TONGA BIODIVERSITY STOCKTAKING

TECHNICAL REPORT NO. 1

FOR THE DEVELOPMENT OF A NATIONAL BIODIVERSITY STRATEGIC ACTION PLAN (NBSAP)

DEPARTMENT OF ENVIRONMENT

AUGUST 2004

Funding: GEF/UNDP

Printed: Taulua Press

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Department of Environment 2004.

Glossary of Abbreviations and Terms

ADB	Asian Development Bank
AusAID	Australian Agency for International Development
CBD	Convention on Biological Diversity
CPD	Central Planning Department
DCC	Development Coordination Committee
DOE	Department of Environment
Ecosystem	A community of organisms and the physical habitat in which they live
EIA	Environmental/ecological impact assessment
EEZ	Exclusive Economic Zone
ESCAP	Economic and Social Commission for Asia and the Pacific (United Nations)
EPACS	Environmental Planing and Conservation Section under the Ministry of Lands, Survey and Natural Resources, until July 2001 EPACS became the Department of Environment
FFA	Forum Fisheries Agency
FAO	Food and Agricultural Organization
GOT	Government of Tonga
GEF	Global Environment Facility
HABITAT	Place or type of site where an organism or population naturally occurs
JICA	Japan International Co-operation Agency
MAFF	Ministry of Agriculture, Forestry and Food
MET	Tonga Meteorological Services
MOE	Ministry of Education
MOFA	Ministry of Foreign Affairs
MCA	Ministry of Civil Aviation
MLCI	Ministry of Labour Commerce and Industry
MLSNR	Ministry of Lands, Survey and Natural Resources
MOF	Ministry of Fisheries
MOH	Ministry of Health
MOW	Ministry of Works

MOFin	Ministry of Finance
MMP	Ministry of Marine & Ports
MOP	Ministry of Police
NBSAP	National Biodiversity Strategies and Action Plan
NEMS	National Environment Management Action Strategy
NGO	Non Government Organization
Species	Scientific identification, separation and naming of organisms
SPREP	South Pacific Regional Environment Programme
SPC	Secretariat for the Pacific Community
SOPAC	South Pacific Applied Geosciences Commission
SPBCP	South Pacific Biodiversity Conservation Programme
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

TABLE OF CONTENTS:

GLOSSARY OF ABBREVIATIONS AND TERMS III

TABLE OF CONTENTS V

CHAPTER ONE 1

INTRODUCTION 1

1.0 INTRODUCTION 1

1.1 SHORT DESCRIPTIONS AND OBJECTIVES 1

1.1.1 The Process and Specific Activities 2

1.2 DEFINITION OF BIODIVERSITY 3

1.3 WHAT COVERS IN THIS STOCKTAKING REPORT AND THE PROCESS 5

1.4 BIODIVERSITY CONSERVATION PRESSSURES AND THREATS 6

1.4.1 Priority Setting for Biodiversity Conservation 8

1.5 THE NEXT STEPS 10

CHAPTER TWO 11

AGRICULTURAL BIODIVERSITY AND CONSERVATION 11

2.0 INTRODUCTION 11

2.1 ROOT CROPS 12

2.1.1 Aroids 21

2.2 FRUI & FOOD TREE CROPS 24

2.2.1 Fruit Tree Crops 25

2.2.2 Food Tree Crops 28

2.3 FRUITS 29

2.4 VEGETABLES 32

2.4.1 Other Vegetable Species 34

2.5 TRADITIONAL CROPS 36

2.6 LIVESTOCK 39

2.7 THREATS AND PRESSURES ON THE AGRICULTURAL BIODIVERSITY 41

2.8 AGRO-BIODIVERSITY GENETIC 42

2.8.1 Use of Agricultural Genetic/Biological Resources 42

2.9 INSTITUTIONAL FRAMEWORK AND HUMAN RESOURCE BASE FOR AGRO-BIODIVERSITY CONSERVATION 43

2.9.1 Agricultural Policies and Legislation 45

2.9.2 Human Resource Base 46

2.11 REFERENCES 51

2.12 ANNEXURES 52

CHAPTER THREE 59

TERRESTRIAL FAUNA 59

3.0 INTRODUCTION **59**
3.1 TERRESTRIAL FAUNA BIODIVERSITY AND CONSERVATION 60
3.1.1 Inverterbrates *60*
3.1.2 Fruits *60*
3.1.3 Vegetables *63*
3.1.4 Rootcrops *65*
3.1.5 Forestry *66*
3.2 VERTEBRATES 66
3.2.1 Agricultural Livestock *66*
3.2.2 BIRDS OF TONGA **67**
3.2.3 Herpetofauna *71*
3.2.4 Peka -Tongan Fruit Bat *72*
3.2.5 Rodents *73*
3.2.6 Feral Cats *73*
3.3 ECOLOGICAL ZONES IN TONGA 74
3.3.1 Dryland *74*
3.3.2 Wetlands *75*
3.4 THREATS AND PRESSURES ON TERRESTRIAL FAUNA BIODIVERSITY 76
3.5 INSTITUTIONAL FRAMEWORK AND HUMAN RESORUCE BASE FOR TERRESTRIAL FAUNA 77
3.6 LEGAL AND POLICY FRAMEWORK FOR TERRESTRIAL FAUNA BIODIVERSITY CONSERVATION 78
3.7 PROGRAMMES AND PROJECTS FOR TERRESTRIAL FAUNA 78
3.8 REFERENCES 80
CHAPTER FOUR **85**
FORESTRY **85**
4.0 FORESTRY BIODIVERSITY AND CONSERVATION 85
4.1 LOCATION AND EXTENT OF NATURAL FOREST COVER 85
4.2 EXOTIC FOREST PLANTATION 87
'Eua Forest Plantation: *87*
4.2.1 Coconut Palm Resources *87*
4.2.2 WEED AND INVASIVE SPECIES 88
4.3 SPECIES RICHNESS AND ENDEMISM 89
4.3.1 Important Tree Species *90*
4.4 UNIQUE ASPECTS OF THE ECOSYSTEM 92
4.4.1 Coastal Littoral Forest *93*
4.4.2 COASTAL SAVANNA 94
4.4.3 Swamp Forest *94*
4.4.4 Marshland *95*
4.4.5 Mangrove Swamps *95*
4.4.6 Tropical Lowland Forest & Secondary Vegetation *95*
4.4.7 Grassland Savanna *96*
4.4.8 High Density Coconut Stands *96*
4.4.9 Leucaena galuca Stands *96*
4.4.10 Coconut Plantations (Pasture) *96*
4.4.11 Urban Vegetation *97*
4.5 DEGREE OF DEGRADATION OF FORESTRY ECOSYSTEMS 100
4.5.1 Local Coconut Timber Sawmilling & Utilization *100*

4.5.2 Agricultural Development ... *101*
4.5.3 Natural Disasters ... *101*
4.5.4 Pest and Diseases ... *101*
4.6 Economic, Cultural and Historical Importance of the Forestry Sector ... 102
4.6.1 Forest and Trees Valued as Wood or Timber Products ... *102*
3. Medicinal values ... *103*
4.6.2 Service Functions of the Forests Ecosystems ... *103*
4.7 Protected Area System ... 104
4.7.1 National Parks ... *104*
4.7.2 Agroforestry Development ... *105*
4.7.3 Captive Bird Breeding ... *105*
4.7.4 Employment Opportunities ... *105*
4.7.5 Education and Science ... *105*
4.7.6 Handicraft Development ... *106*
4.7.7 Tourism ... *106*
4.8 Proposed Criteria for Priority Setting ... 106
4.9 Ranking of Priority Ecosystems for Biodiversity Conservation ... 108
4.10 Threats and Pressures on Forestry Biodiveristy ... 109
4.11 Ways that Forestry Biodiversity is being Used ... 112
4.11.1 Forest Products ... *112*
4.12 Service Functions of Forests and Trees ... 116
4.13 Sustainable use in terms of Biodiversity Loss ... 116
4.14 Trends in the Threats, Pressures and Sustainability of Resources ... 118
4.16 Lgal and Policy Framework for the Conservation of Forestry Biodiversity ... 122
4.16.1 Legal basis for Protecting Intellectual Property Rights ... *123*
4.16.2 Legislation ... *123*
4.16.3 Protection and Conservation ... *123*
4.17.1 Institutional Strengths and Weaknesses ... *127*
4.18 Programs and Projects for Forestry Biodiversity Conservation ... 129
4.19 References ... 133
4.20 Annexures ... 135

CHAPTER FIVE ... 162

MARINE – PELAGIC BIODIVERISTY AND CONSERVATION ... 162

5.0 Introduction ... 162
5.1 Marine – Pelagic Biodiversity ... 163
5.1.1 Endangered and Threatened Species ... *163*
5.1.2 Cultural Significance Species ... *164*
5.2 Priorities for Pelagic Biodiversity Conservation ... 164
5.2.1 Unique Aspects of the Pelagic Ecosystem ... *165*
5.2.2 Economic and Cultural Importance of Documented Fisheries Resource ... *167*
5.3 Cartilaginous Fishes ... 170
5.4 Reptiles ... 171
5.5 Molluscs ... 172
5.6 Squid and Cuttlefish Fisheries ... 173
5.7 Marine Mammals ... 173
5.8 Marine plant - Phytoplankton ... 174
5.9 Threats and Pressures of Pelagic Biodiveristy ... 174

5.11 Sustainable Use of Pelagic Biodiversity 175
5.11.1 Tuna Fishery *175*
5.11.2 Whale and Turtle Fishery *176*
5.11.3 Bottom-line Fishery *176*
5.12 Trends in Threats, Pressures 177
5.12.1 Causes of Threats and Pressures for Unsustainable Uses *178*
5.13 Equitable Sharing of Benefits 179
5.13.1 Indigenous Knowledge *179*
5.13.3 Equitability of Exploitation *180*
5. 14 Institutional Framework and Human Resource Base 181
5.14.1 Current Institutional Responsibilities *181*
5.14.2 Institutional Strengths and Weakness *182*
5.15 Legal and Policy Framework 182
5.15.1 Legislative and Policy Framework *182*
5.15.2 Tuna Exploitation Policy 186
5.16 Relevant Programs and Projects 188
5.17 References 191
Annexures: 194

CHAPTER SIX 200

COASTAL BIODIVERSITY AND CONSERVATION 200

6.0 Introduction 200
6.1 Coastal Biodiversity and Conservation 201
6.1.1 Coral Reef Ecosystem *201*
6.1.2 Endemism *207*
6.2 Endangered and Threatened Species 207
6.3 Mangrove Ecosystem 211
6.3.1 Mangroves Distribution in Tonga *213*
6.4 Lagoon Ecosystem 214
6.5 Seagrass 218
6.6 Analysis of Threats and Pressures 219
6.6.1 Anthropogenic *219*
6.6.2 Natural Factors *226*
6.7 Coastal Biodiversity Use 229
6.7.1 Sustainability of Coastal Biodiversity *230*
6.7.2 Trends in Threats and Pressure *232*
6.7.3 Equitable Sharing of the Benefits *234*
6.7.4 Beneficiaries of Present Use of Marine/Coastal Biodiversity *237*
6.7.5 Inequitable Sharing of Benefits *238*
6.7.6 Reinvestment in Sustainable Management of Coastal Biodiversity *239*
6.7.7 Equitability of the Exploitation *240*
6.8 Institutional Framework and Human Resource Base 241
6.8.1 Human Resources for Biodiversity Conservation *241*
6.8.2 Available Funding *242*
6.9 Legal and Policy Framework 243
6.9.1 Strengths and Weaknesses of Existing Legislation *247*
6.10 Existing Programmes and Projects 250
6.11 References 257

6.12 ANNEXURES 259

LIST OF FIGURES:

Figure 2.1: Common Root Crops in Tonga 12
Figure 2.2: MAFF STRUCTURE 43
Source: Tonga: Issues and Options in the Energy Sector, 1985 111
Figure 4.1: Causal Analysis of the Identified Threats and Pressures. 120
Figure 4.1 Map of 'Eua Vegetation 158
Figure 4.2 Map of 'Eua Soils 159
Figure 4.3 Map of 'Eua Buffer Zones 160
Figure 4.4 Maps of 'Eua National Park 161
Figure 5.1 Tonga Exclusive Economic Zone (EEZ) 162
Figure 5.2: Average Landing Catch main export Species from Deepwater Fishery 167
(1987 – 2003). 167
Figure 5.3. Total landing catch for Tuna Fisheries for 1982 to 2003 178
Figure 6.1: Coral Reef distribution in Tonga 202
Figure 6.2 Ecological map of Fanga'uta and Fangakakau Lagoon. 215
Figure 6.3 Map of Tongatapu with areas below 5 m contour that would be affected by a 3.8 m SLR 228

Picture 1: The "makafeke", traditional bait 235

LIST OF TABLES:

Table 2.1.1 Root Crop species Researched by M.A.F.F during 1970s -1990s 15
Dioscorea alata: (Yams) – Tongan name : 'Ufi 15
Table 2.1.2 List of Popular and Commonly Cultivated species and varieties. 19
Table 2.1.3 List of Musa spp. and varieties grown in Tonga 31
Table 2.1.4 Tomato Varieties Researched by M.A.F.F. 1970s – 1990s 34
Table 2.1.5 Recommended Vegetable Varieties for Tonga. 35
Table 2.1.6 Lists of Livestock species and breeds: Past and Present in Tonga. 40
Table 3.1.1 Proportion of Households with Respect to the Level of Agricultural Activity to the Total Households, by Location of Households, 2001 59
Table 3.1.2 Number of Households Keeping Livestock and Number of Livestock kept as of the Time of Enumeration, by Kind of Livestock, Kingdom of Tonga: 2001 67
Table 3.1.3 A checklist of Tongan birds 71
Table 3.1.4. Distribution of Terrestrial Reptiles on Island groups of the Tongan archipelago, based on specimens collected, identified and preserved at Auckland Institute and Museum .. 72
Table 4.1.1: Tentative Biomass Balance for Tongatapu, 1983. 111
Table 4.1.2: Sawntimber - Domestic Production and Import. 113
Table 4.3: Household Energy Use for Cooking 113

Table 4.1.4	Impacts of human Activities on the Forest Resources	118
Table 4.1.5	Beneficiaries of present use of Forest Biological Resources	121
Table 4.1.6	Institutuinal Strengths and Weaknesses	127
Table 5.1.1:	Identified Pelagic Species found in Pelagic Zone (Coastal and Oceanic)	163
Table 5.1.2:	Species Recorded on Offshore Seamounts (Depth > 200 meters)	166
Table 5.1.3:	Total landing Catch of some Pelagic Species from Artisanal Fishery (kg).	169
Table 5.1.4	Number of Longline Vessels and Company which participated	175
	on Exploitation of Tuna Fisheries Resources	175
Table 5.1.5	Current Game and Sports Fishing Operators	175
Table 5.1.6	Total revenue collected from Multilateral Treaty	179
Table 5.1.7.	Total Export for Fisheries Product 2000 - 2002.	180
Table 5.1.8	Summary of Licensing Structure for the Longline Fishery	181
Table 6.1.1	Corals Species in Tonga	203
Table 6.1.2	Reef Fish of Tonga	203
Table 6.1.3	Most common Reef Fishes in Tonga	204
Table 6.1.4	Mollusc found in Coral Reef of Tonga	204
Table 6.1.5	Echinoderms found in Coral Reef of Tonga	205
Table 6.1.6	Crustaceans found in Coral Reefs of Tonga	205
Table 6.1.7	Major Class of planktonic organisms found in Tonga.	206
Table 6.1. 8	Algae species found in Tonga.	206
Table 6.1.9	Number of polychaete worm species found in Tonga.	206
Table 6.2.1	List of Rare or Endangered Coastal Species	208
Table 6.2.2	Subsistence and Commercial Fisheries (Annual mean production – 1989-1992)	209
Table 6.2.3	Catch Landings (tones). FAO Digital Atlas, 1998	209
Table 6.2.4	Total value of aquarium fisheries per year	209
Table 6.2.5	Mangrove species Found in Tonga	213
Table 6.2.6	Common species found within the mangrove ecosystem	213
Table 6.2.7	Sustainability of the Coastal Ecosystem Use	230
Table 6.2.8	Status of some Coastal Biodiversity (copied from Prescott, 2003)	233
Table 6.2.9	Summary of the type of fishery and Benefeciary Groups	237

CHAPTER ONE

INTRODUCTION

(Netatua Prescott[1])

1.0 Introduction

The Government of Tonga acceded to the United Nations Convention on Biological Diversity (CBD) in May 19, 1998. The CBD addresses 42 articles on various biodiversity issues, particularly the sustainable use of natural resources and the conservation of biological diversity. Tonga ratified the Cartagena Protocol on Biosafety to the CBD on 18 May 2003. The protocol binds party members to a framework to address biosafety issues and to develop national framework to that effect.

Consequently, the Department of Environment (DOE) as the operational focal point developed an Enabling Activity (EA) in accordnace with the operational criteria for Biodiversity to enable Tonga to implement its obligations under the CBD, while at the same time address national biodiversity issues and priorities for its sustainable management. The EA was through a National Biodiversity Conservation Strategy Action Plan (NBSAP) that aims to formulate through a participatory and analytical process, the strategies and actions necessary for the protection and sustainable use of the biodiversity in Tonga, and to prepare a Plan for their implementation. The EA will also assist Tonga to meet its reporting requirements (National Communications) to the Conference of the Parties (COP).

1.1 Short Descriptions and Objectives

Tonga's Biodiversity EA main objective is to develop the National Biodiversity Strategy and Action Plan (NBSAP). The NBSAP will include measures for the conservation (Article 8 and 9 of the CBD) and sustainable use (Article 10) of biodiversity, identify incentive measures (Article 11) for the promotion of conservation and sustainable use of biodiversity, the requirements and provisions of Article 15 (Access to Genetic Resources), Article 16 (Access to and Transfer of Technology) and 19 (Handling of Biotechnology and Distribution of its Benefits), Article 20 (Financial Resources).

[1] Netatua Prescott is the chair of the Biodiversity Technical and Consultancy Group.

The NBSAP will include developing a monitoring programme to routinely assess its implementation. Further, the NBSAP will also develop a programme for the mainstreaming of the NBSAP into the national decision-making process.

1.1.1 The Process and Specific Activities

The development of the NBSAP and the Country Reports to the COP were through a process of community consultations/workshops, to ensure a high participatory, strategic planning process and establish priorities for actions for the sustainable management and conservation of biodiversity in Tonga.

The process undertakes intergovernmental and private sector consultation on intergration of biodiversity management into sectoral and cross-sectoral plan and policies. National Workshops, including an introductory and familiarization workshop for the development of the strategies and action plan. The introductory and familiarization workshops bring together representatives from government agencies (e.g. agriculture, fisheries, environment, and customs), the private sector, community groups, tertiary institutions and NGOs/CSOs. The workshops raise awareness of the NBSAP process and key issues likely to be raised therein.

Key issues likely to be raised include: the Tongan biodiversity and critical habitat areas; a general picture of stresses to Tongan biodiversity; importance and benefits of biodiversity conservation and management; introduced or invasive species and their impacts; import and export controls and issues of sustainable use and benefit sharing; and restoration of key habitats. Specific activities undertaken include the following:

- Stocktaking and analysis of the status of biodiversity relying on studies, including biodiversity resource use practices, successful management including existing legislation, policies and programme, institutional and financial arrangements and develop strategies for biodiversity conservation. The strategies for biodiversity conservation will address the preservation of relevant traditional knowledge, and monitoring the implementation of the NBSAP
- Establish a biodiversity database for Tonga based on information collected from the review and stocktaking

- Capacity building in providing training and introductions of methodologies necessary for biodiversity planning
- Prepare the first National Report to CBD-COP
- Prepare public awareness (video, pamphlets, posters, etc.) materials based on information collected from NBSAP for national workshops to assist Tonga to gain a better appreciation of the frailty and economic importance of its biodiversity assests

1.2 Definition of Biodiversity

The way in which the concept of biodiversity is defined is central to the understanding of this report and subsequent work to develop the National Biodiversity Strategic Action Plan (NBSAP). An ecosystem approach was adopted in assessing the status of biodiversity, whereby diversity of species are considered and assessed together with the status of their habitat or ecosystem and management practices.

Thaman et. al., (1996), stated that for the Ha'apai Group, biodiversity conservation is seen as synonymous with sustainable use. For the people of Ha'apai, "biodiversity" is not just a matter of scientific, economic (in monetary terms), recreational or ecological value. It is a capital inheritance that has been passed on, relatively intact or in some cases enhanced, by past generations to current generations. Biodiversity is not income to be spent or destroyed. It is the "capital" needed for development and maintenance of the local communities and upon which almost all "income" (both cash and non-cash) is derived.

Thaman et al., (1996) further argued, based on the experiences of other areas of the world, that if the biodiversity of Ha'apai is not conserved or used on a sustainable basis, and if traditional sustainable management practices, and the knowledge and language (e.g., plant and animal names and language associated with farming and fishing techniques, seasons, tides, etc.) are not maintained or strengthened, that all other modern development (e.g., business, education, tourism, handcraft and industry, etc.) may fail in the long term.

Whereas the predominant focus for most rich-country motivated biodiversity conservation includes uniqueness or endemism, scientific importance, importance as potential gene pools for genetic engineering, biotechnology, plant breeding, medicinal discoveries or other technological breakthroughs for the benefit of humankind, export or touristic potential, or the ecological benefits of biodiversity and

ecosystem preservation, for the people of Ha'apai, the focus of biodiversity conservation should be the CONSERVATION OF THEIR BIODIVERSITY as the basis for ecological, cultural and economic survival of local communities.

As there has been no other study that has defined 'biodiveristy' in the context of Tonga, this report adopted Thaman's and the people of Ha'apai's definition. As suggested above, biodiversity can be defined in terms of both the diversity of different types of ecosystems or in terms of diversity of plants and animals (organisms or taxa) found in a given place.

It becomes clear that, the importance of biodiversity as a basis for sustainable human development becomes even clearer when a cultural or "ethnobiological" dimension is added, and an attempt is made to catalogue the uses and the cultural importance of biodiversity. Moreover, if cultural survival and economic sustainability are important objectives, the focus of biodiversity conservation programmes should NOT overemphasise only native and endemic terrestrial and marine species, or larger "charismatic megafauna", such as the whales, sea turtles, giant clams, rare birds, endemic plants, etc., but must also include a wide range of endangered or ecologically and culturally important ubiquitous indigenous and exotic (non-indigenous), and wild and domesticated, species or varieties (Thaman et al., 1996).

This is seen as particularly critical in the context of smaller island countries, such as Tonga (with few exception of Kao, Tofua and 'Eua) have limited terrestrial ecosystem diversity and few if any endemic plants or animals of global scientific interest, but where the protection of often ubiquitous plants and animals, both indigenous and exotic, must be given at least equal priority as the protection of rare, highly endemic biota of larger islands, because it is their ONLY biota.

The report is divided into the thematic areas of Agricultural Biodiversity, Terrestrial Fauna, Forestry, and Marine Biodiversity that covers Coastal and Oceanic Biodiversity. In each thematic area, the report presented the findings of the stock-taking, inventory and analysis on the status of biodiversity in Tonga, relying on previous studies, including review of existing information, legislation and policy; management and resource use practices; activities or factors that seem to be responsible for the endangerment of biodiversity and its ecosystems; and actions that could be promoted to conserve or enhance biodiversity and ecosystems in Tonga.

1.3 What Covers in This Stocktaking Report and the Process

This Report is the first output report towards the development of the National Biodiveristy Strategic Action Plan (NBSAP). This is the 'Stocktaking' activity that reviewed and analysed the status of biodiversity relying on studies, including biodiversity resource use practices, successful management including existing legislation, policies and existing institutional and financial arrangements and existing national programmes.

The Stocktaking Report is divided into the thematic areas of Agricultural Biodiversity, Terrestrial Fauna, Forestry, and Marine Biodiversity that covers Coastal and Oceanic Biodiversity. In each thematic area, the report presented the findings of the stocktaking and analysis of the status of biodiversity in Tonga, relying on previous studies, including review of existing information, legislation and policy; management and resource use practices; activities or factors that seem to be responsible for the endangerment of biodiversity and its ecosystems; and actions that could be promoted to conserve or enhance biodiversity and ecosystems in Tonga.

A Biodiversity Technical and Consultancy Group (BTCG)[2] was established by the National Biodiversity Advisory Committee[3] to undertake the stocktaking exercise. Members of the BTCG took leave to undertake the stocking exercise except for the chair, NBSAP coordinator and project officer. A term of Reference (TOR) was developed for each thematic area (Chap. 6 Annex 3). The chair convenes the BTCG twice a month to discuss the progress of the review, draft reports from the Group, share experiences and resources relevant to the good progress of the stocktaking exercise, and to ensure quality of the review.

[2] Members of the BTCG are Dr. N. Prescott (chair), P. Folaumoetu'I (NBSAP Coordinator), K. Kilisimasi (NBSAP Project Officer), Finau Pole, Taniela Hoponoa, Viliamu Kami, Poasi Ngaluafe & 'Asipeli Palaki.

[3] Cabinet established national Biodiveristy Advisory Committee in 2002 (C.D. No. 488, 27 March) to oversee the implementation of the NBSAP. Members are: Director of Environment (Chair), Director of Agriculture, Forestry and Food, Secretary of Fisheries, Director of Tourism, Secretary of Lands, Survey and Natural Resources, Director of Central Planning Department, Director of Education, President of TANGO, Secretary of Labour, Commerce & Industries, Secretary for Foreign Affairs, President of Chamber of Commerce, NBSAP Project Coordinator/DOE

1.4 Biodiversity Conservation Presssures and Threats

Terrestrial Biodiversity:

Pressures and threats on terrestrial biodiversity are mainly related to population growth and the development of services required by the population and economic development such as agriculture. Several key biodiversity conservation issues and problems become apparent in terms of ecosystem and biodiversity degradation such as:

- increased soil degradation, which is indicated by the increase in commercial agriculture and the increase in use of fertilizer and pesticide;
- increased pests, weeds and plant diseases;
- loss of native forest and general deforestation;
- loss of habitat, biodiversity and wildlife;
- problems of increasing waste quantities requiring management.

The state of the terrestrial biodiversity, however, is difficult to determine due to lack of reliable information, adhoc research, lack of appropriate national indicators developed for biodiversity conservation, inconsistent policies and data collection methods differs, which make it difficult to establish reliable biodiversity use trends.

Outdated and Lack of Enforcement of Existing Legislation:

Although legislation is the main instrument used in Tonga to protect the environment, some of the existing legislation is old and no longer applicable to the current physical and socio-economic environment of Tonga.

Dependency on Donor Funding:

The number of donor funded projects listed clearly shows that terrestrial biodiversity conservation related research and activities are linked to external funding. This suggests that most of the government as well as civil society responses are linked to a donor. When the donor funding ends, the related national activities also stop.

Lack of Community and NGOs Awareness and Participation:

There are only a few NGOs active in biodiversity conservation programmes. The stock taking exercise shows that there a very few NGOs who consciously planned and implement biodiversity conservation related programmes, such as Tonga Trust. Most related NGOs work programs in the community are focusing on 'keeping the village clean', tree planting or determine by the objectives of the donor available.

Marine/Coastal Biodiversity:

Pressures and threats on coastal and marine biodiversity include natural phenomena and human activities. Several key marine and coastal biodiversity issues and problems have been mentioned highlighted in this review. It seems that the potential impact of climate change and sea level rise is not yet integrated into any national program as reflected in the lack of related responses identified.

Coastal area and wetlands reclamation have caused loss of mangrove areas and littoral forest, especially around Fanga'uta and Fangakakau Lagoon, on the main island of Tongatapu. A further allocation of coastal foreshore areas for residential and commercial purposes in the southern and eastern coast areas of Tongatapu has led to the destruction of the protective coastal tree belt and an increase in the damage caused by seawater spray.

Biodiversity and habitat loss caused by quarrying coral and removing sand from beaches for construction is increasing at an alarming rate. Environmental degradation with offshore dredging of sand is yet to be researched.

Coastal pollution from land-based activities and waste is becoming a major threat to coastal biodiversity, for example, siltation from reclamation, solid waste dump sites, potential eutrophication and groundwater seepage into the lagoon or coastal waters.

Although marine reserves have been established as well as a major environmental management plan (Fanga'uta Lagoon Management Plan), there is a lack of commitment for implementation due to lack resources, lack of skilled manpower and to unclear institutional arrangement.

From the few studies that have been concentrated in Tongatapu, coastal fisheries habitats such as seawater quality, mangroves, and seagrass show signs of degradation as a result of development. The

impacts of fishing activities have not been fully understood and this will continue to be the case in the absence of a well-organized collection and assessment of fisheries related data.

- Anecdotal evidences and the few studies available pointed to a decline of coastal fisheries resources. However, the extent (what species, which areas/part of Tonga, effect of seasons/weather, migration/spawning patterns, fishing technology use, market preference etc.) is not yet fully understood.

Determining the state and trend of the coastal biodiversity resources is limited as information and data available is from mainly one survey only. Not only that, the lack of national indicators further constrained the effort to determine the state of marine/coastal biodiversity. The available data and information as shown in this stocktaking reflects only the priorities of the implementing agencies, what donor funded projects were running, and individual researchers' interests.

1.4.1 Priority Setting for Biodiversity Conservation

Despite the incomplete 'picture' of the state of the terrestrial, marine/coastal biodiversity as documented in this stocktaking, each thematic areas of this report has described biodiversity conservation priorities according to the TOR of the stocktaking. While each chapter is to be appraised in detail during the process of the drafting of the NBSAP as they have a wealth of relevant information and recommendation, the following priority areas are summerised here.

Terrestrial Biodiversity:

One of the main pressures of terrestrial biodiversity is commercial agriculture. Although commercial agriculture is inevitable in Tonga, its high input of agrochemicals, pesticides and machinery tillage is a priority area to be addressed as it leads on to other biodiversity conservation problems such as deforestation, erosion etc. Specific area of priorities include the following:

- Ensuring food security;
- Promoting local food crops diversity;
- Management of weeds and invasive species;
- Management of the 'lifecycle' (what is imported, how it is used and how it is disposed) agrochemicals/pesticides;

- Promoting organic farming and agroforestry;
- Solid waste management;
- Biodiversity conservation (addressing important cultural and indigenous fauna and flora);
- Conserving endermic plants and associated habitats; and
- Domestic animals (pigs) scavenging.

Marine/Coastal Biodiversity:

Pressures on marine/coastal biodiversity are a combination of fishing practices, coastal developments and natural and manmade phenomena (i.e. cyclones, sea level rise associated with global warming etc.) Although there are still many uncertainties as to how coastal ecosystems 'react' to each pressure, and also incomplete data and information about Tonga, the following priority areas/needs require immediate and long-term action to prevent further degradation or biodiversity loss:

- Strict enforcement of prohibited fishing practices (dynamite, 'wall of death', fishing nets);
- Regular monitoring of key habitats (coral reefs, mangroves, seagrass);
- Systematic information/data collection of coastal fisheries activities (methods, type of catch and quantity, season variability etc.);
- Development of strategies for sustainable marine/coastal biodiversity management;
- Sustainable development of offshore pelagic fishing;
- Environmental codes of practice are needed for businesses (including yacht operators and large boats) to encourage voluntary good environmental ethics and practices; and environmental codes of practice are needed for coastal reclamation to minimize siltation and habitat destruction;
- All developments from 15.24 m above high water mark and any major developments (aquaculture, wharves, tourist facilities, causeways) should have Environmental Impact Assessments (EIAs), which specifically addresses impacts on the marine/coastal biodiversity;
- Consideration for shoreline reforestation/mangroves replanting to minimize loss of sediments, shoreline erosion and salt water sprays.

1.5 The Next Steps

The next step towards the development of the NBSAP is to take the main findings of the stock taking to the community through a consultative process to identify gaps in the stocktaking assessment and identity community priorities and strategies for biodiversity conservation. The community consultation process will be documented when completed.

Based on these two documents (Stocktaking & Community Consultation Reports) a draft National Biodiversity Strategic Action Plan will be developed.

CHAPTER TWO

AGRICULTURAL BIODIVERSITY AND CONSERVATION

(Finau Savelio Pole[4]**)**

2.0 Introduction

Generally, there is very little information kept of any studies done on indigenous agricultural biodiversity. The only informations available are records of crop species and livestock animals cultivated and/or domesticated by man throughout history.

Obviously, the most primitive farmers were gatherers and hunters. There was no cultivation involved. The process of natural selection was so slow, that many plant species were in the process of losing. This forced man to begin cultivating many of the useful plants. This is the beginning of agriculture in the world; which then slowly spread to Tonga.

Tonga is known to have a rich agricultural biodiversity of which many species and varieties are endangered and threatened of being extinct. Thus, there is an urgent need for some programmes of agricultural biodiversity conservation, to save some of these species and/or varieties.

This study will look at the country's agricultural biodiversity; which is hereby classified into the following classifications; followed by stocktaking of species and varieties in each category. This will allow one to look at endangered species and varieties.

Classification of Agricultural Biodiversity

1. Root Crops
2. Fruit & Food Tree Crops
3. Fruits
4. Vegetables
5. Traditional Crops
6. Livestock

[4] Finau Savelio Pole is the main author of this chapter. He is an Agromonist and Plant Breeding specialist.

2.1 Root Crops

Figure 2.1: Common Root Crops in Tonga

Traditionally, root crops form the most important part of Tonga's agriculture (Fig. 2.1). The true traditional Tongan farming system is one where the major components of the cropping sequence is made up of root crops mainly which have been occupying about two thirds (2/3) of the land in agricultural production; despite the increasing acreage of commercial farming. Root crops comprises of a number of different plant families, genus and species.

(i) ***Dioscorea spp.*** **(Yams):**

In Tonga, yam is the most valued of all food crops, and is considered the best tasting of all root crops. Traditionally, yam has the highest social value; being the first crop reserved for presentation to royalty and nobility, and for ceremonial functions and feasts.

Six species of Dioscorea are found in Tonga, some are almost extinct. Only three species are being cultivated, and even some varieties of these species are threatened of being disappearing (extinct).

(a) ***Dioscorea alata*** **(Yams). Tongan name: 'Ufi**

The most cultivated and widely distributed species throughout the Kingdom. This is the species we in Tonga refer to when we talk yams, as compared to *D. cayensis* or rotumdata when Africans talk of yams. Some varieties of this species is probably endemic to Tonga. This species is quite rich in diversity, but some varieties are in danger of disappearing. Refer to Chapter 1, Annex 1.

The most popular variety of *D. alata* cultivated in Tonga is Kahokaho. It is known to be the most chiefly and prestigious variety, as well as being the oldest variety. This is probably the only variety of D. alata, which is being cultivated and grown throughout the islands Kingdom, despite being the most difficult one to cultivate. Because of the importance and value of this variety; there is never a threat of it being an endangered variety. However, many varieties are in danger of being lost over the years.

A survey in 1988/1989 showed that 86 varieties of *D. alata* were still cultivated, including variety kahokaho. Some of these varieties were cultivated more than others, and today some of these varieties are becoming less cultivated. Thus, of the 86 varieties shown in Chapter 1, Annex 1 - Variety Kahokaho is probably the most secured variety not in danger of being lost. Table 2.1, shows a list of all root crop varieties researched at the Research Station, MAFF, between 1970s and 1990s.

(b) ***Dioscorea esculenta*: (Sweet yam). Tongan name: 'Ufilei**

In 1989 records showed that 8 varieties of sweet yam were being cultivated compared to 11 varieties in Table 2.1. This species of Dioscorea is better adapted to areas with sandy soils. This makes Niuatoputapu, and parts of Ha'apai to be the main producers of Dioscorea. This species is generally in danger of being lost and some of the varieties are slowly disappearing. Table 2.1.1 gives a list of varieties of this species being cultivated and those being endangered.

(c) ***Dioscorea bulbifera*: Tongan name: Hoi**

This is a wild species and it is growing wild in the entire island group. No conservation of biodiversity is required.

(d) ***Dioscorea pentaphylla*: Tongan name: Lena**

This species was once consumed only in times of food shortage & famine. Another species threatened of being lost. This species is still seen at Tofua Island today.

(e) ***Dioscorea nummularia*: Tongan name: 'Ufi Palai**

This species has very tough textured tubers, which is normally grown as a perennial. It was never cultivated in the cropping area, but left grown under big trees for a number of years, and are harvested over time (multiple harvests). This species was more specifically grown on 'Eua Island, and is another of the species in danger of being lost.

(f) ***Dioscorea rotundata*: Tongan name: Lose**

This is a recently introduced species, which has gained popularity during the last few years. Initially, the species was restricted to Tongatapu; but not very long; it has spread to outer islands. The beauty of this species is its immunity to anthracnose disease[1], plus its adaptability to a wide range of soil types including infertile soils. This species is gaining popularity, and thus has no priority for biodiversity conservation.

