ramiflorum* (masikoka). Under favourable conditions undisturbed secondary growth forest may complete the succession to lowland forest.

Figure 2. Remnant native forest is reserved in the Mt Talau National Park, Vava'u

Figure 3. Remnant forest on the steep coast of 'Eua

Figure 4. Secondary growth of native forest on Ha'apai

Sandalwood is an important commercial species of the lowland forest. Only one species, *Santalum yasi*, occurs naturally in Tonga. This species is native to Fiji and genetic studies have found no significant genetic variation between populations within the two island groups *(Huish, et al., 2010)*. The Indian sandalwood, *S. album*, has been introduced to Tonga where it grows very well and readily hybridises with the local *S. yasi*.

Sandalwood is reported to have been widely distributed throughout Tonga in the past but natural stands are now restricted to small remnants of native forest. The densest natural populations exist on the island of 'Eua and they contain about 50-60 trees per hectare but most of these are less than 50 cm in height and there are only about 1.3 to 1.6 trees per hectare of harvestable size (Huish, 2008). Elsewhere in Tonga sandalwood occurs within uncultivated bush allotments (Figure 5) and in gardens and town allotments that have been established from the planting of nursery seedlings or from the transplantation of wildlings. Ongoing harvesting of young sandalwood and a low level of replanting are the major factors contributing to the ongoing decline of the sandalwood population.

Figure 5 – Sandalwood sapling in secondary growth on Ha'apai

Littoral forest occurs as a narrow band of salt tolerant plants that grow from the high water mark to 5 or 10 m elevation. The native tree species are *Hernandia nymphaeifolia* (fotulona), *Tournefortia argentea* (touhuni), *Guettarda speciosa* (puopua), *Xylocarpus moluccensis* (lekileki), *Excoecaria agallocha* (feta'anu), *Terminalia catappa* (telie) and *Allocasuarina equesisetifolia* (toa).

Mangrove forest is common on Tongatapu and Vava'u (Figure 6). The three most typical mangrove species are *Rhizophora mangle* (tongo), *Rhizophora stylosa* (tongo), and *Bruguiera gymnorrhiza* (tongolei). Mangroves thrive in saline, waterlogged, anaerobic situations where other trees cannot grow.

Figure 6. Mangrove forest at the water-line with native forest secondary growth on higher slopes, Vava'u

3.2 Forest plantation

Tonga's only major forestry plantation is located in 'Eua. It comprises approximately 500 hectares of predominantly Caribbean Pine (Figure 7), with minor but important plantings of red cedar, mahogany and other species. The plantations were managed by the Forestry Division until 2003, when the forests and associated assets were transferred to a Government Public Enterprise, Tonga Timber Limited, now Tonga Forest Products Limited (TFP).

The current management of the plantations falls well short of optimising their full economic potential. The pine stands are healthy and vigorous but most are overstocked. The mixed stands contain reasonable stocking of red cedar, but this species is largely sub-dominant and suppressed within the mixed stands. The plantations are currently harvested at levels well below the sustained yield of 3,000 m^3 p.a.

There is also a small pine plantation of approximately 50 ha within the Queen's estates. This plantation also has very good growth rates but it is generally unthinned and overstocked.

Figure 7 – Pine plantation in 'Eua

3.3 Coconut woodland

Coconut woodland covers 74% of the country (Table 1). Under section 74 of the *Land Act 1988* every tax allotment is required to have 200 coconut trees planted in rows 9m apart or 4.5m apart in rows 18m distant from each other. This legislative provision was introduced through amendments to the Act in 1936 and 1980 but it is not enforced. Throughout Tonga many of the natural and planted coconut stands are relatively old (Figure 8) and there are no strategies for replacing and managing the resource in the longer term. An inventory of the coconut resource in 1996 by New Zealand Landcare Research (Burrows, et al., 1996) found that the number of coconut trees had declined by 27% over the previous 17 years due to clearing for intensive cropping for squash and for timber utilisation. Marked differences occurred between islands, with a loss of 39.5% of coconut trees on Vava'u, 36.0% on Tongatapu and 9.9% on Ha'apai. The rate of loss may have slowed in recent years with the collapse of both the squash export trade and the coconut wood sawmilling sector but the population continues to decline as a result of natural loss and continued clearing without sufficient re-planting. Some trees are used for firewood or posts but much of the timber resource is simply wasted as there are no current markets or incentives for commercial utilisation.

The Forestry Division has an active program to encourage coconut replanting, particularly on sites previously cleared (e.g. for squash production). The nursery on Tongatapu provides coconut seedlings and technical advice and assistance to landholders at no cost. The Division in 2009 aimed to replant about 250 ha with 15,000 seedlings. It achieved about one-third of this target.

The coconut replanting program has been a matter of importance to the government for three basic reasons. First, the production of copra has been an important industry for Tonga in the past and whilst the sales are now significantly lower, there is a hope that the markets will improve again in the future with the opportunity of new markets, e.g. for biofuels. Second, the coconut resource is rapidly approaching senility. The population has a normally distributed (bell-shaped) age class structure, with a mean age of approximately 45 to 50 years and a marked deficiency of younger age classes. New plantings are necessary to maintain the population into the future. Third, whilst there is little local use of the timber, there is potential to develop new processing options and markets for products such as flooring and furniture.

Figure 8. Coconut woodlands cover much of Tonga but much of the resource is senile

3.4 Other tree resources

Other than coconuts, trees have been extensively planted throughout Tonga for many purposes, including shade and shelter for agricultural crops, and the provision of fruit, timber and firewood. The main species planted are Caribbean pine, breadfruit, eucalypts, mahogany, kauri pine, teak, sandalwood and red cedar (see Appendix 1 – Main tree species, for the scientific and Tongan names).

The distribution and abundance of such plantings is unknown. Although the resource is small and scattered the plantings are potentially a high value resource. The features of this resource can be summarised as follows (Wilkinson, 2010)-

i) Species such as red cedar, mahogany, teak, kauri pine and others grow very well, with no major pests or diseases. High value merchantable size classes can be achieved within 30 years.

ii) The current volume of the resource is likely to be low and declining because of ongoing removals and a lack of replacement plantings over recent years.

iii) The value per stem is potentially very high. The international demand for fine quality timbers from sustainable sources is high and likely to remain so.

iv) The resource is currently being wasted, used for firewood or sold for a fraction of its potential value. A continuation or increase in the current level of felling will rapidly exhaust the resource and landholders will receive only a fraction of the otherwise substantial financial returns that would be available under a better marketing framework. Urgent inventory and management strategies are needed to maximise the current and future value of this resource.

Timber species (mainly pine) currently account for only 13% of sales from the forestry nursery in Tongatapu. The production of high value tree species ceased in about 2003 due to a lack of demand.

Figure 9 - Red cedar planted in a tax allotment in Tongatapu

4. Land Tenure

The land tenure system in Tonga is based on the Constitution of 1875 and the *Land Act* of 1882 (and subsequent revisions). These instruments provide that all land is the property of the Crown and that it may not be sold but it may be allocated or leased. Two principal forms of allocation exist: hereditary estates held by nobles; and allotments granted to Tongan males. Other land includes the royal estates and government land. Section 7 of the Land Act provides that every male Tongan upon reaching the age of 16 years is entitled to receive *a grant of land not exceeding 3.3387 hectares as a tax allotment* and *an area not exceeding 1618.7 square metres in a town as a town allotment* (s 7). Tax (bush) allotments may be extended to five hectares in certain circumstances (s 46). Once the plot is registered, the leasehold becomes perpetual, inheritable by the eldest son. Men who do not inherit an allotment may seek to acquire a vacant allotment. However, because of the growth of the population, the proportion of eligible males who can acquire garden allotments in their own names has been continuously reduced. The scarcity of unallocated land and the insecurity of existing allotments has prompted calls for land tenure reform (Kennedy, 2012).