Dioscorea species, in particular *D. alata*, contains quite a rich diversity, which has a high priority for conservation; as indicated for each species above: Many varieties of this species are in danger of being lost, and thus require some conservation measures to maintain the richness of the species. Some of the varieties of D. alata shown in Table 2.1.2 is now either not cultivated any more, or are very restricted to only a very few farmers e.g. varieties kivi; Heketala; Malekini: Mamange; Nise; Palatea, Panama, and many others.[5]

Table 2.1.1 Root Crop species Researched by M.A.F.F during 1970s -1990s
Dioscorea alata: (Yams) – Tongan name : 'Ufi

Varieties	Unique Features	Varieties	Unique Features
1. Fafa		66. Malekini	
2. Falahola		67. Moala hina	
3. Hale hina	3 & 4Tough	68. Moala kula	
4. Hale kula	Textured	69. Natoto	
5. Heketala fisi		70. Ngu hietua	
6. Haketala hina		71. Ngu kafakafa	
7. Heketala kula		72. Ngu palatea	
8. Heketala lolo'a		73. Ngu puku	
9. Heketala palau		74. Ngu kia'imoa	
10. Heketala puku		75. Ngu tu'upakata	
11. Heketala vai		76. Ngu vaihina	
12. Heleveka		77. Ngu vaikula	
13. Kafiu kula		78. Nise	
14. Kafiu punailave		79. Nuku	
15. Kahokaho kulufau	15-20 Good Taste	80. Paholo hina	80 & 81 soft textured
16. Kahokaho muihina		81. Paholo kula	
17. Kahokaho siamane		82. Palangi	
18. Kahokaho tavake		83. Palatea	
19. Kahokaho tefau		84. Poa hina	84 & 85 Distinct, nice odour
20. Kahokaho vai		85. Poa kula	when cooked.
21. Kahokaho 'ulumaka	21 Big head	86. Sikau felefele	86 & 87 Tubers grow
22. Kapakau'ikava muihina		87. Sikau tulalo	sideways
23. Kaumeile hako	23-34 Long variety	88. Sivoli hina	88 & 89 Yams for famine
24. Kaumeile hina	White flesh colour,	89. Sivoli kula	
25. Kaumeile kula	sticky texture	90. Solomone hina	
26. Kaumeile lautoka	Red flesh colour	91. Solomone kula	90 & 91Good eating quality
27. Kaumeile lokoloka	All kaumeile yams	92. Taiakona	
28. Kaumeile pekavalu	have good eating	93. Takulevu hako	
29. Kaumeile punuluo	quality	94. Takulevu hina	91-96 Good shaped tubers
30. Kaumeile toua		95. Takulevu kula	
31. Kaumeile ve'e'ikuli		96. Takulevu puku	
32. Kaumeile 'eua		97. Tamuni hina	
33. Kaumeile 'ata		98. Tamuni kula	
34. Kaumeile 'uli		99. Tamuni keu	
35. Kivi hina	35 - 37 Soft texture	100. Tapuane	
36. Kivi hako		101. Tefau	
37. Kivi kula			
38. Konisela hina	38 & 39 Thin, long		
39. Konisela kula	head, with round		
	base tyber		

[5] Anthracnose is the most serious disease of D. alata. It can destroy a whole crop of susceptible varieties. It is caused by fungus. (***Colletotrichum gloeosprioides***)

Con't – Table 2.1.1

Varieties	Unique Features	Varieties	Unique Features
40. Koukau hina		102. Tua fietua	102-110 Long. Thin, hairy tubers
41. Koukau kula		103. Tua hina	
42. Kulo hako		104. Tua kula	Used for long tuber competitions
43. Kulo hina		105. Tua maka	
44. Kulo kau		106. Tua ukumaka	
45. Kulo kula		107. Tua vai	
46. Kulo matapuko		108. Tua 'ata	
47. Kulo puku		109. Tua 'atavai	
48. Langi		110. Tua 'ata kafiu	
49. Laumahi hina		111. Tu'upakata hina	
50. Laumahi kula	50-52 Good taste	112. Tu'upakata kula	
51. Laupoa		113. Vesivesi felei	
52. Lausi hina		114. Vesivesi hako	
53. Lausi kula		115. Vesivesi hina	
54. Levei		116. Vesivesi puhipulu	
55. Lokoloka hina		117. Vesivesi puku	
56. Lokoloka kula		118. Voli hako	118-121 Elongated/Round tuber
57. Lokoloka mangavalu		119. Voli hina	
58. Mahoa'a lotuma	58-60 Large Tuber size	120. Voli kula	
59. Mahoa'a hina		121. Voli leka	
60. Mahoa'a leleva		122. 'Ufi fisi hina	122-125 Hard – Texture
61. Mamange fau		123. 'Ufi fisi kula	
62. Mamange hina		124. 'Ufi fisi langakali	
63. Mamange kula		125. 'Ufi fisi punuluo	
64. Malau tu'a		126. Panama	126 Endangered
65. Malau melie		127. Hawaii lo'a	
		128. Hawaii mangamanga	128Branching Tubers Good taste
		129. Lavelio	
		130. Lose	130 Hard Texture. Highly resistant to anthracnose

Con't – Table 2.1.1

Dioscorea esculenta			
1. 'Ufilei fie'ufi hina 2. 'Ufilei fie'ufi kula 3. 'Ufilei heke 4. 'Ufilei hina 5. 'Ufilei kauhola 6. 'Ufilei kula	1 & 2 Long Tubers 6 Endangered	7. 'Ufilei lavilavi 8. 'Ufilei lotuma 9. 'Ufilei mo'ata 10. 'Ufilei vai 11. 'Ufilei 'ulu'ikuma 12. 'Ufilei Tonga	 10 Big tubers 12 Hairy
Ipomoea batatas			
1. Hawaii 2. Tongamai 3. Kumala kula 4. Teiko 5. Melefakahau 6. Piukala 7. Taiuani 8. 'Amelika 9. Kaloti 10. Siale kula 11. Siale hina 12. Palu hina 13. Palu kula 14. Laufuopotopoto (lalahi) 15. Muka'i hehea 16. Lauveveli 17. Kumala lesi (fisi) 18. Kumala Siapani 19. Kumala vai hina 20. Siale lau'ila	1 Purple flesh colour Good eating, but susceptible to scab. 4 Lost 6 & 7 Lost 9 Endangered.Best in Ha'apai 13 Endangered 15 Endangered 16 Lost 17 Endangered 19 Lost	21. Fokisi 22. 'Aliki 23. Silika 24. Vili suli – Ha'apai – 1982 25. Tolu mahina-Ha'apai - 1982 26. Mosese kula – Ha'apai - 1982 27. Lau'i manioke-Ha'apai 1982 28. Papua 29. Halasika 30. Kumala vai kula 31. Lau fuopotopoto (iiki) 32. Finau 33. Kumala 'eua 34. Lokoloka 35. Koli leka 36. TIS - 3030 37. TIS - 2498 38. TIS - 11 39. TIS - 1499	21-25 Lost 26-28 Red skin colour, white flesh odour 29 & 30 Lost 33 Lost 36-39 Introduced from Nigeria, 1980s

Con't – Table 2.1.1

Colocasia esculenta			
1. Lau'ila 'uli 2. Lau'ila hina 3. Manu'a 'uli 4. Manu'a hina 5. Talo Niue 6. Sikavi hina 7. Sikavi 'uli 8. Mangamea	1 & 2 Most common variety grown, white flesh. 5 Endangered Popular export variety	9. Manga koka 10. Talo enga 11. Manga siva 12. Talo valeti 13. Talo kula 14. Talo kape ('Eua) 15. Alafua Sunrise 16. Samoa Hybrid	10 Yellow flesh colour 13 Red stem 14 Elongated tubers 15 & 16 Introduced from Samoa
Manihot esculeta			
1. Mataki'eua 2. Falaoa 3. Leka kula 4. Leka hina 5. Lepa kula 6. Lepa hina 7. Silika	1 Common variety 3 & 4 Dwarf growing habit 7 Endangered	8. Engeenga 9. Lau pulepule 10. Tano'a 11. Manioke fisi 12. Manioke 'Eua 13. Manioke koka'anga	8 Yellow flesh 9 Ornamental 13 Endangered
Xanthosoma sagittifolium			
1. Talo kula 2. Talo mahele'uli (Talo Tofua) 3. Talo enga 4. Talo tea	1 & 2 Commonly grown Yellow flesh-Endangered 3 & 4 Hard textured Endangered	5. Talo vale 6. Talo panefu 7. Talo Lotuma 8. Talo futuna	5 & 6 Lost
Alocasia macrorrhiza			
1. Kape hina 2. Kape 'uli 3. Fohenga 'uli 4.Fohenga engeenga (Tafahi)	1 White flesh and stem 2 & 3 Black stem Good eating qualities 4 Yellow flesh	5. Kape vai 6. Kape talo ('Eua) 7. Kape fulai	7 High calcium oxalate - Itchy to mouth
Solanum tuberosum			
1. Red Pontiac 2. Serrana 3. Dalisay 4. Sebago	1 Red skin colour. Most popular variety 4 White tubers	5. Sequoia 6. Bintze 7. Ilam hardy 8. Rua	6 Chips variety. 7 & 8 New Zealand variety.

Source: M.A.F.F. Research Annual Reports: 1970s – 1990s

Table 2.1.2 List of Popular and Commonly Cultivated species and varieties.

(i) ***Dioscorea alata*:**

	Varieties		Comments
1.	Heketala	-	Some forms of this variety are still cultivated
2.	Kafiu		
3.	Kahokaho	-	The most popular, and widely cultivated variety. It has many forms. Good eating quality
4.	Kapakau'i kava	-	Usually more than one tuber per mound. Good eating.
5.	Kaumeile	-	Many forms exist – but are popular for, good eating quality having sticky texture.
6.	Kivi	-	Popular for soft – Texture – food for old aged.
7.	Konisela	-	Different forms. Distinct long thin head, with round base tuber.
8.	Lausi	-	Not very common
9.	Lokoloka	-	Not very common, but famous for multiple tubers per mound.
10.	Mahoa'a	-	Different forms – but have round to elongated round, big tubers.
11.	Ngū	-	Many forms, but known for hard-textured tubers.
12.	Paholo	-	Soft – Textured. Good for old aged.
13.	Poa	-	Famous for its distinct odour when boiled.
14.	Sikau	-	Tubers grow sideways like cassava.
15.	Solomone	-	Good shaped elongated tubers. Good for eating
16.	Takulevu	-	Comonly grown variety. Good shape.
17.	Tamuni	-	Still cultivated by some farmers.
18.	Tua	-	Many forms. All famous for growing very long; and hairy tubers.
19.	Vesivesi	-	Still cultivated by some farmers.
20.	Voli	-	A famous round shaped tuber variety. Good for eating.
21.	'Ufi Fisi	-	Very hardy, less susceptible to diseases.
		-	Tough textured tubers
22.	Panama	-	An introduced variety during the 1970s. It is now becoming less popular.
23.	Hawaii	-	The popular one has short-finger-like tubers

(ii) ***D. esculenta:***

	Varieties		Comments
1.	'Ufilei fie'ufi	-	Two forms are known. Still popular in cultivation. Also known as lavilavi.
2.	'Ufilei heke	-	Still cultivated, although it may be decreasing.
3.	'Ufilei kauhola	-	Also known as 'ufilei lotuma. Two forms are white and purple.
4.	'Ufilei vai	-	Still cultivated most popular in Niuatoputapu and Niuafo'ou. Very large tubers.
5.	'Ufilei Tonga	-	Cultivated in Niuatoputapu and Vava'u. Has hairy tubers.

(iii) ***Dioscorea rotundata:*** **-** Become one of the most cultivated species, for the reasons given.
No varieties

(iv) ***Ipomoea batatas:***

	Varieties		Comments
1.	Hawaii	-	Popular variety, although not the most cultivated one.
2.	Tongamai	-	Very susceptible to leaf-scab disease [6]. Best eating quality. Not widely cultivated.
3.	Mele fakahau	-	Still widely distributed.

[6] Leaf scab disease caused by fungus ***Elsinoe batatas***

4.	Kaloti	-	Most popular and best in Ha'apai.
5.	Tolu mahina	-	An early maturing variety – 3 months as indicated by name.
6.	Papua	-	Still common in many places.
7.	Setaita	-	One of the most common varieties.

(v) ***Colocasia escilenta***

Varieties		**Comments**	
1.	Lau'ila	-	Most popular, and most cultivated variety.
2.	Manu'a	-	Still cultivated in many area including outer islands.
3.	Talo Niue	-	Not a very popular variety, although export market is good.
4.	Sikavi	-	Common in many areas.
5.	Mangakoka	-	Cultivated in some areas.
6.	Talo enga	-	Produce multiple, jointed corms. Not very common, but it is still cultivated.
7.	Talo kape	-	Elongated corms-like Alocasia. Most common in 'Eua.

(vi) ***Manihot esculenta*:**

Varieties		**Comments**	
1.	Mataki'eua	-	Most commonly cultivated variety
2.	Falaoa	-	Cultivated in some area
3.	Leka hina & kula	-	Cultivation depends on preference and availability of planting materials.
4.	Lepa hina & kula	-	Similar to No. 3
5.	Silika	-	Cultivated but very limited.
6.	Engeenga	-	Very popular and widely cultivated.
7.	Tano'a	-	Cultivated in many areas
8.	Manioke Fisi	-	Cultivation increasing widespread.
9.	Manioke koka'anga	-	Cultivation very limited.

(vii) ***Xanthosoma sagittifolium***

Varieties		**Comments**	
1.	Talo kula	-	One of the most cultivated varieties
2.	Talo mahele'uli	-	The second most cultivated variety
3.	Talo tea	-	Becoming less cultivated

(viii) ***Alocasia macrorrhiza:***

Varieties		**Comments**	
1.	Kape hina	-	Still the most commonly cultivated variety.
2.	Fohenga	-	Commonly cultivated but not as much as No.1. Most popular in Vava'u.
3.	Kape 'uli	-	Sometimes mixed up with variety No.2. But it is not very common.
4.	Kape Fulai	-	High oxalate causing itching to the mouth. Still cultivated.

(ix) ***Tacca leonopetaloide:***

- Marked decrease in cultivation.

(x) ***Solanum tuberosum:***

Varieties		**Comments**	
1.	Red Pontiac	-	Most popular and most cultivated variety.
2.	Serrana	-	Cultivation depend on seed imported.
3.	Sebago sequoia And Dalisay	-	Cultivated only if seeds are imported.

Source: Adapted from Table 2.1.1

2.1.1 Aroids

This is a group of the Root Crops, which contain some important species, both socially and economically. Only three species of this category are being cultivated; and some varieties of these are in danger of being lost to a point of extinct. These are: *Colocasia esculenta*, *Xanthosoma spp*, and *Alocasia macrorrhiza*.

(a) ***Colocasia esculenta*: (Taro): Tongan name: Talo Tonga**

This is an important species in this group of plants that is grown for both the export and local markets. This species is widely distributed throughout the islands but is more adapted to areas with higher rainfall and areas with forest land still available –e.g. Vava'u and 'Eua. In 1982, 14 varieties of this species were recorded to have been on trials, (See Table 2.1.1). However the only most widely grown variety is "Lau'ila". This is only the result of farmer's selection process over the years.

During the late 1980s and 1990s, a Taro Variety Evaluation Project allowed tests with different clones of Colocasia esculenta – aimed at the selection of varieties that are tolerant to drought. Out of this variety evaluation, 7 new varieties were released in 2000 after being named by Her Royal Highness Princess Pilolevu Tuita. These new varieties are:

1. Mileniume
2. Katoanga 2000
3. Holoitounga
4. Omeia
5. Lavilavi
6. Vahenga
7. Laulelei

Two varieties also were named by the Prime Minister in 2000 as

1. Fisi'i fekika
2. Talo Heilala

(b) ***Xanthosoma sagittifolium*: (American taro) – Tongan name : Talo Futuna**

This aroid species was said to be introduced after the Europeans, during the 19th century, possibly via Hawaii (Barrau, 1961: 40). It is generally more tolerant to drought than *Colocasia esculenta*, and thus is more widely distributed both within and inter islands. In 1982, 8 varieties known were being researched by the ministry, (Table 2.1.1). Only varieties 1, 2 and 8, are still commonly cultivated. The other varieties are either lost; or are almost endemic to some areas.

(c) ***Alocasia macrorrhiza*** **(Giant Taro): Tongan name: Kape**

This species was once important in the tradional farming system of shifting cultivation, because when the new piece of land is cleared, giant taro is planted as an intercrop with yams as the main crop. Also traditionally, it is second only to yams in its role, for presentation to nobility. Varieties are limited only, and these have remained the same varieties, except that a few varieties are slowly disappearing. Only varieties kape hina and fohenga are still commonly cultivated. Refer to Table 2.1.2 (viii)

(d) ***Tacca leonopetaloides*** **(L) (Polynesians arrowroot) Tongan name: Mahoa'a Tonga or Koka'anga.**

This species was once grown to be used as glue for Tapa making. It was also used as a source of food, during food shortage by extracting starch from the tubers.

Very little of it is now used both as food and for tapa making. This is because an artificial method of gluing tapa has been invented. Thus, there is a threat of this species being lost in areas of Tongatapu. The island of Tofua & Kao still hold a rich treasure of this species where they do grow wild. No variety names are recorded.

(e) ***Amorphophallus campanulatus*****: Tongan name: Teve**

This species was traditionally grown on Tax allotments as a food source during times of food shortage. It is now being abandoned by most tax allotments; and thus being in danger of being lost forever.

(f) ***Cyrtosperma chamissonis*** **(Giant Swamp Taro) Tongan name: Pula'a**

This is another wild species, which was used for food only during times of food shortage. It is now very scarce and thus is in danger of extinction. No cultivation

(iii) ***Ipomoea batatas*** **(Sweet Potato) – Tongan name: Kumala**

Sweet potato is one of the root crop species, which has gained great importance over the years. Its importance has been gained both as a staple food, as well as a cash crop; despite its difficulties with export due to Quarantine problems[3]. It is probably second only to cassava, as the most consumed staple food crop in Tonga. It has the advantages of the short crop duration as well, as it is quite tolerant to drought. Table 2.1.2 (vii) shows a list all sweet potato varieties being in Tonga at that time.

During the late 1970s, almost all varieties of sweet potatoes were attacked by a serious fungus disease, which almost wiped out the sweet potato industry. Only one variety proved to have some resistance to the disease. This was because; the genetic base of sweet potato was very narrow; and it was highly susceptible to scab.

Thus in early 1980s, a sweet potato breeding program started, aiming at widening the genetic base. Introducing new varieties of sweet potatoes from other sweet potato growing countries were carried out. These were allowed to hybridize with local varieties, thus allowing broadening of its genetic base.

After the Breeding Programme, the following new varieties were added to the list of varieties:

1. Lole
2. Afilika
3. Satu
4. Dua
5. Tiga
6. Lafalafa
7. Setaita
8. Hawaii Kolosi

New varieties are being added to this list through new introductions and new hybrids. The danger of variety lost in this species seems to be counter by the number of new varieties being produced. This is because; travellers bring new promising varieties from overseas. Also, there is some degree of natural hybridization, producing new varieties.

(iv) *Manihot esculenta* (Cassava, Manioc or Tapioca): Tongan name: Manioke

Although cassava is considered of lower grade food crop, it is not only the most widely consumed staple food; but it is also the most well distributed single root crop species; occupying the greatest diverse habitat. The economic value of this species has been increasing during the last five to ten years when the quantity exported frozen has increased tremendously[7]. This species does not have a very rich diversity; and the number and names of varieties have remained unchanged for the last forty to fifty years. Very few new varieties have been introduced or produced during these years. The name of the varieties cultivated are given in Table 2.1.2 - ix

Unlike sweet potato, cassava variety diversity cannot easily be increased, because it is not easy to be smuggled into the country; as well as the impossibility of any natural hybridization.

[5] Export forbidden because of sweet potato weevils

Solanum tuberosum **(Irish Potato) – Tongan name: Pateta.**

This species is said to have been introduced by Europeans, in the 1930s, as table potatoes for cooking. From these, a few plants were planted in the backyard gardens. The quantity of table potatoes was slowly increased, and thus the cultivation also increased.

It was not until the 1970s, that there was a real increase in the diversity of this species when different clones and varieties were imported for trials. Of the hundreds of clones and lines tested at the Research Station, only seven varieties have since been cultivated continually. The most commonly grown variety in Tonga is Red Pontiac. Table 2.1.2 (x) show a list of Potato varieties being researched at the Research Station.

(vi) ***Arachis hypogaea*** **– (Peanuts or Groundnuts): Tongan name: Pinati**

Two known types of this species have been identified growing in the Kingdom:

(a) Virginia bunch - Have alternate branched forms with true runners and true bunch forms. There are typically two seeds per pod.
(b) Spanish-Valencia - Sequential branch forms with erect branch forms. Seeds per pod vary from 2-6.

Of the two types of this species cultivated, Virginia bunch has been the most popular type grown, since the 1960s. Since then mixtures of the two types and their different varieties have been introduced; and during these years, there was a danger of the degrading of the Virginia bunch types and thus the fear of it being lost. It is seen today, that cultivation of the Spanish types is slowly increasing and overtaking the Virginia type. Biodiversity of this species is very limited, as import of peanuts is forbidden.

The richness of this species is not known really; as all is known of any variety differences are seed number per pod; and the testa colour of the matured seeds. Thus classification of varieties and names are normally given by: 2 seeded, 3 seeded, 4 seeded etc. There is a maximum of 6 seeds per pod. Thus names used are “Pinati fo ua; fo tolu etc.

2.2 Fruit & Food Tree Crops

This category of plants contain a vast diversity of both species and varieties; some of which are becoming endangered species or varieties, and should require some conservation measures to save them from losing. The plant species are either Fruit Trees supplying fruits or Food Trees, providing food in the diet.

2.2.1 Fruit Tree Crops

(i) ***Mangifera indica*** **(Mangoes) – Tongan name: Mango**

Yuncker recorded only four varieties in 1959. These varieties are thought to be indigenous. There are also varieties, which have known to be grown for a long period of time. These are:

1. Mango lesi - Four forms of this variety does occur
2. Mango kaimata - There are different forms of this variety, differing in size and shape; but all have the character that fruits are sweet even before ripening.
3. Mango kalasini – Fruit has an odour resembling kerosene
4. Mango nui – Very large fruit
5. Mango ‘akau – Two forms occurs
6. Mango ‘uli
7. Mango Ha’apai – This is probably one of the varieties “mango kaimata”, known to have been specific to Ha’apai. However, it has now been spread to other islands.
8. Mango Tahiti – A later introduced variety, probably from Tahiti.

There are numerous other exotic varieties existing in the country, which has been brought in at various times from different countries. e.g.:

9. Variety Bowen from Australia
10. Tommy Atkins from Australia
11. Kalabau from Philippines
12. Ervin
13. Hayden
14. Ken
15. Kait

There may be other varieties, which are not recorded.

(ii) ***Pometia pinnata*** **(Pacific litchi) – Tongan name: Tava**

Yuncker, T.G., (1959) recorded that this species is well distributed from Tongatapu, ‘Eua and throughout the northern islands. It is considered one of the best tasting fruits, being very similar to litchi. Unfortunately this species does not have a rich diversity. Yuncker recorded the following varieties:

1. Tava moli
2. Tava kula
3. Tava toua
4. Tava hina

This species is considered an endangered species, as many areas in Tongatapu, and other islands are experiencing fast decreases in the number of trees still producing. This is because there is hardly any replanting of this species; and also there is no conservation program to try and save.

(iii) ***Citrus spp.***

This group of fruit trees was once evenly distributed throughout the Island groups, with fairly rich species, varieties and different forms. Yuncker, (1959) recorded that they were found growing in forests & thickets; but were not seen in cultivation. Yuncker recorded the following species and varieties.

(1) ***Citrus maxima*** **(Synonym: C. grandis or C. decumana) – Tongan name: Moli Tonga**

This is pomelo. A number of varieties were recognized but no names were given. In Tongatapu this species is rapidly disappearing and thus is in danger. Reports of few trees of this species are still found in Ha'apai.

(2) ***Citrus sinenisi*** **(Sweet orange) – Tongan name: Moli kai**

There were many varieties of these found throughout the islands, but no variety names are given. Differences are shown in fruit size, skin thickness, % sugar etc. Today, there is a danger of this species rapidly disappearing.

(3) ***Citrus reticulata*****: (Mandarins, Tangerins) – Tongan name: Molipeli**

This was also a rich species with different varieties although; they were all called Molipeli (Mandarins), and no variety names. The report of this species, in the 1950s and 1960s, were known to be abundantly distributed over the islands. Today, there is a very significant loss of this species (as with other Citrus spp), and thus is a clear indication already of the need for the Citrus spp. biodiversity conservations.

(4) Citrus aurantifolia - limes
(5) Citrus lemons - lemons
(6) Citrus paradisi - grape fruit
(7) Moli uku - was reported to be present at the time.

Citrus spp. in general, is amongst the most endangered species. In Tongatapu for example; there is a very scarce supply of most species especially the sweet oranges and mandarins. This is due to the following reasons:

(a) Absence of any replanting scheme or programs to keep the species surviving
(b) There was a very fatal attack by fungus and viruses during the 1970s & 1980s; which speeded up the process of spp. losses. Today, the only major supply of citrus is from 'Eua.

(iv) ***Syzygium malaccense* (L) – (Malay apple) Tongan name: Fekika**

This is one of the tropical fruit tree species which used to be a popular fruit, which was recorded by Yuncker, (1959) to be found in all the islands: Tongatapu, Vava'u, Ha'apai & 'Eua. Unfortunately; there is no record or mention of any varieties, although some variety differences are observed. This species is already an endangered species in that, the number of plants still growing, is decreasing tremendously over the last 10-20 years, throughout the island group.

The main reason for the species decrease is because senile trees are dying through natural death and land clearance; but there is no replanting scheme. Also, the new habitats of many areas are not suitable for the species to survive and grow well.

(v) ***Cocos nucifera*: (Coconuts) – The "Tree of Life" - Tongan name: Niu**

This is one of the most important crop species cultivated in Tonga. Expatriates, who leased land to run coconut plantations, for the export of copra, did first cultivation of coconuts.
This species did have quite a rich diversity; however, some varieties are slowly disappearing.
The following varieties are recorded:

1. Niu Vai
2. Niu Kafa
3. Niu matakula
4. Ta'okave
5. Niu 'ui
6. 'Utongau
7. Loholohotaha
8. Niu mea lava
9. Niu Tea
10. Niu Leka
    - Tonga Dwarf
    - Red Polynesian Dwarf
    - Yellow Samoan "
    - Red Malayan "

The most endangered species are:
Niu 'utongau, Loholohotaha, Niu vai & Niu kafa.

M.A.F.F. Research is making efforts to keep germplasm collection of the varieties. This is one way of ensuring the conservation of the crop diversity.

2.2.2 Food Tree Crops

(vi) ***Artocarpus altilis*** **– (Breadfruit) – Tongan name: mei**

1. Aveloloa
2. Avenonou
3. Kea Kulufau
4. Kea ma'ama'a
5. Loutoko
6. Maopo
7. Puou
8. Vahivahi
9. Mei Fisi
10. Ma'ofala

This is an important food crop species, which provides staple food during the shortage of root crops. This species is well distributed throughout the islands. Its diversity is naturally conserved, through continuous planting of replacement trees; either in tax allotment or in the town allotments.
The only varieties considered endangered are: maopo and vahivahi.

(vii) ***Inocarpus edulis*** **(Tahitian chestnut) – Tongan name: Ifi**

This is a useful food tree species, which has existed for many years. However, this species is considered a wild species; as it has never been cultivated. There are only three varieties recorded:

1. Ifi mea
2. Ifi 'ui
3. Ifi monosivai

This is an endangered species, as there is no cultivation or replanting done.

(viii) ***Carica papaya*** **(Pawpaw) – Tongan name: Lesi**

This is considered a popular Tropical fruit, which is well distributed in all habitats in the country. This species is reported by Thaman, as a post-European introduction (Barrau, 1971: 5). He reported that it grows on almost all bush and town allotments, in both wild and cultivated states; and is a dominant species in many secondary vegetation communities.

Some of the varieties recorded and still grown are:

1. Lesi meleni
2. Lesi Initia
3. Lesi Tonga
4. Lesi Hawaii - Sunrise
   - Waimanalo
5. Lesi Taiwan.

(ix) ***Anona muricata*** **(Soursop) – Tongan name: 'Apele 'Initia.**

This is a fruit species, which has been increasingly grown in many parts, as it was once promoted to be grown for export. There are no varieties recorded.

(x) ***Annona squamosa*** **(Custard apple) – Tongan name: 'Apele Tonga**

Again no varieties recorded. This species is in danger of being lost; unless some programme of conservation is started.

(xi) ***Spondias cytherea*** **(L) Syn. *S. dulcis* (Parkinson) – Tongan name: Vi**

This is a fruit tree species reported by Yuncker, 1959, to be present in all islands of Tongatapu, 'Eua, Vava'u and Ha'apai and Niuatoputapu. It is a species, which was naturally grown, with no cultivation done. Thus, this is one endangered species; which is slowly decreasing in occurance.

(xii) ***Persea americana*** **(L) (Avocado) – Tongan name: 'Avoka**

This is reported by Yuncker, as an introduced species, which is now panatropic in distribution. A number of varieties are observed, although, no records of variety names are known. This species is not cultivated; but is mostly grown naturally.

Similar to other fruit trees and tree species the danger of biodiversity loss is due to dying of senile trees; with no replacement trees been planted.

2.3 Fruits

(1) ***Citrulus vulgaris or C. lunatus*** **– (Watermelon) : Tongan name : Meleni**

Captain Cook first introduced watermelon, on his second voyage (Beaglehole, 1969: 262). This crop was first planted at Uoleva Island, in Ha'apai. Today, reports state that no better watermelons are grown elsewhere, other than in Uoleva. It is said to be the best habitat for watermelon.
An important species in this category, which at a time it was an important export crop. Today it is cultivated mainly as a cash crop for the local market. It has a long-standing export reputation.
Two traditional varieties have been cultivated overtime:

(1) Candy Red
(2) Sugar Baby

Two other varieties reported by Thaman, (1975) are: Market wonder & Ice cream

However, since development of research and introduction of new varieties; the following varieties have since been grown:

1. Charleston Grey
2. Charleston (Grey (Hyb.)
3. Family fun
4. Summer fun
5. Mini-lee
6. New Dragon
7. Congo
8. Cannon ball
9. Early Kloudike

Apart from the most commonly grown varieties; past researches have tested new varieties over the years; and also farmers have access to bring in their own varieties. Thus, here is a list of some of these varieties; taken from Annual Research Reports.

10. Royal sweet
11. Empire No. 2
12. Early star
13. Rubin
14. New Dragon
15. Jack of hearts
16. Gold baby
17. Lucky Sweet
18. Sweet marvel

(ii) ***Ananas comosus*: (Pineapple): Tongan name: Fainā**

Yuncker (1959) reported that this species was already seen in plantations. Three varieties only were reported at that time. Today, four varieties are grown:

1. Faina Ha'amoa
2. Faina Tonga
3. Faina 'Initia
4. Faina Hawaii

Only varieties Faina Tonga and Faina Hawaii are the most commonly cultivated varieties. Faina Ha'amoa and 'Initia are threatened as disappearing soon. This is because; the eating qualities are not as good as the two popular varieties.

(iii) ***Passiflora spp.*: Tongan name: Vaine, Pasione**

This group of plant species are collectively called locally as vaine; but they consist of a number of different varieties. The two main ones grown are:

1. ***Passiflora edulis*** – This is referred to as vaine kai
   3 varieties normally grown in Tonga:
   - Vaine palangi (big yellow fruits)
   - Vaine fefeka (rind is hard)
   - Vaine Molu (small yellow, soft fruits)

2. ***Passiflora quadrangularis*** –

Commonly called giant granadilla; or Pasione in Tonga. Vaine palangi was once cultivated in plantations, and thus distributed over the country. The other two varieties are normally grown wild. Pasione, is normally grown as single plants in the town allotments, near the houses on shelters. This is one way of conservation of the spp. diversity.

(iv) ***Musa spp.*****: Tongan name: Fa'ahinga 'o e siaine**

This plant species has a very rich diversity, varying in the eating qualities, growth habits; plant types; plant and fruit size and colour etc. Some species must be cooked before eating, while some are eaten raw/ripe. There are tall and dwarf varieties with green fruits, some yellow and some are red. All musa spp present in Tonga can be grouped into three main types, as shown in Table 2.1.3.

Table 2.1.3 List of Musa spp. and varieties grown in Tonga

(a) **Type AAB: (Musa balbisiana) – Tongan name : Hopa**

This group consists of all the plantain varieties and misipeka. The following varieties are reported:

1. Feta'u kula
2. Feta'u 'ulu'ikuma
3. Ta teau
4. Tokoni vai
5. Tu'utu'ukautala
6. Uhotaha
7. Vaivai hako
8. Vaivai puku
9. Maholi hina
10. Maholi 'uli
11. Puko
12. Putalinga kula
13. Putalinga puku
14. Misipeka
15. Lehia
16. Pikipiki hina
17. Tateau

(b) **Type ABB: (Bluggoe) - Pata**

1. Pata Tonga
2. Pata lahelahe
3. Mamae
4. Mahimahi
5. Ducasse – a new introduction

(c) **AAA Type** – (Cavendish)

1. Siaine Tonga
2. Siaine Ha'amoa
3. Siaine Fisi
4. Siaine Hawaii

Varieties 1 & 2 are commercial varieties that were cultivated for export during the 1960s and 1970s. Export was discontinued due to economic reasons; caused by pests and disease infection.

The danger of this species diversity loss is due to the infestation of serious pests and diseases, caused by both fungus and viruses. The two most serious diseases are: bunchy-top and black-leaf streak.

2.4 Vegetables

This category of plants has shown the greatest loss in indigenous biodiversity, although there is an increase in the exotic species biodiversity. This is an effect of the development of agriculture, introducing new species of vegetables to replace the indigenous species. Consumers, who changed their taste from indigenous vegetables to introduced vegetable species, unfortunately welcomed this.

Most of the edible indigenous green vegetables are no longer consumed now, although they are still available. For example, sweet potato leaves; Ameranthus spp.; some wild species of capsicum. These are being replaced now by vegetables like cabbages, lettuce etc.

These are the vegetable species, still commonly consumed today; beginning from the most indigenous to the most recently introduced species.

(i) ***Amaranthus spp.*** **Tongan name: Tupu'a; Longolongo'uha**

Yuncker (1959) reported this species to have been used as a vegetable. Unfortunately, this is not consumed any more as a vegetable, although some varieties are still growing as weeds. This species however, is still regarded internationally as a valuable green vegetable. Starting a collection of varieties still present in the country can easily conserve this species.

(ii) ***Taro top*** **- Tongan name: Lu**

This is the young leaves of Xanthosoma spp. and the older leaves of Colocasia esculenta. This is still the most popular green vegetable consumed. The richness of this species diversity is based on those discussed for Xanthosoma spp., and Colocasia esculenta. There is no danger of any biodiversity decreasing.

(iii) ***Abelmoscus manihot*** **(Aibika) – Tongan name: Pele**

This species is known as *Hibiscus manihot*. This is reported to be one of the high nutritious green vegetables. It has been the only other indigenous green vegetable still widely consumed, the other being lū (taro tops).

This is one of the indigenous crop species with very rich biodiversities as reported else where in the Pacific. Papua New Guinea has recorded about 200 different varieties of this species. However in Tonga the only reports of any variety differences is in the different plant characteristics

e.g. stem and leaf colours, leaf lobing, venation etc.

(iv) ***Cucurbita maxima*** – (Local pumpkin) – **Tongan name: Hina kai**

This is known to be a local species growing wild, and used as a cooked vegetable. This species is in danger of decreasing rapidly to a point of extinction for two reasons.

(a) Opening up and clearing of large areas for commercial farming.
(b) The dramatic increase in the production of squash pumpkin for export to Japan; disgarding the existence of local pumpkins.

The rest of the species in this category are a list of introduced vegetable species, at different times which have become important both for consumption as well as being cash crops.

(v) ***Lycopersicon esculentum*** **– (Tomatoes) – Tongan name: Temata**

Tomato is one of the highest consumed vegetables in Tonga. The only variety of tomato consumed before the European was a cherry – type variety referred to as a wild tomato (temata vao).

When new varieties were first introduced, they were mainly open – pollinated varieties. So, as the new varieties were brought into the country, the richness of the species biodiversity kept increasing. However, with the development of agriculture, improved hybrid varieties were brought into the country. Today, there is an increasing use of new hybrids, and this has unfortunately gradually destroyed the species biodiversity. This is because as the open pollinated varieties are disappearing, so are the genotypes of those varieties. This is because seeds only propagate this species.

With increasing use of hybrid varieties seeds from the progeny cannot be used to conserve the genes of those varieties. This is the problem with species, which cannot be propagated vegetatively.

Table 2.1.4 Tomato Varieties Researched by M.A.F.F. 1970s – 1990s

Variety	Cultivation Status	Comments
1. Floradade	Not very common	Seeds – expensive
2. Summer taste		
3. Money maker		
4. Island red		
5. Beef steak	Common variety	
6. Flora America	Not common	Seeds – expensive
7. Hope No.1	Not cultivated	Seeds not available
8. Grandens	"	"
9. Bestom	"	"
10. Tropic boy	Very common	Good variety
11. Tough boy	Not cultivated	Seeds not available
12. Passion	"	"
13. Mamalee	"	"
14. Precious	"	"
15. Capitan	"	"
16. Maxim Ps	"	"
17. King Kong	"	"
18. Florida MH-1	Not cultivated	Seeds not produced any more
19. UN-52	"	Seeds - expensive
20. Tropic VF	Not cultivated	Seeds not available
21. Roma	Still cultivated	Common variety
22. San Marzano	Not cultivated	Seeds not available
23. Chico III	"	"
24. Ventura	"	"
25. Napoli	"	"

Source: M.A.F.F. Annual Research Reports (1970s 1990s)

Table 2.1.4 shows a list of Tomato varities researched by MAF (1970s – 1990s). It shows that only a few varieties are still cultivated for the reasons mentioned. Either the seeds are too expensive, or seed suppliers do not import them.

2.4.1 Other Vegetable Species

The other vegetable species are similar to tomatoes in nature; as they are all introduced species. Initially, the introduction of open pollinated varieties keeps increasing the species biodiversity. But with the increased introduction of Hybrid varieties, and decreasing use of open pollinated varieties; the loss of biodiversity per species becomes obvious. Table 2.1.5 gives a list of varieties for each vegetable species, recommended for use in Tonga.

These recommendations were based on researches done as Variety Trials. The attributes tested include: yield; pest and disease resistance; seasonality and price of seeds. The farmer finally decides the cultivation of varieties.

Table 2.1.5 Recommended Vegetable Varieties for Tonga.

1.	**TOMATO**		12.	**CARROT**	
	A - UN-52 (hybrid) B - Master No. 2 C - Floradel D - Tropic V. F. E - Floralou F - Florida-MH 1 **Canning – Pear Shape** A - Napoli B - San Mazano C - Ventura D - Chico III E - Roma			A B C D E	New Kuroda Manchester Table Royal Cross Des Dan Red Heart
2.	**CABBAGE**		13.	**CUCUMBER**	
	A B C D E	YR Summer 50 Hy K-K Cross Succession O-S Cross Hy K-Y Cross		A B C D E	Giant Climbing Southern Cross Hybrid Apple Shaped Money Maker Short Green Glacier
3.	**CHINESE CABBAGE**		14.	**CAULIFLOWER**	
	A B C D E	Saladeer Tropicana Michihili Wong Bok Pack Choy		A B C D E	Snow Peak Snow King Puakea Tropical Cauliflower Snow Queen
4.	**CAPSICUM**		15.	**ROCK MELON, MUSKMELON**	
	A B C D E F	Mercury California Wonder 300 New Ace Hybrid Florida Giant Bell Boy Yolo wonder		A B C D E	Wonderful King Dixie Jumbo Summer Dream Hybrid FiHybrid Sampson Hales P.M.R.45
5.	**EGGPLANT**		16.	**WATERMELON**	
	A B C D E	Florida Market Black Beauty Long Purple Kurume Long Purple Money Maker		A B C D E F G	Candy Red Charleston Grey Congo Cannon ball Sugar baby Mini lee Family fun
6.	**LETTUCE**		17.	**SQUASH BUTTERCUP**	
	A B C D E	Great Lakes 54 Great Lakes 366 Green Wayahead Green Mignonette Great Lakes		A B C D E F G H I J K L M	Kurijiman Dandy Boy Nutty Delica T-110 T-113 Ajihei Kurijiman Delica ebisu Unebi Emiguri Nishiki ebisu Kuriko Kurohikari

7.	**ONION – WINTER**		18.	**OKRA**	
	A	Tropic Ace		A	Clemson Spineless
	B	Henrey' Special		B	Dwarf long Pod Green
	C	Yellow Granex F_1		C	Perkins Mamoth
	D	Texas Yellow Grano 502		D	Gold Coast Dwarf
	E	Red Tropicana		E	White Velvet
	F	Superex			
8.	**BEET ROOT**		19.	**PEAS**	
	A	Early Wonder		A	Laxton Progress
	B	Tall Top		B	Manoa Sugar (Edible podded)"summer"
				C	
				D	Victory Freezer
				E	Dwarf Alderman
					Green Arrow
9.	**CLIMBING BEAN**		20.	**PUMPKIN**	
	A	Kentucky Wonder		A	Queensland Ble
	B	Hawaiian Climbing		B	Gold Turban
	C	Yard Long		C	Tetsukabuta hybrid
	D	Mangro			
	E	Snake Bean Green			
10.	**BUSH BEAN**		21.	**RADISH**	
	A	Seminole		A	Tama Cross
	B	Top Crop		B	Mamoth White Globe
	C	Tender Green		C	Long Scarlet
	D	Cherokee		D	French Breakfast
	E	Contender		E	Comet
11.	**SWEET CORN**				
	A	Golden Cross Banton (open pollinated)			
	B	Hawaiian Sugar			

Source: Englberger, K. et al (1983) and Englberger, K. (1986)

These varieties keep changing from time to time and as new varieties are being recommended. Old varieties become less and less available. Thus, the biodiversity richness per species is unclear, as the available varieties per species at a particular time are not known.

2.5 Traditional Crops

Crops in this category are considered to have a significant importance traditionally, and therefore it is very important to maintain and ensure the conservation of their biodiversity. Some of these species are, although not endemic to Tonga, they are not found as important in other countries.

(i) *Broussonetia papyrifera* (Paper mulberry) – Tongan name: Hiapo

This species is the raw material for making of tapa. Although its habitat is not limited but can be grown in all islands; some areas however, are more popular for its production e.g. in Tongatapu, although it is widely distributed on the island; but areas with Leucaena trees, like Niutoua, Lavengatonga etc. are best for production of this species. Similarly, In Ha'apai Islands; Foa is most suitable for growing of

this crop and these areas, as in Tongatapu, are areas covered with leucaena (siale mohe). The biodiversity of this species is unknown. No variety names are known, although two distinct types are observed:

(i) Those with entire leaves
(ii) Those with lobed leaves

(ii) ***Pandanus spp***. – **Tongan name: Lou'akau**

This is also an important plant species used as raw materials for mats, and many kinds of handicrafts.

As with paper mulberry; distribution is throughout the islands, but the importance of the species has been more specific with handicraft and mat weaving centers of Ha'apai, Vava'u and Niuas. Today, there is an increasing demand for this species in Tongatapu, and thus there is already an automatic biodiversity conservation program going on for this species.

There is quite a rich biodiversity of this species, varying in species or varieties; some of which are specific to special kinds of mats, e.g., fala paongo, fala tofua, kie Tonga etc, are all made from different plant spp. or varieties.

Some of the recorded spp. and or varieties by Yuncker, 1959 are:

1. *Pandanus odoratissimus* (L): (var *savaiensis*) – Tongan name: Fa
2. *Pandanus odoratissimus* (variety *pseudo-linnaei* – Tongan name: Fahina, hingano
3. *Pandanus odoratissimus* (var sinensis) – Tongan name: Falahola
4. *Pandanus whitmeeanus* (Martelli) – Tongan name: Paongo
5. *Pandanus corallinus* – Tongan name: Fa Kula

Other varieties:

6. Fāfā
7. Loukie - For weaving thin, soft mats
8. Loutotolo – Leaves are not spiny
9. Tofua
10. Tapahina – Leaves are white striped
11. Tutu'ila – Leaves are not spiny

Pandanus spp. biodiversity is secured by the fact that the users of the pandanus for specific products ensure the conservation of those particular biodiversities by replanting those particular species or varieties.

(iii) ***Piper methysticum***: **Kava**

Kava is very important both traditionally and economically. It is the plant of the national drink; as well as one of the export crops. This makes this species able to secure its biodiversity from danger of losing, through continuous cultivation. There are seven varieties of this spp. cultivated throughout the Kingdom.

Varieties:

1. ‘Akau kula
2. ‘Akau hina
3. Leka kula
4. Leka hina
5. Valu
6. Lau fulufulu
7. Kava Niua (Tafahi)

Variety 7 is more specifically grown in Tafahi and Niua Toputapu. The rest of the varieties are fairly evenly distributed. The increasing cultivation of kava for export during the last ten years is one way of ensuring its biodiversity conservation; although there is no formal conservation program in place.

(iv) ***Saccharum officinarum*: To**

Traditionally, this species has a significant importance, when presented with the kava at Pangai, to signify its legend story. However, in everyday consumption, it is chewed, as a high sugar source. One variety of this species is significant because initially it was used as the best thatching material for Tongan house roofings. But it required special skills for the preparation. This variety is called “Au”. The varieties known to grow throughout the islands are:

1. Au
2. Fo’ufa’u
3. Heleveka
4. Ngata hina
5. Ngata kula
6. To hina
7. To kula

There is danger of biodiversity losses in that some varieties are not found more readily as before. This includes au, fo’ufa’u, heleveka, and generally other varieties are on the decrease in occurrence, due to less replanting.

(v) ***Cordyline tesminalis*: Tongan name: Si**

1.	Si	(a)	Si ‘akau	(d)	Si kula
		(b)	Si futu hina	(e)	Si matalea
		(c)	Si futu kula		

These species were reported by Yuncker, 1959 (pp. 79) from all islands of Tongatapu, ‘Eua, Vava’u, Kao etc. Thaman (1975) reports that these species are native to Southeast Asia – Pacific region; and was present before European contact (Barrau, 1971:21). These species are found both as ornamental and also as food during food shortage.

It is no longer used for food; thus the edible variety, which normally grow wild in the plantations; are now slowly disappearing, due to development of agriculture. The ornamental varieties are still found growing wild in Tax allotment, or grown as ornamentals in home gardens.

2.6 Livestock

Throughout Tonga’s history, the exposure to other cultures and their technologies has had considerable effect on the agricultural system. These contacts also led to the introduction of various plants and animals, which are now important components of the agricultural systems. This is how the Livestock industry developed in this country. Mainly Captain Cook during his visits introduced a number of livestock species at different times. They were left to breed, and be multiplied hoping to become useful livestock species for the country. Some of the livestock species, were either unsuitable or were not useful and thus were selected out over the years, (Beaglehole, 1967:120 and 1969: 262). Thaman, R. R. (1975: 85) stated that Captain Cook introduced new cultigens and domesticated animals such as melons, pineapple, pulses, cattle, sheep, horses, rabbits and deer.

During the latter half of 19th century; resident traders and large trading companies, obtained leasehold rights to land and developed plantation agriculture around copra, cotton, coffee and livestock. A number of these large-scale plantations still exist today.
The introduction of rabbits and deer must have been unsuccessful; as there are no further records of their existence.

Table 2.1.6 shows a list of the different livestock species, and breeds of each species that have been introduced, kept and developed as livestock species.

Table 2.1.6 Lists of Livestock species and breeds: Past and Present in Tonga.

1.	**Cattle**			
	(a)	Diary Type	-	Holstein Friesian
			-	Jersey
			-	Gurnsey
	(b)	Beef	-	Hereford
			-	Santa Gertrudis
			-	Brahman
			-	Shorthorn
			-	Australian Illawara Shorthorn (AIS)
			-	Aberteen Angus
			-	Charolais
			-	Simmental
			-	Limousin
2.	**Horses**		-	Belgian Heavy Draught
			-	Mustang
			-	Island Pony
			-	Local breed
3.	**Pigs**		-	Tamworth
			-	Large white
			-	Landrace
			-	Duroc
			-	Birkshire
			-	Wessex shaddle back
			-	Local breed
4.	**Chickens**		-	White leg horn
			-	Rhode Island red
			-	Australorp
			-	White shaver
			-	Brown shaver
5.	**Goats**		-	Anglo Nubian
			-	Saana
6.	**Sheep**		-	Romney Marsh
			-	Preangan
7.	**Dogs**		-	German Sheperd
			-	Labrador Retriever
			-	Great dane
			-	Golden retriever
			-	Bulldog
			-	Yolkshire derrier
			-	Spaniel
			-	Rottweiler
8.	**Cats**		-	Calico breed
			-	Dabi
			-	Moggie
9.	**Ducks**		-	unknown
10.	**Donkeys**		-	Unknown. Now non-existing

2.7 Threats and Pressures on the Agricultural Biodiversity

Each category, as classified and discussed already, shows that there are species and varieties which are more endangered than others, both within and between categories. Most if not all agricultural developments is concerned with utilization of biological resources and therefore results in losses of biodiversity rather than conservation. Therefore, the degree of biodiversity losses depends very much on the sustainability of the use of the agricultural biological resources.

Between categories, the most endangered species of being lost are in the Fruit and Food Tree Crops.

This is due to the following reasons:

(i) Clearing of areas through agricultural development, resulting in felling of these trees

(ii) Dying of senile trees, without any replacement plantings

(iii) Absence of any proper conservation programmes in place to save some of the more endangered species and/or varieties.

As discussed in the first part of this report, some of the most endangered species in this category are:

(i) **Citrus spp.**

Apart from the reasons given above, loss of this species is even made worse by the serious attacks by fungus and virus diseases. This rapid loss of the citrus species and varieties is being observed generally in the country. But it has been most noticeable in Tongatapu, and slowly spreading to outer islands.

For example, Pomelo or “Moli Tonga” can hardly be found in Tonga, but most severely missing in Tongatapu, similarly to mandarins or “molipeli”.

(ii) The other most endangered species in this category are Pometia pinnata or “Tava”, and Malay apple or “Fekika”.

Threats and pressures on the agricultural biodiversity of the other categories are not very severe as with the ones mentioned. This is because, as mentioned already for each category; the importance of each species ensures its continuous cultivation, and thus conservation of its biodiversity. In some cases although there are continuous losses in species or varieties; they are continually replaced by new ones, e.g., in root crops, although varieties are continually lost, new varieties are continually being produced, either naturally or by mankind.

Similarly, the same thing happens to vegetables. Researchers have been able to produce new varieties to replace those that do not perform. This, in a way ensures the sustainability of the agro-biodiversity.

2.8 Agro-Biodiversity Genetic

Most of the Tree Crops face this problem of decreasing agro-biodiversity, due to the continuous losses of tree species due to land clearance, and dying from old age, without any replanting scheme.

With root crops, losses of varieties result in narrowing genetic base. However, continuous hybridization and introduction of new varieties ensure a continuous maintenance of a wider genetic base. This is not as true for yam varieties because there is hardly any hybridization in yams. Thus, genetic base of yams can only be widened by direct introduction.

Generally speaking, the sustainability of a species and a variety will depend very much on the importance of that variety; for example, Yam variety "Kahokaho" is one of the most secured varieties because of its importance, both traditionally and economically. This variety has been cultivated for a number of centuries, despite difficulties in cultivation.

Similarly, sweet potato varieties Tongamai and Mele Fakahau are susceptible to a severe fungus disease. Yet, they are still being cultivated, using chemicals to control the disease. Even further, their genotypes have been bred to the local gene pool. This is one of the best ways of conserving the biodiversity.

2.8.1 Use of Agricultural Genetic/Biological Resources

The development of agriculture in the country has not made use of agricultural biotechnology, as has been used elsewhere, internationally. The only practice resembling this technology is the use of Tissue Culture as a means of conserving some of the agricultural biological resources. Many varieties of root crops are maintained in Tissue Culture.

Similarly, the use of plant breeding has been practiced in widening the genetic base of crops like sweet potato. Once these new varieties are produced, they are then stored in Tissue Culture. This is one of the ways we can exchange biological resources internationally.

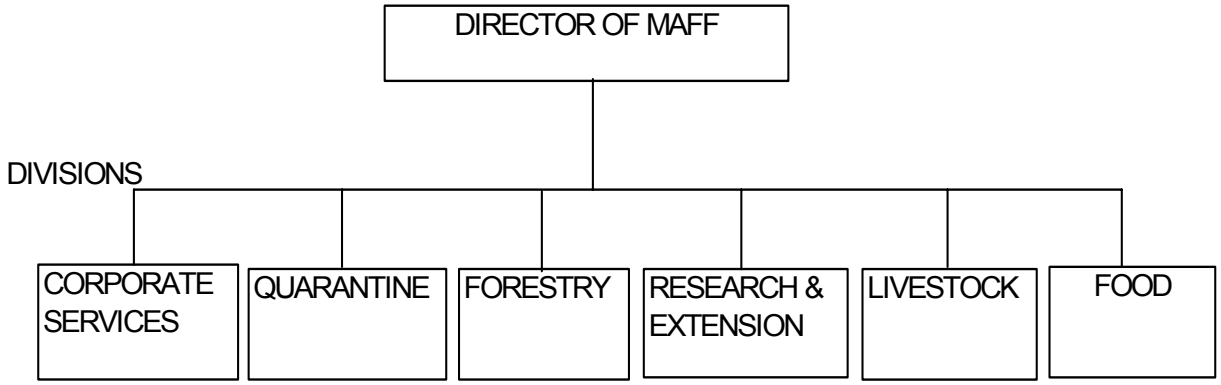
As yet, there is no legal basis for protecting the intellectual property rights for agricultural biodiversity.

2.9 Institutional Framework and Human Resource Base for Agro-Biodiversity Conservation

Presently there is quite a strong institutional framework and human resource base set up for conservation of agricultural biodiversity at the M.A.F.F (Refer Fig 2.2). Although most agricultural developments primarily aim at biodiversity utilization, they are in the long run, contributing to the process of biodiversity conservation.

There is a proper set up for both crops and livestock researches, which aim at improving production, and this in turns ensures biodiversity conservation. There are laboratories and equipments; there are facilities and other resources available to enable any researches e.g. Tissue Culture Lab.

Figure 2.2: MAFF STRUCTURE



All of the above six divisions of MAFF are all either directly or indirectly contributing to the Minitry's role of agro-biodiversity conservation.

Corporate Service

The function of this Division includes human resource management and training, finances, policy and planning, administration and proveds any extra services required by other Divisions.

Quarantine & Quality Management Division

This Division includes Biosecurity in its area of responsibility. That is they are responsible for the safety of the country's agricultural biodiversity by controlling the import of any materials that may harm any of the existing biodiversity of Tonga.

Forestry Division

This Division is covered in the Forestry Sector of this report.

Research and Extension Division

This is the most vital Division of MAFF, in its responsibilities and contributions to biodiversity conservation. The Research Section conducts reasearches on different aspects of crops and livestock. Variety trials, plant progagating, multiplication, livestock breeding trials among others are carried out.

The Extension Section is responsible for recommending and advicing farming communities and farmers to carry out the recommendations form the Researchers.

Livestock Division

The major role to this Division is to help livestock farmers, and to advice them on better animal husbandary practices. They also carry out clinical role of treating sick animals and animal health care. The Research Division does the research component.

Food Division

This is a recently established Division in 2003, which is responsible for the Food Quality Assurance. They will be looking at Post-Harvesting measures that will improve the quality of agricultural and livestock produce. This will feed back to the production line, thus in the long run, benefiting any agro-biodiveristy conservation strategies.

2.9.1 Agricultural Policies and Legislation

Agricultural policies are described in the National Strategic Development Plan (SDP 7) and the Ministry's Corporate Plan for 2004-06/07. MAFF has among its working policies two major goals aiming at ensuring the country's prosperity.
(i) Increasing Export earning by expansion of agricultural export produce
(ii) Ensuring Food Security by increasing production of food corps and livestock.

Through these two major goals, certain high value export crops are continuously grown. Stable food crops for the local and overseas market are also produced. However, some 'traditional' species (Table 2.1 and 2.2) may be indanger of being lost, as it is no longer popular for consumption or for export.

Mixed farming, semi-permanenet cultivation, practising the use of short legume fallows as well as other traditional and sustainable farming practices are encouraged to promote the conservation of agro-biodiversity. MAFF discourages the heavy use of machinery and inorganic fertilizers and agro-chemicals.

2.9.1.1 Relevant Legislation

There are very few legislatin covering agricultural bio-diversity. Few of the existing ones cover the following areas:

- In relation to the Land Act …it provides for a certain number of coconut trees to be grown in each tax allotments
- Every tax allotment holder must cultivate his land with crops or he could be taken to court for not growing crops
- A crop compensation rate of crop values covering almost all crops to be charged for any damages to corps caused by either roaming animals, fire or machinery
- The Quarantine Act prohibits the importation of live plants or animals into the country. Authorisation for the importation of any live specimen or parts is in the Minister of Agriculture, Forestry and Food.
- The *2003 Pesticide Act* provides for the registration of pesticides by the Registra. This Act is to control the importation of any pesticides, which may be harmful to the agro-biodiversity, environment and to human health.

2.9.2 Human Resource Base

The availability of a strong human resource base for such activities is one of the strong holds of this area. The following personnels are available, and have time available for such conservation activities.

1. 1 PhD – expert on Plant breeding and crop production
2. 1 Post-graduate – Plant breeding and crop production – Root Crops and Vegetables.
3. 1 Graduate – On general crop production.
4. 1 Graduate – On agricultural engineering in relation to Crop Production e.g. irrigation.
5. 1 Graduate – On Fruit Tree Production including Coconuts.
6. 4 Technical Officers on Crop Production
7. 1 Graduate on Livestock Production
8. One graduate with expertise on Tissue culture.

2. 10 Programs and Projects in Agro-Biodiversity

Most of the existing programs and projects regarding the above are only extensions, and continuation Projects that have been completed as far as funding is concerned. During the 1980s, many donor funded Project were conducted, and most of them are now completed and closed. Some of these Projects are:

(i) **A.C.I.A.R Project No. 8433:**

Titles: Sweet Potato – Pathogen Tested (P.T) Germplasm for the South Pacific (SP)

Objectives: - Identify the most suitable available sweet-potato cultivars for the South Pacific.

-Produce and supply Pathogen Tested Sweet Potato Germplasm to collaborating and interested countries in the region.

- Long term storage of Pathogen Tested germplasm in Australia and Fiji.

Donors: Australian Centre for International Agricultural Research (A.C.I.A.R)

Implementing Agencies: M.A.F/Tonga and Department of Agriculture and Rural Affairs. (D.A.R.A.); Victoria, Australia.

Dates: 1st July 1985 – June 1988

Budget: T$20,300.00

Strategies Used: Each collaborating country to identify and send sweet potato cultivars to Australia for clean up (disease-indexing). These are sent back to each country as Pathogen Tested materials (clean materials)
Each country, then carry out agronomic trials to compare Pathogen Tested materials and "dirty" materials grown locally.

Results: Originally, Tonga sent 16 cultivars to Australia for clean up. These were sent back; and cultivars Mele Fakahau and Taiuani were used for the agonomic trials.

Trial results showed no significant difference between Mele fakahau Pathogen Tested and "dirty materials. However, yield for Taiuani Pathogen Tested, was significantly higher than dirty material.

However, the overall benefit of this Project was that, we had access to Pathogen Tested materials, which in the long run is a conservation measure for the crop biodiversity. Also, we had access to access to exchange any promising materials from other collaborating countries.

Source: *Mason, A. et al.*

(ii) **P.R.A.P. Project No.4:**

Title: Selection, Trial and Dissemination of Swee Potato Cultivars.

Objectives: Collaborating countries to select sweet-potato cultivars, from a list prepared by The Project from different countries in the region; and made available in Tissue Culture. Each country conducts trials and report to P.R.A.P Project Coordinator, based at Papua New Guinea. These data informations are then made available to all countries to share; and request for materials if the require.

Donors: European Union, through Forum Secretariat.

Implementing Agents: Pacific Regional Agricultural Program and Collaborating Countries/ M.A.F.F. Tonga.

Dates: April 1995 – December 1999.

Budget**:** T$33.196.70

Strategies Used: Project cleans up sweet potato cultivars from participating countries, and keep then in Australia. Each country requests for any materials they need and carry out trials. Results are reported to Coordinator at Papua NewGuinea, who has this information available to all participating countries.

Results: Tonga was able to add materials from different countries to their germplasm, thus widening crops genetic base. e.g. materials from Papua New Guinea. These new materials were then incooperated into our breeding programme.

Source: *Van Wijmeersch, P. et al (1983)*

(iii) Title: Evaluation of the Tonga Tall Variety of Coconuts

Objectives: Selection of imdividual palms within Tonga Tall population for multiplication and evaluation thus increasing the low production problem.

Donors: Asian Development Bank.

Implementing Agencies: International Plant Genetic Resource Institute (IPGRI) /MAFF, Tonga.

Date: 1996 - 1998

Budget: T$13,000.00 for 3 years.

Strategies Used:
- Selection of mother palms in island groups
- Collect seed nuts and establish nurseries.
- Evaluate young palms in the field.

Results: Selection of mother palms were completed in year 1. In year 2 – seed nuts Were collected and planted in nurseries of the three major islands. The final stage of field planting was not completed, due to lack of farmer's interest.

Evaluation: The final evaluation of increased yield of seedling will not start until 2005/2006. However, the increased acreage of coconut plantings is an important output.

Source: *Fili, L. (1999)*

Most current projects regarding biodiversity conservation then are only continuation of donor funded projects, which are now long gone. Continuations of these projects are now operating under local funding from the Ministry's annual Budgets. These include:

1. **Vegetable Research**

Objectives: Carry researches on different aspects of vegetable production especially variety evaluations. This will result in recommendations of new varieties for Tonga.

Budget : T$3,000.00 - 2003/04 Financial year.

2. **Potential Export Crops**

Objectives: To carry out researches on different aspects of potential crops for export e.g. papaya; new vegetables like kanpyo

Budget: T$5,500.00 – 2003/2004 Financial year.

3. **Root Crops Research and Development**

Objectives: Carry out researches on different aspects of root crops. This will include continuation of past breeding programmes of sweet potatoes; variety trials of *Colocasia* etc. This will also include germplasm collection of root crop species.

Budget: T$8,315.00 – 2003/2004 Financial year.

4. **Fruit Trees and Coconut Improvements**

Objectives:

(i) To maintain a collection of Fruit Tree block on station

(ii) To maintain the coconut nursury

(iii) To carry out researches on different aspects of Fruit Trees; both exotic and native species.

Budget: T$5,700.00 – 2003/2004 Financial year.

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2.12 Annexures

Chapter 1- Annex 1: List of D. alata varieties grown in Tonga as surveyed in 1988/1989

No.	Varieties	Endangered	No.	Varieties	Endangered
1.	Falafala	Yes	**44.**	Lokaloka	
2.	Fua'i 'Ufi	Yes	**45.**	Mahoa'a	No
3.	Hau'ofa	Yes	**46.**	Mahoa'a Leleva	No
4.	Hawaii No. 1	No	**47.**	Mahoa'a Lotuma	No
5	Hawaii No. 2		**48.**	Mahoa'a Tonga	No
6.	Heketala	Yes	**49.**	Malau	Yes
7.	Heketala Puku	Yes	**50.**	Malekini	Yes
8.	Heketala Vai	Yes	**51.**	Mamange	Yes
9.	Kafiu		**52.**	Moala	Yes
10	Kahokaho	No	**53.**	Ngu	
11.	Kahokaho 'Ulumaka	No	**54.**	Ngu Hako	Yes
12.	Kahokaho Fau	Yes	**55.**	Ngu Hale	Yes
13.	Kahokaho Muihina (Vai)	Yes	**56.**	Ngu Hina	
14.	Kahokaho Siamane	No	**57.**	Ngu Kafakafa	
15.	Kahokaho Tavake	No	**58.**	Ngu Kia'imoa	Yes
16.	Kahokaho Vai (Muihina)	No	**59.**	Ngu (Tu) Pakata	
17.	Kapakau'i Kava	Yes	**60.**	Ngu Vaihako	
18.	Kaumeile 'Uli		**61.**	Ngu Vaikula	
19.	Kaumeile 'Uluenga	Yes	**62.**	Nise	
20.	Kaumeile 'Ululo'a		**63.**	Paholo	
21.	Kaumeile Hina	No	**64.**	Paholo Hina	
22.	Kaumeile Kula	No	**65.**	Paholo Kula	No
23.	Kaumeile Kulofau	Yes	**66.**	Palatea	
24.	Kaumeile Laukoka	No	**67.**	Panama	Yes
25.	Kaumeile Lavelio		**68.**	Poa	No
26.	Kaumeile Malau	Yes	**69.**	Sikau	Yes
27.	Kaumeile Pekakula	No	**70.**	Solomone	No
28.	Kaumeile Puku	No	**71.**	Takulevu	No
29.	Kaumeile Punuluo		**72.**	Takulevu Hina	No
30.	Kaumeile Toua		**73.**	Takulevu Kula	
31.	Kaumeile Toua/Panulu	Yes	**74.**	Tamuni	No
32.	Kivi		**75.**	Tua	
33.	Kivi Hako	Yes	**76.**	Tua'ata	No
34.	Kivi Hina	Yes	**77.**	'Ufi Fisi	No
35.	Kivi Kula	No	**78.**	'Ufi Fisi Hina	
36.	Kulo	No	**79.**	'Ufi Fisi Langakali	No
37.	Kulo Fuopotopoto	Unknown	**80.**	'Ufi Fisi Ve'ei Kuli	
38.	Kulo Hako		**81.**	Vanuatu - Lose	No
39.	Kulo Kau		**82.**	Vesivesi	No
40.	Kulo Matapoko		**83.**	Voli	No
41.	Kulo Puku		**84.**	Voli Hako	
42.	Laumahi		**85.**	Voli Hina	
43.	Lausi	No	**86**	Voli Leka	

Source: M.A.F.F. Technical Bulletin No. 10. pp 27-28

Chapter 1- Annex 2: List of Root Crops still cultivated in the Outer Islands: 'Eua, Vava'u, Ha'apai, Niuatoputapu and Niua Fo'ou – as surveyed by M.A.F.F staff in February 2004.

NIUATOPUTAPU

ROOT CROPS

Crops	**Varieties**	
Yam		
	- Kahokaho 'ulumaka	- Hauofa
	- Kahokaho muihina	- Poa
	- Kahokaho siamane	- Lavelio
	- Kahokaho vai	- Takulevu
	- Kaumeile hina	- Solomone 'uli
	- Kaumeile toua	- Langakali
	- Kaumeile lo'a	- Ulungaue
	- Kaumeile pekavalu	- Vesivesi
	- Kaumeile punuluo	- Nguvai
	- Kapakau'i kava	
Late Yam	- Solomone	
	- Voli	- Panama
	- Voli hina	- Paholo
	- Kulo	- Lose
Colocasia		
	- Lau'ila	- Katoanga 2000
	- Vahe	- Mileniume
	- Sikavi	- Holoitounga
	- Niue	- Alafua
	- Mahele'uli	
Alocasia		
	- Kape lau fuopotopoto	- Kape talo (kape ha'amoa)
	- Kape lau loloa	- Kape vai
	- Kape hina ma'a	- Kape fuahenga 'uli
	- Kape fulai	- Kape fuahenga engenga
Cassava		
	- Mataki'eua lau loloa	- Koka'anga
	- Mataki'eua lau fuopotopoto	- Leka kula
	- Lepa	- Leka hina
	- Engeenga	- Tano'a
	- Falaoa	- Silika
		- Setaita
Sweet potato		**Sweet yam**
	- Papua	- 'Ufilei vai
	- Hawai'i	- 'Ufilei tonga
	- Solomone	
	- Mahina tolu	- 'Ufilei fie'ufi (lavilavi)
		- 'Ufilei lotuma (kauhola hina)
	- Mele fakahau	- 'Ufilei lotuma (kauhola valeti)
	- 'Ufilei heke	

‘EUA

ROOT CROPS

Crops **Varieties**

Yam

- Kahokaho
- Kaumeile
- Solomone
- Mahoa’a
- Heketala
- Takulevu
- Voli
- Kulo
- Hawai’i
- Paholo
- Ngu
- Tamuni
- Panama
- Lavelio
- Lokoloka
- Vesivesi
- Tu’a’ata
- Fisi langakali
- Hale

Colocasia

- Sikavi
- Lau’ila
- Niue
- Manua
- Talo kape
- Talo engeenga

Cassava

- Tano’a
- Lepa
- Mataki’eua
- Fisi
- Silika
- Engeenga
- Sainai
- Manioke koka’anga

Xanthosoma

- Mahele’uli
- Talo tea
- Talo kula

Sweet yams

- ‘Ufilei fie’ufi
- ‘Ufilei vai
- Kauhola
- Lavilavi
- ‘Ufilei heke

Sweet Potato

- Siale
- Mele Fakahau
- Tongamai
- Hawaii
- Papua
- Palu kula
- Setaita
- Kaloti
- Mahina tolu
- Hawai’i kolosi
- Mukai Hehea
- Palu hina

HA’APAI

ROOT CROPS

Crops **Varieties**

Sweet Potato

- Mele Fakahau
- Tonuma (Setaita)
- Hawaii
- Kaloti
- Tolu mahina
- Papua
- Kumala Vava’u

Yams

- Kahokaho ‘Ulumaka
- Kahokaho Tavake
- Kahokaho Siamane
- Kaumeile Hina
- Kaumeile Toua
- Voli Hako
- Kivi Laukoka
- Takulevu
- Lavelio
- Mahoa’a Tonga
- Mahoa’a Leleva
- Mahoa’a Lotuma
- ‘Ufi fisi
- Kulo hako
- Kulo puku
- Voli hina
- Ngu kula
- Paholo
- Kapakau’i kava
- Hawaii
- Lose
- Poa
- Malekini

Sweet Yams

- ‘Ufilei kauhola
- ‘Ufilei ‘ulu’ikuma
- ‘Ufilei vai
- ‘Ufilei fie’ufi

Xanthosoma

- Talo futuna
- Talo tea
- Talo mahele’uli

Colocasia

- Sikavi
- Lau’ila
- Talo ‘uli

Cassava

- Manioke silika
- Manioke lepa
- Manioke engeenga
- Laufopotopoto
- Tano’a
- Mataki’eua
- Manioke fisi
- Manioke ‘uli
- Mataki’eua lauloloa

Alocasia

- Kape ‘uli
- Kape tea
- Kape fohenga

VAVA’U

ROOT CROPS

Crops	**Varieties**
Early Yam	
Kahokaho	- ‘Ulumaka
	- Tavake
	- Siamane
	- Mui hina
	- Tonga (manako tu’u lahi)
Kaumeile	
	- Hina
	- Kula
	- Pekavalu
	- Toua
	- Punuluo
	- Laukoka
	- Langi enga -kakano enga (cream)
Takulevu	
	- Hina

- Kula
- Vai

Tua

- Hina
- Ata
- Vai

Heketala

- Pala'a
- Vai (Toahola)
- Fisi
- Puku

Tamuni

- Leka
- Kia'imoa ('ulupiko)

Kivi

- Hina
- Kula

Ngu

- Hako
- Hale (Kano fefeka)
- Puku
- Kapakau'ikava
- Mamange
- Pala'atea
- Lavelio
- Solomone
- Kafiu
- Laumahi
- Poa
- 'Ufi fisi
- Fisi Langakali
- Vesivesi
- Lausi
- Lose
- Panama

Late Yam

Mahoa'a

- Lotuma
- Leleva

Voli

- Leka (puku)
- Hako

Kulo

- Puku
- Konisela (Kau)
- Hako

Paholo

- Kula
- Hina

Hawaii

- Mangamanga
- Hina (fulufulu e foha)
- Paholo kula (kano fefeka)

Lokoloka Kula

- Tu'u lahi tatau mo e vesivesi

Sweet Yam

- 'Ufilei Tonga (fulufulu)
- 'Ufilei vai
- 'Ufilei fie'ufi
- 'Ufilei heke
- 'Ufilei kauhola
- 'Ufilei lotuma

Cassava

- Mataki'eua
- Tano'a
- Lepa
- Engeenga
- Silika

- Leka kula
- Leka hina

Alocasia

- Kape hina
- Fohenga enga
- Fohenga ‘uli

Colocasia

- Lau’ila
- Sikavi
- Manu’a’uli
- Manu’a hina
- Manu’a pule (streak)
- Manga koka (foha mangamanga)

Xanthosoma

- Talo futuna
- Talo tea
- Talo enga
- Talo tofua (mahele’uli)
- Panefu

Sweet Potato

- Setaita
- Mahina 3
- Foketi
- Kolosi

NIUAFO’OU

ROOT CROPS

Crops ***Varieties***

Xanthosoma

- Talo tea
- Talo kula
- Mahele’uli
- Talo ‘uli
- Talo kape

Colocasia

- Lau’ila
- Manu’a
- Talo hina
- Talo kula
- Vahe tu’u lahi
- Vahe tu’u taha
- Talo vale
- Talo enga
- Talo ‘uli
- Sikavi

Alocasia

- Kape hina
- Fohenga ‘uli
- Fohenga enga
- Falaoa
- Fisi
- Koka’anga

- Talo
- Fulai (Fifisi)

- Talo ‘uli (fa’a ‘uli, kano ‘uli)
- Mileniume
- Katoanga 2000
- Holoitounga hina
- Holoitounga kula
- Alafua

- Talo mahele’uli

- Mileniume
- Katoanga 2000
- Niue
- Huli mama’o

- Kape vao
- Kape'uli
- Kape tafahi

Sweet Potato

- Papua
- Kaloti
- Valu
- Uini
- Siale
- Mahina 3
- Hawaii
- Setaita
- Melefakahau

Yam

- Kahokaho siamane
- Kahokaho 'ulumaka
- Kahokaho tavake
- Kahokaho vai
- Kaumeile lo'a
- Lose
- Nuku
- Kaumeile toua
- Kapakau'i kava
- Laumahi
- Vesivesi
- Tupakata
- Voli
- Mahoa'a lotuma
- Ngu vaikula
- Kafiu
- 'Ufifisi Langakali
- Hawaii

Sweet Yam

- 'Ufilei lotuma
- Lavilavi kula
- 'Ufilei heke
- 'Ufilei vai
- 'Ufilei fie'ufi
- 'Ufilei Tonga

Cassava

- Mata-ki-'eua
- Tano'a
- Manioke engeenga
- Manioke silika
- Lepa
- Manioke fisi
- Faifekau (lau fuopotopoto)

Source: M.A.F.F Staff – Outer Islands and Selected farmers

CHAPTER THREE

TERRESTRIAL FAUNA

(Viliami Kami[8])

3.0 Introduction

The stocktake on Terrestrial fauna biodiversity in Tonga as for other countries involves all the living animals that dwell on land. This report will endeavor to cover all research conducted on the invertebrates and vertebrates of Tonga.

The inverterbrates will mainly include the order insecta whereas the verterbrates will cover agricultural livestock, birds and the reptiles of Tonga.

A lot of research conducted on invertebrates in Tonga has been in the field of agriculture due to its importance to the economy and our society (Table 3.1.1). Terrestrial fauna (insect pests) involved in agriculture are mainly exotic insect pests recently introduced into the country and occur in many other countries.

Table 3.1.1 Proportion of Households with Respect to the Level of Agricultural Activity to the Total Households, by Location of Households, 2001

Location of Household	Total Households	Proportion of Households (%), by level of Agricultural Acivity		
		Agriculturally Active	Minor Agricultural	Non-Agricultural
Tonga	**15,738**	**64.2**	**5.3**	**30.4**
Tongatapu	10,583	54.2	7.3	38.6
Vava'u	2,625	83.2	1.4	15.4
Ha'apai	1298	82.9	1.5	15.6
'Eua	863	89.7	1.3	9.0
Niuas	369	90.5	0.5	8.9

Source: Ministry of Agriculture and Forestry & Statistics Department, Government of Tonga(Department of Statistics and MAF 2001).

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3.1 Terrestrial Fauna Biodiversity and Conservation

After reviewing all information available regarding the terrestrial fauna of Tonga it is best that the review be grouped into **Invertebrates** and **Verterbrates**. The invertebrates will consist of the order Insecta, arachnids, etc., where as the verterbrates will involve work on agricultural livestock and also on wild life such as birds, reptiles and rodents.

3.1.1 Inverterbrates

Unfortunately almost all of the existing information on previous research and studies conducted on inverterbrates is on insect pests of agricultural crops in Tonga. A summary is outlined below on the research activities on the major insect pests.