Landholders have rights to cultivate their land as they see fit. An allotment may be forfeited under section 68 of the *Land Act 1927* for failure to plant coconut trees (see section 3.3 Coconut woodland, above) or if the land is not cultivated for a period of three years. However, these provisions are not enforced and a significant number of allotments have been abandoned by Tongans living abroad. Abandoned land is often considered to be degraded although some of it contains trees and secondary growth that contributes to Tonga's extensive tree cover.

5. The management of forests and trees

The management of the forest and tree resources in Tonga is very different to that which is normally encountered in other countries for the following reasons-

- The area of 'forest' is very small but the area of tree cover is very high. Most tree cover occurs as a component of agroforestry systems of land use within allotments (Figure 10)
- The timber resources are very small and are managed mostly under individual private holdings (allotments) of 3.3 and 5 hectares in area
- Basic road access already exists and there is little justification for substantial construction or upgrading of roads for forestry purposes.
- The environmental risk of forestry and tree felling operations is generally low due to the small scale of operations, predominantly gentle topography, relatively low risk of erosion and an absence of streams.

Whilst trees are ubiquitous in the landscape the involvement of most Tongan landholders in tree planting and felling is relatively infrequent and small scale and predominantly for their own use for products such as firewood, fence posts and buildings. These operations in general do not warrant measures such as individual forest management plans or detailed operational plans. However, social and economic changes associated with increasing urbanisation and transition towards a cash economy may affect the future management of forests and trees. Accordingly, current and future landholders need access to good information about the sustainable management of the forest and tree resources. In addition government and society need to ensure that the economic, social and environment benefits are equitably shared in a manner that recognises both the private rights of landholders and the public goods and services that forests and trees provide to the broader community.

Figure 10 - Trees are an integral part of Tonga's system of agroforestry

6. Legal and policy framework

6.1 Legislation

The primary legislation relevant to forestry and tree management in Tonga is summarised in Table 2.

The principal legislation for forestry is the *Forests Act 1961*. This Act is now outdated and it has been subject to a process of revision since 2009. The latest revision has been incorporated into a draft Forests Bill 2015, which was prepared following consultations with government ministries and agencies, non-government organisations (NGOs), district and town officers and interested members of the public. The main provisions of the Bill are as follows-

(i) clarify the functions of the Ministry and the Forestry Division, in relation to the management of forest and tree resources in Tonga;
(ii) provide overriding principles for the exercise of functions of the Ministry;
(iii) incorporate environmental issues and values;
(iv) incorporate empowering provisions to give effect to the National Forestry Policy and the draft Sandalwood Regulations of the Ministry;
(v) update licensing requirements under the Act; and
(vi) update enforcement provisions under the Act.

Table 2 – Legislation relevant to forests and tree resources

Act or regulation	Main provisions relevant to forestry
Biosafety Act 2009	Regulates the development, use and movement of living modified organisms and the application of modern biotechnology
Birds and Fish Preservation Act 1915 (revised 1988)	Provides for protected species of birds and fish; prohibits damaging activities, including the clearing of mangroves, in declared protected areas.
Business Licences Act 2002 (amended 2012)	Requires a person carrying on any business activity for the purpose of generating revenue in trade, commerce or industry to hold a business licence.
Customs and Excise Management Act 2007	Provides controls on the import and export of products
Environmental Impact Assessment Act 2003	Requires environmental impact assessments (EIAs) for development projects, including- the removal of trees (including mangroves) or natural vegetation > 0.5 ha; and the operation of a sawmill cutting > 2,000 m^3 of timber.
Environmental Impact Assessment Regulations 2010	Sets out the procedures and fees for EIAs.
Environmental Management Act 2010	Establishes the Ministry of Environment and Climate Change to ensure the protection and proper management of the environment and the promotion of sustainable development; provides powers to stop any activity that is causing environmental harm.
Forests Act 1961 (rev 1988)	Provides for the setting aside of land as forest areas or reserved areas and for the control and regulation of such areas and issuing of licences to take forest produce.
Forest Produce Regulations 1979 (Cap 126A)	Requires any person who wishes to export any forest produce to apply for approval of the Director of Agriculture, Forests and Fisheries or duly authorised officer.
Land Act 1927 (rev 1988)	Sets out the ownership of land and the manner in which land may be allocated and leased and related matters (see section 4 of this report).
Land (Timber) Regulations 1967 (rev 1988)	Requires any person who wishes to cut or remove timber from any Crown land to obtain a permit and pay royalties to the Minister.
Land (Removal of Sand) Regulations 1936 (rev 1988)	Prohibits the taking or removal of sand from the foreshore or from Crown land or any other holding without a permit signed by the Minister.
Noxious Weeds Act 1906 (rev 1988)	Provides that any owner or occupier who fails to use every means to eradicate a noxious weed from his holding shall be guilty of an offence and liable to a fine.
Parks and Reserves Act 1977 (rev 1988)	Provides for the establishment of a Parks and Reserves Authority and for the establishment, preservation and administration of parks and reserves; prescribes offences, including removing or causing damage to any feature within a park or reserve.
Pesticides Act 2002	Regulates the registration, manufacture, import, sale, storage, distribution, use and disposal of pesticides.

Act or regulation	Main provisions relevant to forestry
Plant Quarantine Act 1981 (rev 1988)	Provides that plant material may not be imported into Tonga unless a permit has been issued by the Minister under such conditions and regulations as the Minister may prescribe
Public Enterprises Act 2002	Sets out the objectives, rules and procedures relating to public enterprises (including Tonga Forest Products)
Renewable Energy Act 2008	Regulates the use of renewable energy, which includes biofuels, biomass and plant resources.
Roads Act 1920 (rev 1988)	Requires every land occupier adjoining a public road to cut down or lop away trees or shrubs so as to prevent the same from overhanging the public road.
Tonga Tourism Authority Act 2012	Provides that environmental impacts from tourism developments are to be minimised, and due regulatory processes are to be applied to ensure the protection and conservation of biodiversity, water resources and terrestrial and marine environments.
Tonga Water Board Act 2000	Provides the Board with powers to enter land and carry out works, including diverting watercourses and removing trees that may interfere with infrastructure.
Sandalwood Regulations 2015 (not yet proclaimed)[1]	Sets out a regulatory regime for the harvesting and trade of sandalwood, including requirements for the tagging and recording of all harvested sandalwood.

[1] The Sandalwood Regulations 2015 were prepared following extensive consultations with stakeholders. The Regulations are not yet in effect. The main elements of the Regulations are as follows –

(a) a sandalwood grower or trader must register with the Forestry Division;
(b) a tagging system is established to provide for the tagging and identification of sandalwood trees in order to provide verification of a sandalwood source and to discourage theft;
(c) a sandalwood exporter must apply to the CEO of the Ministry for a license to export sandalwood and certain fees apply;
(d) a Sandalwood Appeals Tribunal is established to review decisions of the Chief Executive Officer relating to the issuance of a Sandalwood Export License;
(e) a system for determining prescribed fines is established; and
(f) offences and penalties for the violation of the regulations are established.

6.2 Policies, strategies and codes of practice

The primary instruments relevant to forestry are summarised in Table 3. These are primarily strategic documents other than the two codes, which are regulatory in nature. The codes are not legally enforceable at present due to the lack of powers to apply and enforce them under current legislation. This situation is being addressed through the inclusion of powers in the draft Forests Bill.

The objective of the National Forest Policy is *to support the management of the forests and trees of Tonga in a sustainable manner to provide benefits for current and future generations of the Tongan people. This includes indigenous forests, planted exotic forests, agroforests, and trees on farms and in urban communities. Implicit in this objective is the requirement to manage the forests and trees for the conservation of biodiversity, soil, water and other environmental values, as well as for*

economic and social benefits. The inherent impacts of climate change, growing urbanisation and globalisation have been closely considered.

Table 3 – Instruments relevant to forests and tree resources

Instrument	Main relevance to forests and trees
Code of Harvesting Practice for the 'Eua Forestry Plantations 2009	Prescribes the required forest practices for the harvesting and reforestation of the 'Eua plantations
Code of Practice for the Sustainable Management of the Forests and Tree Resources of Tonga 2010	Sets out the desired management practices for forests and trees in Tonga
Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management 2010-2015	Includes increased protection of coastal trees and increased tree planting as actions to combat climate change
National Biodiversity Strategy and Action Plan 2006	Contains strategies to improve the conservation of biodiversity in forests and other ecosystems
National Forest Policy for Tonga 2009	Sets out the policy objectives for the sustainable management of the forests and trees of Tonga

6.3 Institutional arrangements and capacity

The legislation and policy instruments relevant to forests and trees in Tonga are administered by a range of government ministries. The primary legislation for forestry is administered by the Ministry of Agriculture and Food, Forests and Fisheries (MAFFF). The Forestry Division of MAFFF has responsibility for tree seedling nurseries, extension work and monitoring of forestry operations on 'Eua. The work of the division falls under the Head of Forestry, who is assisted by forest officers in Tongatapu, 'Eua, Vava'u and Ha'apai. The forestry officers have a mixture of tertiary and technical qualifications in forestry or agriculture. There are no formal training courses in forestry in Tonga; most officers have received assistance to gain technical or professional qualifications in forestry from overseas institutions, mainly in New Zealand, Fiji and Papua New Guinea. The division has a high degree of expertise in nursery management and tree species selection and silviculture. There is little capacity and less expertise in the fields of timber processing, utilisation and marketing.

The forest plantations on 'Eua and the sawmills on Tongatapu, 'Eua, Vava'u and Ha'apai were managed by the Forestry Division up until 2003, when they were transferred to a Government Public Enterprise, Tonga Timber Limited, now Tonga Forest Products Limited (TFP). The Forestry Division has no direct role in the operations of TFP although under the *Code of Harvesting Practice for the 'Eua Forestry Plantations 2009* it retains responsibility for the approval of timber harvesting plans, the approval of chemical use and for reviewing and publishing the outcomes from monitoring reports that are required to be submitted by TFP.

The placement of the divisions of agriculture and forestry within MAFFF was intended to foster close cooperation and collaboration on cross-sectoral topics such as coconut planting and agroforestry. In practice the degree of collaboration has been variable and this has led to inconsistent advice from the ministry to landholders on tree management. Various projects have identified the need for agricultural extension officers to better understand and promote the benefits of trees (Wilkinson, 2015). Similarly there is a need for forestry officers to better quantify the costs and benefits of trees, including the nett effect on agricultural crops that are grown under agroforestry regimes.

Figure 11 – The Forestry Division has substantial expertise and experience in managing nurseries for tree seedlings

The responsibility for the administration of the Land Act falls within the Ministry of Lands, Survey and Natural Resources (MLSNR). The ministry includes the Department of Environment and Climate Change (DECC), which is responsible for environmental management, including national parks and reserves, environmental impact assessments, monitoring and reporting on the state of the environment, including biodiversity.

The above agencies have limited budgets to undertake their activities. The Forestry Division does not have the internal capacity to undertake many core functions, such as inventory, monitoring and reporting, research and development. World-wide trends show a decline in public funding for forest management as governments address the priorities of health, education, infrastructure and law and order. Tonga is not immune from this trend. Much of the work done by the Forestry Division is dependent on technical and financial support from international donors, which is subject to the vagaries and competitive nature of international aid. One of the upsides of this is that forestry officers have had good opportunities for study and training at overseas institutions as well as continuing education through attendance at regional and international workshops. The downside is that officers are often absent from their workplace. The frequency and duration of projects, many of which are of peripheral relevance to forestry priorities in Tonga, can seriously disrupt the core business of small organisations with limited staff and cause 'workshop fatigue' in key staff.

7. Forest and tree values

The direct economic value of forestry to Tonga is modest, representing 1.6% of Gross Domestic Product (GDP) (Government of Tonga, 2010a). However, the indirect value of forests and trees to the economic, social and environmental well-being of Tongans is substantial.

The forests and trees of Tonga provide a broad range of services and benefits (Figure 12), including-

- Timber
- Non-timber forest products
- Coastal protection
- Catchment protection
- Habitat for biodiversity
- Agroforestry
- Cultural and social values
- Carbon storage and climate mitigation

Figure 12. Benefits provided by forests and trees in Tonga

7.1 Timber

The plantations on 'Eua produce mill logs, poles and posts for domestic processing and consumption (Figure 13). In recent years the rate of cut has been around 700 m^3 per year, which is well below the sustainable yield of 3,000 m^3 per year.

The coconut wood resource is very extensive but the milling capacity and market for coconut wood has declined to virtually nil.

Timber is harvested from allotments for local use but the quantity is not known and local milling capacity is very limited (see section 8.14). Wood for carvings and handicrafts is important for local use and trade (Figure 14). As noted above (section 3.4) Tonga has a small but potentially high value resource of timber species planted in tax allotments. Many landholders are not aware of the potential value of these trees. As a result, the resource is currently often wasted or used for low value purposes such as firewood (Figure 28). There is currently little interest in new plantings.

Figure 13 – The pine plantations on 'Eua provide employment and timber for local use

Figure 14 – Wood carvings in Tongatapu for local use and for sale to tourists

Firewood is an important energy source for cooking for many families. It has been increasingly replaced by bottled gas and electricity for everyday cooking but it remains as the preferred fuel for traditional purposes, such as *umu* (Figure 15). In Tongatapu and Ha'apai firewood is increasingly in short supply. In Vava'u and 'Eua solid firewood is still relatively plentiful from the clearing of secondary growth on allotments. Most of the solid wood used for firewood comes from dead trees killed by burning and ringbarking during clearing operations for agriculture. Individual trees on allotments are also killed and allowed to dry out for firewood by heaping and burning debris around the base of the tree. There is little active replanting of trees for firewood and the future supply will largely depend upon the continued clearing of secondary growth on allotments. Most firewood is collected by families for their own use. There is a small trade in firewood, mainly in Tongatapu (Figure 16).

Sandalwood has been extensively harvested in Tonga for hundreds of years but overcutting and illegal harvesting has resulted in production levels falling from an average of 60 tonnes per year in the period 2002 to 2008 to less than 2 tonnes in 2009 and 2010. Landholders are very keen to plant sandalwood and the planned introduction of a regulatory regime to discourage illegal cutting will do much to foster the development of a significant sandalwood sector in Tonga.

Overall, the domestic consumption of sawn timber and roundwood (excluding firewood) is about 8,000 m3/year, most of which is imported, resulting in a trade deficit of more than TOP 4 million per year (Government of Tonga, 2009).

Figure 15 – Firewood is widely used for the traditional umu

Figure 16 – Firewood for sale in Nuku'alofa

7.2 Non-timber forest products

Fruit trees such as coconut, breadfruit and mango are important agricultural commodities. In addition to fruit for local consumption they provide shade and shelter and they contribute to the maintenance of habitat for biodiversity. The timber from fruit trees can be used for a variety purposes, including canoes, furniture, handicrafts and firewood. Fruit trees account for 61% of total agricultural species and their contribution is increasing due to the introduction of improved varieties from North Queensland, Australia (Government of Tonga, 2010b).

The fronds and leaves of species such as coconut and pandanus are used for products such as baskets, mats and linings for buildings (Figure 18). Tapa cloth (*ngatu*) is an important traditional material made from the pounded inner bark of various trees, such as the paper mulberry and breadfruit. The traditional Tongan *ta'ovala* dress mats are made from materials such as pandanus leaves and hibiscus bark.

Medicinal, ceremonial plants and special trees (e.g. for carving) are becoming very scarce in Tonga. The ongoing harvesting of these products greatly exceeds their replacement through natural regeneration or replanting. Individual trees and plants are highly valued by landholders and by the local community. A list of high conservation value species has been prepared for Tonga, but there is no legislated process for the management of these species. Of the 60 plant species that are listed as threatened 55% are used for traditional medicines and other purposes, 38% are used for cultural and other purposes and 33% are used for timber and other purposes (Government of Tonga, 2010b).