3.1.2 Fruits

3.1.2.1 Coconuts

The coconut tree remains is arguably the most important tree to Tonga as it is used for many different things i.e food source, energy source, timber, roofing etc. It was a huge source of revenue for people during the copra days and is present on all of the inhabited island

Due to its cultural value it is important that terrestrial fauna affecting this tree be recorded and included as part of the stocktake.

- **Rhinoceros beetle** *Oryctes rhinoceros* (Linnaeus)
  Coleoptera: scarabaeidae

The rhinoceros beetle known in Tonga as the 'manukainiu' or coconut eating insect is native to the region from India to Indonesia (Waterhouse and Norris 1987). It is known to attack over 31 genera of palms. In Tonga the rhinoceros beetle is known as a pest of the coconut tree (*Cocos palmif*) where its damage is most visible in the crown with the characteristic wedge shape gaps in the leaflets thus reducing photosynthesis.

The rhinoceros beetle has been recorded in Tonga since 1900, which led to the *1912 Rhinoceros Beetle Act.* It was recorded in 1925 as a pest of coconuts in Tonga, (Simmonds, 1925).

Research conducted led to an intergrated approach towards controlling the rhinoceros beetle which included the use of the fungal entomopathogen *Metarhizium anisopliae* (MAFF, 1969; Waterhouse and

Norris 1987), the *Oryctes baculovirus* or *rhabdovirus* (MAFF, 1974; Waterhouse and Norris 1987) in line with cultural control practices e.g burning of felled, standing and discarded coconut trunks. The greatest amount of work on the control of rhinoceros beetle was conducted in the early 1980s under the Tonga-German Plant Protection Project (Keyserlingk, 1980; MAFF, 1980; MAFF, 1981; Fall, 1982; MAFF, 1982; MAFF, 1983; and MAFF, 1984) covering all the major island groups (Tongatapu, Eua, Ha'apai and Vava'u). Monitoring of damage levels was also conducted that covered most of the inhabited islands of Tonga (Fall, 1982; MAFF, 1982; Shanower and Keyserlingk 1983; Heimoana 1985; MAFF, 1985; and Rapp, 1986).

These surveys and recent reports and sightings confirm that the rhinoceros beetle is present on all inhabited islands of Tonga.

- **Coconut Flatmoth** *Agonoxena argaula* (Lepidoptera: Agonoxenidae)

Surveys and reports have confirmed coconut flatmoth (CFM) to be in the Tongatapu, Ha'apai and Vava'u groups (Rapp, 1986; (Rapp and Fakalata et al., 1987; MAFF, 1987) with no confirmation from the Niuas group. CFM is a well-documented pest that damages the coconut leaves during its larval stages. The larvae tend to feed on the leaves leaving elongated or rectangular looking scars and holes in the damaged leaves. *A.argaula* outbreaks have occurred on a sporadic basis affecting large number of trees by causing heavy defoliation on the trees, effectively reducing yields. Outbreaks were reported on Vava'u and Ha'apai between August and December 1987 (MAFF, 1987).

Biological control is the best means of controlling cfm. A couple of native parasite *Apanteles argaula* and *Brachymeria* fijiensis effectively controls the cfm. Efforts have been made to introduce *Bracon sp* from Fiji with some success in rearing them in 1989 (Kami, 1989) but have had no confirmation since, of their establishment in the field. Outbreaks have occurred in the outer islands of Ha'apai.

Tongatapu experienced a major outbreak of cfm in 1996, which took 4-5 years for the coconut trees to recover fully.

- **Coconut spike moth** *Tirathaba rufivena* Lepidoptera

This moth is responsible for large losses in yield due to feeding on the inflorescence of the coconut tree. The control programme on the coconut spike moth (csm) included use of some insecticides but conclusively returned to the use of natural enemies (Litsinger, 1974). Damage surveys gave some

indication of its effect on yield and essentially "nut" drop (Shanower and Keyserlingk 1983) (Shanower, 1984)

- **Coconut stick insects** *Graffea crouanii* (Orthoptera: Phasmida)

The adult plus its nymphs feed on the leaves and can cause heavy damage leading to complete defoliation of a tree in extreme cases. Infestations are very localized. This pest is abundant on Tongatapu, Ha'apai and Vava'u. Two egg parasites *Paranastatus nigriscutellatus* and *Paranastatus sp* were discovered in 1976 to be responsible for 30-40% egg parasitism. Another egg parasite *Paranastatus verticalis* was introduced from Fiji to complement current biological control activity in 1978 (Crooker, 1979).

Chemical trials were conducted in an attempt to control stick insect activity through the use of Orthene (acephate) as an alternative to Bidrin (dicrotophos) (MAFF, 1980).

- **Coconut scale** *Aspidiella hartii*

The coconut scale is another pest on coconuts that is locally controlled by the parasite *Aphytis sp* and also by the coccinellid predator *Chilocorus nigritus.*

3.1.2.2 Citrus, Tava, Papaya

Tropical fruits remain our greatest potential for export but are continuously hampered by the constraints imposed by the fruitfly species present in Tonga. These fruitfly species are of such great importance that they are the core reason for quarantine protocols that regulate bilateral agreements on the trade of soft bodied fruits.

- **Fruitflies**

Six major species exist in Tonga and rated in terms of economic importance according to the amount of damage they cause to agricultural fruit. The species of agricultural importance are *Bactrocera fascialis* Coquillet, *Bactrocera xanthodes* Broun and *Bactrocera kirki* Froggart. Non-economic species are *Bactrocera distincta* Malloch*, Bactrocera nsn passiflorae* and*, Bacrocera obscura* Malloch.

B.fascialis is endemic to Tonga and is present in all the Island groups except the Niuas (SPC, 2001). *B.fascialis* attacks 64 fruit and vegetable species covering 48 genera and 29 plant families (SPC, 2001). *B.xanthodes* attacks 18 host fruits and vegetables in Tonga including avocado, breadfruit etc. *B. kirki*

attacks several fruits i.e guava, avocado etc. *B.distincta* attacks fruits from the Sapotaceae family such as star apple, sapodilla, kau tahi, kalaka and kau'uta (SPC, 2001). *B.nsn passiflorae* occurs in the Niuas attacking avocado, giant granadilla, guava, mandarin, papaya, sweet orange etc.

B.obscura is collected regularly from pheromone traps but has not been able to determine its range of hosts.

Fruitfly work over the past 3 decades has looked at different methods of control starting from the use of various insecticides, (Litsinger, 1974; MAFF, 1974; Crooker, 1979; and MAFF, 1979). The emphasis was on avoiding contaminated fruit being exported to New Zealand, Australia and other potential markets. Control methods currently used are based on the use of protein based baits that have shown to be highly effective and are very eco-friendly as compared to previous conventional chemical control methods, (Nemeye, 1995). A quarantine surveillance system is in place to monitor against the possible introduction of other invasive fruitfly species which involves the use of pheromone lures and host fruit surveys (MAFF, 1995; and SPC, 2001).

- **Banana weevil** *Cosmopolite sordidus*

Considerable amount of focus on the banana weevil occurred during the years of good banana production for export to NZ which ran frpm the late 1970s to the late 19880s (MAFF, 1986). Control methods ranged from chemical to the introduction of a nematode trial that would effectively control the weevil.

- **Fruitpiercing moth** *Hippotion celerio*

Work has been conducted on FPM regarding its control, as it is a major pest of softbodied fruits. Its potential to be a hindrance in the event of establishing a fruit industry in the future is warranted. The use of insecticides has proven to be ineffective against the adult moth (Crooker 1979). Natural enemies such as telenomus sp and Ooencyrtus sp were introduced in the 1990s and established in the field. However there was no guarantee of any reduced effect on the damage levels or on the field population of adult moths.

3.1.3 Vegetables

Commercial vegetable productions is increasing in the major island groups and as a result have an impact on our natural environment due to the need to control the damage levels caused by different

insect species by using insecticides. Most of the vegetable production is concentrated on Tongatapu due to its large population and its obvious demands.

- **Diamondback moth** *Plutella xylostella*

Diamondback moth is the major pest of cabbages in Tonga and is effectively controlled by the use of insecticides. Research on DBM in the past initially focused n chemical control as shown by research conducted by (Crooker, 1974 and 1970). This emphasis shifted in the late 1980s to the mid 1990s to an integrated approach including chemical, natural and cultural control methods(MAFF, 1982). Current research is looking at the possible use of natural enemies and other means of control that are friendlier to the environment. Another pest that has had research conducted on in the past has been the **Large Cabbage moth** *Croccidolomia binotalis* that is another major pest of cabbage. The large cabbage moth has been subjected to insecticide trials (Crooker, 1979; MAFF, 1979). Intercropping trials were also conducted to determine if it had any minimal effect on the levels of damage they conduct to cabbage crops (MAFF, 1987).

- **Corn earworm** *Heliothis armigera*

H.armigera is a major pest of tomato and corn in Tonga and has been subjected to many insecticide trials over the last 2 -3 decades (MAFF, 1982).

- **Aphids**

Over 17 species of aphid have been collected and identified in Tonga to date. The major ones that have had some work conducted on them in the past are the **Melon Aphid** *Aphis gossypii* and the **Banana Aphid** *Pentalonia nigronervosa, A.craccivora*, *R.maidis.* The parasitoid *Lysiphlebus testaceipes* were introduced twice in 1986 and 1987 to control the banana aphid as part of the control strategy for bunchy top virus.

- **Leafminer**

The Leafminer *Liriomyza sp* is a major insect pest of potatos, tomato and cucurbits and is normally controlled by systemic insecticides. It is known to occur on Tongatapu. Three different parasitoids were reared from leafminer larvae and were sent for identification (MAFF, 1987). Engleberger, (1988) introduced a parasite to control the leafminer in 1988 and 1989.

- **Whiteflies**

More recent to the scene is the generalist type of insect pest such as **Spiralling Whitefly** *Aleuroidicus dispersus* Russell Hem, introduced to Tonga in 1989 but had a successful biological control program that involved the introduction of the parasitoid *Encarsia haitiensis*. **Silverleaf whitefly** *Bermisia tabaci* biotype B was recently identified in August 2003 after silverleaf symptoms on squash plants were observed affecting many fields throughout Tongatapu. The whiteflies are normally very polyphagous and therefore will feed on many species of flora in our natural environment (Kami, 2003).

3.1.4 Rootcrops

Root crop production has remained as a traditional means of agricultural over the centuries.

- **Yam scale** *Aspidiella hartii*

Yam scale is a major pest of stored yams and have had numerous chemical trials using systemic insecticides to control it on planting material and also for the prospects of export (MAFF, 1986)

- **Rose beetle** *Adoretus versutus*

Named for its ability to feed on rose leaves and petals the rose beetle is a major pest of the yam cultivar 'kahokaho' which is highly valued locally. The rose beetle is polyphagous as it is also feeds on many species of the *Malvaceae* family and the ornamental rose from the *Rosaceae* family, from which its name is derived.

- **Taro hornworm** *Hippotion celeri*

Insectide evaluation Trials were conducted on taro (*Colocasia esculenta*) for the control of *H.celerio* (Litsinger 1974). Defoliation trials were also conducted to evaluate impact on yields due to infestation by *H.celerio* or *S.litura* (Engelberger and Tupou et al., 1985)

- **Cluster caterpillar** *Spodoptera litura*

The same trials conducted on *Colocasia esculenta* for *H.celerio* also included *S.litura* since it also is a pest. (Litsinger, 1974; Engelberger and Tupou et al., 1985)

- **Sweetpotato weevil** *Cylas formicarius*

Cultural control methods such as the use of organic mulch, soil mulches of varying depths (10cm,20cm and 35cm) and soil ridges of 20cm, were conducted in a trial but was not successful due to rodent

infestation, cattle feeding on foliage(Crooker, 1979; MAFF, 1979). Pheremone trials were also conducted in 1988-1989, 2000-2002, to control *C.formicarius* populations in the field (MAFF, 1991); (Kami, pers comm, 2004).

3.1.4.1 Tonga Insect Collection

An agricultural based collection of insects is currently based at the Vaini Research Station on Tongatapu. The collection comprises of over 500 species of insects with almost all specimens occurring in Tonga. Most of the specimens were from collections conducted during 1976 (Orton Williams, Maddison et al., 1976) and 1990 (Williams and Watson, 1990).

Insect collections were dated back to the late 1700s. Ant specimens preserved in the the New Zealand Arthropod Collection were collected from Tonga as far back as 1793 (Rhode and Berry, 2000). 27 ant species are in the collection (Rhode and Berry, 2000) which is quite a few in contrast to the land mass that constitutes Tongas total land area.

- Pest Database for Tonga

A database of agricultural pests and diseases recorded in Tonga (SPC 2002) is now available to all interested parties. The database comprises of 295 insect pest species based on several insect collections conducted in 1976 (Orton Williams, Maddison et al. 1976; Williams and Watson 1990) and also other collections following that (Engelberger and Foliaki, 1992).

3.1.5 Forestry

The Forest Health Surveillance Project funded by ACIAR and co-ordinated by the Queensland Forestry Institute in calloboration with MAF-Tonga, CSIRO (ACIAR, 2002). The aim is to update the skil1s of the forestry staff in the field of forestry entomology and pathology, which will lead to a collection of forestry insects.

3.2 Vertebrates

3.2.1 Agricultural Livestock

In terms of agricultural livestock there has been a consistent import of cattle to boost the beef and dairy industry in the kingdom in terms of increasing stock numbers and diversifying gene pool (MAFF, 1975; MAFF, 1977). Pigs have also been imported consistently over the last 3-4 decades (MAFF, 1975; MAFF, 1978). Poultry remains an important source for eggs and meat(Situa, 1995).

Table 3.1.2 Number of Households Keeping Livestock and Number of Livestock kept as of the Time of Enumeration, by Kind of Livestock, Kingdom of Tonga: 2001

Kind of Livestock	No. of Households	No. of Livestock Kept	Average No. of Livestock kept
Cattle	2,311	10,354	4
Pig	11,594	113,580	10
Horse	1,640	3,255	2
Goat	805	2,741	3
Chicken	7,729	177,829	23
Duck	126	1,119	9

Source: Ministry of Agriculture and Forestry & Statistics Department, Government of Tonga(Department of Statistics and MAF 2001)

The agricultural census carried out in 2001 (Table 3.1.2) convey the importance of livestock in Tonga clearly outlined by the number of households that claim to produce livestock (Department of Statistics and MAF, 2001).

Pigs are clearly the highest value livestock animals due to its social and cultural value as they are required for weddings, funerals and many other festivities where food is involved. Most households produce pigs in a semi intensive to free range setting (Situa, 1995; Department of Statistics and MAF, 2001).

Disease surveys on agricultural livestock have been carried out previously by visiting consultants and residential veterinarians (Saville, 1996). The most recent survey was conducted from September 1992 and March 1994. It confirmed the absence of any exotic diseases but also reported that there is a concern for the high number of cattle tested positive for bovine leptospirosis as it is a public health concern (Saville, 1996). Other diseases recorded for pigs and poultry were common throughout the region, (Saville, 1996).

3.2.2 Birds of Tonga

Studies have confirmed that Tonga currently supports 20 fresh water and sea bird species. Rinke, (1986b) and Stattersfield, (1998) confirmed that only one of these is endemic and that is the **Hengehenga** (Tongan whistler *Pachycephala jacquinoti*) which is confined to the Vava'u group. The

Malau (Niuafo'ou megapode *Megapodius pritchardii*) is considered as not fully endemic since it has a subspecies population extirpated to Vanuatu, (Refer to Chap 3 Annexures for some of the birds found in Tonga).

Fonualei Island in the Vava'u group of islands is confirmed as a sanctuary for more than 100,000 **Sooty terns** *Sterna juscata* where they breed in the crater (Jenkins, 1980).

A survey conducted in 1990 by Rinke, (1990) confirmed the following sightings.

'Ata: the island that had the greatest diversity of seabird species in Tonga mainly due to its isolation and absence of human inhabitants. Only place in Tonga where largest tropical **Ngutulei** (Masked Booby *Sula dactylatra*) breeds: Tavake **Toto** (Red tailed tropic bird *Phaethon rubricauda)*, **Blue-grey noddy** *Procelsterna cerulea* -similiar to the **Tala** (Fairy tern *Pterodroma heraldica*), two kinds of **Lafa** (Herald Petrel *Pterodroma heraldica* and Audubons shearwater *Puffinus lherminieri*). 2 kinds of **Ngongo** (Noddy terns *Sterna stolida*), 2 kinds of **Lofa** (frigatebirds), 2 other kinds of Ngutulei (Booby), **Manu'uli** (wedge-tailed shearwater *Puffinus pacificus chlororhynchus*), There was also the presence of a healthy population of, **Moa Kaivao** (Red Jungle Fowl *Gallus gallus*) Tala, and **Tavake** (white-tailed Tropicbird *Phaethon lepturus dorotheae*). The survey continued to include the following islands and their respective species as listed below

Kalau: small island south of Eua consisted of a large variety of birds. **Fuleheu** (Wattled Honeyeater *Foulehaio carunculata*), **Misi** (Polynesian Starling *Aplonis tabuensis*) **Sikotaa** (White Collared Kingfisher *Halcyon chloris*), **Veka** (Banded Rail *Gallirallus philippensis*) and **Lupe**(Pacific Pidgeon *Ducula pacifica*) in the forests. 2 types Ngongo, and Ngutulei (Red footed booby), Tala breeding on island, Lofa and Brown Booby *Sula leucogaster* also present.

'Eua: new spp of Gecko (Eua Gecko) discovered 1986. Only island **Kaka** or **Koki** (Red Shining Parrot *Prosopeia tabuensis*) was found (before being dispersed to Tofua, Late and Fonualei in 1994, (Tutu'alo, Baudry et al. 1996). Rare sp. of Manuma'a (Many Colored Fruit Dove *Ptilinopus perousii*) also found there.

Eueiki: similiar to Kalau in species richness. **Fuiva** (Red Vented Bulbul *Pycnotus cafer*) found there. The only island in southern Tonga to have **Henga** (Blue Crowned Lorikeet *Vini australis*). Also abundant is Fokai (banded iguana) - found on many islands but most in low abundance.

Hunga, Ha'apai: very similiar to Ata in seabird abundance but not as many species. Outstanding is the 350000 burrows of Manu'uli and a colony of Tavake toto which is rare for Tonga. The ground bird species included fuiva and Tu.

Tofua: **Taiseni** (swamp harrier *Circus approximans*) only found on Tofua. The **Pacific swallow** *Hirundo tahitica* also found here and on other islands in Ha'apai.

Late: **Tu** (Friendly ground dove *Gallicomlumba stairii*) was very common, **Hengehenga** (Tonga whistler) also very abundant and only found in 'Vava'u. Highest numbers of the forest bird species there. Late also had the largest population of Ngutulei and Lofa of the tropical pacific area located to the east of the Solomon Islands.

Niuafo'ou: **Malau** (Niuafo'ou megapode *Megapodius pritchardii*) endemic and only in Niua fo'ou. Lives in forests surrounding main crater lake. It digs its eggs in warm volacanic soil. Also a special variety of **Misi** (Polynesian starling *Aplonis tabuensis*) darker with yellow eyes are found in Niuafo'ou. Unfortunately **Ngutu'enga** (Jungle Myna *Acridotheres fuscus*) has colonized and eats many fruits.

Other land species reported to be in Tonga are the **Fulva (**Fiji Shrikebill *Clytorhynchus vitiensis*) which has a patchy distribution with presence on Niuatoputapu and Tafahi, small islands in the Nomuka group, Tofua, Kao and the Hungas, and on 'Eueiki and Kalau in the Tongatapu group. Its last refuge in the Ha'apai group is on 'Uiha, where it is very rare. On most islands, the Shrikebill is less common than the Wattled Honeyeater and the Polynesian Starling. On a few remote coral islands in the Nomuka group (Fetokopunga, Lalona, and Nuku) however, it can be found in extremely high densities. The Fiji Shrikebill disappeared from many islands in the Ha'apai and Tongatapu groups during this century. Main causes were de-forestation and the introduction of roof rats, which prey upon eggs and nestlings.

The **Phoenix petrel** (*Pterodroma alba*) and **Bristle-thighed curlew** *(Numenius tahitiensis*), also found in Tonga and are considered vulnerable(Hilton-Taylor 2000).

Misi Palangi (European starling *Sturnus vulgaris*) is found mainly on ‘Eua and Tongatapu.
Sikiviu (Polynesian triller *Lalage maculosa*) is found on all the largest islands except for Niaufo’ou.
Kulukulu (Purple-crowned fruit dove, *Ptilinopus porphyraceus*) quite a common bird found living on most of the islands. Hard to observe due to its green feather coat but its distinctive call is unmistakeable.
Moro (Spotless crake *Porzana tabuensis*) originally from Niuafo'ou, Fonualei, Late and Hunga Ha'apai. Now probably extinct in Tonga.
Kalae (Purple swamphen**,** *Porphyrio porphyrio*) these birds are almost present on every island in the kingdom, even small coral islets.
Motuku (Pacific Reef Heron *Egretta sacra*) very common on almost all the islands and tends to dwell along the coast.
Toloa (Grey Duck *Anas superciliosa*) has been recorded on several islands, but common only on Tongatapu, Nomuka, Late and Niuafo'ou. In smaller numbers in Toula and 'Uta Vava'u.
Long tailed cuckoo (*Eudynamys taitensis*) E. taitensis is a migratory bird that is found in Tonga during the months of May to September. It normally found in NZ and migrates up north to avoid the cold temperatures during winter.

Watling (2001) has reported confirmed records of sightings of 74 bird species (Table 3.1.3). 51 bird species are breeding species resident in Tonga (Watling, 2001). 22 of these species are native land birds, 23 are sea bird species, while 6 species are introduced (Watling 2001). The remaining 23 species are migrant or vagrants of which 6 species are shore birds, 13 are seabirds and the remaing 3 species are land & wetland birds (Watling, 2001).

Table 3.1.3 A checklist of Tongan birds

Species	Status	Species	Status
Wandering Albatross	VS	Spotless Crake	BL
Southern Giant Petrel	VS	Purple Swamphen	BL
Cape Petrel	MS	Pacific Golden Plover	MW;OW
Tahiti Petrel	S	Bristle-thighed Curlew	MW
Phoenix Petrel	VS	Bar-tailed Godwit	MW
White-naped Petrel	MS	Wandering Tattler	MW;OW
Herald Petrel	BS	Sharp-tailed Sandpiper	?
Kermadec Petrel	BS	Ruddy Turnstone	MW;OW
Mottled Petrel	MS	Sanderling	MW
Black-winged Petrel	BS	Pomarine Skua	VS
Collared Petrel	VS	Arctic Skua	VS
Gould's Petrel	?	South Polar Skua	VS
Steijneger's Petrel	?	Crested Tern	BS
Audubon's Shearwater	BS	Black-naped Tern	BS
Wedge-tailed Shearwater	BS	Sooty Tern	BS
Short-tailed Shearwater	MS	Grey-backed Tern	BS
Buller's Shearwater	VS	Bridled Tern	BS
Sooty Shearwater	MS	Roseate Tern	?
Wilson's Storm-petrel	?	Blue Noddy	BS?
Polynesian Storm-petrel	BS?	Grey Noddy	BS
Red-tailed Tropicbird	BS	Brown Noddy	BS
White-tailed Tropicbird	BS	Black Noddy	BS
Masked Booby	BS	White Tern	BS
Brown Booby	BS	Feral Pigeon	I
Red-footed Booby	BS	Friendly Ground-dove	BL
Great Frigatebird	BS	Pacific Pigeon	BL
Lesser Frigatebird	BS	Many-coloured Fruit-dove	BL
Eastern Reef Heron	BL	Crimson-crowned Fruit-dove	BL
White-faced Heron	BL	Blue-crowned Lory	BL
Mangrove Heron	VL	Red Shining Parrot	I
Pacific Black Duck	BL	Long-tailed Cuckoo	ML
Northern Pintail	VL	Barn Owl	BL
Tongan Megapode	BL	White-rumped Swiftlet	BL
Junglefowl	I	White-collared Kingfisher	BL
Pacific Harrier	BL	Pacific Swallow	BL
Banded Rail	BL	Polynesian Starling	BL
European Starling	I	Tongan Whistler	BL
Jungle Mynah	I	Polynesian Triller	BL
Red-vented Bulbul	I	Wattled Honeyeater	BL
Lesser Shrikebill	BL		

NX Extinct/extirpated native breeding species (historic times)
IX Extirpated introduced species;
I Introduced breeding species
? Current status uncertain or questionable/unverified record
BL "Resident, native breeding land bird"
BS Resident breeding seabird
VL Vagrant Land bird (irregular visitor or arrival)
VS Vagrant Seabird (irregular visitor to country's waters)
VW Vagrant Shorebird (irregular visitor)
S Seabirds not known to breed but are regularly present throughout the year
ML Migrant Land bird (of annual occurrence)
MS Migrant Seabird (believed to be of annual occurrence)
MW Migrant Shorebird (believed to be of annual occurrence)
OW Wader known to overwinter

Source: Walting, 2001

3.2.3 Herpetofauna

20 known species make up the herpetofauna of Tonga. One iguanid species (South Pacific Banded Iguana (*Brachylophus fasciatus*) which is also found in many islands in Fiji also in 'Eua, Eueiki,Tongatapu, Talai (Allison 1996), (refer Table 3.1.4). It is considered an endangered species ((Hilton-Taylor, 2000). The skink *Tachygia microlepsis* is considered extinct (Hilton-Taylor, 2000).

Nine gecko, nine skinks species and the Pacific boa (*Candioa bibroni)* were also confirmed to be identified in Tonga. One gecko species *Lepidodactylus euaensis* and a skink *Tachygia microlepis* are both endemic to Tonga (Gill and Rinke 1990).

Several specimens of the reptile species that were collected in Tonga between 1969 and 1990 have been preserved at the Auckland Museum, Auckland, New Zealand (Gill and Rinke 1990).

Table 3.1.4. Distribution of Terrestrial Reptiles on Island groups of the Tongan archipelago, based on specimens collected, identified and preserved at Auckland Institute and Museum (Source: Gill and Rinke 1990)

Reptile species	**Common name**	**Islands, Island Groups**							
		*Nf	Nt	V	L	H	T	E	A
Brachylophus fasciatus	Sth Pacific Banded Iguana			+			o		
Gehyra oceanica	Common Gecko	+	+	+	+	+	o	+	
Gehyra mutilate	Pacific Gecko					+	+		
Lepidodactylus lugubris	Mourning gecko	+	+	+		+	+	+	
Lepidodactylus euaensis[t]	-							+	
Cyrtodactylus pelagicus	Polynesian gecko			+		+		+	
Cryptoblepharus eximius	Green tree skink	+		+	+	+	+	+	+
Lipinia noctua	Moth skink	+	+	+			+	+	
Emoia cyanura	Blue tailed skink/emoia	+	+	+	+	+	+	+	+
Emoia pheonura	-	+	+	+		+	+	+	+
Emoia trossula	-			+		o	o	+	
Emoia nigra	Black skink	+	+						
Emoia Murphyi	-	+	+	+					
No of Species recorded		8	7	10	3	8	9	9	

*Nf- Niuafo'ou, Nt- Niuatoputapu, V- Vava'u, L- Late, H- Ha'apai, T- Tongatapu, E- Eua, A- Ata, + - voucher specimen (seen by B.J. Gill), o – sighting only by D. Rinke and/or B.J Gill. [t]- endemic gecko species.

3.2.4 Peka -Tongan Fruit Bat

Pteropus tonganus (White-Necked fruit bat / Insular fruit bat / Flying fox)

Colonies of the Peka or Tongan fruit bat *Pteroptus tonganus* are abundant in Tonga. This species is distributed throughout Polynesia to include Fiji, Samoa, Cook Islands and American Samoa. Colonies can be found on all the Island groups in Tonga with the largest colonies present on Tongatapu. Their forbidden status has enabled Tonga to maintain what is arguably the longest standing colony in the South Pacific.

The fruit bats are a major tourist attraction. They feed on fruits as indicated by their common name. The tongan fruit bat *Pteroptus tonganus* is closely related to *Pteroptus samoensus*.

3.2.5 Rodents

Three species of rodents are found on Tonga. Two are introduced species (Norwegian rat *Rattus novergicus* and the black rat *Rattus rattus*) and the native Polynesian rat *Rattus exulans*. Rodents have had an enormous impact on agriculture and the environment. They have been contributed significantly to reduced yields by damaging crops in the field e.g rootcrop tubers, fruits and in storage(MAFF, 1971; Litsinger, 1974; MAFF, 1974). Rodents have also contributed to the reducing populations of land bird species by consuming the eggs and young offspring.

Efforts were made to eradicate the rodent population on 3 islands (Maninita, Taula and Lua Loli) in the Vava'u group in order to allow a build up of land and sea bird populations (Watling, 2002; Houston, 2003). Watling (2002) reported 138 rats caught from a population density of over 114 rats per 100 corrected night traps.

3.2.6 Feral Cats

Cats can be catergorised as the domestic, stray and the feral cat. A brief definition of each catergory is provided below.

Domestic cat - This is a pet or house cat living in close connection with a household where all its ecological requirements are intentionally provided by humans (Moodie, 1995). Domestic cats may still impact on native fauna by their predatory activities, but do not rely on hunting for food.

Stray cat - This is a cat that relies only partly on humans for provision of its ecological requirements (Moodie, 1995). Stray cats may obtain food or shelter that has been provided intentionally or otherwise by humans, and include animals kept on farms for rodent control, dumped animals, and cats living in urban fringe situations such as garbage dumps. Moodie (1995) notes that urban strays, purposely fed by humans but which live independently in other ways, are often referred to, confusingly, as feral cats in the literature.

Feral cat - This is a free-living cat which has minimal or no reliance on humans, and which survives and reproduces in self perpetuating populations (Moodie, 1995). Note that ii to iv provide operational

definitions of cats that are based primarily on the degree of use that is made of human derived resources. Individual cats can potentially move between categories during their lifetimes (Moodie, 1995), as has been exemplified by Newsome (1991).

The cat provides negative impact on native fauna in three ways.

- It provides competition to the native species thus depleting available resources.
- It is a predator of native fauna species.
- And also act as a vector in the transmission of disease, parasites or pathogens to native species with minimal effect on the cat.

3.3 Ecological zones in Tonga

The ecological zones in Tonga can be classed into 2 basic catergories such as the drylands and the wetlands.

3.3.1 Dryland

3.3.1.1 Tropical Moist forests

The tropical moist forests occur on Tongatapu along the coastal fringes of the island. It is also prevalent on Eua and many other uninhabited islands such as Tofua and Late.

3.3.1.2 Tropical grasslands

Guinea grass *Panicum maximum* is the dominant grass that covers the flat portions of the islands such as Tongatapu. These grasslands occur on all the Island groups due to the clearing and destruction of natural vegetation for agricultural purposes.

3.3.1.3 Tropical Volcanic conditions

The volcanic activity occurs on Kao, Fonualei, Late, Niuatoputapu, and Niuafo'ou. The crater zone of most volcanic islands has a distinct but sparse herbaceous flora, and there is moss (cloud) forest on the summit of Kao and on Tafahi, to the north of the Vava'u Group. About 770 species of vascular plants have been recorded, including 70 ferns (three endemic species), three gymnosperms (one endemic species) and 698 angiosperms (nine endemic species) (Dahl, 1986).

3.3.2 Wetlands

Although most of the larger islands are raised coral limestone islands, much of the soil is volcanic, having been deposited as ash and cinders from the chain of volcanoes to the west. The original vegetation on limestone islands comprised lowland rain forest dominated by Calophyllum. However, virtually all of the primary forest on the flat islands was cleared for agriculture many years ago, and there are now large areas of secondary vegetation with Lantana and Psidium scrub, and Sorghum and Panicum grasslands, particularly on the islands of Tongatapu, 'Eua and 'Uta Vava'u. Coastal scrub with Barringtonia and Scaevola occurs on most islands, and Casuarina woodlands are found on recent lava flows.

3.3.2.1 Summary of Wetland Situation

There are three main types of wetlands in Tonga: partially enclosed tidal lagoons with mangrove forest; totally enclosed brackish to saline lagoons with saltwater marshes and/or mangroves, and freshwater crater lakes. Several of the wetlands are very large by Pacific island standards, and the total area of lakes and internal waters amounts to over 2,963 ha. There are, however, very few streams of any significance, and no permanent streams on any of the low-lying limestone islands.

The principal wetlands are as follows:

- a large, partially enclosed double lagoon system with extensive mangrove swamps near Nuku'alofa on Tongatapu;
- volcanic crater lakes on Niuafo'ou, Tofua, Kao and possibly also Late;
- enclosed brackish lagoons on Nomuka and 'Uta Vava'u;
- a freshwater marsh near Tu'anuku on 'Uta Vava'u.

Mangrove swamps, dominated by species of *Rhizophora*, are well developed in the lagoon system on Tongatapu, in parts of the Vava'u Group, and around the totally enclosed lagoon on Nomuka in the Ha'apai Group. Seven species of mangrove have been reported from Tonga: three species of *Rhizophora*, two species of *Xylocarpus*, *Bruguiera gymnorrhiza* and *Lumnitzera littorea* (Woodroffe, 1987). The total area of mangroves has been estimated at 1,000 ha.

Very little information is available on the wetland fauna. Rather few species of waterbirds occur in the islands, and only five species are resident: the Pacific Reef Heron (*Egretta sacra*), Pacific Black Duck (*Anas superciliosa*), Banded Rail (*Rallus philippensis*), Spotless Crake (*Porzana tabuensis*) and Purple Swamphen (*Porphyrio porphyrio*). Six species of shorebirds occur on migration and during the austral summer: Pacific Golden Plover (*Pluvialis fulva*), Wandering Tattler (*Heteroscelus incanus*), Bristle-thighed Curlew (*Numenius tahitiensis*), Whimbrel (*N. phaeopus*), Bar-tailed Godwit (*Limosa*

lapponica) and Ruddy Turnstone (*Arenaria interpres*), but only the plover and tattler would appear to be common (Pratt *et al.*, 1987; Watling and Talbot-Kelly, 1982). The Great Crested Tern (*Sterna bergii*) is a common resident in inshore waters, frequently feeding and resting on the reef flats. Land birds, which occasionally visit the wetlands, include the Swamp Harrier (*Circus approximans*), which is confined to the Ha'apai Group, and the widespread Collared Kingfisher (*Halcyon chloris*).

3.4 Threats and Pressures on Terrestrial Fauna Biodiversity

The drylands ecological zones are currently under threat from:

- Destruction of the natural habitat of land terrestrial fauna species through the clearing of the tropical moist forests for agricultural purposes.

- The intensity of current agricultural practices and the growing trend towards commercial agricultural production already has had a huge effect on our fragile ecologies. Commercial agriculture has increased the amount of land being utilized for agriculture plus the use of insecticides that will affect insects in the environment. Fertilizers are being used intensively and are also causing run off to surrounding wetlands.

- There is an urgent need to conduct insect collection survey that will focus on insects in our natural environment. This will also help us refocus and ensure that our current strategies are compatible with the environment.

- Recent squash production exploits on ‘Eua have led to acreages of natural forests being cleared to make way for more agricultural production.

- Rodents have always been a problem and will have a great impact on avifauna. Current efforts by the Tongan government to target Maninita Island at Vava’u for rodent eradication is proving to be successful(Watling, 2002; Houston, 2003).

- Feral cats are clearly recognized as a threat to the avifauna of Tonga.

The wetlands are under threat from a variety of sources. Some wetland habitat has been reclaimed for urban development, especially around the big lagoons on Tongatapu. The discharge of sewage from tourist facilities and destructive fishing techniques has been identified as the most acute environmental hazards in coastal wetlands and reef systems (Chesher, 1984). Other hazards include the use of lead in paints used for water catchment systems, increasing use of pesticides, siltation of harbour environments, and construction of causeways without ducts for water circulation. Pernetta (1988) suggests that climatic change and sea-level rise could have severe impacts on the coastal systems in the islands, and could possibly lead to economic and social disruption, inter-island movement of populations, and emigration.

Little attention has been given to the conservation of wetlands in Tonga, except on the island of Tongatapu, where a large reserve of 2,835 ha has been established to protect the Fanga'uta and Fangakakau lagoons. There are prohibitions on the dumping of any effluents, on the cutting of any mangroves, on commercial fishing and on certain forms of subsistence fishing in the lagoons. This reserve, which was established under the provisions of the Birds and Fish Preservation Act, is the only protected area in the Kingdom, which contains significant wetland habitat. All other existing protected areas were established to protect small islands, reefs systems and sites of cultural interest (IUCN, 1991).

A comprehensive Environmental Management Plan (Interdepartmental Environment Committee, 1990) has recently been prepared in a cooperative effort between the United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP) and the Government of Tonga. The objectives of the Environmental Management Plan are: to examine the existing state of the environment in Tonga and summarize the relevant existing information in a single document; to determine the environmental participants in the Kingdom and their resource needs; to discover environmental resource needs that are not being met and identify these as problems; and to recommend a plan of action to deal with existing and projected environmental problems. The plan makes a series of recommendations relevant to the conservation of wetlands and water resources, and identifies a number of opportunities for further protected areas, several of which would contain wetlands. The plan also makes a series of recommendations aimed at increasing public involvement in environmental issues, monitoring and research (IUCN, 1991).

3.5 Institutional Framework and Human Resoruce Base for Terrestrial Fauna

The Department of Environment is at the frontline for all activities regarding terrestrial fauna biodiversity, as it is part of their mandate.

However there is great need for the department of environment to try and utilize other government ministries and NGOs in order to enhance their ability to implement their activities. There is great need to work closely with ministries such as the ministry of agriculture so as to utilize their expertise in order to develop strategies that will lead to agricultural and forestry practices that will promote sustainable terrestrial fauna biodiversity.

- **Insects in the natural environment**

There is a need for Department of Environment to work with MAF to setup an insect collection survey that will target insects in the natural environment since there is very little records of insect species. This activity could lead to expansion of the current agricultural insect collection based at Vaini Research Station. The current insect collection could eventually become the national insect collection, which will be open to the public and for educational purposes.