Figure 17 – Fruit from trees such as breadfruit (left) and coconut (right) are staple foods in Tonga

Figure 18 - Coconut palm fronds are used for traditional products such as baskets, mats and building linings.

7.3 Coastal protection

Coastal erosion by storm events is a major concern in Tonga, particularly for the low lying island groups such as Tongatapu and Ha'apai. Trees provide the first line of defence against damaging winds and storm surges: tree roots bind the soil and help to reduce erosion and tree canopies help to protect inland areas from the effects of wind and salt-blow (Figure 19). Mangroves play a key ecological role in filtering sediments, stabilising and protecting coast-lines from erosion and providing important habitat for fisheries and coastal bird populations.

Figure 19 - Littoral forest provides the first line of defence from winds and storm surges

7.4 Catchment protection

Most of the water for human use in Tonga comes from the direct collection of rainfall or from underground aquifers. Much of the topography is flat and there is little surface drainage. On islands with steeper slopes trees and ground vegetation help to prevent erosion by binding the soil and slowing the rate of run-off. The run-off from rainfall is generally rapidly absorbed into the porous soil profile and the surface drainage channels do not carry water once the rainfall event has subsided. Nevertheless, careful management of catchments in hilly or steeper areas is important to minimise erosion and the movement of sediment into surface and sub-surface drainage features (Figure 20).

Tonga's main plantation resource was established within the 'Eua water catchment to replace the previous agricultural land use. Agricultural practices were believed to be causing high levels of turbidity in the water supply because of the regular cycle of soil disturbance and exposure through cultivation and burning. In contrast, forest plantations provide long term protection of the soils providing that forest roads and logging operations are carefully managed in accordance with the code of harvesting practice.

Figure 20 – Sediment channel in the 'Eua water catchment. Trees and ground layers protect the water quality in the catchment by filtering the run-off.

7.5 Habitat for biodiversity

Given the very low proportion of native forest left in Tonga, the remnant forests are critically important as the primary habitat for many plants and animals (Figure 21). Individual trees across the landscape also contribute to the maintenance of biodiversity by providing food and habitat for many species.

The flora and fauna of Tonga is relatively small and the rate of endemism is low, which is typical of geographically isolated, small islands with low elevation. There are an estimated 581 species of plants, 45 birds, 23 mammals and 16 reptiles (Government of Tonga, 2010b). It is estimated that about 80% of the plant species, 65% of reptiles and 5% of birds and mammals are threatened; however less than 16% of Tonga's species have had a formal assessment of their conservation status (Government of Tonga, 2010b).

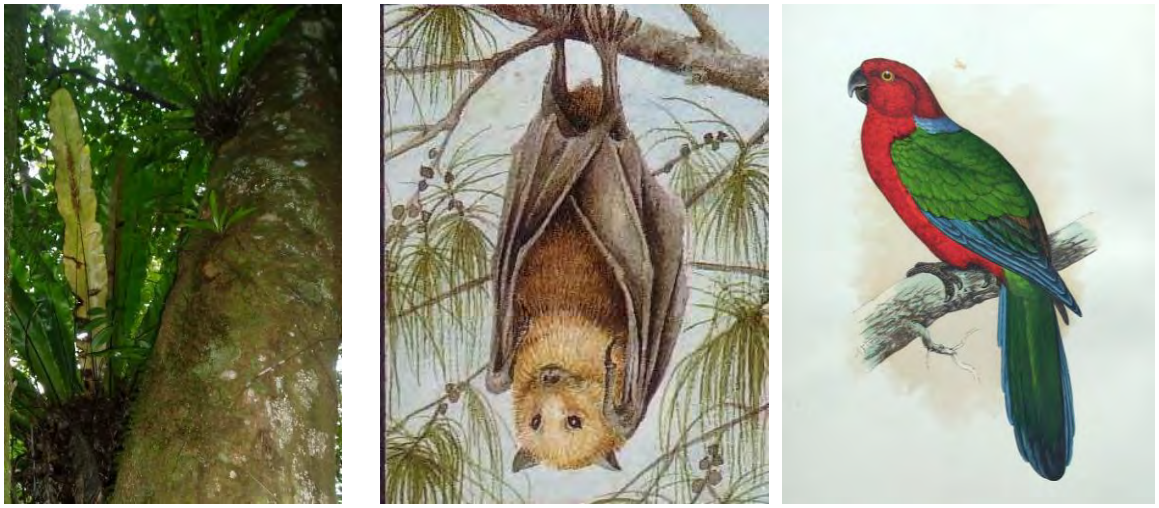

Figure 21 – Forests and trees provide habitat for other plants and for animals

7.6 Agroforestry

Trees are an important component of the agroforestry systems used in agriculture, which contributes 49% to GDP (Government of Tonga, 2010a). Agroforestry has been practiced in Tonga for over 2,500 years (Stevens, 1999). It comprises the planting of agricultural crops under a partial overstorey of scattered native and/or introduced trees, including coconuts. Trees provide shade and shelter for the crops and they demarcate the allotment boundaries. Agroforestry has long been recognised as a highly sustainable form of land use in Tonga-

While the original colonizers of the Pacific clearly had significant effects on the topography and biology (especially the bird life) of the islands they colonized, the islanders imported and rapidly established agroforestry systems that remained productive for as long as 2,500 years. These agroforestry systems represent impressively sustainable production systems …… (Stevens, 1999).

Row plantings along allotment boundaries are the most common form of tree plantings. Single rows are generally the rule, with occasional double or multiple rows of single or mixed species. Pine is the preferred species because of its fast growth rate. However, high value species also achieve very impressive growth rates in allotment plantings. Pines have been used effectively as nurse crops to achieve good form in species such as red cedar, which can otherwise assume an open-grown habit. Ongoing management is important as a lack of thinning can result in suppressed trees. Excellent stands of high value species have been achieved where the nurse species have been thinned or removed to maximise growth on the retained stems.

Current day landholders in Tonga continue to believe that trees can help to improve the productivity of agricultural crops (Wilkinson, 2015). Trials sponsored by SPC have demonstrated the benefit of partially retained secondary growth canopy on the growth of root crops and kava (Figure 22). However, there is generally a paucity of quantitative data on the impacts of tree cover on the growth of various agricultural crops in Tonga.

Sandalwood is a highly preferred tree species for planting within allotments because of its smaller size, shorter rotation length and higher commercial value than other high value timber species.

Figure 22 - Agroforestry trials in Tongatapu– healthy growth of taro below a partial canopy of trees (left photo) compared with poorer growth in an open plot (right photo)

7.7 Cultural and social values

Forests and trees are an integral part of the landscape and culture that are enjoyed by Tongans and visitors (Figure 23). They provide the materials for cultural, handicraft and medicinal purposes and firewood for the traditional *umu.* The products from many species such as sandalwood have a long history of traditional use in everyday life as well as ceremonies and cultural events.

Tongans continue to recognise the benefits of trees. Data from the production and sale of seedlings from the forestry nursery on Tongatapu show that ornamental, medicinal and cultural plants account for 45% of sales, with timber species (13%), coconut (7%) and kava (35%) accounting for the remainder.

Figure 23 – Forests and trees are a key part of the landscape and culture enjoyed by Tongans and visitors

7.8 Carbon storage and climate mitigation

On a global scale the nett effect of carbon emissions and storage in Tonga is minute but the principles and practice of wise management carbon are equally important in Tonga as in any other country given that the potential consequences of climate change are very serious.

Data since 1950 show a substantial variation in rainfall from year to year and a clear decreasing trend in the annual and wet season rainfall at Nuku'alofa (Government of Australia, 2011). Sea level

has risen near Tonga by about 6 mm per year since 1993, which is larger than the global average of 2.8–3.6 mm per year (Government of Australia, 2011).

The National Forest Policy recognises that Tonga has an obligation to proactively tackle the challenges of carbon emissions and climate change by reducing further deforestation and degradation and by developing strategies and actions for adaptation and for building resilience to climate change. Tonga's *Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management 2010-2015* includes increased protection of coastal trees and increased tree planting as actions to combat climate change (Government of Tonga, 2010a).

8. Threats to the sustainable management of the forest and tree resources

8.1 Lack of inventory

It will not be possible to adequately report on progress towards the sustainable management of the forest and tree resources of Tonga unless basic inventory information is available and updated on a periodic basis. There is thus an urgent need for a national inventory to gather data on the forest and tree resources of Tonga and to monitor trends in the quantity and quality of the resource over time, particularly with respect to tree species and volumes, health and condition of the forests and trees, and the biodiversity values.

Coconut resource - There is an extensive and substantial resource of coconuts, both in naturally regenerated and planted stands. Information is required on the age class structure of this resource, noting that many stands are senile with declining nut production and few younger stems. It will be difficult for Tonga to develop potential processing options for this resource unless the size of the resource and sustainable harvest level are determined.

Native forest - Much of the remnant native forest occurs within reserves and inaccessible areas, where an inventory of conservation values is more relevant and important than timber values. However, the secondary growth on abandoned allotments contains a potential economic resource that needs to be quantified through formal inventory.

Plantings of timber species - Tonga contains an unknown, but potentially valuable source of high quality timber species, which, outside of the 'Eua plantations, occur mainly as individual trees and rows of trees in allotments. In general landholders do not appreciate the potential value of these trees. As a result the trees are currently either used for firewood or are sold for relatively low prices. The lack of information about the potential value of these plantings means that there is little incentive for landholders to engage in replanting programs. The resource is therefore in decline and Tonga is potentially missing out on the opportunity for higher returns on a sustainable basis.

Sandalwood – The substantial potential economic importance of this species warrants a separate process for maintaining an up to date inventory of plantings to ensure that the trade and potential downstream processing of sandalwood are developed on a sustainable basis.

Plantation resource – Given that the plantations on 'Eua are a government resource it is important that data on the standing volume and sustainable yield are publicly available to ensure a transparent and fair process for the utilisation of this resource.

8.2 Agricultural clearing

The clearing of trees for agriculture is the main cause of tree loss in Tonga. The traditional rotational system of agroforestry and fallow can maintain a healthy and productive cover of trees across the landscape. However, the clearing of trees for intensive forms of agriculture results in a significant decline in tree cover. The first major agricultural industry for Tonga was the planting of coconuts from the 1830s, which helped to maintain tree cover but often at the cost of replacing native species (Whistler, 2011). The development of the banana industry in the 1960s heralded the first form of intensive market-crop production that resulted in the wide-scale removal of trees to facilitate cultivation and to provide timber for making boxes for shipping the bananas (Stevens, 1999). The subsequent decline of the banana export industry due to diseases was followed by the development of the export squash industry in 1987, which saw further clearing of trees. The export of squash reached a peak in 2005 before it declined significantly due to competition from other countries. The replacement of agroforestry systems with intensive agriculture offers landholders the prospect of higher financial returns but this comes at the cost of much higher environmental impacts, including higher chemical use, declining soil fertility and loss of biodiversity.

The encroachment of agriculture into forest reserves is a continuing problem (Government of Tonga, 2010b), resulting in local impacts on biodiversity and in the wasting of valuable timber resources. Such encroachments are illegal and enforcement is difficult, particularly on remote islands (Figure 24).

Figure 24 – Clearing of trees for agriculture is a regular part of the traditional cycle of cropping after fallow (left photo). Illegal encroachment causes the loss of forests in coastal reserves and other remnants (right photo)

8.3 Coastal development

The coastal vegetation in Tonga is very important for mitigating the effects of coastal erosion and salt spray. Much, but not all, of the foreshore is designated under Section 113 of the Land Act as a coastal reserve extending 15.24 m from the high watermark. This land is the property of the Crown but the Minister may approve the use of the land for wharves, jetties, residences and the cutting and removal of stone. The cutting and removal of timber is prohibited within the foreshore under the *Land (Timber) Regulations 1967* but this is poorly enforced and cutting for developments and firewood collection continues to occur in coastal fringes and mangroves.

There is overwhelming evidence of accelerated and substantial coastal erosion in many areas due to regular events such as cyclones and storm surges. Climate change projections tend to show a

decrease in the frequency of tropical cyclones by the late 21st century but an increase in the proportion of more intense storms (Government of Australia, 2011). In the worst affected areas, the coastal vegetation will only slow, not prevent, ongoing erosion and it is likely that there will be long term changes to coastal geography. Overall, the coastal vegetation serves as a critical line of defence against land loss and degradation and for this reason every effort must be made to protect the coastal reserves and hinterland. Threats to the conservation function of coastal areas include the following.

- *Clearing for buildings and other infrastructure*- Coastal fringes are attractive places for the location of residences and hotels but the clearing of the protection coastal vegetation can increase the risk of erosion and wind damage.
- *Alteration of drainage systems within mangrove and low lying areas by roads and other developments* – Roads constructed within mangrove and swampy areas have caused significant dieback of natural vegetation due to their impact on the natural drainage and salinity levels (Figure 25). The obstruction of drainage is exacerbated by the infilling of sites for residential developments. The roads also provide access for further unregulated cutting of trees for firewood and rubbish dumping.
- *Physical damage to the coastal geomorphology due to road construction and sand mining*- Small scale but locally significant impacts on coastal vegetation and geomorphology are associated with the construction of roads and the removal of sand for construction purposes. Physical loss of vegetation and ground disturbance directly threaten the stability of coastal defences by rendering subject areas more susceptible to erosion. Sand mining is often concentrated on sandy dunes or hillocks within lower lying coastal land and the physical lowering of the ground surface through the excavation of the sandy layer alters the natural drainage patterns and makes these sites prone to water logging and coastal erosion.

Figure 25 – The construction of a road and firewood cutting have resulted in the dieback of mangrove forests in Tongatapu

8.4 Poor logging practices

The operation of heavy machinery and vehicles has the potential to cause environmental harm, damage to infrastructure and injury or death to operators and other people. The environmental risk is highest in 'Eua and Vava'u where the steeper slopes are susceptible to erosion, resulting in damage to roads, the loss of soils and sedimentation of coastal waters and underground drainage systems (Figure 26).

Figure 26 – Roads that are not well built and maintained are unsafe and are a continuing source of erosion and sedimentation ('Eua)

8.5 Cutting of sandalwood

Sandalwood for many years has been a very high value commodity for the land owners and the economy of Tonga. However, the resource is now severely depleted due to overcutting and insufficient replanting, 'checking' of immature stems causing wind throw and decay (Figure 27), and the theft of trees which discourages many land owners from planting sandalwood. . The natural regeneration and replanting of sandalwood are also limited by a shortage of seed due to the low number of large, mature fruiting trees. Sandalwood has the potential to make a substantial, ongoing socio-economic contribution to the landowners and the Tongan community, but only if an effective policy and regulatory framework is implemented to promote plantings, control theft and achieve sustainable management of the resource.

Figure 27 – 'Checking' of young sandalwood causes serious damage, resulting in the decay of the valuable heartwood or wind throw of the tree

8.6 Tree removals for firewood and other purposes

Whilst much of the firewood used in Tonga is sourced from tax allotments some is taken illegally from natural forests, coastal fringes and mangrove. Trees are also removed illegally for other uses such as wood carving (Government of Tonga, 2009).

8.7 Land tenure

Insecure land tenure is a threat to the long term management of forests and trees. A conservative estimate is that insecure tenure affects at least one-third of all land in use in Tonga (Wolff, undated). Landholders who do not have secure tenure are generally unlikely to be interested in a long term commitment to the management of forests and trees and are more likely to pursue short term land uses that often result in the removal of trees.

The relatively high rate of 'abandoned' allotments in some areas is a potential short term benefit for the retention of forests and trees where these allotments have regenerated to secondary growth. However in the longer term they are a threat to sustainable forest management if they are leased or transferred to persons who wish to use the land for intensive agricultural practices.