- The Avifauna of Tonga

There is need to further strengthen our local expertise in the areas of ornithology to try and sustain our current bird populations. Surveys are required to update data on bird populations in the kingdom. Urgent attention to the setting up of reserves is required.

- The Hepterofauna of Tonga

Again local expertise is required so as to easen the task of setting up surveys to monitor current population levels and to study in depth the threats that exist.

3.6 Legal and Policy Framework for Terrestrial Fauna Biodiversity Conservation

The stocktake has exposed areas that require urgent attention such as the need for affirmative action to setup natural reserves, conduct thorough surveys in order to update all information on terrestrial fauna present in the kingdom.

There is a need to clarify the government's stance on establishing reserves as it is vital for the sustainability of terrestrial fauna biodiversity

The monitoring of invasive or introduced invertebrates/vertebrates for should also involve the department of environment. However this would require complete and updated database of the flora and fauna of Tonga. The legislation fails to provide specifics on the screening of imported beneficial insects for biological control activities, which require the Departments involvement.

3.7 Programmes and Projects for Terrestrial Fauna

- Relocation of Kaka (Red Shining Parrot) to Tofua, Ha'apai: Late and Fonualei in Vava'u. 12 adult birds of the Kaka were released at Late and Fonualei in 1994. A visit in 1996 found the birds flying around.(Tutu'alo, Baudry et al. 1996)

- Relocation of the Malau (Tongan megapode) to Late and Fonualei in Vava'u
  In 1991-1993 70 malau eggs and chicks were transferred from the Tonga Wildlife Centre to Late and Fonualei. A visit in 1996 found the birds had established on the islands. (Tutu'alo, Baudry et al., 1996)

- Rat eradication on Mininita Island, Vava'u
  Rats were eradicated on Mininita Island, Vava'u from 2001 to 2002 in order to allow the avifauna and hepterofauna to increase in numbers(Houston, 2003).

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Annexures:

Blacknapedtern (Lafa)
Puffinus iherminieri

Crested Tern

Brown bobby (Ngutulei)
Sula leucogaster

Birdled tern (ekiaki)
Strena anaethetus

Masked Booby

CHAPTER FOUR

FORESTRY

(Taniela Hoponoa[9])

4.0 Forestry Biodiversity and Conservation

This chapter covers native and introduced forest, invasive and pest plants species, forestry management and forestry use and existing national programmes.

4.1 Location and Extent of Natural Forest Cover

Desloges (1994) summarized that, out of the 691 km² of total land area of Tonga, 8,000 ha (approximately 80 km² or 11 %), is covered by natural forests of primary and secondary growth. Pacific Island Economies (1995), estimated that the total natural hardwood forest area for Tonga as being 4,000 ha. This report referred to primary forests and not secondary growth. Cited in ADP (1979) the South Pacific Agricultural Survey 1979, (Table 12.1 p.276) presented an estimation of 3,000 ha total forest cover or 4 percent of total land area.

The wide range of figures (3,000 to 8,000 ha) on the extent of the natural forest cover may have occurred due to a number of reasons.

a) Information and reports extracted from previous written work and not specific inventory work.
b) A national inventory, covering the whole of Tonga, has not been done.

Tongatapu and ‘Eua:

Most of the studies on natural forest cover found to be concentrated on the islands of Tongatapu and ‘Eua. This attributed towards the heavy involvement of the New Zealand Government on Tonga Forestry Development Projects which was the major donor agency to the Forestry Division of MAFF. In addition, the inititial forestry development activities such as coconut sawmilling and establishment of the ‘Eua forest plantation, started in Tongatapu (1976) and ‘Eua (19xx) respectively.

One comprehensive inventory of Tongatapu Natural Forest was done by Wiser et. Al., (1999). A detailed description of the forest-cover types on Tongatapu presented to be totaling at 26,844 ha. The

natural forest area (covering interior forest, coastal forest, and coastal swamp forest areas only) reported to be 862 ha. The report also presented a map indicating the "land cover type" for Tongatapu, (Chapter 4, Annex - Figure 4.1). Such comprehensive resource map is vital in planning of forestry, and associated fauna and flora groups in Tonga. Thaman 1976 (p.38) discussed in detail the vegetation cover types of Tongatapu and presented a sketch map, showing the "Vegetation of Tongatapu Island", (Chap 4 Annex - Figure 4. 2).

Bellingham and Fitzgerald (1996) presented the following maps; Figure 3, *"Map of 'Eua Vegetation";* Figure 4*, "Maps of 'Eua Soils";* (Chap 4 Annex - Figure 4.3)*, "Maps of 'Eua Buffer Zones";* and (Chap 4 Annex - Figure 4.4)*, "Maps of 'Eua National Parks"*. It is reported that approximately 43 % of the total land area of 'Eua (8,900 ha) was under forest cover in the early 1980's, (RAS/92/361, 1994 Field Ddocument No. 5).

Kao and Tofua islands:

Tofua and Kao contain some of Tonga's very best rainforest ecosystems but are relatively poor in the number of native plants and animals compared to other land areas Park and Whistler (1998). There is virtually no endemic species despite their isolation resulting from the islands being isolated and active volcanoes subject to violent eruptions. The real extent of the islands rainforest ecosystems is not discussed in this study.

Resource maps of similar nature to that in (Chap 4 Annexures - Figures 4.1 to 4.4) were not available for the other island groups in Tonga (Vava'u, Ha'apai, (including the resource rich islands of Kao and Tofua), Niuatoputapu (including Tafai) and Niuafo'ou (including Fonuafo'ou)).

Findings and recommendation:

The real extent of the natural forest ecosystems for Tonga is not defined precisely in the revised texts. Resource maps, indicating their extent and locations confined mainly to Tongatapu and 'Eua. It is evident from previous studies cited above that there is an urgent need to carry out a national forest inventory for the remaining islands. Aerial photographing and mapping need updating to outline the actual extent of the country's forest resources. Aerial photographing and mapping should be followed by ground surveillance to confirm exact location and extend of forest cover. Digitized resource maps, like that produced by Wiser (1996) should be made on all major islands centers especially the 'resource rich' islands such as Kao, Tofua, Late, 'Ata etc. MLSNR and DOE could take the leading role in producing resource maps with Forestry Division to provide back up support.

[9] Taniela Hoponoa is a Forestry and an Community Participatory Expert

4.2 Exotic Forest Plantation

'Eua Forest Plantation:

Some 750 ha of exotic forest plantation is planted on the island of 'Eua (Pacific Island Economies, 1995). The 'Eua exotic forest plantation, initially established by the Forestry Division of the Ministry of Agriculture, Forestry and Food (MAFF), was later transferred to Tonga Timber Limited (TTL) in 2003 to fully commercializes timber utilization. Major exotic species comprised of *Pinus caribaea* (Paini)*, Toona ciliate* (Sita Kula)*, Sweitenia macrophylla* (Mahokani)*, Agathis robusta* (Kauli) and *Eucalyptus spp* (Pulukamu). The current rate of new plantings, replanting of logged areas, enrichment planting of natural forest stands, and logging started intensively mid 2003, is not available during this review. Chap 4 Annex - Figure 4.4 gives the exact location of the forest plantation area on 'Eua.

An estimated 50 ha of exotic forest plantation, mostly on 'Eua island, is private owned.

Figures on areas and number of trees planted on boundaries of private allotments through agroforestry activities of the Forestry Division of the Ministry of Agriculture, Forestry and Food (MAFF) is also not available.

Findings and recommendation:
Due to the unavailability of figures on the progress of planting and harvesting of forest plantations and private woodlots, a mechanism be formulated from a focal agency such as the Department of Environment (DoE), to monitor resource development in terms of exotic forest plantation. Forestry Division's capacity to produce maps and records of plantation development should be supported so that they should be able to keep tract of all on-going plantation development whether government or private-own.

4.2.1 Coconut Palm Resources

Tongan people sometimes referred to Coconut palm, *Cocos nucifera,* as the "tree of life", due to its multipurpose uses. Coconut palm is found in all the islands of the archipelago. The agricultural lands estimated as amounting at 48,000 ha (approximately 64 % of total land area). The area covered with coconut palms reported to be around 35,347 ha (approximately 50 % of total land area or 74 % of agricultural lands) Burrows and Douglass (1996). All of Tonga, except Niuatoputapu and Niuafo'ou districts, covered in this coconut resource inventory.

Detailed maps on the extent and distribution of coconut palm resources are not available. Understandably, coconut grows in all islands and in most forest/vegetation-cover types i.e. from the extreme coastline to the high points of raised coral islands. Plant density varies greately based on the locality and farming systems existed.

It is noted with interest that coconut palms were not once referred to by any of the references, covered during this review, as a forest species although it covers land area four times more than natural and exotic forests put together. In this review, coconut palm is considered as a "forest species" hence categorized as a separate forest type. In all cases, coconut is associated with lower vegetation, agricultural crops in both the traditional and/or commercial cropping systems. Coconut is an integral part or base crop in traditional agroforestry inter-planted with trees, crops and/or livestock) systems. Most of the coconut regeneration occurred naturally. (Forestry Division Annual Report, 2002)

Findings and recommendation;

The rate of replanting of coconut palms is very slow particularly in Tongatapu. The Coconut Replanting Scheme (CRS) of MAFF should be supported especially the replanting programme. Coconut nurseries should be established and operationalized in Vava'u, Ha'apai, 'Eua, Niuatoputapu and Niuafo'ou. Coconut wood resource users like Tonga Timber Limited should be encouraged to invest in the CRS of MAFF.

4.2.2 Weed and Invasive Species

Approximately 200 species were accidentally introduced to Tonga as "weeds". Early settlers of the Polynesian people in Tonga introduced around 70 'weeds' prior to the European era. The similarity of the flora of Tonga to that of the adjacent islands has been a major factor in the naming of Tongan plants, Whistler, W.A., 1991.

Pacific Island Ecosystems at Risk project (PIER)

The Pacific Island Ecosystems at Risk project (PIER) was established with a purpose of compiling and disseminating reference information on exotic plant species of known or potential threat to Pacific island ecosystems.

The ever-accelerating rate of biotic invasion is a major element of human-induced global change. Alien plant species, in particular, pose an increasing danger to ecosystem integrity, especially on islands.

Through a request made by MAFF, PIER facilitated a national survey on invasive species of Tonga in 2001. The survey was carried out by two USDA forest experts, (Space and Flynn), surported by officers of MAFF Tonga. Plant species that are threats to natural or semi-natural ecosystems of all types are listed. Excluded from the PIER lists are species that are primarily agricultural, lawn and garden weeds.

Space and Flynn, (2001) grouped invasive species in Tonga into four major categories:

1. Some 259 species invasive elsewhere in similar ecosystems but were not seen or reported in the literature as being present in Tonga

2. Some 31 introduced species reported to be invasive elsewhere and are also invasive or potentially invasive in Tonga.

3. Species that are invasive or weedy elsewhere and are common, weedy or cultivated in Tonga (135 species)

4. Native species that exhibit aggressive behavior (9 species)

Annexures 3-6 outlined the invasive and potentially invasive species present on Tongatapu, Vava'u; and Ha'apai islands.

Findings and recommendation:
The work of PIER should be encouraged and follow up activities should be a priority to ensure that introduction of invasive species is stopped. Public awareness and training is a very important component of forest biodiversity conservation. Publications should be produced (or formulated/translated if not available) and disseminated throughout Tonga.

4.3 Species Richness and Endemism

Whistler, (1989) recorded flowering plants species native to Tonga as around 330, with approximately one third consisting of ferns. He further discussed that the rate of plant endemism in the archipelago is low. Nearly two-third of the native species are also found in Samoa, with an even higher percentage shared in Fiji. Specifically, Whistler mentioned that there are about 11 endemic species in Tonga. Details and names of these endemic species were not given in the text or any of the text covered during the review of literature. With regard to rare species, Wiser et.al., (1999) did not list them but recommended that proper recording (database and a booklet) of rare species be developed and updated.

Fusimalohi (Date n.a) mentioned Kolitoto, Fekika *Syzygium malaccense*, and Nukonuka *Decaspermum fruiticorsum,* as being rare in Tongatapu, Vava'u, Ha'apai, and 'Eua islands. These

species are valuable flower, food and medicinal plants. This is a result of a number of community PRAs (participartory rural appraisal) carried out by Fusimalohi.

In later works of Park and Wistler (1998) in Kao and Tofua, they listed the following species as endermic to Tonga:

LANGAKALI VAO *(Aglaia heterotricha)*
- Endemic to the forest of 'Eua,
- Small-Medium size trees

MO'OTAMEA (Dysoxylum tongense);
- Large trees
- Endemic to forests of 'Eua
- Kula & Mea = lanu kulokula
- TUFAHO in Niuafo'ou

UHIUHI (*Podocarpus pallidus);*
- Endemic to the forests of 'Eua,
- Wood for carving and tool handle

Others likely to be endermic to Tonga:

AHI VAO (Vavaea amicorum)
AKE (Zanthophyllum pinnatum)
FEIFAI *(Schleinitzia insularum)*
FUE FAILOLO *(Piper graeffei Warb.)*
FEKIKA VAO *(Syzygium culsiifolium)*
KAHIVA'E *(Dicranopteris linearis)*
Mafua (Niuatoputapu)
FULULUPE *(Xylosma orbiculatum)*
FETO'UMAKA *(Carcinia myrtifolia)*
FANGALE *(Lumnitzera littorea)*
KULUKULUFA *(Meryta macrophylla)*
TE'EPILO 'A MAUI *(Geniostoma rupestre Frost.f*)
PUALIKI *(Crataeva religosa)*
PASIVAKA *(Stenochlaena palustris)*
MOTOU *(Cryptocarya hornei)*
MO'OTA *(Dysoxylum forsteri)*
MASALU NGAUE *(Schizaea dichotoma)*
MALOLO *(Glochidion ramiflorum)*
MALAMALA'ATOA *(Memecylon harveyi Seem.)*

Prioritization of rare tree species was carried out by species but not by ecosystems. Prioritized rare species can be categorized into two major classes in food and cultural uses.

4.3.1 Important Tree Species

Fruit/Food species:

Fruit trees were reported by Thaman 1976, as the dominant vegetation type on most town allotment in Tongatapu. They are available in township areas because of their value as food to the local community. Some of the food producing species listed include; *Artocarpus altilis, Mangifera indica, Cocos*

nucifera, Pometia piñata, Citrus spp., Inocarpus edulis, Terminalia catappa, Spondias dulcis, Anona muricata, Persea americana, Carica papaya, Annona squamosa, and Psidium guajava.

Minor forest products:

Other important tree species used as supplementary food crops as well as cultural uses, handicrafts, as well as fuel-wood sources. Amongst this category are species namely; *Plumeria spp., Hibiscus tiliaceus, Aleurites moluccana, Ceiba pentandra, Pandanus tectorius, Glochidion spp., Casuarina equisetifolia, Bischofia javanica, Cananga odorata, Erythrina variegate, Syzygium aromaticum, Cinnomonum zeylanicum, Phaleria disperma, Aglaia slatotrium, Morinda citrifolia, and Callophyllum inophyllum.* Variety of products for cultural and social uses can be found on the above species and many more not listed.

Timber species:

The exotic plantation forest, situated on the island of ‘Eua, is dominated by *Pinus caribaea, Toona ciliate, Sweitenia macrophylla, Cortia aliatora* and *Eucalyptus spp.* The ‘Eua plantation aims at producing high quality timber to cater for local consumption hence minimizes import of timber to the country. *Cortia aliatora,* although possess good wood production ability, is a highly invasive species which can invade a broad areas in a relatively short time and are difficult to eradicate.

Cultural/Social species:

Cultural species especially Heilala *Carcinia cessilis* poses a social and cultural value and it is amongst the highly endanged species (SPRIG 2003)

Findings and recommendations:

There are no specific sites, apart from the national parks, to plant and protect trees of important value to the general public. Understanding of propagation and management techniques of these species is very much lacking. The rate of exploitation is of concern in view of sustainability and conservation. The potential for economic gain in terms of export of a number of the highlighted species is growing in strength.

Rcommendations:

- The forestry division is to promote and encourage increased replanting of the priority species,
- Increase production of high quality seedlings for public sale and distribution from its nurseries,
- Provide the public with more information of priority species, how to propagate and care for them,
- Organize national competitions such as the Bi-annual Royal Agricultural and Industrial Show
- Establish gene conservation stand/seed orchard in the main island centers of Tonga,
- Undertake research to fill critical gaps in our knowledge of priority species ecology, such as propagation and cultivation, seed storage physiology, vegetative propagation, optimum water requirements, reproductive biology etc.
- Improve public awareness in conservation of priority species
- Formulate and enforce appropriate policies and regulations to improve public contribution towards replanting and conserving of potential species

4.4 Unique Aspects of the Ecosystem

In looking at the aspects of ecosystems, it is important to point out that description of ecosystems varied significantly due to a number of reasons.

a) Studies were carried out on varies forestry related topics such as the study of Thaman (1976) on Tongan Traditional Agricultural Systems.
b) Some reports were based on land-use pattern or objectives, hence given names to a forest type based on land-use.
c) Some identified ecosystems according to locality of forest stands

Resulting from having variations in defining of forest ecosystems, prominent classifications of each of the major references presented separately, by author, for ease of reference.

Thaman, 1976 (*with specific references to*; McCracken and Fitzgerald (1997), Burrows and Douglass 1996, and Pacific Island Economies 1995):

Thaman (1976) explains that previous studies were focused on the identification and listing of species and their uses and very little on plant communities. Thaman's discussion of the primary vegetation (of Tongatapu) was based on two major criteria. One criterion is a site or location in which such vegetation type is found. For instance, mangrove swamp refers to mangrove species found on swampy areas. Secondary, a reference to the species composition such as high density coconut stand and *Leucaena galuca* stands. Thaman therefore classified the Tongatapu primary vegetation types as follows:

4.4.1 Coastal Littoral Forest

Found of sandy or rocky soils in the areas exposed to strong winds and salt sprays. Thaman described that on the sandy or rocky seaward edge of Tongatapu, low, salt-tolerant vegetation predominates and comprised of the following dominant species: *Scaevola frutescens, Canavalia serisea, Ipomea pre-caprae, Vigna marina, Wedelia biflora, Thuarea involuta, Spinifex littoreus, Pemphis acidula, Suriana maritime, Sesuvium portulacastrum, Euphobia atoto, Cassyth filiformis, Fimbristylis cymosa, Derris trifoliate, Phaleria disperma, Vitex trifolia, Bikkia tetrandra, Colubrina asiatica,* and *Pandanus spp.*

Larger trees are found in dense littoral forests including the following species: *Hibiscus tiliaceus, Macranga harveyana, Barringtonia asiatica, Ochrosia oppositifolia, Casuarina equisetifolia, Thespesia populnea, Acasia simplicifolia, Tournefortia argentea, Hernandia ovigera, Callophyllum inophyllum, Desmodium umbellatum, Morinda citrifolia, Heritiera littoralis, Myristica hypargyraea, Premna taitensis, Gymnosporia vitiensis, Planchonella costata, Canthium barbatum, Guettarda speciosa, Cordia subcordata, Cerbera manghas, Ximenia Americana, Terminalia catappa, Grewia crenata, Pisonia grandis, Pipturus argenteus, Pandanus tectorius, Mertya macrophylla, and Ficus scabra.*

Other characteristics of this type are; found in rocky & sandy soils; usually exposed to excessive salt spray; found to have salt-tolerant scrub vegetation; unsuitable for agriculture; some bush allotments (along the coasts) include considerable portions of this marginal land; provide valuable resource in terms of timber, medicinal plants, pandanus, wood for carving, fuel-wood etc.

McCracken and Fitzgerald (1997) also listed some of the mixed maritime hardwood species discussed by Thaman as being found in coastal littoral forest. They also emphasized the vital role of coastal littoral forest in protecting inland crops from salt spray and storm-wind damage as well as their fuel-wood and medicinal qualities. Soil erosion control as another important function of this type was mentioned.

4.4.2 Coastal Savanna

The coastal savanna vegetation is restricted to a narrow flat zone of flat limestone terraces along the south and east coasts of Tongatapu. Vegetation is characteristically prostrate with *Pemphis acidula, Sesuvium portulacastrum, Portulacca samoensis,* and *Fimbristylis cymosa* predominating among the cracks and shallow soil pockets in the limestone.

An understory of grasses including *Spinifex Littoreus, Thuarea involuta,* and *Ischaemum murinum* along with *Wedelia biflora, Canavalia sericea, Vigna marina* and *Cassytha filiformis* is also found in the coastal savanna forest. Low-herbaceous vegetation is found throughout this understorey comprised of *Pandanus tectorius, Scaevola sericea* and *Tournefortia argentea*.

Other characteristics of this type was noted as never extends more than 90 meters inland and possibly the lowest potential areas for agriculture

4.4.3 Swamp Forest

Areas of swamp forest are found primarily in the low-lying areas along the north coast (of Tongatapu). These areas are characterized by hydromorphic soils that are inundated from time to time throughout the year due to the excessive rain and tidal oscillations.

Thaman went on to describe that swamp forest as being characterized by an open to semi-closed forest with an understory of salt tolerant shrubs. The dominant trees in this type are: *Excoeria agallocha, Xylocarpus granatum, Hibiscus tiliaceus, Thespesia populnea, Lumnitzera littorea, Heritiera littoralis, Ficus prolixa, Inocarpus edulis, Psidium guajava, Pandanus tectorius,* and *Rhizophora spp.* In the some areas, the predominant species are *Xylosma orbiculantum, Macaranga harveyana, Santalum yasi, Grewia crenta, Rhus taitensis, Morinda citrifolia, Glochidion sp., Ficus sp., Hibiscus tiliaceus, Cerbera manghas, Syzygium dealatum,* and *Diospyros ferrea.*

Exotic species such as *Lantana camara, Psidium guajava,* and *Stachytarpheta urticaefolia* have become naturalized in the swamp forests.

This type was also reported as having soils with high organic content provide high crop yield if water logging can be avoided, and also a source of many plant products valuable to most Tongans

4.4.4 Marshland

Marshland areas have standing water throughout most of the year. These waters are sometimes blackish owing to tidal ingression. The predominant species are *Cyperus javanicus, Ischaemum murinum, Paspalum conjugtum, Coix lachrymal-jobi, Eleocharis dulcis,* and *Jussiaea erecta.* Also scattered are *Psidium guajava, Lumnitzera littorea, Hibiscus tiliaceus* and *Excoecaria agallocha.*

This type was also reported as having no agricultural potential unless reclaimed and has potential for aquaculture (Folaha village).

4.4.5 Mangrove Swamps

This association consists of trees actually growing in salt or blackish water on a muddy substratum below the limits of high tide. Three major species found in mangrove swamps, these are *Rhizophora mangle, Rhizophora mucronata* and *Bruguiera conjugate.*

This type was also reported as having little agriculture potential unless reclaimed, major source of dyes for tapa making as well as timber, fuelwood, wood carving etc.

4.4.6 Tropical Lowland Forest & Secondary Vegetation

The remnants of tropical lowland forest have characteristically closed canopy composed of trees reaching heights over 60 feet, a limited understorey, and a number of epiphytes and lianas. The dominant tree species are *Rhus taitensis, Alphitonia ziziphoides, Elaeocarpus tonganus, Ellattostachys falcate, Aleurites moluccana, Ervatamia orientalis, Dysoxylum forsteri, Sysygium clusiaefoluim, Grewia crenata, Tarenna sambucina, Xylosma orbiculantum, Vavaea amicorum, Santalum yasi, and Ficus spp.* Outer margins comprised of more open areas dominated by secondary species including *Hibiscus tiliaceus, Glochindion spp., Macaranga harveyana, Morinda citrifolia,* and *Bischofia javanica*

Understory species consists of *Micromelum minutum, Jasminum simplicifolium, Alyxia stellata* and *Dryopteris invisa.*

Lianas and epiphytes found in tropical forest and secondary vegetation include *Entada phaseoloides* and *Asplenium nidus.*

Thaman suggested that regardless of the species composition, the remaining stands of tropical lowland forest represent probably the best potential agricultural land on Tongatapu with respect to soil fertility.

In addition, these stands are valuable sources of timber, firewood, and traditional medicine.

4.4.7 Grassland Savanna

Referred to agricultural land invaded by panicum grass, an exotic grass species recently introduced as livestock feed. Repeated ploughing contributes towards these species being rapidly disseminated throughout the islands.

4.4.8 High Density Coconut Stands

Found mainly on coastal areas and bush fallow sites characterized by uneven spacing, no distinctive age classes and close spacing.

4.4.9 Leucaena galuca Stands

Exotic nitrogen fixing tree species recently introduced but spread quickly and became invasive. A valuable fuelwood source but also known for its invasive ability and monoculture establishment due to its fast growing ability.

4.4.10 Coconut Plantations (Pasture)

The main findings of Burrows and Douglass (1996) are listed below:

- Mean coconut palm density for all main island groups of Tonga is 91 stems/hectare. The range is from 71.6 stems/hectare on Tongatapu, to 135.6 stems/hectare on Ha'apai.
- The overall stem density of coconut palms in the inventory area declined by 26.6% over the last 16 years.
- The decline in Tongatapu and Vava'u has been more than 35%

- Stem height-class distribution for all island groups is unbalanced, with the majority of stems being in the middle height-class. Over 50% of stems were between 10 an 15 m tall, while only 5% < 5 m and 8% > 15m.

Burrow and Douglass summarises that the overall number of coconut palms in Tonga to be approximately 2,828,000 (±5.8 %). It was also estimated that 35,000 ha covered by coconut palms amounting at 5 million palms with which 2 million (40 %) being young to mature, 1 million (20 %) old, and 2 million (40 %) over-mature to senile, (Pacific Island Economies, 1995).

There was no specific mention of the exact locations of coconut palms apart from its high density on coastal areas. This is a reflection of its ability to disperse by means of sea current.

4.4.11 Urban Vegetation

This type refers to tree stands and individual trees grown on town settlement area.

An inventory on natural forest for Tongatapu and ‘Eueiki islands were carried out by Wiser, et al. 1999. They defined the land-cover types of Tongatapu, with assistance of Aerial Photographs. Forest types were defined as having a canopy greater than 3m while the shrub-land types were referred to as having canopy less than 3m. This study focused more on forest types in contrast to a broader assessment of the vegetation types done by Thaman 1976.

Most of the land surface (of Tongatapu) was reported by Wiser as being actively farmed, including coconut and other tree plantations. Together, these classes comprise 72% of the land-cover. Regeneration forest or fallow types comprise 8% of the cover. Natural cover types comprise 8% of the cover, of which 5% is non-forest types such as mangroves and swamps, while only 3% of the land surface has natural forest as its cover. The area of normal forest is 863 ha. This forest is predominantly coastal swamp forest (56%) and coastal forest (36%). Interior forest comprises only 8% of total natural forest area and less than 1% of the total land surface.

Wiser et. al. 1999 discussed major land-cover types as as follows;

1. Interior tall forest and shrubland (subdivided into **interior forest** and **shrubland)**.

1.1 Interior forest dominated by a wide range of native trees, including fo’ui *(Grewia crenata),* tavahi *(Rhus taitensis),* ngatata *(Ellatostachys falcate),* motou *(Cryptocarya hornei),* and ifi *(Inocarpus fagifer).*

1.2 Interior shrubland is dominated by native woody species such as fau *(Hibiscus tiliaceus)* or naturalized woody species such as kuava *(Psidium guajava),* and sialemohemohe *(Leucaena leucocephala).*

2. Coastal forest (subdivided into **coastal forest** and **coastal shrub-land*)***.

2.1 Coastal forest was reported as dominated by native tree species including fao *(Neisosperma oppositifolium),* kotone *(Myristical hypargyraea),* fotulona *(Hernandia nymphaefolia),* and tanetane vao *(Polyscias multi juga).*

2.2 Coastal shrubland was reported as dominated by thickets of fa *(Pandanus tectorius),* fau, and ngahu *(Scaevola taccada).*

3. Swamp forest, subdivided into **coastal swamp forest** and **swamp/march forest**.

3.1 Coastal swamp forest is usually dominated by feta'anu *(Excoecaria agallocha)* and is periodically inundated with salt water. (Sopu lagoon)

3.2 Swamp/march forest was reported as dominated by herbaceous plants or shrubs (Folaha village).

4. Coconut with secondary woody vegetation.

This type typically occurs where land has been abandoned from agriculture, either temporary as bush-fallow or permanently. It is distinguished from interior shrub-land by the presence of an overstorey or planted trees; otherwise, the character is similar. Stands may be regenerating into native forest and have developed stands of native trees and shrubs beneath coconut, or the understorey may be dominated by dense stands of siale mohemohe or kuava.

5. Plantation of trees was defined as a new type. This includes pine and other plantation woodlots as well as shelterbelts and stands of fruit trees such as mango *(Mangifera spp.)*

Desloges (1994) reported that Tonga has limited forest resource and is composed of three types.

1. Natural hardwood forests, less than the 4,000 ha (8,000 ha forests and woodlands combined), remaining mainly on the inaccessible slopes of the island of 'Eua.

2. Plantation forest situated on the island of ‘Eua covering some 600 ha of *Pinus caribaea, Toona ciliate, Sweitenia macrophylla, Eucalyptus spp, and Tectona grandis.*

3. Coconut plantation estimated to be 5 million palms.

The Pacific Island Economies (1995) highlighted a different approach to classification of Tonga’s forest resources. In spite of its relatively limited forest resources, Tonga is one of the few countries in the Pacific, which has classified its forests according to land use.

A land use survey of the existing forest and the area to be reforested categorized the areas into the following five main forest types, each with specific objectives and a management plan for its future development. Since this report was based on Tonga’s country report to the Head of Forestry meeting of 1994, it is understood that this classification was made in line with Forestry Division’s work program. The main forest types discussed were:

1. Plantation Forests

The actual establishment of the ‘Eua forest plantation began in 1958 but the large scale planting did not begin till 1984. Some 750 ha were planted with *Pinus caribaea* and *Toona ciliate (autrialis).* The plantation is dominated by exotic timber species.

Combined with coconut timber production, the forest plantation was estimated as being able to supply 80 % of domestic sawn timber demand.

2. Protection Forests and Conservation Forests

Protection forests included inaccessible and steep slops of high islands such as ‘Eua, Late and ‘Ata; coastal regions; and national parks. Apart from the National Park in ‘Eua, no further work had been done to regulate protection and conservations strategies anticipated for the targeted areas.

3. Conversion Forests

Although this forest type was not discussed in details, it is assumed as being referred to native forests or vegetations being transferred to exotic woodlots on private farm allotments (‘api ‘uta) and soil depleted sites (Trees planted on boundaries of private ‘api ‘uta).

4. Watershed Management Forests.

This refers to the watershed areas fall within the boundaries of the ‘Eua forest plantation. Concern rises for the watershed areas, especially for ‘Eua, because their main water supply is sourced from the watershed or water catchment’s areas. It is vital that appropriate protection and conservation action is done to guarantee production of high quality water for the general public.

At this stage, the reviewer believes that, although a fair overlap in the discussions of the forest types by the authors, it is necessary to leave each discussion separately. This will allow flexibility in interpretation and adoption of views by readers. However prioritizing of each ecosystem can be made based target requirement or required plan of action.

4.5 Degree of Degradation of Forestry Ecosystems

4.5.1 Local Coconut Timber Sawmilling & Utilization

Desloges (1994 p.29&30) stressed that domestic timber production depends more and more on the coconut palm resources as the indigenous forest are almost completely exhausted. He went on to estimate that 80 % of the total domestic cut (amount at 1,700 m^3/year) sourced from coconut palm logs.

All the main island centers of Tonga (Tongatapu, Vava’u, Ha’apai, ‘Eua, Niuatoputapu and Niuafo’ou) operates coconut sawmills. Apart from the sawmill facilities in the two Niuas, all other sawmills are run by the government-own entity in Tonga Timber Limited.

The actual degree of degradation due to cutting down of coconut palms is not known. In line with cutting done of coconut for timber, information on the amount of degradation resulting from other

factors such as agriculture mechanization, slash and burn, natural disaster, and human settlement is not known as well.

Burrows & Douglass 1996 reported that 72,500 coconut palms are cut annually throughout Tonga for the last 30 years. Annual losses attributable to utilization of timber equate to <25 % of all losses for the period of most active timber utilization (1985-1995). Replacement plantings have been at about 25,000 new palms per year for the last 15 years. They recommended that for maintenance of the resource at the current levels would require at least 100,000 new palms planted per year, this equivalent to about 800 hectares of new coconut plantation. It is estimated that 90 percent of local timber production are used locally mainly for house framing. Coconut timber is exported to Hawaii. (per. comm. Manu Pomelile TTL)

Available information for this review indicated that cutting down of coconut for timber is the major cause of degradation to this type (coconut).

4.5.2 Agricultural Development

Agriculture has been the main contributor of foreign revenue to the country. Consequently, malpractices and unsustainable monocropping systems does have a detrimental effect in the forest as well as coconut resources. Burrows & Douglass pointed out that, agricultural activities are the second major cause of coconut palm exploitation.

4.5.3 Natural Disasters

Burrows & Douglass suggested that, cyclones and/or hurricanes have not caused significant damage to the coconut palm resources.

4.5.4 Pest and Diseases

Currently, a regional project called “Forest Health Surveillance” is undertaking surveys throughout Tonga to determine the status of pest and disease on forest species in the country. To date, specific and detailed studies regarding pest and diseases on forest species had not been done.

4.6 Economic, Cultural and Historical Importance of the Forestry Sector

Forestry's contribution to Tonga's economy is small compared to other sectors. Its importance tends to be underestimated because many forest products and services are not included in the national accounts and their benefits have yet been assigned monetary value, Pacific Island Economies, 1995.

Further, Tonga's natural forest resource was exploited with little attention to reforestation. As a result, the country has been forced to import increasing quantities of timber from abroad. For instance, timber imports have increased from 3,000 m^3 in 1979 to 15,000 m^3 in 1991. The price of imported timber also increased from T$140/ m^3 to T$414/ m^3 over the same time period.

4.6.1 Forest and Trees Valued as Wood or Timber Products

1. **Fuel wood**

Desloges (1994) pointed out that apart from timber product, it is estimated that the amount of fuel wood used in Tongatapu is 100,000 tonne/year and 70 % is for domestic use. The main source of fuel wood is large hardwood trees and shrubs scattered on tax allotments. An increasing portion is shipped from 'Eua and other nearby islands. Other major sources of fuel wood are sawmill residues and coconut husks. He also alarmed the possibility of local fuel wood shortage in the near future.

Fuel wood demand on the main islands of Tongatapu has been estimated at 100,000 tonnes (airdry) per year. This is approximately equivalent to 200,000 m^3 of wood. Approximately 80 % of households depend on fuel wood for cooking. The main source of fuel wood is large hardwood trees and shrubs scattered on tax allotment lands on Tongatapu. In recent years, an increasing amount of fuel wood is transported from the island of 'Eua. Other major fuel wood sources include: sawmill residues, coconut husks and shells, Pacific Island Economies 1995.

Statistics such as volume of fuel wood harvested and consumed were not readily available for this review. The government statistics department does not have a formal data collecting system in place to cover local wood consumption. Further, the government produce markets do not collect data on fuel wood sold in the market apart from informing the general public on its availability and prices.

2. **High valued tree species (potential export)**

Sandalwood *Santalum yasi* is a potential export crop that has been has been overexploited in the last three decades.

Wood carving yield better prices from products derived from the indigenous forest species mostly found in coastal and primary forests.

3. **Medicinal values**

Whistler (1992) discussed that the best account of early Tongan medical practices is based on the experiences of William Mariner, who was a youth stranded and nearly killed in Tonga when English ship, the *Port au Prince*, attacked and burned in Ha'apai in 1806. Whistler (1991) provides documentation on Tongan Herbal Medicine and scientific names and uses of Tongan plants (including medicinal ones) respectively. Some of the species with medicinal values are listed below.

4.6.2 Service Functions of the Forests Ecosystems

McCraken and Fitzgerald (1998) discussed the following service functions of forests and trees based on problems addressed and suggested agroforestry responses.

4.6.2.1 Environmental Related Services

1. **Coastal Protection**

Littoral forest protects inland crops and trees from salt spray and storm-wind damage. Littoral forest species are salt and wind tolerant, produces excellent fuel-wood, medicinal plants as well as minor food products.

2. Salt-spray control

This is linked directly to the failure of coastal protection due to increased loss of forest cover and coconut canopy. When these were intact they afforded protection to crops and trees. Salt-tolerant coastal species withstands consistent salt-spray.

3. Soil Erosion control

Soil erosion is evident on all islands with some topographical relief. Some coastal areas on lowlands, like the eastward lagoon side of the far western district experiences soil loss due to sea water movement. Coastal forests act as buffer hence minimizes the intensity of sea water movement.

4. Improve soils quality

Secondary forest re-growth allowed soil structural and nutritional recovery following cropping cycles. Nitrogen fixing tree species assist in rapid restoration of soil structure and fertility.

5. Biodiversity provides habitat for trees and animal species.

Findings and recommendation;

Forest ecosystems provide significant contribution to the well-being and the economy of Tonga as production and service functions. As such, effort should be made, to:

- Enforce regulation for protection of existing forest scosystems,
- Forestry Division propagate priority tree species for the public,
- Promote replanting of degraded sites
- Enhance public awareness on forest conservation
- Promote use of Multi-purpose tree species (MPTS) for soil improvement purposes and soil erosion control
- Promote CRS on agricultural lands

4.7 Protected Area System

4.7.1 National Parks

Bellingham and Fitzgerald (1996) discussed Social and Economic Development Opportunities in their report "Management Plan for 'Eua National Park". They mentioned that traditional approaches to national park management and protection have emphasized legal and regulatory frameworks,

enforcement, penalties for illegal use, and patrol by rangers. With emphasis on legal means of controlling of the national parks, the establishment of national parks for national benefit can mean a reduction in local well being. Locals will be faced with reduced food availability or cash, loss of access to culturally significant resources, and limited local development opportunities. Consequently, local people may thwart the law in an attempt to meet their needs.