8.8 Social and economic factors

The benefits of forests and trees include intangibles and 'common pool resources' such as an attractive landscape, biodiversity and carbon storage. These benefits are shared by the broader public without direct financial benefit to the landholder. They can be lost to the community where a landholder chooses to clear trees in order to manage the land in a manner that will optimise his/her private benefits. In most jurisdictions, including Tonga, there is a lack of mechanisms whereby the public can compensate the landholder for any loss that may be incurred through the retention of trees.

The tension between private and public benefits is exacerbated by the fact that the economic return to a landholder from trees alone cannot usually compete with the potential returns from agriculture. A notable exception to this rule is the growing of sandalwood, which not only produces a very high economic return but can do so without unduly constraining the productivity of other planted crops.

A further threat to the long term retention and management of forests and trees in Tonga is the extent to which Tongan society has increasingly changed from people living in or near their bush allotments to higher degrees of centralised, urbanised and remote habitation (Wolff, undated). The physical separation of people from the land and forests usually results in a loss of traditional knowledge and less awareness of their environmental and cultural values. Tonga's continuing transition from a subsistence to a cash-based economy also means that many landholders are encouraged to pursue short term cash crops rather than traditional agroforestry regimes.

8.9 Institutional capacity

As noted under section 6.3, the Forestry Division does not have the capacity to undertake many key functions. Tonga is unlikely to be different from other forestry agencies throughout the region which face a decline in public funding and an increasing expectation that forestry activities must become more 'self-funded' on a commercial or user-pays basis. This trend usually results in the transfer of forests and assets to more commercially-oriented government businesses (as with the transfer of the 'Eua plantations and sawmills to Tonga Forest Products) or the sale of the assets to the private sector. Cut-backs in governmental forestry budgets and staffing lead to the withdrawal of services to the public. At present, the Forestry Division is the sole provider of key services such as the provision of tree seedlings from nurseries and advice on tree selection, planting and management. There is currently no capacity within the private sector to provide some or all of these services.

The loss of institutional knowledge and capacity within government presents a threat to the sustainable management of forests and trees unless alternative mechanisms are put in place to ensure that landholders and the forest industry sector are equipped to deliver outcomes that satisfy both private interests as well as the interests of the broader community.

8.10 Lack of knowledge

Tongan landholders have a high degree of expertise and experience in the growing and use of trees as part of their traditional agroforestry regimes. However, they are less experienced in the following areas-

- Selection of species and silviculture of high value timber species for agroforestry plantings, including thinning, pruning and control of competing understory and overstorey plants
- Establishment of trees for rehabilitation purposes in coastal zones and other sensitive areas
- Rehabilitation and management of mangroves
- The establishment and management of woodlots and small plantations for timber production or other purposes (such as carbon and biodiversity)
- Management of host plants and nurse species for sandalwood
- Determining the financial maturity of potentially high value trees (i.e. the best time to harvest so as to maximise financial benefit)
- Determining the best end-use and potential markets for high value trees so as to maximise financial benefit and avoid waste (such as using high value timber species for firewood).

A lack of knowledge can lead to unsustainable practices and waste, such as the felling of high value trees for firewood (Figure 28).

Figure 28 – These red cedar trees have been ring-barked for use as firewood due to the landholders' lack of knowledge of their potentially high value as timber trees ('Eua)

8.11 Climatic factors

Rising sea levels, tropical cyclones and drought are the three major climate-related threats to the forests and trees of Tonga.

Rising sea levels and increased severity of storm surges associated with tropical cyclones will result in increased coastal erosion and the loss of front-line trees and vegetation fringes (**Error! Reference source not found.**). Climate change predictions suggest that whilst the frequency of cyclones affecting Tonga may decrease in the future, the proportion of intense storms may increase, resulting

in greater potential damage (Government of Australia, 2011). Cyclones and the associated salt blow cause damage to vegetation ranging from defoliation to crown breakage and complete uprooting. Tonga's vegetation is adapted to the periodic effects of cyclones and under natural conditions it will recover by re-shooting and regeneration from seed and vegetative means. However, its recovery is hampered in situations where the vegetation has been degraded or modified by human impacts and where the vegetation affected by cyclones is removed by people as part of clean-up operations or the salvage of firewood (Figure 30).

Temperatures are predicted to rise by 0.3 to 1.1^{o}C. An increase in rainfall is predicted for the wet season, with a decrease in the dry season. The overall effect of climate change on drought events is difficult to predict (Government of Australia, 2011). However, reduced rainfall and increasing periods of drought will result in increased moisture stress on trees and crops. Less rain during the dry season may also make Tonga more prone to wildfires.

Figure 29 - Coastal erosion and undermining of front-line trees, Ha'apai

Figure 30 - Storm damage to coastal vegetation is exacerbated where people clear the debris and hamper natural regeneration processes

8.12 Biological factors

Biological threats to Tonga's forests and trees include pests, weeds, diseases and gene pollution.

Weeds compete with native plants for light and moisture and they can significantly alter local vegetation patterns and lead to the localised extinction of species. Tonga's vegetation has been highly modified by the introduction of hundreds of weed species by the original Polynesian settlers and more recent European impacts (Whistler, 2011). At least 31 aggressive weed species present in Tonga have, or have the potential to have, serious ecological and economic impacts on Tonga's natural vegetation (Space, 2001). The most serious are- *Adenanthera pavonina* (lopa, coral bean tree), *Asparagus setaceus* (taupo 'ou, ornamental asparagus), *Coccinia grandis* (ivy or scarlet gourd), *Cordia alliodora* (kotia, Ecuador laurel, salmwood), *Dieffenbachia seguine* (spotted dieffenbachia or dumb cane) and *Flemingia strobilifera* (luck plant). The coral bean tree has displaced the native canopy and formed single species stands in the Mt. Talau National Park. *Cordia alliodora* was introduced to Tonga as a forestry tree and it is now becoming invasive in Tongatapu, 'Eua and Vava'u. Many other weed species within the Pacific have the potential to become major problems in Tonga and strict quarantine controls will be required to prevent their introduction to Tonga.

Tonga is relatively free from vertebrate pests. Rats, dogs and pigs were introduced by the Polynesian settlers but their impact on forests and trees is not considered to be significant, although uncontrolled pigs can have localised impacts on vegetation and soils. Wallowing of pigs in sinkholes in 'Eua is a source of soil disturbance, resulting in increased turbidity of the water supply. Pigs are also a source of mortality and damage to tree seedlings and young trees due to physical uprooting from the soil and rubbing of bark (Figure 31).

Figure 31 - Rubbing of a young sandalwood tree by pigs has resulted in serious bark damage, which will affect the growth and health of the tree

Invertebrate pests and diseases are not currently considered a major threat to Tonga's trees. Other than the pine plantations on 'Eua, there are no extensive mono-species tree plantings in Tonga. The diversity of species within the largely agroforestry landscape is credited with helping to maintain the general health of plants and ecosystems (Government of Tonga, 2010b).

The importation of seed and plants of species that hybridise with local species represents a threat to local gene pools. Tonga has only one native species of sandalwood (*Santalum yasi*), which readily

hybridises with introduced species such as *S. album*, and *S. austrocaledonicum*. Maintaining the genetic purity of *S. yasi* will require controls on the importation of plant material and the isolation of pure stands of *S. yasi* from plantings of other species of *Santalum*.

8.13 Rubbish and pollution

The dumping of rubbish in forest areas is unfortunately common in many countries, including Tonga. Rubbish can attract vermin and contaminate soils, water resources and air quality (if burnt). It is also unsightly and lowers the aesthetic and amenity qualities of many otherwise attractive and productive areas.

Poor practices relating to the maintenance and servicing of vehicles and machines can lead to the pollution of soils and groundwater from contaminants such as fuels, hydraulic liquids and discarded containers and machinery components.

Herbicides, fertilizers and pesticides can be significant pollutants although the use of these compounds in forestry operations in Tonga is currently low.