Bellington and Fitzgerald argued that the best possible approach to obtaining maximum social and economic benefits from the national parks is to combine conservation and resource management objectives with local development objectives. They refer to this approach as "Integrated Conservation and Development" (ICAD). These are economic and cultural importance of the National Park identified by Fitzgerald and Bellingham to have potential for intergraded development and conservation opportunities.

4.7.2 Agroforestry Development

Establish nurseries to produce valued, rare, and sought-after planting materials. Establish seed plots to conserve endangered species (seed bank). Promote replanting of culturally valuable tree/plant species thus ease pressure of mining of national park resources.

4.7.3 Captive Bird Breeding

Establishment of a captive bird breeding either in closure or in separate aviaries was suggested. This might be used to boost wild bird populations in the national park.

4.7.4 Employment Opportunities

Employment opportunities can be sought by mean of provision of labor in maintenance of recreational amenities and facilities, work as park rangers and tour guides especially in establishing and maintaining of the ʻEua National Park.

4.7.5 Education and Science

Out-door recreation education and research is largely untapped on the national park. This can apply to

local students as well as overseas scholars.

4.7.6 Handicraft Development

The valuable handicraft species can be utilized on a sustainable basis if they are wisely used.

4.7.7 Tourism

Opportunities from tourism would come in different forms including; accommodation, site tours, carving etc. The whole community could benefit more and in a long-term basis.

4.8 Proposed Criteria for Priority Setting

A. Priorities concerning Policy-related Issues in Forestry Biodiversity Conservation.

Policy-related areas may include establishment of a National Forestry Biodiversity Advisory Committee (NFBAC) through cabinet approval, formulation of a National Forestry Biodiversity policy; promote land use planning, and actual implementation of the proposed policy. Formulation of National Forestry Biodiversity policy is considered as a "suitable vehicle to start the necessary discussion process on the issue of land use in Tonga". Further, a lead agency to be appointed to operate under the direction of NFBAC. Representatives from the community, NGOs, Department of Environment (DoE), Central Planning Department (CPD), Ministry of Lands, Survey and natural Resources (MLSNR) and Crown Law is suggested.

B. Priorities concerning Capacity-Building Forestry Biodiversity Conservation.

Identifying of special training needs in agroforestry was proposed with a sense of urgency. This includes in-country short term training as well as long term formal training of MAFF personnel.

C. Priorities concerning Research and Extension in Forestry Biodiversity Conservation

Inventory on existing agroforestry systems in Tonga was regarded as the most important activity in this area. It was also mentioned that no forestry/agroforestry inventory been carried out on private land

holdings in Tonga. The identified agroforestry systems should be analyzed for its appropriateness. In addition, it was stressed that strong linkage between research and extension activities is a key requirement in order to achieve impacts at the farmer's level.

D. Priorities concerning sustainable management of Forestry Biodiversity Conservation.

The key priorities here are the need to implement replanting of potential tree species such as coconut, fruit trees and trees with cultural and medicinal value; Promote planting of fast growing nitrogen fixing tree species for soil improvement purposes; promote planting of handicraft species; and promoting national competitions to enhance public awareness.

E. Risk factors

Several risk factors should be considered during priority setting. It may include issues such as susceptible to pest and diseases, forest fire, forest land prone to being transformed to agricultural land, and uncertainty of land holding (land tenure systems).

F. Economic factors

Careful assessment of the economic importance of trees and the ecosystems as a whole should be done. Previous assessments were made based on single species and their traditional and cultural uses. The econimic information on the production value of trees is not readily available. They should be formulated, published and disseminated to appropriate stakeholders. Such move will enhance peoples' participation in promoting forestry biodiversity conservation. Activities such as promoting plantation forest to increase local timber production thus minimizes timber import, promote eco-tourism through managing of the forest ecosystems especially in historical places and promote planting of high value tree species for export like Santalum yasi should be encouraged.

G. Socio-economic factors

Peoples' participation in Forestry Biodiversity Conservation is essential. This can be achieved through education, improve awareness, intergrade management systems by involving people in planning, managing as well as getting benefits from the resources.

4.9 Ranking of Priority Ecosystems for Biodiversity Conservation

At this stage of the review of literature, six (6) major forest ecosystems is highlighted;

A. Natural primary indigenous forests

This ecosystem covers primarily the national parks in ‘Eua and inaccessible forests of Kao, Tofua, Late, and Tafai islands. Most of these vegetations are undisturbed or least disturbt. Attention should be geared towards maintaining and conserving these ecosystems because of their vital role in watershed management, soil improvement and preservation of numerous species with social and economic values.

B. Secondary indigenous forests

Including are the interior tall forests and shrublands, tropical lowland forests and secondary vegetation, stands of exotic tree species such as *Leucaena lecocephala,* and grasslands. This ecosystem usually occupied with secondary vegetation growth on disturbed area mainly due to agricultural activities. Secondary indigenous forests also characterized by incursion of exotic species of invasive nature. Marshland forests are categorized in this ecosystem.

C. Coastal Forests

This ecosystem covers the coastal littoral forests, coastal savanna, and mangrove forests. All these types situated adjacent to or on the coasts, whether on the lagoon side or open (liku) side.

D. Plantation forests

There are two plantation forests in Tonga. One is the government owned forest plantation in ‘Eua and the other, also located in ‘Eua belongs to Her Majesty, Queen Halaevalu Mata’aho. These plantations dominated by fast growing exotic tree species purposely planted for timber.

E. Coconut stands

Coconut palm stands are naturally grown or exist in plantations. In all cases, coconut associates with shrub forest species as well as agricultural crops.

F. Agroforestry systems

This system, not described in the literatures reviewed, but it covers tree planting on private agricultural lands, urban vegetations and agroforestry systems. Further work needed to be done clearly define this type as it is one of the alternative for reforestation of private lands.

4.10 Threats and Pressures on Forestry Biodiveristy

Five problem-based aspects (McCraken and Fitzgerald)

Threats and pressure on the forestry biodiversity in five different problem-based aspects:

A. Environmental

Pressure applies to inland agriculture development eventuates in the form of salt spray, storm-wind damage and fire damage to natural resources. Major root causes being identified as cultivation (agriculture) and burning practices (slash and burn). In response, they highlight urgent need for coastal protection programs in place.

Soil erosion due to surface water run-off occurs on higher islands as well as low-lying portions throughout the country. Major root causes being identified as excessive land cultivation and deforeatration.

Loss of biodiversity in tree species considered as being due primarily to loss of primary natural forests. A systematic ecological inventory of Tonga's natural forest is therefore recommended. Wiser's 1999

Loss of habitat for birds and animal resulting from low primary and secondary forest is highlighted

B. Farming Systems

Problem related to forest/tree resources recognized in four major areas. One is lack of proper tree/crop interaction. This caused farmers to remove trees from their farm areas instead of formalizing tree/crop interaction or making trees as part of the farming systems.

Lack of fallow management and unsustainable farming practices identified as caused by pressure for cheap land and lack of sense of stewardship for maintaining the quality of land.

Wondering stock identified as another problem caused by lack of systematic animal management.

Monocropping and commercial agriculture have brought about land mechanization and repeated cultivation in contrast to shifting agriculture. These factors combined result in trees being forced out of the system to make way for agricultural crops.

The government of Tonga is concerned for the continued loss of forest and trees cover to agricultural land, the equivalent of 600 ha per year over the last 16 years (Burrows and Douglas, 1996). As a result, MAFF revived the coconut-replanting scheme (CRS), which was temporarily halt due to financial difficulties.

C. Resources

Lack of fuelwood due to rapid loss of traditional tree cover and fuelwood sources was identified as one major resource problem. Tonga: Issues and Options in the Energy Sector, 1985

This report highlighted deforestation problems in the country and noted that there was no comprehensive national biomass resource inventory. It gave an estimate of 4,000 ha to be Tonga's remaining natural forest cover mostly found on 'Eua. The report also referred to MAFF 1979 survey (reference cited not certain) and noted that Tonga has a total coconut population of about 5 million stems covering 40,000 ha out of which 45% being senile (matured). Senile coconut palms are considered unproductive in terms of nut production but favorable for timber production. It was estimated that coconut husk and shell resource amounted at 45,000 tonne per annum. Presumably, these were used as fuelwood purposes. Refer to Table 4.1.1, for a Tongatapu biomass balance 1983.

Table 4.1.1: Tentative Biomass Balance for Tongatapu, 1983.

Supply	Tonne/year	Thousand toe/year
Source		
o Sawmill residues	900	0.30
o Small trees and Bushes	12,240	4.04
o Coconut husk and shell	27,300	12.01
Sub-total	40,440	16.35
Demand	Tonne/year	Thousand toe/year
Function		
o Domestic cooking	20,800	7.93
o Industrial copra drying	2,000	0.88
o Smallholder copra drying	15,640	6.88
o Institutional use	2,000	0.66
	40,440	16.35

Source: Tonga: Issues and Options in the Energy Sector, 1985

In addition, the report suggested that only a small part of the coconut resource is consumed in the timber industry. The remainder is unutilized due to high-density wood that makes coconut a difficult wood to process.

Hurricane Issac (1978) damaged about 10 percent of the coconut palm population. It was estimated that damages caused by cyclones are not significant. The report warned that if there are no fresh initiatives to improve the biomass situation, a critical biomass shortage is expected in future years.

Moreover, there is high dependent on imported timber and wood products. This problem was thought to be resulting from loss of self-sufficiency in timber production and lack of information and economic evaluation of forest and trees.

In terms of food supply, the report stated that there is shortage of supply of local fruits.

Tables 7 and 8 summarises the Quantity and Value of Wood Import 2000 – 2002; and Quantity and Value of Wood Export 2000 – 2002 respectively

D. Social

Here are some of the social-related problems outlined in the report:

- Shortage of planting materials for cultural and social tree/plant species. This is caused by lack of information and plant resources.

- Shortage of raw materials for cultural, social and economic species. This is caused by loss of natural forest resources.

- Unavailability of valued trees with cultural and social potential due to lack of information on location and seedling, propagation, demand and endangered status triggered attention.

- Emerging shortage of coconut palms known to be caused by crops being neglected, senility, poor financial return and lack of replanting initiatives.

- Loss of traditional, sustainable cropping systems due to shift to commercial cropping. Root causes identified as short term leasing of land, low financial return from traditional land management, physical inconvenient of trees to modern cultivation practices and introducing of cash crops os light-demanding species.

- Increase competition between food, tree and cash income have forced most locals to adopt short term cash crops instead of trees.

- Lack of awareness on resource depletion was highlighted as one of the major resource problems.

- Generally, there is lack of technical knowledge in plant propagation, replanting and tending.

E. Economics

Two major problems noted as increased demand by farmers for cash from farming and increased demand from the (macro) economy.

4.11 Ways that Forestry Biodiversity is being Used

4.11.1 Forest Products

1. Sawn Timber

Sawn timber in Tonga is primarily used for construction purposes. Table 4.1.2 shows the domestic and imported timber volume from 1979 to 1990. Domestic production from indigenous hardwoods is declining as this resource is almost exhausted and local production is increasingly dependent upon the coconut palm resources. RAS/86/036 Field Document 9, 1992

Table 4.1.2: Sawntimber - Domestic Production and Import.

Year	Unit cost (T$/m³)	Domestic production m³	Imported m³	Total supplies m³
1979	143.00	1,374	2,913	4,287
1980	147.00	1,860	1,716	9,576
1981	180.00	2,172	6,887	9,059
1982	209.00	2,666	12,294	14,960
1983	205.00	1,354	7,327	8,681
1984	209.00	1,075	8,737	9,812
1985	261.00	1,193	7,412	8,605
1986	302.00	1,089	4,507	5,596
1987	373.00	1,319	6,161	7,480
1988	476.00	1,080	2,971	4,051
1989	423.00	1,088	5,141	6,226
1990	450.00	1,489	4,793	6,282

Source: RAS/86/036 Field Document 9, 1992

2. Fuelwood

There is no comprehensive study on the total volume of fuelwood consumed in Tonga. Only rough estimate of the total biomass consumed as fuelwood have been made. RAS/86/036 Field Document 9, 1992 estimated some 97,000 tons/year (air dry) consumption (67%) on Tongatapu. The report estimated that approximately 75% of Tongan households cook using fuelwood. Table 4.3, summarizes household energy use for cooking. Fuelwood comes from scattered large hardwood and shrubs, which are found on tax allotments as well as urban settlement areas. The ither major source of fuelwood comes from coconut slabs, off-cuts, husks and shells.

Table 4.3: Household Energy Use for Cooking

Type of cooking fuel used	Number of Households per Main Island Districts			
	Tongatapu	**Vava'u**	**Ha'apai**	**'Eua**
Electricity; 1986	327	32	5	3
1976	257	20	Not known	1
Gas; 1986	1,817	178	90	212
1976	514	30	4	5
Kerosene; 1986	797	76	46	10
1976	3,716	402	240	125
Wood ; 1986	**6,574**	**2,225**	**1,453**	**722**
1976	**3,948**	**1,952**	**1,515**	**615**
Other; 1986	15	3	2	Not known
1976	10	1	4	Not known
Not stated 1986	191	33	20	23

Source: RAS/86/036 Field Document 9, 1992

3. Minor forest products;

Tonga produces a variety of wooden handicrafts mainly for export markets as well as for tourists visiting the Kingdom. Wood carving products are found mainly as coastal or lowland tropical forests. Coastal species of high value for wood-carving includes *Thespesia polulnea* (Milo), *Guettardia speciosa* (Puopua), and *Xylocarpus granatum* (Lekileki).

Other products is of value to Tongan handicraft is dye from koka tree *Bischofia javanica* used for painting tapa cloth. *Alphitonia zizyphodoides* (Toi) is an alternative producer of dye in the absence of koka dye. Whistler 1992 added Mangrove species *Rhizophora mangle* (Tongo), *Aleurites mollucana* (Tuitui), and *Garuga floribunda* as other sources of dye for tapa cloth making.

Poles and posts are becoming more available locally from thinning on ‘Eua exotic forest plantation. Imported posts and poles are available at higher cost in contrast to locally produced products.

Whistler 1992, in his studying of the Tongan Plants, categorized them by usage as food plants, material plants, dye plants, fish poisons, ornamentals, medicinals, and “others”. Many species fit into more than one category;

- **Food plants** includes fruit trees such as *Artocarpus spp* (Mei), *Cocos nucifera* (Niu), *Pometia pinnata* (Tava), and *Inocarpus fagiferous* (Ifi)

- The **Material Plants** category has several subcategories, such as **fabric plants** such as *Broussonetia papyrifera* (Hiapo) and *Pandanus spp* (Lou’akau),

- **Cordage plants** including and *Hibiscus tiliaceus* (Fau) and *Cocos nucifera* (Niu),

- **Timber trees** dominated by *Casuarina equisetifolia* (Toa), *Artocarpus spp.* (Mei), *Alphitonia zizyphodoides* (Toi), *Calophyllum inophyllum L.* (Feta’u), *Calophullum neo-ebudicum* Guillaumin (Tamanu), and *Pometia pinnata* (Tava) and **thatch plants**.

At least five species of plants are used to produce **fish poisons**. The most popular one is (Kava Fisi), (Kavahuhu, Kavahaha), (Futu), (Masi Kona), and (Ngahu) see page 14, Whistler.

4. Cultural Uses

Fusimalohi during her community participartory research meetings picked 5 most important cultural specis out of the 54 native trees identified. Listed, in order of priority, are *Garcinia sessilis* (Heilala), *Aglaia saltatorium* (Langakali), *Cananga odorata* (Mohokoi), *Fragaea berteria* (Puatonga), and *Cardinia toitensis* (Sialetonga). These species are non-edible but have valuable cultural uses such as oil making and flower for decorations.

5. Medicinal Uses

Five most important medicinal species, of the 59 identified, were prioritized in descending order of importance; *Tarenna sambusina* (Manonu), *Morinda citrifolia* (Nonu), *Euodia hortensis* (Uhi), *Xylocarpus gradatum* (Lekileki), and *Syzygium corynocarpus* (Hehea). Again, priority species are non-edible, *Whistler 1991.* Table 7 illustrates, scientific names of medicinal plants, Tongan names, habitat for which they are found, non-medicinal uses.

In contrast to the study carried by Fusimalohi (1998), Whistler (1992) discussed the 77 most commonly used or best-known medicinal plants in Tonga. This is a more detailed study on Tongan Herbal Medicine in which the actual uses of each individual species, habitat of each species and other background information on how it is used are given.

6. Ornamental Uses

There are similarities is species composition in this category and cultural uses. However, most ornamental species were recently introduced to Tonga.

7. Income Generation

Trees with handicraft qualities like *Bishcofia javanica* (Koka), *Pandanus spp* (Lou'akau) were amongst the top species for income generation. A number of food production species like *Cocos nucifera* (Niu) and *Artocarpus spp* (Mei) were amongst this category.

Numerous handicrafts are produced from non-wood forest products. Including in this category is dye for tapa making made out of koka, *Bischofia javanica* and *Tongo.* Sandalwood ahi, *Sandalum yasi* is amongst the high potential wood product that has been exported from the country in the past 2 to 3 decades.

In descending order of importance, 4 of the 21 species identified are listed as food source; *Cocos nucifera, Mangifera spp* (Mango), *Citrus spp* (Moli), and *Pometia pinnata* (Tava).

4.12 Service Functions of Forests and Trees

The forest ecosystems play a vital role, thus providing intangible benefits to human being and the community as a whole. Amongst its service functions are soil erosion control, improve soil structure and conditions, and act as shelterbelts or windbreaks and salt spray control.

4.13 Sustainable use in terms of Biodiversity Loss

1. Education

School curriculum, at all levels (primary, secondary and tertiary) does not address the biodiversity conservation issues adequately. Special attention should be geared towards promoting formal training of human resources in forestry and environmental science. On land resource education, agriculture is given huge support and a lion share of the formal education system.

2. Land Tenure Systems

Limited land availability and accessibility, coupled with increasing use of short-term cash crops have great impact the forest biodiversity. Short-term lease of farm land (1-5 years) have forced the leaseholders to “mine” the land. Mechanization of cropping pushes trees out of the croplands that are becoming dominated by grass and invasive weeds. Repeated cultivation of leased land adds fuel into this critical condition. Appropriate legistlations should be formulated to ensure that sound land tenure systems are encouraged to ensure that the biodiversity is utilized and maintained on a sustainable basis.

3. Technical know-how on Biodiversity Conservation Priniciples

The general public lacks the basic knowledge on tree propagation and maintenance. This applies to both indigenous and exotic tree species. For instance, *Carcinia cessilis* (Heilala) is one difficult cultural species to propagate from seeds. As a result, this slow growing species is listed amongst the endangered species (SPRIG 2002). Education must be strengthened in all level of the society in order

to ensure that the biodiversity is given due respect of its significant contribution to the community. Principle areas of concern hence demanding close attention by the decision makers include watershed management of catchment areas; coastal protection; national park conservation; erosion control of steep slopes and lowland coastal areas; propagation of plants; wildlife conservation and intergrated (sustainable) land management systems or agroforestry systems.

4. Reforestation Programme

Apart from the development of ‘Eua forest plantation, which has a business plan that covers its reforestation programs, the rate of tree plantings on private farm land is slow. Forest Division of MAFF is the main facilitator of the national tree planting efforts including replanting of coconut palms. FD operates forest nurseries all over Tonga and coordinate tree planting activities as well as awareness activities and community-based tree planting activities.

Special attention should be given towards organizing and implementing of national replanting programs on potential crops such as ahi, handicrafts species and medicinal plants. These species are to be promoted on private lands and organize local community to manage them for its economic, social and cultural values.

5. Economic Pressure

The increased demand for cash by the community is proven counterproductive to the biodiversity conservation strategies that the current government can offer. Land resource users tend to favor agricultural cash crops with quick returns. Focus should be diverted towards promoting of potential crops with shorter rotation. Multipurpose tree species, such as those with food, medicinal, cultural and wood producing values shall be promoted and planted.

4.14 Trends in the Threats, Pressures and Sustainability of Resources

Prescott (2003) discussed the impacts of human pressures and related activities on indigenous Forest Resource. (Table 4.1.4)

It is evident from Prescott's findings that human activities are the main threat to sustainability of forest resources. Legal framework, whether in place or not, are not enforced by appropriate institutions. Human activities led directly and indirectly towards rapid clearance of forest resources. Directly, forests are cut for timber, firewood, medicine and other cultural and social purposes. Indirectly, forests are disturbed by infestation of pests and diseases occurs due to monoculture or and introduction of new crops.

Table 4.1.4 Impacts of human Activities on the Forest Resources

Impact	Explanation of Impacts	Sources of Information
Easy access to logging and clearing of forest for other uses and agriculture	No permits required for logging your 'own' land/trees, Informal arrangement if logging from 'someene' else's land, From government land (coastal area), no permit required (as regulation is not enforced), Led to less shade and humus for the soil, less nutrients being brought up from the lower soil horizons, faster run-off of storm water, Coastal forest strip dramatically reduced, therefore more exposure to wind and sea sprays, more rapid drying, Native forests are cleared to allow for mechanization in commercial agriculture	EPACS, (1990) Wiser et. al., (1999)
Increased weeds and pests	Spread into remaining forest area due to increased fragmentation and disturbance	Wiser et. al., (1999)
Free-Ranging Domestic Animals	Pigs, dogs, goats and horses led to destruction of new plants, crops and dug up the ground, Commonly reported by women's groups as the major environment problem, Introduction of mammals (rats, Rattus, and cats), Fiji shrikebills and Friendly ground doves have almost been wiped out by cats and rats	EPACS, (1990) Thaman, (1995b) Per.obs. Rinke, (1990)
Increased demand for wood for firewood, carving and medicinal of oil perfumery	Common in all types of forest, tracking is common, Indigenous trees species which are good for carving are also in high demand, Lack of firewood, fruits and nuts, medicines, cultural perfumery and timber, Bark stripping is for preparation of medicines or fragrances. These activated further distributed the remaining forest, Wildlife dependent on forest habitat is also affected i.e. fewer birds	EPACS, (1990) Wiser et. al., (1999)

(Source: Prescott (2003)

Findings and recommendations;

Human activities pose major threats and pressures to the sustainability of the forest resources. Increased demand for food and cash has made agricultural development the biggest enemy of forest resources. Lack of appropriate legal framework as well as lack of enforcement of the existing ones is also highlighted as being a major threat. It is noted that awareness on the roles of forests in sustainable development is limited.

Based on the above, the following recommendation is made endeavouring at decreasing threats and pressure on the forest resources:

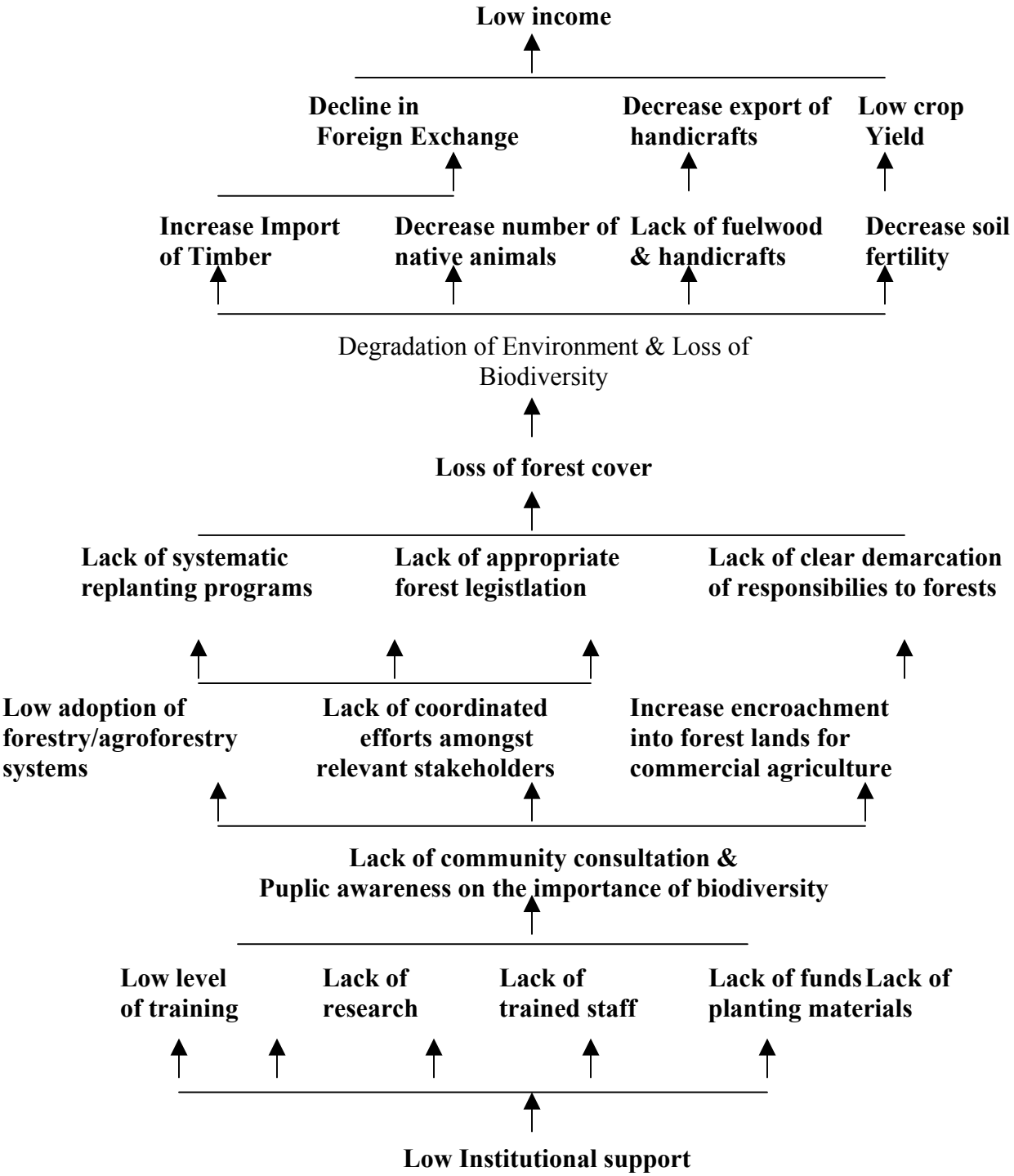
- ✓ Improve awareness efforts in the area of sustainable development, importance of forests and trees as producer of products with cultural, social and economic values and its contribution to the well-being of the ecosystem,
- ✓ Provide training to communities and educate them on ways to minimize threats and pressures on forest resources,
- ✓ Assist communities in conserving of existing forests, replanting of 'mined' sites with trees,
- ✓ Provide planting materials to allow them to replant trees of value to them.
- ✓ Ensure that appropriate legal framework is put in place as well as enforcing the existing policies and regulations

4.14.1 Direct and indirect Causes of Threats, Pressures and Unsustainable Uses

In analyzing the identified threats, pressures and sustainable uses, the author carried out a simple 'causal analysis' exercise as in Figure 4.1. It outlined the author's perception of the casual analysis. However, Figure 4. 1 should be modified in a later rural appraisal exercises in order to formulate an objective tree for which appropriate logical framework on sustainable forest resource development and management can be derived.

Figure 4.1 highlights that the need to prioritize the identified threats and pressures (at least at this stage) is not necessary. Various factors collectively contribute towards degradation of environment and loss of biodiversity in a 'cause and effect' relationship. As such, a participartory causal analysis should be done to adequately address this section i.e., to analyze the direct and indirect causes of the identified threats, pressures and unsustainable uses, especially of the most importance threats.

Figure 4.1: Causal Analysis of the Identified Threats and Pressures.



4.15 Equitable Sharing of the Benefits from Forestry Biobiveristy

Indigenous knowledge on forestry biodiversity

Whistler, in his 1992 publication of "Tongan Herbal Medicine" used a lot of local people in identifying of medicinal plants as well as its uses. From this research, it became evident that there is tremendous amount of indigenous knowledge hold by locals but are not well documented. Nevertheless, the work of Whistler indicates that the local knowledge is important only if it is made known to the community, of whom they may benefit from the use of the available medicine. Indigenous knowledge should be documented and disseminated.

Development of forestry biotechnology in Tonga

Biotechnology in forestry biodiversity conservation is not common to Tonga. Hence, no record is found in this area.

Beneficiaries of present use of forest biological resources

Table 4.1.5 presented beneficiaries of forestry boidiveristy and how each beneficiaries group uses these resources.

Table 4.1.5 Beneficiaries of present use of Forest Biological Resources

Groups	Beneficiaries	Remarks
Local communities	➢ Household cooking with fuelwood. Social occasions such as wedding, funeral and church activities requires large amount of fuelwood for cooking. Sunday 'umu' or underground oven is common throughout the country ➢ Medicinal plants for various users ➢ Cultural trees produces flowers for numerous purposes such as 'kahoa' and 'sisi' for entertainment and decorations, ➢ Ornamental plants become source of decorative materials as well as cash from sales of domesticated varieties ➢ Dye produced from 'koka' and 'tongo' is of utmost important to women groups ➢ Forests is also a supplier of food to rural communities especially those resides adjacent to forest areas.	➢ The rate of deforestation exceeded rate of replanting. Conserving of natural vegetations (primary or secnady) is becoming difficult due to reasons given in opposite column. ➢ There is no 'gene bank', in which collection of culturally important tree species is planted and conserved. ➢ Lack of understanding of the value of forests by the communities led to increased 'mining' of the forest resources. ➢ Cultually important tree/plant species are diffult to propagate hence, largely unavailable in terms of seedling. ➢ People need to be trained and educated on the importance of biological resources.
Farmers	➢ Farmers benefit indirectly from the service functions of the forest resources. Such benefits are in numerous forms: o Forests improve soil fertility and structure, hence regenerate	➢ Commercial farmers causes major destructions to biological resources by due to several reasons: o Mechanization of farming at all levels (land preparation, crop

	soil nutrient. Forest soils is the most favourable medium for all forms of agricultural cops, o Provides windbreaks and minimize crop damage due to strong winds, o Provide buffer zone and assist in minimizing salt spray on crops and animal communities, o Fallow systems (allowing natural vegetation to regenerate in cropped lands) rejuvenate agricultural lands, o Provide staking materials for yams crop, etc.	management and protection, harvesting, packing and transport), o Increased use of fertilizer and inorganic chemicals, o Shortening of fallow periods due to use of short term crops, o Commonly lease land on short term basis, o Monocropping with the 'market crops' (squash and watermelon) ➢ Subsistence farmers show the opposite of the commercial farmers' practices. ➢ Land owners (farmers) have tendency to conserve forests and trees. Lease holders tend to clear cut forests to make way to agricultural crops.
Export	➢ Wood carving as well as other handicraft products such as tapa cloths and mats have become a potential export commodities ➢ High valued tree species like sandalwood and red cedar fixes high prices at the export markets	➢ Preferred wood carving species found in naural forest and woodlots. No tree planting programme ever initiated aiming at producing woods for carving. ➢ Sandalwood is recently being promoted as one of the potential export tree crop for Tonga by Forestry Division of MAFF.
Tourism	➢ National parks are promoted alongside the idea of 'eco tourism'.	➢ No detailed information covered during this review. This is need for further research.

4.16 Lgal and Policy Framework for the Conservation of Forestry Biodiversity

Formal Forest Policy and Forest Legistlations are yet to be developed. Forestry Division is in the process of submitting project proposal to FAO SAPA for possible funding to assist in formulating policy and legislation.

Conflicts and areas of confusion in the existing laws and policies governing land tenure and access to forestry biological resources, and the legal basis for institutional mandates can only be properly analyzed if the appropriate legal and policy framework are in place.

Appropriate legal and policy framework for the conservation of forestry biodiversity should be formulated urgently if sustainable forestry biodiversity development is envisaged. Responsible stakeholders should be encouraged to contribute towards formulation of national forest policy and forest legistlations.

4.16.1 Legal basis for Protecting Intellectual Property Rights

1. Policies

Tonga does not have a formal national forest policy. Forestry objectives usually described in the Government's Five Year Development Plan. However, Strategic Development Plan (SDP7) (2001) barely touched specific policy guidelines on Forestry Biodiversity. The (MAFF) policy guidelines set out in SDP7 is as follows:

- Broaden the base of agricultural export;
- Diversify export markets for agricultuiral products;
- Create opportunities for agricultural production for export in outer regions;
- Consider possibilities for generating agribusiness profitability;
- Consider possibilities for establishing Export Credit Schemes;
- Provide Institutional Strengthening & Support to key institutions in the industry;
- Consider options for establishing an effective mechanism to facilitate linkages between key players in agriculture;
- Ensure that appropriate supporting infrastructures are in place.

4.16.2 Legislation

Tonga's 1995 Forest Act allows the Government to set up "forest reserves" and control forest use. The act has only limited application and needed to be amended to reflect current realities. A review of the Forest Act was undertaken in 1993, with objective of amending the Act to accommodate the broader and more diverse forest policies set out in the Government's Five Year Development Plan. The final draft submitted to MAFF never made it to the Cabinet.

Effort is currently geared towards revisiting the draft act, modify it and put through the legal channel for further processing.

4.16.3 Protection and Conservation

In 1976 Tonga passed a Parks and Reserves Act to protect natural forests. Under this Act, 450 ha of natural forest on steep, inaccessible areas were gazetted in 1992. The few remnant natural forests of Tonga contain some nationally and internationally significant areas. The small, isolated volcanoes of Tafahi and Kao islands contain intact cloud forest as higher elevations. Other ecologically distinctive forest areas are found on the island of Tofua, 'Aata, Late, and 'Eua, Pacific Island Economies (1995)

4.17 Institutional Framework and Human Resource Base

The following organizations, government and non-government, were recognized during this review as directly responsible to biodiversity conservation of natural and exotic forest and trees resources in Tonga.

1. Ministry of Agriculture, Forestry and Food (MAFF)

The mission statement of MAFF is "To provide clients with high quality services to increase agricultural productivity, food security and productivity while sustaining the environment".

- **Forestry Division**

Forestry is the key player in promoting of forest biodiversity conservation and replanting of forest and trees throughout the Kingdom. Forestry Division is MAFF support service that deals directly with biodiversity conservation towards its role on replanting and conservation of forest and trees, coconut palms, fruit trees and other cash crops, Hinterberger and Sisifa, 2003. The division is responsible for agroforestry related activities in Tonga and is aiming at providing assistance in managing the forest resources in a sustainable manner. Agroforestry development is based on the demand to promote tree planting on private farmland, which makes up approximately 80 percent of Tonga's agricultural land. One other aim is to develop a formal forest policy for Tonga. The Division has the responsibility of monitoring the silvicultural practices of TTL on the 'Eua plantation.

- **Forest Nurseries**

Forestry operates forest nurseries in all the main island centers namely Tongatapu, 'Eua, Ha'apai, Vava'u, Niuatoputapu, and Niuafo'ou. Species being propagated includes exotic timber, cultural species, medicinal plants, fruit tree species, cash crops, coconut palms and vegetables. These nurseries are the major source of seedlings for the people of Tonga.

- **Agroforestry Development**

Forestry Division undertakes a number of tree planting activities through its agroforestry development

activities. This includes boundary of timber trees such as *Pinus caribaea* (Paini) and *Toona ciliate* (Sita Kula) on private farm lands (‘api ‘uta), promoting of replanting of culturally important tree species like *Bischofia javanica* (Koka) and *Carcinia sessilis* (Heilala), Replanting of Coconut Palms for nut as well as timber production, enrichment planting on existing natural secondary vegetations, awareness activities on the importance and vital roles of forests and trees to the environment and promoting inter-planting of Multipurpose Tree Species (MPTS) with agricultural crops. Public awareness is encouraged through community trainings, workshops and field works.

- **Manpower**

Forestry Division currently employed 4 degree holders and 8 diploma holders in various fields of forestry science. It is noted that this is the most qualified team of foresters in the country although some significant specialized areas such as environmental science, botany, forest genetics, and agroforestry requires further training.

2.Tonga Timber Limited (TTL)

TTL initially broke off from Forestry Division of MAFF to operate coconut sawmills and wood processing on the main centers of Tonga in 1995. Hardware goods become a major source of revenue for the corporatised venture.

- **Plantation forestry operation**

In July 2003, the ‘Eua forest plantation was laterally transferred From Forestry Division to TTL given the rights to utilize the maturing forest plantation and manage the forest operation. Forestry Division was delegated the responsibility of monitoring TTL operation to ensure that the logging operations carried out in logical manner.

- **Watershed Management**

Within the designated forest plantation area, the major watershed area that provides the entire island with necessary water supply is located. It is vital to realize that close monitoring must be done to ensure that the watershed areas are well protected and developed.

Apart from the ‘Eua operation, TTL operations in Vava’u, Ha’apai and Tongatapu concentrate on milling of senile coconut logs for timber. Approximately 90 percent of the raw materials for milling come from coconut palms. (per. comm. Manu Pomelile)

3. Department of Environment

DOE’s is responsible for coordinating, liasing, advising, and facilitating the role of Government in relation to environmental protection and management. Its mission is in coordinating sustainable resource-based development of the Kingdom of Tonga.

Key areas of focus for DOE:

1. To provide advice regarding formulation and review of environmental legislation, policy and regulations, which includes monitoring compliance with those acts,
2. Management of national parks and other reserves,
3. Develop and promote environmental education and awareness and
4. Conservation of biodiversity and others

4. Ministry of Lands, Survey and Natural Resources (MLSNR)

MLSNR is in the business of managing lands (crown land, parks and reserves), mineral resources and energy for the benefit of all its stakeholders.

Some of the key result areas are lands, survey and natural resources information and advice and national policies for lands. This includes enforcing crown rights and land policies through appropriate retribution. MLSNR also maintain legal records relating to land. All land registration is done through the MLSNR, including the issuance of deeds of grants for tax and town allotments, leases, permits and sub-leases, extension of land registration and lease transfer, land agreements and mortgages.

- **Energy Division (National Energy Committee)**

Operating under the MLSNR, this division is responsible for energy policy and plans rest with NEC. Its wide representation includes the Ministers of Police, Education and Works and Civil Aviation; Heads of Finance, MLCI, MLSNR, MAFF, Planning Department, Crown Solicitor; and General

Manager of TEPB.

5. Non-governmental Organization (NGO)

- **Tonga Development Trust**

Tonga Trust is an indigenous and non-governmental development organization. It has a major programme in the sector of environment and natural resources with strong involvement in community forestry. Communities are supported in the replanting of diverse tree species, environmental education, preservations of biodiversity, and use of non-timber products as mean a mean of income generation. They run multipurpose nurseries in Vava'u, Ha'apai and 'Eua.

4.17.1 Institutional Strengths and Weaknesses

This review noted that the specific roles within responsible organizations are not clearly defined and some vital duties are duplicated (Table 4.1.6).

Table 4.1.6 Institutuinal Strengths and Weaknesses

Agencies	Strengths	Weaknesses	Adequacy of human resources
MAFF (Forestry Division)	- involvement in resource development such as tree planting activities on private farm allotments, forest plantations, and national park maintenance. - Operate offices with personnel nationwide (operation centers in all main centers of Tonga (Tongatapu, Vava'u, Ha'apai, Niuatoputapu, and 'Eua) - Runs multipurpose forest nurseries (major supplier of seedlings nationwide) - Potentially qualified technical staff employed in all main centers - Donor funded projects assist the division's works - Assisted by regional forestry agencies such as SPC Forest and Trees Programme - Forest nurseries promote a wide range of tree/plant species. For instance, species varies from cultural, ornamental, medicinal, timber, vegetable, kava etc.	- No formal forest policy to provide sound and sustainable guidelines to forestry operations. (Tonga is the only island state in the region that does not have a formal forest policy) - Being a division under MAFF, Forestry development is given lower priority in terms of budget allocation and other resource allocations such as staffing, - Lack of research capabilities within the division. This is due to lack of human and capital resources. Basic research work is done on-farm or on private land. Restrictions in on-farm research occurs in the form of lands being not secured on long term basis, delegation of duties often not work out. For instance, the farmer involved in an on-farm trial is expected to carry out parts of the maintenance. This is often not happened and trials are often	Existing human resource not sufficient. Formal and informal training is required to strength the human resource. Important areas require further training includes, agroforestry, research, resource inventory, policy and legistlation.

		left unmanaged. - Government budget allocation for operational activities decreases annually, - Existing manpower not sufficient	
Tonga Timber Limited (TTL)	- Government supported entity, - Established sawmills and wood processing facilities on main centers (Tongatapu, Vava'u, Ha'apai, Niuatoputapu, Niuafo'ou, and 'Eua), - Core staff of TTL were former employee of Forestry Division. As such, there is a fair degree of technical skills available within the company in order to carry out sustainable resource management, - Operation guided by a government management committee. The committee has laid out ground rules with which the operation within the plantation must be followed	- Profit oriented agency, therefore having the tendency to overlook conservation issues and services in order to minimize costs, - No firm replanting schedule for the 'Eua forest plantation, - Lack of qualified manpower to carry out forest management tasks - Concentrate on the forest plantation. Private farm allotments are given no development in terms of replanting and conservation of forest ecosystems, - TTL currently have rights for timber (timber rights). Land ownership remained within the Ministry of Lands, Survey and Natural Resources, - Encroughment to watershed area in 'Eua continues although the relocation of private land holders is officially completed.	Much of the existing skills is on sawmilling and wood utilization. Human development in line with resource development and management is required.
Department of Environment (DOE)	- Legal setting in place to support resource development, - Qualified staffs in areas of environmental science employed by the department, - Assisted by regional and international donor organization,	- Lack of physical outputs, in terms of forest and tree resource development. It appeared to the reviewer that much of the technical effort is given to information development. - With vital role of coordinating efforts amongsts relevant biodiversity stakeholders, DoE is yet to have notable impact in coordinating physical development apart from important informations gathered,	Human resource is considered sufficient in the current structure. When expertise in other areas such as agriculture and forestry is required, relevant Ministries or Departments shall be called upon to provide assistance.
Ministry of Lands, Survey and Natural Resources (MLSNR*)*	- Mandated towards land management. This is seen to be well looked after with a highly qualified personnel in place, - Legal setting in place to support development, - Qualified staffs in areas of environmental science employed		Human resource is considered sufficient in the current structure.
Tonga Rural Development Trust	- Directly involve in community rural development activities, - Has regional and international partners	- Lack of technical expertices in forestry biodiversity conservation - Limited human and capital resources	Human resource is considered sufficient in the current structure. When expertise in other areas such as agriculture and forestry is required,

			relevant Ministries or Departments shall be called upon to provide assistance.

4.17.2 Institutional Responsibility Gaps

It is evident from the information gathered that relevant stakeholders have developed strategies to adequately address each respective core objectives. For instance, DOE train its staff in environment related subjects whilst Forestry Division provides technical trainings in nursery seedling propagation and plantation forerstry.

Capacity building in biodiversity conservation is the most important strategy for relevant institutions. The primary purpose is to build the capacities of all stakeholders; communities, organisations, and institutions, so that they are able to undertake the initiative and subsequently extend the beneficial results beyond the boundaries of each institution.

Genuine collaboration between institutions is essential to ensure efficient use of resources and effective delivery of results. Institutions have common concerns and agendas, and must be prepared to pool their strategic ideas and resources and engage in genuine partnerships to tackle common issues. To work in partnership, each agency must be able to feel a valued part of the overall initiative, with a stake in learning from each other, and able to contribute to the well being of the civil society.

Biodiversity conservation should design and promoted by multidisciplinary institutions. It should also develop as an integral component of ecologically sustainable development. Conservation projects cannot be carried out effectively in isolation of mainstream social and economic programs, either at the level of local communities or nationally.

4.18 Programs and Projects for Forestry Biodiversity Conservation

Forestry Division of MAFF is the “technical branch” of forestry biodiversity conservation in Tonga. It involves tree planting, coconut replanting scheme, forest health surveillance activities, monitoring of TTL operation on ‘Eua plantation, nursery seedling production, and extension services. Please refer to Tables 4.1.7 - 4.1.9 for information on Forestry biodiversity conservation projects operates under Forestry Division.

(1) Project Title: "SPRIG-2 Project"

1. Project Goal	To help Pacific Island Countries (PICs) conserve, improve and better promote the wise use of the genetic resources of priority regional tree species to enhance environmental protection and to promote economic and rural development.
2. Project Purpose	To strengthen the capacity of the participating Departments and regional organisations to conserve, improve and better promote the wise use of priority genetic resources in order to promote sustainable rural development.
3. Project Components;	Objective(s):
3.1. Institutional strengthening and regional networking	1. To strengthen the capacity of participating national and regional organisations in the South Pacific in the conservation and development of priority forest and tree genetic resources. 2. Facilitating networking of information and germplasm exchange among those working on South Pacific forest and tree genetic resources (including national, regional and international agencies, NGOs, industry, communities and individuals) 3. Progressively integrate appropriate SPRIG conservation, tree improvement, training and information activities within national and regional organisations; eg SPC, SPREP and USP and national institutions.
3.2. Conservation and sustainable management of priority species	To help PICs conserve, improve and better promote the wise use of the genetic resources of priority regional tree species to enhance environmental protection and to promote economic and rural development.
3.3. Tree improvement	To support and enable PICs in the improvement of priority indigenous and exotic tree species and incorporate tree germplasm into commercial and smallholder plantings.
3.4. Demonstrating linkages between conservation, tree improvement and enhanced rural incomes	Demonstrating linkages between conservation and tree improvement in enhancing rural incomes.
3.5. Project management	To meet stated objectives and complete the project on time and within budget.
4. Project Duration	3 years
5. Project Budget	Not available
6. Evaluation of the soundness of the project	• Formal training opportunities made available to responsible staff. This is the most significant impact of the project, • Project activities yet incorporated as an integral part of forestry division operational activities. Much of the planned project activities is done by project management,

(2) Logical Framework (18 April 2000), amended in the subsequent contract between the Australian Managing Contractor and AusAID, and also in the first two Annual Project Plans)

Narrative Summary	Revised, Proposed Objectively Verifiable Indicators
T1.1 Supply of equipment	Equipment delivered, commissioned, maintained and in use.
T1.2 MSc scholarship	MSc scholarship undertaken by Year 4 and successfully completed judged by reports from University and national agency supervisors. By Year 5, formal evidence of successful training, using the Immediate and Subsequent Indicators.
T2.1 Implement the conservation and	A conservation and management plan is being progressively implemented by the

management plan for Santalum yasi	relevant agencies.
T3.1 Seed collection, seed in storage ready for field trials	Reports of germplasm collections of priority FGR, and evidence of satisfactory treatment and storage.
T3.2 Measurement and assessment of SPRIG-1 trials	Trials measured, assessed and reported by Year 2.
T3.3 Three ha per annum of seed orchards and demonstration plantings for 3 years to include 'Eua, Vava'u and Ha'apai	A total of 9 ha of seedling seed orchards and demonstration plantings successfully established by Years 3, 4 and 5 and properly managed, judged by relevant scientific criteria. Annual reports on activities.
T4.1 A feasibility study for the development of a conservation and development plan for endangered tree species in the Ha'apai Conservation Area	Feasibility study completed and reported by Year 3, and report on implementation activities.
T4.2 Marketing studies for multi-purpose trees within Ha'apai Conservation Area	Marketing studies completed and reported by Year 3, and report on implementation activities.
T4.3 Establish seed stands of Santalum yasi	Numbers of sandalwood seed stands successfully established (judged by relevant scientific criteria) by Year 5.
T5.1 SPRIG work programme achieved on time and within budget	Acceptable project reports submitted on time on all aspects of project activities, as specified.
T5.2 Forest genetic resources activities incorporated in Departmental workplans and strategies.	Verbal and written annual reports from national organisations specifying the ways in which project activities are integrated within the organisational plans.

Source: Stevens (2004)

(3) "Development of Forest Health Surveillance Systems for the South Pacific Countries and Australia"

1. Project Number	FST/2001/045
2. Project Category;	
2.1. Type of Project	ACIAR Intermediate Project
2.2. Program Area	Forestry
2.3. Project Manager	Dr. John Fryer
2.4. Country	Kingdom of Tonga
2.5. % Development	40 percent
2.6. % Training	40 percent
3. Geographic region	Fiji, Tonga, Vanuatu, & Samoa
4. Commissioned Organization	Queensland Forestry Research Institute Gate 3, 80 Meiers Road Indooroopilly Q. 4068
5. Project Leader	Dr. Ross Wylie Fax 07 3896 9628
6. Project Duration	One year (2003-2004)
7. Project Budget	Not available

8. Objectives	To increase capacity in Forest Health Surveillance in Fiji, Vanuatu, Tonga and Samoa and establish a support network of relevant experts
9. Expected Outputs	• Draft survey methodologies, trainng materials and project planning, • Adaptation of current Australian plantation survey practices for use in woodlots/agroforestry practices, • Improve survey methodology and basic taxonomy skills, a sueveillance program, a shared basic information on pests and diseases problems in the cpllaborating countries, • Improve pest and disease information through survey of plantation and vegetation adjacent to ports of entry and further refinement of survey methodology and FHS systems, • A review of progress and information collected in the final report, and consider further directions, • A web-based mechanism for data sharing and access to other information resource, • A priority list of damaging forest pest and diseases in the region, • Suggestions for advancing a regional management framework on FHS in the Pacific region formulated.
10. Summary of Strategy	An adaptive research approach, involving partner couthries in the development and application of their own systems, will be used to develop the FHS system. Key components will be systematic surveys of plantations, woodlots and points of entry, earliest pest identification and management, curation, rearing/culturing, data storage and management supported by access to a network of experts. The adaptive approach with its accelerated capacity building is appropriate for this project, given the current knowledge and skills based and the risk to forest assets. This project aims to address training and specialist networking to increase country capacity to conduct forest health surveys. Although basic information will be provided on important allied subjects including quarantine, contingency planning and emergency response, pest management and pest risk analysis, these are main areas which cannot be addressed comprehensively in the current project. These areas could be subject to future projects.
11. Evaluation of soundness of project	• This is the first project with which Forestry Division is directly involved in the area of Forest Health Surveillance. All forestry-related FHS work was assumed to be undertaken by the MAFF Research and Extension Division (RED), • Forestry personnel, develop basic FHS skills in working alongside their Australian counterparts, • Basic rearing, storage and identification tools established within the division, • This project has high potential in improving human capacity for Tonga in terms of FHS.
12. Recommendation	Considering the recent establishment of the project and it's one year duration, it is recommended that effort should be geared towards extention of th project.

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4.20 Annexures

Annex 1. Quantity and Value of Wood Import 2000 - 2002

	Unit	2000		2001		2002	
		Qty	Value	Qty	Value	Qty	Value
Woods in Tons							
Fuel Wood	tons	24.00	8,582	146.00	73,500	86.00	47,228
Charcoal Wood	tons	97.00	37,744	53.00	26,495	17.00	8,942
Sub-Total		**121.00**	**46,326**	**199.00**	**99,995**	**103.00**	**56,170**
Woods in Cubic Meter							
Wood in the rough	M3	1,480.00	580,526	993.00	437,810	2,861.00	1,011,315
Hoopwod: split poles, piles, pickets	M3	509.00	178,390	121.00	67,432	621.00	143,648
Railway or Tramway Sleepers of Wood	M3	1,499.00	741,966	9.00	5,778	8.00	3,000
Wood sawn or Chipped lengthwise	M3	4,889.00	1,925,946	5,097.00	2,290,981	7,512.00	3,373,367
Veneer Sheets and Sheets for Plywood and other Wood Sawn	M3	888.00	376,551	1,278.00	688,100	1,257.00	773,222
Wood (including strips, friezes for parquet flooring)	M3	206.00	25,032	371.00	229,100	797.00	195,389
Particle Board and similar board	M3	1,144.00	85,163	898.00	131,319	688.00	275,702
Fibreboard of Wood and other Ligneous Materials			93,167		27,186		83,551
Plywood, Veneered Panels and similar Laminated Wood			195,914		363,746		821,753
Sub-Total		**10,615.00**	**4,202,655**	**8,767.00**	**4,241,452**	**13,744.00**	**6,680,947**

Annex 2. Quantity and Value of Wood Export 2000 - 2002

	Unit	2000		2001		2002	
		Qty	**Value**	**Qty**	**Value**	**Qty**	**Value**
Miscellaneous							
Pandanus			1,520.00				
Tongan Mats			47,224.00		140,175.00		124,708.00
Tapa			76,319.00		50,545.00		26,596.00
Tongan Handicrafts			16,218.00		8,000.00		3,600.00
Live plants including their roots and mushroom spawn			1,162.00	600.00	44,953.00		60,088.00
Plants and parts of plants including seeds and fruits	tons			10.40	18,599.00	8.20	128,533.00
Foliage, branches and other parts of plants without flowers					5,104.00		37,531.00
Sub-Total		**-**	**142,443.00**	**610.40**	**267,376.00**	**8.20**	**381,056.00**
Woods							
Rough Wood	M3	93.00	5,282.00	48.00	6,000.00	313.00	1,600.00
Wood Sawn	M3	800.00	20,450.00	119.00	11,900.00		
Wood - Continuously Shaped	M3	40.00	500.00	8.00	825.00	140.00	300.00
Densified Wood			1,500.00				
Statuettes and other Ornaments of Wood			76,596.00		10,790.00		42,543.00
Marquetry and Inlaid Wood			37,069.00		14,950.00		830.00
Sub-Total		**933.00**	**141,397.00**	**175.00**	**44,465.00**	**453.00**	**45,273.00**

Annex 3. Scientific names of medicinal plants, Tongan names, habitat for which they are found, non-medicinal uses.

Scientific names	Tongan names	Habitat	Medicinal uses
Curcuma longa	Ango, Ango Hina	Plantations and home sites	Skin sores, rashes of infants
Zingiber zerumbet	Angoango, Ango Kula	Moist secondary forests & old habitation	Peptic ulcers & stomachache
Symphytum asperum	‘Akau ‘o e Mo’ui	Plantations and home sites	Cuts & stomachache
Indigofera suffruticosa	‘Akau Veli	Plantations and disturbed places	Relieve pain from bee stings
Aloe vera	‘Aloe	Plantations and home sites	Burns, cuts stomachache
Annoona squamosa	‘Apele Tonga	Plantations and home sites	Stomachache
Wollastonia biflora	Ate	Littoral & coastal areas of high islands	Cuts & treatment of supernatural ailments
Pandanus tectorius	Fa	Littoral & coastal areas & plantation	Skin sores and stomachache
Neisosperma oppositifolium	Fao	Littoral & coastal areas	Diabetes & hypertension
Hibiscus tiliaceus	Fau	Margins of estuaries and swamps	“pink eye”, eye injuries & stomachache
Syzgium malaccense	Fekika Kai	Plantations and home sites	Abdominal ailments (kahi) & stomachache
Callophyllum inophyllum	Feta’u	Coastal areas	Steambath for supernatural ailments
Jatropha curcas	Fiki	Plantations	Stomachache & supernatural ailments
Bidens pilosa	Fisi’uli	Dominant weed of wastelands & croplands	“pink eye”, cuts & supernatural ailments
Ipomoea indica	Fue ‘ae Puaka	Climber of low vegetation and waste places	Purge (fakahinga)
Faradaya amicorum	Fufula	Climbing shrub on forest canopy (found in ‘Eua)	Purge (fakahinga) & stomachache
Erythrina variegate	Ngatae	Littoral forests and cultivated area	Stomachache
Syzygium corynocarpum	Hehea	Plantations and home sites	Skin inflammation (kulokula) & stomachache
Garcinia sessilis	Heilala	Plantations and home sites	“pink eye” & supernatural ailments
Inocarpus fagifer	Ifi	Plantation & native forests & mangrove forest	Burns & diarrhea
Sigesbeckia orientalis	Kakamika	Not mentioned	Skin sores (mea & tona (yaws) & skin inflammation
Diospyros elliptica	Kanume	Littoral & coastal areas	Stomachache & kahi
Piper methysticum	Kava	Plantations	Insect stings & hukia (poisonous fish)
Macropiper puberulum	Kavakava ‘Ulie	Primary & secondary forests	Skin inflammation (kulokula) & stomachache
Ozalis corniculata	Kihikihi	Disturbed areas & home sites	Infant mouth infectious, late-closing fontanel (mavae ua)
Bischofia javanica	Koka	Secondary forests & plantation	Infant mouth infectious (pala ngutu)
Psidium guajava	Kuava	Plantations, roadsides, disturbed areas etc.	Stomachache
Vitex trifolia	Lala Tahi	Littoral & coastal areas	Infant mouth infectious (pala ngutu)
Phymatosorus scolopendria	Laufale	Native & secondary forests and swamp forests	Skin inflammation (kulokula) & stomachache
Hoya australis	Lau Matolu, Matolu	Climber on low vegetation & epiphytes in coasta lowland forest	Skin inflammation (kulokula), rashes & skin infections
Vigna marina	Lautolo Tahi	Sandy beaches	Treatment for evil sprit ailments
Xylocarpus granatum	Lekileki	Along the margins of mangrove swamps	Stomachache, peptic ulcer, and coughs
Ricinnus communis	Lepo	Road sides & disturbed places	Skin inflammation (kulokula)
Carica papaya	Lesi	Plantations and home sites	Diarrhea (young seeds) & asthma
Macaranga harveyana	Loupata	Disturbed areas & waste places	Kahi & stomachache
Trema cannabina	Mangele	Disturbed places	Mouth infection, cuts & sores
Mangifera indica	Mango	Plantations and home sites	Relapse sickness (kita) (plus moli kai to make vai kita mate)

Tremna sambucina	Manonu	Secondary forest and disturbed places	Kahi & stomachache
Diospyros major	Mape	Native forest & cultivated areas	Kita & stomachache
Glochidion ramiflorum	Masikoka, Malolo, Mahame	Primary & secondary forests	Mouth infection & stomachache
Artocarpus altilis	Mei, Mei Kea	Forest areas, past cultivated areas, home sites	Kita, facial rash & stomachache & "red buttocks" (mui kula)
Thespesia populnea	Milo	Littoral & coastal areas	Mouth infection, peptic ulcer & diarrhea
Cymbopogon citrates	Moengalo	Home sites	Mouth sores
Cananga odorata	Mohokoi	Plantations and home sites	Stomachache
Citrus sinensis	Moli Kai	Plantations and home sites	Kita
Mussaenda raiateensis	Monomono 'A Hina	Open places on ridges and coastal areas	Fe'ea (malnourished infant due to breast feeding from mother who is pregnant again
Dyoxylum forsteri	Mo'ota	Native lowland and disturbed forest	Steambath for supernatural ailments
Morinda citrifolia	Nonu	Lowland forests, plantations & home sites	Stomachache, mouth infection, boils & sty (matafa)
Ficus oblique	'Ovava Tonga	Lowland forests & home sites	Skin inflammation (kulokula), boils & stomachache
Passiflora quadrangularis	Pasione	Home sites	Cuts or wounds to prevent infection (kona)
Capsicum frutescens	Polo Fifisi	Home sites & disturbed places	Skin inflammation (kulokula), and boils
Solanum viride	Polo Tonga	Home sites & disturbed places	Skin inflammation (kulokula), and boils
Fagraea berteroana	Pua Tonga	Home sites & disturbed places	Internal injuries (kafo)
Gyrocarpus americanus	Pukovili	Plantations & home sites	Stomachache & kulokula
Cordyline fruticosa	Si	Home sites & understory shrub of disturbed forest	"swollen eye", toothache & fakamahaki
Gardinia taitensis	Siale Tonga	Home sites & disturbed places	Fakamahaki
Entada phaseoloides	Sipi	High-climbing liana of littoral and lowland forests, often covering forest trees	Stomachache & mental illness (te'ia)
Micromelum minutum	Takafalu	Coastal, lowland, secondary forest. But not very common.	Stomachache & toothache
Lantana camara	Talatala	Weeds mostly in waste places	Cuts
Achyranthes aspera	Tamatama	Sunny coastal habitats	Cuts, prevent infections (kona) or tetanus (kona hamu)
Pomitia pinnata	Tava	Lowland rainforest & home sites	Mouth infections, coughs, kahi & rubbed onto the head of infants to treat an unclosed fontanel (mavaeua)
Senna alata	Te'elango	Disturbed lands & home sites	Ringworm (lafa)
Geniostoma rupestre	Te'epilo 'a maui or Fa'efa'elunga	Coastal to montane forest	Purgative (fakahinga) & Stomachache
Ervatamia obtusiuscula	Te'ete'emanu	Uncommon in native lowland & disturbed forest	Mouth infections & toothache
Terminalia catappa	Telie	Coastal areas & 'Eua plantation	Mouth infection (pala ngutu, pala fefie, pala hina)
Saccharum officiarum	To	Home sites and abandoned plantations	Burns
Casuarina equisetifolia	Toa	Coastal	Mouth infection, emetic effect (fakalua) & Stomachache
Alphidonia zizyphoides	Toi	Native and disturbed forests	Kahi
Centella asiatica	Tono	Weed of damp, sunny or shady places	Infant's infected navel (tapitopito)
Tournefortia argentea	Touhuni	Littoral forests on rocky and sandy coasts	Treating food poisoning & cuts
Aleurites moluccana	Tuitui	Plantations & home sites	Mouth infections & kahi
Jasminum simplicifolium	Tutu'uli	Disturbed areas & home sites	"Swollen liver" ('ate pupula), Jaundice (engeenga)

Euodia hortensis	Uhi	Plantation & home sites	Swollen eye, swollen testicles (lohofua) & headache
Gossypium barbadense	Vavae Tonga	Village areas	Cuts
Spondias dulcis	Vi	Plantations & home sites	Stomachache & matakovi & diarrhea
Premna serratifolia	Volovalo	Coastal & littoral forests	Skin inflammation (kulokula)

Annex 4. Invasive and potentially invasive species present on Tongatapu

Scientific Name	Common Names	Family	Habit
Adenanthera pavonine	English: Coral bean tree, red sandalwood tree, red bead tree, lopa, bead tree, false wiliwili, peacock flower-fence; French: bois de condori; Other: kaikes (Pohnpei); mwetkwem (Kosrae); colales, culalis, kolales, kulales, kulalis (Guam, CNMI); metekam, metkam, metkem, (Kosrae); telengtúngd, telentundalel (Palau); pomea (Fiji, Niue), lera, lere ndamu, vaivai, vaivai ni vavalangi (Fiji), lopa, la‘au lopa (American Samoa, Samoa and Tonga); paina, pitipitio (French Polynesia)	Fabaceae	tree
Albizia lebbeck	English: siris-tree, rain tree, East Indian walnut, kokko, woman's-tongue tree, soros-tree, raom tree ; French: bois noir; Other: trongkon-mames, tronkon mames, mamis (Guam); kalaskas, trongkon-kalaskas (CNMI–Chamorro); schepil kalaskas (CNMI–Carolinian); ukall ra ngebard (Palau); gumorningabchey; ngumorrningobchey (Yap); 'ohai (Hawai'i); vaivai, vaivai ni vavalangi, vaivai ni vavalagi (Fiji); tamaligi pa’epa’e (Samoa); kasia (Tonga)	Fabaceae	tree
Aleurites moluccana	English: candlenut, Indian walnut; French: bancoulier, bancoulier, noyer de bancoul, noyer des Moluques; Other: lumbang (Guam), raguar (Caroline Islands); sakan, shakan (Pohnpei); lama (American Samoa and Samoa); kukui (Hawai’i); tuitui (Cook Islands, Niue, Tonga), 'ama (Marquesas); lauci, lauthe, lauthi, toto, tuitui, tutui, waiwai, sekeci,sikethi, sikeli, nggerenggere (Fiji); tahii tiairi, ti’a’iri, tutui, tahiri (French Polynesia)	Euphorbiaceae	tree
Alpinia purpurata	English: red ginger; Other: thevunga (Fiji); ‘awapuhi ‘ula‘ula (Hawai‘i); teuila (Samoa); tevunga (Tonga)	Zingiberaceae	herb
Annona muricate	English: soursop, prickly custard apple; French: corossolier, cacheimantier épineux, cachiman épineux, corossol épineux; Other: saasaf, sasaf (Chuuk); tapotapo papaa (French Polynesia); laguana, laguaná, laguanaha, laguanaba, labuanaha (Guam); sosap (Kosrae); jojaab (Marshall Islands); syasyap (Northern Mariana Islands), talapo fotofoto (Niue), sausab (Palau); sei, sae, truka shai (Pohnpei); sasalapa (Samoa); ‘apele ‘initia (Tonga); sausau (Yap)	Annonaceae	tree
Annona squamosa	English: sugar apple, sweetsop, custard apple, sugar apple; French: annone écailleuse, pomme-canelle; Other: atis, ates (Guam); ngel ra ngebard (Palau), ‘apele papalangi, ‘apele Tonga (Tonga), tapotapo (French Polynesia)	Annonaceae	tree
Antigonon leptopus*	English: Mexican creeper, mountain rose, Confederate vine, chain-of-love, hearts on a chain, love-vine, coral bells, coral vine, queen’s jewels, kadena de amor, corallita; Other: rohsapoak (Pohnpei)	Polygonaceae	vine
Arundo donax	English: giant reed, Spanish reed, wild cane; French: canne de Provence, grand roseau; Other: ngasau ni vavalangi (Fiji); fiso papalagi (Samoa); kaho folalahi (Tonga)	Poaceae	grass
Asparagus densiflorus	English: asparagus fern, sprengeri fern, smilax, regal fern	Liliaceae	herb
Asparagus setaceus	English: ornamental asparagus, climbing asparagus fern, plumosa; French: asperge plumeuse; Other: taupo ‘ou (Tonga)	Liliaceae	vine
Asystasia gangetica	English: Chinese violet, Philippine violet, coromandel	Acanthaceae	herb
Axonopus fissifolius	English: caratao grass, narrow-leaved carpetgrass	Poaceae	grass
Bambusa spp.	English: bamboo; French: bambou; Other: moor (Yap); iich (Chuuk); pehri en sapahn (Pohnpei); bambuu (Palau); bambu (Kosrae); pi‘ao, pi‘ao palaoan (Guam and Northern Marianas-Chamorro); bwai (Guam and Northern Marianas-Carolinian); kaho palangi (Niue); ‘ohe (French Polynesia); ofe (French Polynesia, Samoa), ‘ofe fiti, ‘ofe papalagi (Samoa); kofe, pitu (Tonga); koe (Rarotonga, Cook Islands)	Poaceae	tree

Bauhinia monandra	English: orchid-tree, St. Thomas-tree, Napoleon's plume; flamboyant (Pohnpei), flores mariposa (CNMI); mariposa (Guam); pink butterfly tree (Fiji); Other: pine fua loloa (Niue), vae povi (American Samoa and Samoa)	Fabaceae	tree
Bidens pilosa	English: beggar's tick, Spanish needle, cobbler's pegs; French: piquants noirs, bident hérissé, herbe d'aiguille, herbe villebague (Mauritius); Other: fisi'uli (Tonga); kofe tonga, kofetoga (Niue); piripiri (Cook Islands); tae puaka (Futuna); batimadramadra, mbatimandramandra, mbatikalawau, matakaro, matua kamate (Fiji); ki, ki nehe, ki pipili, nehe (Hawai'i)	Asteraceae	herb
Blechum pyramidata	English: blackweed (Samoa), Browne's blechum; Other: yerbas babui (Guam), vao uliuli (Samoa)	Acanthaceae	herb
Brachiaria mutica	English: California grass, para grass, buffalo grass, Mauritius grass, signal grass; French: herbe de Para; Other: puakatau (Tonga) (Swarbrick, 1997)	Poaceae	
Breynia disticha*	English: snowbush, snowbush breynia, sweetpea bush, foliage-flower	e	shrub
Bryophyllum pinnatum	plant; Spanish: hoja del aire; Other: kibilia (Marshall Islands); bulatawamudu (Fiji); tupu he lau, tupu noa (Niue); teang (Kiribati)	Crassulaceae	herb
Calliandra calothyrsus*	English: powderpuff red calliandra; Other: kaliana (Samoa)	Fabaceae	shrub
odorata	English: perfume tree; French: canang odorant; Other: ilang-ilang, alang-ilang (Guam, Philippines); ylang-ylang, lengileng (CNMI); chiráng, irang (Palau); ilanlang, ilahnglahng (Kosrae); pwanang, pwuur, pwalang (Chuuk); pur-n-wai, pwurenwai, sair-n-wai, seirin wai, seir en wai (Pohnpei); ilanilan, ilañlañ (Marshall Islands); motoi (Niue); makasoi, makosoi, makusui, mokohoi, mokosoi (Fiji); moso'oi (American Samoa and Samoa); mohoki, mohokoi, mohokoi (Tonga); moto'oi, mata'oi (Cook Islands, Niue, Tahiti); moto'i (Tahiti); lanalana (Hawai'i)	Annonaceae	tree
Canna indica	English: canna, canna lily, Indian shot; French: balisier comestible, tous-les-mois; Other: mongos halum-tano (Guam); luiuenwai (Pohnpei); apeellap, oruuru (Puluwat); fanamanu, fagamanu, fa'i masoa (American Samoa and Samoa); gasau ni ga (Fiji); te riti (Kiribati), misimisi (Tonga); fagafaga (Futuna); ali'ipoe, li'ipoe, poloka (Hawai'i); pia-raroto'a (French Polynesia)	Cannaceae	herb
Cardiospermum halicacabum	English: balloon vine, heart pea, love-in-a-puff; Other: wa niu, vo niu (Fiji); vinivinio (French Polynesia)		vine
Cedrela odorata*	English: cigar box cedar, Mexican cedar, West Indian cedar, Spanish cedar, Barbados cedar; French: cèdre acajou, cèdre des barbares; Spanish: cedro cubano (Galapagos Is.); Other: sita hina (Tonga)	Meliaceae	tree
Ceiba pentandra	English: kapok, kapok tree, silk-cotton tree, pacae; French: kapokier, capoc, bois coton; Spanish: ceibo; Other: koton (Chuuk); algodon de Manila, atgodon di Manila, algidon, atgidon de Manila (Guam); koatoa, atagodon, arughuschel (Saipan), batte ni gan' ken (Yap); bulik, kotin (Marshall Islands); cottin, koatun, koatoa (Pohnpei); kuhtin, cutin (Kosrae); kalngebard, kalngebárd, kerrekar ngebard (Palau); vauvau ni vavalangi, semar (Fiji); vavae (American Samoa, Samoa, Niue, Tonga); vavau ni lokoloko (from Ecoport, source not given)	Bombacacea e	
Cenchrus ciliaris	English: buffelgrass, African foxtail grass, anjan grass; French: cenchrus cilié	Poaceae	
Cenchrus echinatus	English: burgrass, sand-bur, southern sandbur, Mossman River grass (Australia); French: herbe a cateaux (Mauritius); Other: tuitui, vao tuitui, vao papalagi (American Samoa and Samoa); se mbulabula (Fiji); piri-piri, pipiri (French Polynesia); konpeito-gusa, 'ume'alu (Hawai'i); te anti, te kateketeke (Kiribati); cram-cram (New Caledonia); motie vihilago, mosie vihilango (Niue); loklok, lellik, lekelik, liklik, karmwijmwij (Marshall Islands); cauit-cauitan (Philippines); hefa (Tonga)	Poaceae	grass
Centrosema pubescens	English: centro, butterfly-pea; French: fleur-languette, pois bâtard; Other: pi ni ndola (Fiji)	Fabaceae	herb
Cestrum nocturnum	English: night-flowering cestrum, night-flowering jasmine, queen (or lady) of the night; Other: teine o le po, ali'i o le po (American Samoa and Samoa); thauthau, thauthau ni mbongi, kara (Fiji); dama-de-noche (Guam); juñoul rua awa? (Marshall Islands); iki he po (Niue); lakau po'uli (Tonga)	Solanaceae	shrub
Chamaecrista	English: partridge pea, Japanese tea senna; Other: kobo-cha, nemu-cha (Japan)	Fabaceae	small

nictitans			shrub
Chloris barbata	(Hawaii)	Poaceae	grass
Chloris radiata	English: plush-grass, radiate fingergrass		grass
Chrysopogon aciculatus	English: Mackie's pest, lovegrass, seed grass, golden beardgrass, seedy grass (Solomon Islands); French: herbe plate, herbe à piquant; Other: inifuk, palaii (Guam); iul (Palau); manienie ‘ula (Hawai'i); mutia tai, mutia vao (Samoa); mosie fisi (Niue); matapekepeke, matapekapeka matapekepeka (Tonga); herbe plate (Vanuatu), papapa (French Polynesia)	Poaceae	grass
Clerodendrum buchananii var. fallax	English: red clerodendrum, pagoda-flower; Other: talufe (Niue); amo’ula, amo’ule (Tonga), lau'awa (Hawai'i)	Verbenaceae	shrub
Clitoria ternatea*	English: butterfly pea, Asian pigeonwings; French: honte; Other: buikike, bukike, paokeke, bukike paokeke, capa de la reina, kapa de la raina (Guam); putitainubia (CNMI); pepe (Niue); latoela, nawa (Fiji), paipa (Tonga)	Fabaceae	vine
Coccinia grandis	English: ivy gourd, scarlet-fruited gourd; Other: aipikohr (Pohnpei); kundru (Fiji)	Cucurbitaceae	vine
Coffea arabica*	English: coffee; French: café, caféier d’ Arabie; Spanish: café, cafeto; Other: kove (Fiji); kofe (Fiji, Niue, Samoa), kofi (Tonga); kafe (Marquesas); taofe (Tahiti)	Rubiaceae	tree
Commelina diffusa	English: commelina, dayflower, wandering Jew, spiderwort; Spanish: chiriyuyo; Other: semprebiban-damalong (Guam); honohono (Hawai‘i); mau‘utoga, mau‘u Tonga (American Samoa and Samoa); mohuku vai, musie matala pulu (Tonga); ai rorongi, ai rongorongo, airogorogo, cobulabula, rongomatailevu, thombulambula, matembulambula, drano,duludauwere, ndrano, ndulandauwere, luna, tho nggalonggalo (Fiji), ma‘apape (French Polynesia)	Commelinaceae	herb
Cordia alliodora	English: laurel, Ecuador laurel, salmwood, Spanish elm; French: bois de Chypre, pardillo; Other: kotia (Samoa, Tonga)	Boraginaceae	tree
Costus speciosus	English: crepe ginger, crape ginger, wild ginger, Malay ginger, canereed; Other: isebsab (Palau)	Zingiberaceae	
Crassocephalum crepidoides	English: thickhead, fireweed, redflower ragleaf; Other: fua lele, pualele (American Samoa and Samoa); maraburubo (Solomon Islands); fisi puna (Tonga); se vuka (Fiji)	Asteraceae	herb
Cyperus involucratus	English: umbrella sedge, umbrella plant, dwarf papyrus grass	Cyperaceae	sedge
Cyperus rotundus	English: nut grass, nutsedge, purple nutsedge, cocograss; French: souchet rond, souchet à tubercules, herbe à oignon; Other: chaguan humatag (Guam); tuteoneon (Marshall Islands); kili'o'opu (Hawaii); oni ani (Cook Islands); soro na kambani, sora na kambani, soro ni kabani, ivako, malanga, vucesa, motha, vuthesa mot ha (Fiji); mumuta (Samoa, Tokelau); pakopako (Tonga), te mumute (Kiribati)	Cyperaceae	
Delonix regia	English: flame tree, flamboyant, poinciana; Spanish: flamboyan; Other: arbol del fuego, atbot, atbot det fuegu, atbut (Guam and CNMI–Chamorro); fayarbaw (CNMI–Carolinian); nangiosákura, nangyo (Palau); pilampwoia weitahta (Pohnpei); sakuranirow (Yap); sekoula (Fiji); pine (Niue); ‘ohai (Tonga); ngatipa, avarua (Rarotonga, Cook Islands); puke (Tahiti, French Polynesia)	Fabaceae	tree
Desmodium tortuosum	English: Florida beggarweed, Spanish clover, dixie ticktrefoil	Fabaceae	herb
Dieffenbachia seguine		Araceae	herb
Digitaria ciliaris	English: Henry's crabgrass, smooth crabgrass, tropical crab grass, large crab grass, southern crabgrass, fingergrass, summer grass; French: digitaire ciliée; Other: kukaepua'a (Hawai'i); Saulangi (Niue)	Poaceae	grass
Duranta erecta	English: duranta, golden dewdrop, pigeon-berry, sky-flower; Other: ‘olive (Tonga)	Verbenaceae	shrub
Elephantopus mollis	English: elephantopus, elephant’s foot, tobacco weed; French: faux tabac; Other: papago' vaca, papago' halom tano, papago' baka, papago' halomtano' (Guam); lata hina, lau veveli (Tonga); tavako ni veikau, jangli tambaku (Fiji); tapua erepani (Cook Islands)	Asteraceae	herb