Figure 32 – The dumping of rubbish has an adverse impact on forest values

8.14 Wood processing capacity and infrastructure

Tonga has a major wood supply imbalance; it imports at least 90% of its domestic requirements (Government of Tonga, 2009) and exports are very small, mainly sandalwood billets and flitches of high value species such as red cedar. The sole plantation resource (‘Eua) is very small and it struggles to compete with the economies of scale of timber imported from New Zealand and Fiji.

There is currently very limited capacity for the harvesting and processing of timber, comprising one company (TFP), and a few small portable sawmills.

Processing of the plantation timber on ‘Eua by TFP has been limited to a portable Lucas sawmill since 2010 when the old sawmill was decommissioned. Most of the logs from the 'Eua plantations are transported by sea to TFP’s sawmill and treatment plant in Tongatapu (Figure 33). Suitable pine logs are treated and sold domestically for power poles and posts. The remaining pine is sawn to supply local timber. TFP currently only processes about one-third of the sustainable cut from the plantations. There are no data on the volume of timber that is harvested and processed from allotments, but it is likely to be low. The processing of coconut wood is very low due to a lack of suitable equipment and the very low price that has been offered to landholders.

There are approximately 4-5 portable sawmills on 'Eua in addition to the one operated by TFP. The most active is a Rimu mill with horizontal and vertical circular saws. It is used to saw red cedar logs for export to New Zealand, which provides a higher value return than local use. However, it has a wide cutting swage, resulting in high waste and imprecise cutting. A smaller Peterson sawmill has operated since about 2003, cutting local timbers, including coconut, for local housing needs. However, the mill has had little work in recent years, with the owner attributing this to a lack of local markets and an inability to compete with imported timber. A small Lucas Mill is operated by a construction company to saw small volumes of local timber for its own use.

The sawmilling capacity on Vava'u is very limited. The old TFP sawmill is not in use. Its equipment is old and poorly maintained. In the past it has successfully milled large quantities of coconut as well as other local and introduced species. There has been one portable sawmill operating in Vava'u. It is a relatively new and very sophisticated American bandsaw system brought to Tonga to cut high quality timber such as red cedar for a construction project. It has operated at a workshop site that also includes finishing machines such as planers and routers. It is not currently operating on a commercial basis and its future operation in Tonga is not known.

The only sawmill on Ha'apai (TFP) was previously used for sawing coconut logs for local construction purposes. The sawmill is no longer operating and all timber is now imported into the island.

Figure 33 – Logs from the plantations in 'Eua are currently transported by barge (left) to TFP's sawmill in Tongatapu (right)

8.15 Markets and certification

International markets are increasingly demanding evidence of sustainable forest management and verification of legal timber transactions. Formal certification schemes (such as those administered by the Forest Stewardship Council and the PEFC) have been developed to provide a framework for reporting on sustainability. Many markets, including the European Union, America and Australia, have strict requirements for demonstrating the legality of imported timber. Formal certification systems are expensive to develop and maintain, particularly for small forest holdings with only intermittent operations. Tonga currently exports very little timber but it has the potential to increase the volume and value of its timber exports, particularly sandalwood and high value timber species. Any such move could only be taken in the context of market requirements for the sustainability and legality of timber products. This will require Tonga to actively consider means by which it can meet these requirements in a practical and affordable manner. A failure to achieve accreditation of sustainable forest management and the resulting loss of market opportunities could act as a disincentive for landholders to plant and retain trees in the landscape.

9. Potential actions for sustainable forest and tree management

Tonga is faced with challenges and opportunities for optimising the economic, environmental and social benefits that sustainable forest management can bring to individual landholders, communities and to the general population of Tonga. The road to SFM will require creative and practical approaches that enhance the capacity and motivation of landholders and communities to manage their resources in a sustainable manner without undue reliance on the support of governments or funding bodies. The role of government should be to create a business and regulatory environment that encourages investment in the growing and use of forests and trees for multiple purposes. In common with other countries throughout the region, Tonga must address the declining capacity of governments to support forest and tree management by transitioning to a model in which the role of government is to foster responsible self-management by landholders and the business sector.

Options for addressing the threats to sustainable management identified in section 8 (above) are briefly listed in Table 4. These options are presented to foster further review and discussion with stakeholders as part of the current project. Final comments and findings will be used in the formulation of a draft management plan for Tonga's forests and tree resources.

Table 4 – Potential management actions for Tonga's forests and tree resources

Issue/threat	Potential management actions
1. Lack of inventory	1.1 Proceed with the proposed national forest inventory (NFI) in collaboration with a funding body. 1.2 Ensure that the assessment of biodiversity is undertaken as part of the NFI or associated projects. 1.3 Ensure that an inventory of sandalwood is undertaken as part of the NFI or as a separate ongoing inventory. 1.4 Develop a practical, cost-effective mechanism capable of being managed within internal forestry division budgets for monitoring changes in the NFI. 1.5 Publish the results of the NFI to encourage private sector investment in tree planting and utilisation.
2. Agricultural clearing	2.1 Seek to better quantify and publish the effects of trees on agricultural productivity through ongoing research. 2.2 Disseminate information on the benefits of trees, including effects on agricultural productivity and the financial returns from the use of trees for timber and carbon. 2.3 Enhance the capacity and motivation of landholders to plant and maintain trees for multiple purposes (Figure 12) through education and information 2.4 Improve the enforcement of controls on illegal tree clearing.
3. Coastal development	3.1 as for action 2.4 (Improve the enforcement of controls on illegal tree clearing). 3.2 Develop guidelines under the Land Act and the Environmental Impact Assessment Act for circumstances under which developments, including roads, buildings and sand mining, may be permitted within

Issue/threat	Potential management actions
	the foreshore zone and conditions that must be applied to mitigate any adverse impacts. 3.3 Establish and support community coastal care committees to develop and implement management plans for the rehabilitation of degraded foreshores and for the improved management of foreshores, particularly in areas most vulnerable to rising sea levels and storm surges.
4. Poor logging practices	4.1 Develop and implement monitoring and enforcement protocols for the harvesting code of practice for 'Eua and the national code.
5. Cutting of sandalwood	5.1 Implement the Sandalwood Regulations. 5.2 Develop and implement monitoring and enforcement protocols for the Sandalwood Regulations.
6. Tree removals for firewood and other purposes	6.1 as for action 2.4 (Improve the enforcement of controls on illegal tree clearing). 6.2 as for action 2.3 (Enhance the capacity and motivation of landholders to plant and maintain trees for multiple purposes (Figure 12) through education and information). 6.3 Ensure that management plans are in place and are implemented for national parks and reserves.
7. Land tenure	7.1 Develop and launch a program for landholders and lessees for the reforestation of abandoned allotments with native regrowth and/or high value timber species such as sandalwood.
8. Social and economic factors	8.1 as for action 2.3 (Enhance the capacity and motivation of landholders to plant and maintain trees for multiple purposes (Figure 12) through education and information). 8.2 Clarify at law the extent to which a landholder's use of land may be constrained in order to provide a contribution to the public good for 'common pool resources' such as biodiversity, aesthetics and carbon storage. 8.3 Develop mechanisms, where required, for situations where landholders are asked to manage all or part of their land for the public good.
9. Institutional capacity	9.1 Develop and implement a transition strategy for the transfer of knowledge and capacity from government to the private sector, including clarification of the core functions to be retained by government under future expected budgetary constraints and the role of government in fostering entrepreneurship and business development in the forestry sector. 9.2 as for action 6.3 (Ensure that management plans are in place and are implemented for national parks and reserves.) 9.3 Develop and implement procedures for regular monitoring and public reporting on the outcomes of actions taken, the standards being achieved, areas for improvement and progress towards sustainable forest management.

Issue/threat	Potential management actions
10. Lack of knowledge	10.1 as for action 2.3 (Enhance the capacity and motivation of landholders to plant and maintain trees for multiple purposes (Figure 12) through education and information).
11. Climatic factors	11.1 as for action 2.3 (Enhance the capacity and motivation of landholders to plant and maintain trees for multiple purposes (Figure 12) through education and information). 11.2 as for action 3.3 (Establish and support community coastal care committees to develop and implement management plans for the rehabilitation of degraded foreshores and for the improved management of foreshores, particularly in areas most vulnerable to rising sea levels and storm surges.) 11.3 as for action 8.3 (Develop mechanisms, where required, for situations where landholders are asked to manage all or part of their land for the public good.)
12. Biological factors	12.1 Support programs for weed control by local community groups. 12.2 Maintain strict quarantine controls for weed species. 12.3 Develop quarantine controls on sandalwood species other than *S. yasi* and *S. album*. 12.4 as for action 6.3 (Ensure that management plans are in place and are implemented for national parks and reserves.) 12.5 Develop and implement management plans to maintain the genetic purity of natural populations of *S. yasi*, including discouraging nearby planting of other species of sandalwood.
13. Rubbish and pollution	13.1 Continue to support school and community education programs to discourage the dumping of rubbish. 13.2 Ensure that landholders have access to suitable sites for the disposal of rubbish. 13.3 Review and if necessary improve and enforce regulations to control the dumping of rubbish and pollution under the Environmental Management Act.
14. Wood processing capacity and infrastructure	14.1 as for action 1.5 (Publish the results of the NFI to encourage private sector investment in tree planting and utilisation.) 14.2 as for action 9.1 (Develop and implement a transition strategy for the transfer of knowledge and capacity from government to the private sector, including clarification of the core functions to be retained by government under future expected budgetary constraints and the role of government in fostering entrepreneurship and business development in the forestry sector.)
15. Markets and certification	15.1 Continue to liaise with regional countries and agencies to develop and adopt a regional framework for the verification of legality and the certification of sustainability of forest and tree management. 15.2 As for action 5.2 (Develop and implement monitoring and enforcement protocols for the Sandalwood Regulations.)

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Appendix 1 – Main tree species

TONGAN NAME	ENGLISH NAME	BOTANICAL NAME
Kauli	Kauri	*Agathis robusta*
Mei	Breadfruit	*Artocarpus altilis*
Koka	Hiapo	*Bischofia javanica*
	Paper Mulberry	*Broussonetia papyrifera*
Tongota'ane	Mangrove	*Bruguiera gymnorrhiza*
Toa	Casuarina	*Allocasuarina spp*
Tototahi	Mangrove	*Cerbera floribunda*
Niu	Coconut palm	*Cocos nucifera*
pulukamu	Eucalypts	*Eucalyptus spp*
sialemohemohe	leucaena	*Leucaena leucocephala*
Lou'akau	Pandanus	*Pandanus lou'akau*
Paini	Caribbean pine	*Pinus caribaea*
tongolei	Mangrove	*Rhizophora mangle*
tongolei	Mangrove	*Rhizophora stylosa*
ahi	sandalwood	*Santalum yasi*
Mahokani	Mahogany	*Swietenia macrophylla*
hehea		*Syzgium corynocarpum*
	Teak	*Tectona grandis*
milo		*Thespesia populnea*
sita	Red cedar	Toona ciliata

Appendix 2 - Plant species list

Plant Species List from the Toloa Rainforest Reserve
(from Wolff (undated) reference (Wolff, undated))

TONGAN NAME	ENGLISH NAME	BOTANICAL NAME
Canopy Trees		
Feta'u	Alexandrian laurel	*Calophyllum inophyllum*
Fo'ui		*Grewia crenata*
Ifi	Tahitian chestnut	*Inocarpus fagifer*
Kalaka		*Planchonella grayana*
Kakala 'uli		*Cryptocarya turbinata*
Koka	Red cedar	*Bischofia javanica*
Kotone	Wild nutmeg	*Myristica hypargyraea*
Lopa	Red sandalwood	*Adenanthera pavonina*
Malolo or Masikoka		*Glochidion ramiflorum*
Mango	Mango	*Mangifera indica*
Manonu		*Tarenna sambucina*
Masi / Masi'ata	Fig	*Ficus tinctoria*
Mo'ota	"Selfish" tree	*Dysoxylem forsteri*
Niu	Coconut	*Cocos nucifera*
Ngatata	"Rattle" tree	*Ellatostachys falcata*
'Ovava or 'Ovava Tonga	Banyon tree / Strangler fig	*Ficus obliqua*
Pekepeka		*Maniltoa grandiflora*
Tamanu		*Calophyllum neo-ebudicum*
Tavahi		*Rhus taitensis*
Telie	Tropical/Indian almond	*Terminalia catappa*
Te'ete'emanu		*Ervatamia obtusicuscula*
Toi		*Alphitonia ziziphoides*
Sub-Canopy Layer		
Ahi	Sandalwood	*Santalum yasi*
'Ahivao	Wild sandalwood	*Vavaea amicorum*
Fa / Lou'akau	Pandanus / Screw pine	*Pandanus tectorius*

Fekikavao	Mountain apple	*Syzygium clusiifolium*
Filimoto		*Xylosma simulans*
Kanume		*Diospyros elliptica / Diospyros ferrea*
Loupata	Macaranga	*Macaranga harveyana*
Maile		*Alyxia stellata*
Masi / Masi'ata	Fig	*Ficus tinctoria*
Masikona		*Pittosporum arborescens*
Mei	Breadfruit	*Artocarpus altilis*
Moli kai	Orange tree	*Citrus sinensis*
Moli peli	Mandarine orange	*Citrus reticulata*
Nonu	Beach/Indian mulberry	*Morinda citrifolia*
Sialemohemohe	"Sleeping Siale"	*Leucaena leucocephala*
Takafalu		*Micromelum minutum*
Tanetanevao		*Polyscias mulijuga*
Tava	Pacific lychee	*Pometia pinnata*
Te'epilo 'a Maui		*Geniostoma vitiense / Geniostoma rupestre*
Tuitui	Candlenut	*Aleurites moluccana*
Volovalo	Verbena	*Premna serratifolia*
Shrub Layer		
Fau	Beach hibiscus	*Hibiscus tiliaceus*
Kavakava'ulie		*Micropiper puberulum*
Kuava	Guava	*Psidium guajava*
Lesi	Papaya / Pawpaw	*Carica papaya*
Pula		*Solanum mauritianum*
Si	Ti, Ti plant	*Cordyline terminalis / Cordyline fructicosa*
Herbs / Ground Cover		
'Akau veli	Wild indigo	*Indigofera sufructicosa*
Hiku'i kuma	Blue rat's tail	*Stachyrtarpheta urticifolia*
Hulufe	Ground fern	*Dennstaedtia parksii*
Kihikihi	Wood sorrel	*Oxalis corniculata*
Laufale	Sword fern	*Nephrolepis hirsutula / Phymatosorus scolopendria*
Mate loi	Sensitive plant	*Mimosa pudica*

Mate loi	Giant sensitive plant	*Mimosa invasa*
Mo'osipo		*Triumfetta procumbens*
Musie	Grasses	
Musie	Sedges	
Sa'afa	Guinea grass	*Panicum maximum*
Talatala	Lantana	*Lantana camara*
Te'e hoosi		*Malvastrum coromandelianum /Sida parvifolia*
Te'e kosi / Te'e pulu	Peanut weed	*Cassia toro*
Vines		
Alu	Basket vine	*Epipremnum pinnatum*
Fue mea		*Merremia dissecta / Merremia peltata*
Hoi	Aerial yam	*Dioscorea bulbifera*
Laumatolu	Wax plant	*Hoya australis*
Lautolu uta		*Vigna adenantha*
Pula vaine	"Balloon vine"	*Stictocardia tiliaefolia*
Sipi / Valai	Watervine, Drinking vine	*Entada phaseoloides*
Tutu'uli	Wild jasmine	*Jasminum betchei / Jasminum simplicifolium*
Vaine 'ae kuma	"Rat vine"	*Passiflora triloba*
Vaine kai	Passionfruit	*Passiflora maliformis*
Vanila	Vanilla	*Vanilla planifolia*