Eleusine indica	English: goosegrass, wiregrass, goose foot, crow's foot, bullgrass; French: pied de poule; Other: fahitalo, lau ta‘a ta‘a, ta‘a ta‘a (American Samoa and Samoa); kavoronaisivi, vorovoroisivi, ghoraya (Fiji); tamamau (French Polynesia), umog (Guam); manienie ali‘i (Hawaii); mahkwekwe (Kosrae); katejukjuk (Marshall Islands); mosie fahitalo (Niue); deskim, keteketarmalk (Palau); reh takai (Pohnpei); takataka, takataka ‘a leala, mohuku siamane (Tonga); te uteute (from Ecoport, source not given)	Poaceae	grass
Eriobotrya japonica	English: loquot, Japanese plum, Japanese medlar; French: bibassier, néflier du Japon; Other: loketi (Tonga)	Rosaceae	tree
Eugenia uniflora*	English: Surinam cherry, red Brazil cherry; French: cerisier carré, cerisier de Cayenne; Other: kafika, kafika palangi (Niue), pitanga (Brazil)	Myrtaceae	tree
Ficus benjamina	English: weeping fig, baka, Java fig, weeping fig ; Other: ‘ovava fisi (Tonga)	Moraceae	tree
Ficus macrocarpa	English: Chinese banyan, Malayan banyan, Indian laurel; Other: lulk (Palau); nunu (Chamorro, CNMI)	Moraceae	tree
Flemingia macrophylla*		Fabaceae	tree
Flemingia strobilifera	English: luck plant; French: sainfoin du bengale; Other: besungelaiei (Palau)	Fabaceae	shrub
Furcraea foetida*	English: Mauritius hemp, sisal, maguey, giant cabuya; French: aloès vert, chanvre de Maurice; Other: toua (Niue); lautalotalo papalagi (Samoa); faumalila, fau malila (Tonga)	Agavaceae	succulent
Gliricidia sepium	English: mother of cacao, quickstick; Spanish: madre de cacao		tree
robusta	English: silk oak, silky oak, she-oak, silver oak, spider flower; Other: oke' (Tonga)	Proteaceae	tree
Hedychium coronarium	English: white ginger, butterfly lily, ginger lily, garland flower; Other: tunun, sinser (Chuuk); sinter pwetepwet (Pohnpei); tolon (Puluwat); thevunga, ndrove, cevuga vula, dalasika (Fiji)	Zingiberaceae	herb
Heliconia spp.*	English: heliconia, parrot's-flower, parrot's-plantain, crab claw, lobster claw	Heliconiaceae	herb
Hemigraphis alternata	English: metal leaf; red ivy, cemetery plant (Fiji)	Acanthaceae	herb
Hippobroma longiflora	English: star of Bethlehem, fetia, madamfate; Other: pua hoku (Hawai'i)	Campanulaceae	herb
Hyptis pectinata	English: comb hyptis, comb bushmint, mint weed, purple top; French: fausse menthe; Other: mumutun lahe, mumutun palaoan, mumutan ademelon (Guam); tamole ni veikau, tamoli ni vavalangi, timothi ni vavalangi, wavuwavu, ndamoli, ben tulsia (Fiji)	Lamiaceae	herb
Impatiens balsamina	English: impatiens, balsam, garden balsam, rose balsam, spotted snapweed; French: balsamine des jardins, impatience; Other: kamantigi (Guam), polosomo (Tonga)	Balsaminaceae	succulent
Indigofera suffruticosa	English: indigo; Other: aniles (Guam); ‘iniko, inikoa, kolu (Hawai'i); la‘au mageso (Samoa); ‘akau veli (Tonga)	Fabaceae	shrub
Ipomoea aquatica	English: aquatic morning glory, swamp cabbage, water spinach, ung-choi, kang kong; French: liseron d'eau, patate aquatique; Other: ota karisa, ota karisi, wa kumala, ndrinikava, luve ne tombithi (Fiji), cancon, kangkun (Guam); te kang kong (Kiribati); lorenzo (Nauru), ‘umala vai (Samoa); kangkong (Yap)	Convolvulaceae	aquatic herb
Ipomoea spp.	English: morning glory (non-native)	Convolvulaceae	herb
Jatropha curcas	English: physic nut, purging nut, Barbados nut; French: médicinier, pignon d'Inde, purghère; Other: wiriwiri, wiriwiri ni vavalangi, uto ni vavalangi, banidakai, mbanindakai, manggele, maqele, ndrala (Fiji); fiki (Fiji, Tonga); tuba-tuba (Guam); laupata (Samoa)	Euphorbiaceae	shrub
Kyllinga nemoralis	English: white kyllinga, whitehead spikesedge; Other: kili‘o‘opu (Hawai‘i), ta‘a ta‘a, ta‘a ta‘a vili taliga, matie upo‘o, matie tahiti, mo‘u upo‘onui, mo‘u upo‘o, tuise (Samoa); pakopako, pakopako ‘ae kuma (Tahiti); tuise (Tonga)	Cyperaceae	sedge
Lablab purpureus	English: hyacinth bean, lablab, bonavist, Egyptian kidney bean, dolichos; French: dolique, dolique d'Egypte, pois nourrice; Other: ndralawa, natomba, tomba (Fiji); cheribilla apaka, chuchumeko (Guam); papapa, pi (Hawai'i); pini lae puaka (Tonga)	Fabaceae	vine

Lantana camara	English: lantana; Other: landana, rantana, rahndana, tukasuweth (Pohnpei); ros fonacni (Kosrae); kauboica, kaumboitha, mbonambulumakau, mbona ra mbulumakau, tokalau, waiwai, lanitana (Fiji); latana (American Samoa and Samoa); latora moa, tatara moa (Tahiti); lakana (Hawai'i); talatala, talatala talmoa (Tonga); te kaibuaka, te kaibuaja (Kiribati); taramoa (Cook Islands); migiroa (Nauru), taratara hamoa, taratara moa (French Polynesia)	Verbenaceae	shrub
Leonurus japonicus	English: lion's tail, Chinese motherwort	Lamiaceae	herb
Leucaena leucocephala	English: leucaena, wild tamarind, lead tree; French: graines de lin, faux-acacia, faux mimosa (New Caledonia); Other: koa haole, lili-koa, ekoa (Hawaii); tangantangan, tangan-tangan, talantayan (Guam, CNMI, Marshall Islands); talntangan (CNMI); ganitnityuwan tangantan (Yap); tuhngantuhngan, rohbohtin (Kosrae); telentund (Palau); lopa Samoa (American Samoa and Samoa); fua pepe (American Samoa and Samoa); lusina (Samoa); pepe (Niue and Samoa); tavahi kaku (Niue); nito, toromiro (Cook Islands); siale mohemohe (Tonga); vaivai, vaivai ni vavalangi, vaivai dina, balori (Fiji); atiku (Marquesas); cassis (Vanuatu); te kaitetua (Kiribati); namas (from Ecoport, source not given)	Fabaceae	tree
Ligustrum spp.*	English: privet	Oleaceae	shrubs, small trees
Lonicera japonica*	English: Japanese honeysuckle, Hall's honeysuckle; Other: honekakala (Hawai'i)	Caprifoliaceae	vine
Macroptilium atropurpureum	English: siratro, purple bushbean	Fabaceae	herb
Melia azedarach	English: Chinaberry, pride-of-India, indian lilac, Persian lilac, white cedar, margosa tree, tira; French: lilas des Indes, arbre à chapelets; Spanish: jazmin (Galapagos Is.); Other: paraiso, para'isu (Guam); lelah (Pohnpei); prais (Yap);sili, tili (Niue); dake, bakain (Fiji), sita (Tonga)	Meliaceae	tree
Melinis minutiflora	English: melinis, molasses grass; French: herbe molasses, herbe à miel; Other: puakatau (Tonga)	Poaceae	grass
Melinis repens	English: Natal redtop, Natal grass, red Natal grass, Holme's grass, blanketgrass; French: herbe du Natal, herbe rose, herbe pappangue; tricholène (New Caledonia); Other: salapona (Tonga)	Poaceae	grass
Mikania micrantha	English: mile-a-minute weed, Chinese creeper, American rope, bittervine; French: liane américaine, liane-serpent; Other: fue saina (American Samoa, Samoa and Niue); fou laina (Niue), wa mbosuthu, wa mbosuvu, wa mbutako, wa ndamele, ovaova, wa bosucu, usuvanua (Fiji); kwalo koburu, (from Ecoport, no source given)	Asteraceae	
Mimosa pudica	English: sensitive plant, sleeping grass; French: sensitive; Other: la'au fefe, vao fefe, vao tuitui, tuitui (American Samoa and Samoa); ra kau pikikaa, rakau pikika (Cook Islands); tho ngandrongandro, tho kandrodandro, cogadrogadro (Fiji); betguen sosa (Guam); memege (Niue); mechiuaiu (Palau); limemeihr (Pohnpei); pohe ha'avare, pope ha'avare (Tahiti); mateloi (Tonga)	Fabaceae	herb
charantia	English: balsam-apple, bitter-melon, bitter gourd, balsam pear, squirting cucumber, cerasee, peria; French: momordique, margose (Réunion, Mauritius Islands), margose amère, momordique amère, concombre amer, concombre africain; Spanish: achoccha silvestre; Other: almagosa, atmagosu (Guam); atmagoso (Guam, CNMI); markoso (Palau); kerala (Fiji); meleni 'ae kuma, vaine 'initia (Tonga)	Cucurbitaceae	vine
Moringa oleifera*	English: horseradish tree, drumstick tree, ben nut, morango; French: ben ailée, moringa ailée, pois quénique; Other: malungkai, marronggai, marungai, marunggai, malungay, katdes (Guam); sajina (Fiji)	Moringaceae	tree
Murraya paniculate		Rutaceae	shrub/tree
Neonotonia wightii	English: glycine; French: soja pérenne	Fabaceae	vine
spp.*	English: water lily	Nymphaeaceae	herb
Ocimum gratissimum	English: wild basil, clove basil, tree basil; French: basilic, menthe gabonaise; Other: la'au sauga (Samoa)	Lamiaceae	herb
Odontonema	English: fire spike, cardinal flower	Acanthaceae	shrub

tubaeforme*			
Operculina ventricosa	English: paper rose, St. Thomas lidpod; Other: alalag (Guam); palulu (Samoa); fue hina (Tonga)	Convolvulaceae	vine
Opuntia spp.*	English: prickly pear; Other: lengua de vaca (Guam)	Cactaceae	succulent shrub
Orthosiphon aristatus	English: cat's whiskers; Other: emadecharebub (Palau), kumi ni pusi (Fiji), kava 'i pusi (Tonga)	Lamiaceae	herb
maximum	English: Guinea grass, green panic, buffalograss; French: herbe de Guinéa, panic élevé, capime guiné, fataque; Other: saafa (Tonga)	Poaceae	grass
Paspalum conjugatum	English: T grass, ti grass, sour grass; sour palpalum, buffalo grass, carabao grass, Hilo grass (Hawaii); French: herbe sure, herbe créole; herbe de tauère (New Caledonia); Other: fetin wumwune (Chuuk); muhsrasre (Kosrae); udel ra ngebei (Palau); rehn wai (Pohnpei); moise vailima, motie vailima (Niue and Tonga); vao lima (American Samoa and Samoa), vailima matafao (Samoa); vailima, (Samoa, Tonga, Niue)	Poaceae	grass
Paspalum dilatatum	English: paspalum, dallis grass, water grass; French: paspalum dilaté, herbe sirop, herbe de miel, herbe de dallis, millet bâtard; Other: hiku nua (Niue)	Poaceae	grass
Paspalum fimbriatum	English: fimbriate paspalum, winged paspalum, Panama paspalum, Panama crowngrass, Columbia grass	Poaceae	grass
Paspalum orbiculare	English: rice grass; ditch millet (Fiji); Other: co duru levu, tho nduru levu, tho ndina, tho ni ndina (Fiji); karasi (Solomon Islands)	Poaceae	grass
Passiflora edulis	English: passion fruit, yellow passion fruit, purple passion fruit, qarandila, purple granadilla; French: grenadille; Spanish: maracuya (Galapagos Is.); Other: liliko'i (Hawai'i), pompom (Pohnpei); pasio (Samoa); vaine (Tonga)	e	vine
Passiflora foetida	English: love-in-a-mist, wild passion fruit, passionflower, stinking passionflower; French: passiflore; Spanish: bedoca (Galapagos Is.); Other: pasio vao (American Samoa and Samoa); bombom (Chuuk), sou, loliloli ni kalavo, qaranidila (Fiji); pohapoha (Hawai'i); tea biku (Kiribati); vine vao (Niue); kudamono (Palau); pompom, pwomwpwomw (Pohnpei); kinahulo' atdao, dulce (Saipan); vaine 'initia (Tonga); tomates (Yap)	Passifloraceae	vine
Passiflora laurifolia	Other: pasio (Samoa); vaine 'ae kuma (Tonga)	Passifloraceae	vine
Passiflora maliformis	English: hard-shelled passionfruit, sweet calabash, sweet cup; French: pomme calabas; Other: pasio (Samoa), vaine Tonga, vaine kai (Tonga)	Passifloraceae	vine
Passiflora quadrangularis*	English: granadilla, giant granadilla; French: barbadine; Spanish: badea (Galapagos Is.); Other: parapotina maata (Cook Islands); para pautini (French Polynesia); palasini, palatini, vine fua lalahi, vine palasini, tinitini (Niue); kudamono (Palau); pasio (Samoa); pasione (Tonga)	Passifloraceae	vine
Persea americana*	English: avocado, alligator pear; French: l'avocat; Spanish: aguacate; Other: apoka (Cook Islands); pea (Fiji); avoka (Niue, Tonga); aviota (Samoa); avota (Samoa and Tahiti); bata (Palau); alageta (Chamorro, Guam)	Lauraceae	tree
Pimenta dioica	English: pimento, allspice; Other: sipaisi (Tonga)	Myrtaceae	tree
Pinus caribaea	English: Caribbean pine, Bahamas pine; Other: paina (Samoa), paini (Tonga)	Pinaceae	tree
Piper auritum	English: eared pepper, anise piper, Veracruz pepper; Spanish: hoja santa, anisillo, hinojo, sabalero, hoja de la estrella; Other: Hawaiian sakau, false sakau, false kava (Pohnpei)	Piperaceae	shrub
Plectranthus amboinicus	English: Mexican mint, Spanish thyme, Cuban oregano; French: oreille; Other: rhaivoki, sage (Fiji); pasiole (Niue, Tonga); la'au tai'e, lau tai'e, militini (Samoa); kaloni (Tonga)	Lamiaceae	herb
Pluchea carolinensis	English: sour bush	Asteraceae	shrub
Psidium guajava	English: guava; French: goyavier; Spanish: guayaba, guayabo; Other: ku'ava, ku'avu, tu'avu (American Samoa and Samoa); kuafa (Chuuk); kuava (Cook Islands, Tonga, Fiji, Samoa); quwawa, nguava, ngguava ni India, amrut (Fiji); tuava, tumu tuava, tuvava (French Polynesia); abas guayaba (Galapagos); (Guam, Saipan-Chamorro, Yap); kuawa (Hawai'i); kuhfahfah (Kosrae); te kuawa (Kiribati); guabang, kuabang (Palau); guahva, kuahpa (Pohnpei); kuwawa (Nauru); kautoga, kautonga, kautoga tane, kautonga tane (Niue); apas (Saipan); abwas (Saipan-Carolinian); tu'ava (Samoa)	Myrtaceae	tree

Pueraria montana var. lobata	English: kudzu, Japanese arrowroot; Other: deday (Yap); aka (American Samoa, Tonga, Niue, Wallis and Futuna); a'a (American Samoa and Samoa); yaka , wa yaka, nggariaka (Fiji); akataha, fue'aepuaka (Tonga); acha, nepalem	Fabaceae	vine
Pyrostegia venusta*	English: flame vine, flame flower, golden shower, orange trumpet vine	Bignoniaceae	vine
Ricinus communis	English: castor bean, castor-oil plant; French: ricin; Spanish: higuerilla; Other: agaliya (Guam); gelug, maskerekur, uluchula skoki (Palau); tuitui, tuitui fua ikiiki (Niue); koli (Hawaii); lama palagi, lama papalagi (American Samoa and Samoa); lepo, lepohina (Tonga); mbele ni vavalagi, toto ni vavalagi, utouto (Fiji)	Euphorbiaceae	shrub
Rivina humilis	English: baby pepper, bloodberry, coral berry, rouge plant; Other: polo (Tonga)	Phytolaccaceae	herb
Samanea saman	English: monkeypod, rain tree, saman; French: arbre de pluie; Other: tronkon mames, trongkon-mames (CNMI-Chamorro); filinganga (CNMI-Carolinian); gumor ni spanis (Yap); 'ohai (Hawaii); vaivai ni vavalangi, vaivai ni vavalagi (Fiji), malapa (Samoa); kasia (Tonga)	Fabaceae	tree
Sambucus mexicana	English: elderberry, Mexican elder	Caprifoliaceae	small tree
Sanchezia parvibracteata*	English: Sanchezia	Acanthaceae	shrub
Schefflera actinophylla*	English: octopus tree, umbrella tree, ivy palm; French: arbre ombelle	Araliaceae	tree
Schefflera arboricola*	English: dwarf brassia, dwarf schefflera, Hawaiian elf schefflera	Araliaceae	shrub
Senna alata	English: candle bush; candelabra bush, Roman candle tree, emperor's candlesticks, ringworm bush (Australia), alcapulco; French: epis d'or, bois dartre, dartres; Other: arakak (Chuuk); akapuku, andadose, candalaria, take-biha (Guam); kerula besokel, yult (Palau); rakau honuki, truke-n-kili-n-wai, tuhkehn kilin wai, tirakahonuki (Pohnpei); flay-n-sabouw (Yap); mulamula (Niue); bakau plant (Solomon Islands); mbai ni thangi (Fiji); fa'i lafa, la'au fai lafa (American Samoa, Samoa and Tonga); te'elango (Tonga)	Fabaceae	shrub
Senna tora	English: foetid cassia, stinking cassia, Java-bean, sickle senna, sicklepod, Chinese senna, peanut weed, sickle senna; French: cassier sauvage, pois puant, séné; Other: kaumoce, kaumothe, pini, tarota (Fiji); mumutun admelon, mumutun palaoan, amot-tumaga carabao (Guam), vao pinati (Samoa); te'epulu, tengafefeka (Tonga)	Fabaceae	shrub
Setaria pallide-fusca	English: foxtail, garden bristle grass, yellow bristlegrass, Queensland pigeon grass (Australia), cat's tail grass (Fiji); French: sétaire glauque	Poaceae	grass
Solanum mauritianum	English: bugweed, wild tobacco, tree tobacco; Other: pua nana honua (Hawai'i), pula (Tonga)	Solanaceae	shrub
Solanum torvum	English: prickly solanum, devil's fig, turkeyberry, terongan; French: fausse aubergine, aubergine sauvage épineuse; Other: piko (Vanuatu); tisaipale (Tonga); kausoni, soni, kauvoto-votua, kaisurisuri, katai, bhankatiya, soni ni vavalagi (Fiji)	Solanaceae	shrub
Solenostemon scutellarioides	English: coleus; Other: lata, lau lata (Fiji); weleweka (Hawai'i); selevese (Niue); koramahd, koaramahd (Pohnpei); pate, patiale, la'au fai sei (Samoa)	Lamiaceae	herb
Sorghum halepense	English: Johnson grass, Aleppo grass, Aleppo milletgrass; French: sorgho d' Alep, sorgo de Alepo, herbe de Cuba; Other: kola (Tonga); gumai (Russia); zacate Johnson, grama China, cañuela, Don Carlos	Poaceae	grass
Sorghum sudanense	English: Sudan grass; French: sorgho du Soudan, sorgho menu; Other: kola (Tonga)	Poaceae	grass
Spathodea campanulate	English: African tulip tree, fireball, fountain tree; French: tulipier du Gabon, pisse-pisse; Spanish: tulipan africano; Other: apär (CNMI); rarningobchey (Yap); tuhke dulip (Pohnpei); tiulipe (Tonga), taga mimi (Fiji)	Bignoniaceae	tree
Sporobolus indicus	English: smutgrass, wiregrass, Indian dropseed; Other: fisihina (Tonga)	Poaceae	grass
Stachytarpheta cayennensis	English: blue rat's tail, dark-blue snakeweed, false verbena, nettleleaf velvetberry; French: herbe bleue; Other: ouchung, sakura (Chuuk), louch beluu (Palau); mautofu tala, mautofu vao, matofu fualanumanoa (American Samoa and Samoa); te uti (Kiribati); mautofu Samoa, motofu Samoa (Niue); hiku 'i kuma, hiku'kuma, 'iku 'i kuma, iku 'ikuma (Tonga); turulakaka, tumbutumbu, serakawa, lavenia, se karakarawa (Fiji)	Verbenaceae	herb

Syngonium podophyllum	English: arrowhead plant, goosefoot plant	Araceae	climber
Syzygium cumini	English: Java plum; jambolan plum; French: faux-pistachier, jamelon-guier, jamélongue, jambolanier; Other: duhat (Guam); mesegerak, mesekerrak, mesekerrák, mesigerak (Palau); jamelonguier (New Caledonia); kavika ni India, jammun (Fiji)	Myrtaceae	tree
Tecoma stans	English: yellow bells, yellow-elder, yellow trumpetbush; Other: peeal (Puluwat), piti (French Polynesia, Tonga)	Bignoniaceae	small tree
Thevetia peruviana*	English: yellow oleander, be-still tree, lucky nut; French: oléandre jaune; Other: koneta (Chuuk); nohomalie (Hawai'i); irelepsech (Yap)	Apocynaceae	small tree
Thunbergia alata*	English: black-eyed susan vine; French: suzanne aux yeux noirs; Other: tagamimi (Samoa)	Acanthaceae	vine
Thunbergia fragrans	English: white lady, white thunbergia, sweet clock-vine; Other: fue hina (Tonga)	Acanthaceae	vine
Tillandsia usneoides*	English: Spanish moss, old man's beard, grandfather's whiskers, air plant; French: cheveaux du roi, barbe grise, fille de l'air	Bromeliaceae	bromeliad
Toona ciliata	English: Australian red cedar, toon; Other: tuna (Samoa), sita kula (Tonga)	Meliaceae	tree
Tradescantia spathacea	English: oyster plant, boat plant, boat lily, moses in a boat; Other: talotalo, laupapaki (Niue)	Commelinaceae	herb
Tradescantia zebrine	English: wandering zebrina, wandering jew, inchplant	Commelinaceae	herb
Triumfetta rhomboidea	English: Chinese burr, paroquet burr, burr bush; Other: dadangsi, masiksik lahe (Guam); mo'osipo (Tonga); mosipo (Niue); manutofu, mautofu, mautofu vao (American Samoa and Samoa); qatima (Fiji), urio (French Polynesia)	Tiliaceae	shrub
Triumfetta semitriloba	English: Sacramento bur; Other: dadangsi, masiksik lahe (Guam)	Tiliaceae	shrub
Urena lobata	English: hibiscus burr, aramina, caesarweed, pink Chinese burr, urena burr, bur mallow; French: jute africain, cousin urène; Other: dadangsi, dadangsi apaka, dadangsi machingat, dádangse (Guam); chosuched e kui, osuched a rechui (Palau); karap, korop (Pohnpei); nognuk, ocher (Chuuk); motipo, mosipo (Niue); mautofu, manutofu (American Samoa and Samoa); qatima, gataya, nggatima (Fiji); mo'osipo Tonga (Tonga), piripiri (French Polynesia)	Malvaceae	shrub
Wedelia trilobata	English: wedelia, trailing daisy, Singapore daisy, creeping ox-eye; Other: ngesil ra ngebard (Palau); dihpw ongohng, tuhke ongohng (Pohnpei); rosrangrang (Kosrae); atiat (Puluwat); ate (Tonga)	Asteraceae	herb

Annex 5. Invasive and potentially invasive species present on Vava'u

Scientific Name	Common Names	Family	Habit
Abelmoschus moschatus	English: fautia, musk mallow, musk okra; French: ambrette, gombo musqué, ketmie musquée, graine de musc; Other: kamang, ka'mang (Guam); karereon, karereon nikapwerik nik, kareron, likonokon (Chuuk); gongul (Palau); metei, mety, methey (Pohnpei); hathongethong, kamwayang, nikapwerik, setmwechin, sotumo (Yap); wakiwaki, wakewake, wakeke, vakeke, aukiki, okeoke, o'e'e (Fiji); fou ingo (Niue), fau ingo (Wallis and Futuna); 'aute toga, fau tagaloa, fua samasama (American Samoa and Samoa); loa, fau'ingo (Tonga)	Malvaceae	herb
Adenanthera pavonine	English: Coral bean tree, red sandalwood tree, red bead tree, lopa, bead tree, false wiliwili, peacock flower-fence; French: bois de condori; Other: kaikes (Pohnpei); mwetkwem (Kosrae); colales, culalis, kolales, kulales, kulalis (Guam, CNMI); metekam, metkam, metkem, (Kosrae); telengtúngd, telentundalel (Palau); pomea (Fiji, Niue), lera, lere ndamu, vaivai, vaivai ni vavalangi (Fiji), lopa, la'au lopa (American Samoa, Samoa and Tonga); paina, pitipitio (French Polynesia)	Fabaceae	tree
Aleurites moluccana	English: candlenut, Indian walnut; French: bancoulier, bancoulier, noyer de bancoul, noyer des Moluques; Other: lumbang (Guam), raguar (Caroline Islands); sakan, shakan (Pohnpei); lama (American Samoa and Samoa); kukui (Hawai'i); tuitui (Cook Islands, Niue, Tonga), 'ama (Marquesas); lauci, lauthe, lauthi, toto, tuitui, tutui, waiwai, sekeci,sikethi, sikeli, nggerenggere (Fiji); tahii tiairi, ti'a'iri, tutui, tahiri (French Polynesia)	Euphorbiaceae	tree

Annona muricate	English: soursop, prickly custard apple; French: corossolier, cacheimantier épineux, cachiman épineux, corossol épineux; Other: saasaf, sasaf (Chuuk); tapotapo papaa (French Polynesia); laguana, laguaná, laguanaha, laguanaba, labuanaha (Guam); sosap (Kosrae); jojaab (Marshall Islands); syasyap (Northern Mariana Islands), talapo fotofoto (Niue), sausab (Palau); sei, sae, truka shai (Pohnpei); sasalapa (Samoa); ‘apele ‘initia (Tonga); sausau (Yap)	Annonaceae	tree
Argyreia nervosa	English: elephant creeper, Hawaiian baby woodrose , silver morning glory, woolly morning glory; French: coup d'air, liane a minguet, liane d' argent	Convolvulaceae	vine
Aristolochia littoralis	English: Dutchman's pipe, calico flower; Other: fue paipa holani (Tonga)	Aristolochiaceae	vine
Asparagus setaceus	English: ornamental asparagus, climbing asparagus fern, plumosa; French: asperge plumeuse; Other: taupo ‘ou (Tonga)	Liliaceae	vine
Asystasia gangetica	English: Chinese violet, Philippine violet, coromandel	Acanthaceae	herb
Bambusa spp.	English: bamboo; French: bambou; Other: moor (Yap); iich (Chuuk); pehri en sapahn (Pohnpei); bambuu (Palau); bambu (Kosrae); pi‘ao, pi‘ao palaoan (Guam and Northern Marianas-Chamorro); bwai (Guam and Northern Marianas-Carolinian); kaho palangi (Niue); ‘ohe (French Polynesia); ofe (French Polynesia, Samoa), ‘ofe fiti, ‘ofe papalagi (Samoa); kofe, pitu (Tonga); koe (Rarotonga, Cook Islands)	Poaceae	tree
Bauhinia monandra	English: orchid-tree, St. Thomas-tree, Napoleon's plume; flamboyant (Pohnpei), flores mariposa (CNMI); mariposa (Guam); pink butterfly tree (Fiji); Other: pine fua loloa (Niue), vae povi (American Samoa and Samoa)	Fabaceae	tree
Bidens pilosa	English: beggar’s tick, Spanish needle, cobbler's pegs; French: piquants noirs, bident hérissé, herbe d'aiguille, herbe villebague (Mauritius); Other: fisi'uli (Tonga); kofe tonga, kofetoga (Niue); piripiri (Cook Islands); tae puaka (Futuna); batimadramadra, mbatimandramandra, mbatikalawau, matakaro, matua kamate (Fiji); ki, ki nehe, ki pipili, nehe (Hawai'i)	Asteraceae	herb
Blechum pyramidata	English: blackweed (Samoa), Browne’s blechum; Other: yerbas babui (Guam), vao uliuli (Samoa)	Acanthaceae	herb
Bothriochloa bladhii	English: blue grass, Australian beardgrass, Caucasian bluestem; Other: desum (Palau); latoka grass, thamboni grass (Fiji)	Poaceae	grass
Brachiaria mutica	English: California grass, para grass, buffalo grass, Mauritius grass, signal grass; French: herbe de Para; Other: puakatau (Tonga) (Swarbrick, 1997)	Poaceae	grass
Breynia disticha*	English: snowbush, snowbush breynia, sweetpea bush, foliage-flower	Euphorbiacea e	shrub
Bryophyllum pinnatum	English: life plant, air plant, resurrection plant, Canterbury bells, cathedral bells, Mexican love plant; Spanish: hoja del aire; Other: kibilia (Marshall Islands); bulatawamudu (Fiji); tupu he lau, tupu noa (Niue); teang (Kiribati)	Crassulaceae	herb
Cananga odorata	English: perfume tree; French: canang odorant; Other: ilang-ilang, alang-ilang (Guam, Philippines); ylang-ylang, lengileng (CNMI); chiráng, irang (Palau); ilanlang, ilahnglahng (Kosrae); pwanang, pwuur, pwalang (Chuuk); pur-n-wai, pwurenwai, sair-n-wai, seirin wai, seir en wai (Pohnpei); ilanilan, ilañlañ (Marshall Islands); motoi (Niue); makasoi, makosoi, makusui, mokohoi, mokosoi (Fiji); moso‘oi (American Samoa and Samoa); mohoki, mohokoi, mohokoi (Tonga); moto‘oi, mata‘oi (Cook Islands, Niue, Tahiti); moto‘i (Tahiti); lanalana (Hawai‘i)	Annonaceae	tree
Canna indica	English: canna, canna lily, Indian shot; French: balisier comestible, tous-les-mois; Other: mongos halum-tano (Guam); luiuenwai (Pohnpei); apeellap, oruuru (Puluwat); fanamanu, fagamanu, fa‘i masoa (American Samoa and Samoa); gasau ni ga (Fiji); te riti (Kiribati), misimisi (Tonga); fagafaga (Futuna); ali‘ipoe, li'ipoe, poloka (Hawai'i); pia-raroto‘a (French Polynesia)	Cannaceae	herb
Cedrela odorata*	English: cigar box cedar, Mexican cedar, West Indian cedar, Spanish cedar, Barbados cedar; French: cèdre acajou, cèdre des barbares; Spanish: cedro cubano (Galapagos Is.); Other: sita hina (Tonga)	Meliaceae	tree
Ceiba pentandra	English: kapok, kapok tree, silk-cotton tree, pacae; French: kapokier, capoc, bois coton; Spanish: ceibo; Other: koton (Chuuk); algodon de Manila, atgodon di Manila, algidon, atgidon de Manila (Guam); koatoa, atagodon, arughuschel (Saipan), batte ni gan' ken (Yap); bulik, kotin (Marshall Islands); cottin, koatun, koatoa (Pohnpei); kuhtin, cutin (Kosrae); kalngebard, kalngebárd, kerrekar ngebard (Palau); vauvau ni vavalangi, semar (Fiji); vavae (American Samoa, Samoa, Niue, Tonga); vavau ni lokoloko (from Ecoport, source not given)	Bombacacea e	tree
Cenchrus	English: buffelgrass, African foxtail grass, anjan grass; French: cenchrus cilié	Poaceae	grass

ciliaris			
Cenchrus echinatus	English: burgrass, sand-bur, southern sandbur, Mossman River grass (Australia); French: herbe a cateaux (Mauritius); Other: tuitui, vao tuitui, vao papalagi (American Samoa and Samoa); se mbulabula (Fiji); piri-piri, pipiri (French Polynesia); konpeito-gusa, 'ume'alu (Hawai'i); te anti, te kateketeke (Kiribati); cram-cram (New Caledonia); motie vihilago, mosie vihilango (Niue); loklok, lellik, lekelik, liklik, karmwijmwij (Marshall Islands); cauit-cauitan (Philippines); hefa (Tonga)	Poaceae	grass
Centrosema pubescens	English: centro, butterfly-pea; French: fleur-languette, pois bâtard; Other: pi ni ndola (Fiji)	Fabaceae	herb
Cestrum diurnum	English: inkberry, day jessamine, day cestrum, China berry; Other: thauthau (Fiji); tinta ‘n-China, tentanchinu, tintan China (Guam, CNMI); sugi vao, suni vao (Samoa); vaitohi (Tonga)	Solanaceae	shrub
Cestrum nocturnum	English: night-flowering cestrum, night-flowering jasmine, queen (or lady) of the night; Other: teine o le po, ali‘i o le po (American Samoa and Samoa); thauthau, thauthau ni mbongi, kara (Fiji); dama-de-noche (Guam); juñoul rua awa? (Marshall Islands); iki he po (Niue); lakau po‘uli (Tonga)	Solanaceae	shrub
Chamaecrista nictitans	English: partridge pea, Japanese tea senna; Other: kobo-cha, nemu-cha (Japan)	Fabaceae	small shrub
Chrysopogon aciculatus	English: Mackie's pest, lovegrass, seed grass, golden beardgrass, seedy grass (Solomon Islands); French: herbe plate, herbe à piquant; Other: inifuk, palaii (Guam); iul (Palau); manienie ‘ula (Hawai‘i); mutia tai, mutia vao (Samoa); mosie fisi (Niue); matapekepeke, matapekapeka matapekepeka (Tonga); herbe plate (Vanuatu), papapa (French Polynesia)	Poaceae	grass
Clerodendrum buchananii var. fallax	English: red clerodendrum, pagoda-flower; Other: talufe (Niue); amo’ula, amo’ule (Tonga), lau'awa (Hawai'i)	Verbenaceae	shrub
Clitoria ternatea*	English: butterfly pea, Asian pigeonwings; French: honte; Other: buikike, bukike, paokeke, bukike paokeke, capa de la reina, kapa de la raina (Guam); putitainubia (CNMI); pepe (Niue); latoela, nawa (Fiji), paipa (Tonga)	Fabaceae	vine
Coccinia grandis	English: ivy gourd, scarlet-fruited gourd; Other: aipikohr (Pohnpei); kundru (Fiji)	Cucurbitaceae	vine
Cordia alliodora	English: laurel, Ecuador laurel, salmwood, Spanish elm; French: bois de Chypre, pardillo; Other: kotia (Samoa, Tonga)	Boraginaceae	tree
Crassocephalum crepidoides	English: thickhead, fireweed, redflower ragleaf; Other: fua lele, pualele (American Samoa and Samoa); maraburubo (Solomon Islands); fisi puna (Tonga); se vuka (Fiji)	Asteraceae	herb
Cynodon dactylon	English: Bermuda grass, giant Bermuda grass, bahama grass, devil's grass, couch grass, Indian doab, grama, devilgrass, couchgrass, balama grass; French: chiendent, petit chiendent, chiendent pied-de-poule; Other: manini, manienie (Hawaii); motie molulu (Niue); kambuta, kabuta (Fiji); mosie molulu (Niue); herbe de couverture (New Caledonia); pasto bermuda, zacate bermuda, grama dulce, gramón, hierba fina, grama-seda, (from Ecoport, no source given)	Poaceae	grass
Cyperus rotundus	English: nut grass, nutsedge, purple nutsedge, cocograss; French: souchet rond, souchet à tubercules, herbe à oignon; Other: chaguan humatag (Guam); tuteoneon (Marshall Islands); kili'o'opu (Hawaii); oni ani (Cook Islands); soro na kambani, sora na kambani, soro ni kabani, ivako, malanga, vucesa, motha, vuthesa mot ha (Fiji); mumuta (Samoa, Tokelau); pakopako (Tonga), te mumute (Kiribati)	Cyperaceae	sedge
Digitaria ciliaris	English: Henry's crabgrass, smooth crabgrass, tropical crab grass, large crab grass, southern crabgrass, fingergrass, summer grass; French: digitaire ciliée; Other: kukaepua'a (Hawai'i); Saulangi (Niue)	Poaceae	grass
Duranta erecta	English: duranta, golden dewdrop, pigeon-berry, sky-flower; Other: ‘olive (Tonga)	Verbenaceae	shrub
Elephantopus mollis	English: elephantopus, elephant’s foot, tobacco weed; French: faux tabac; Other: papago' vaca, papago' halom tano, papago' baka, papago' halomtano' (Guam); lata hina, lau veveli (Tonga); tavako ni veikau, jangli tambaku (Fiji); tapua erepani (Cook Islands)	Asteraceae	herb
Eleusine indica	English: goosegrass, wiregrass, goose foot, crow's foot, bullgrass; French: pied de poule; Other: fahitalo, lau ta‘a ta‘a, ta‘a ta‘a (American Samoa and Samoa); kavoronaisivi, vorovoroisivi, ghoraya (Fiji); tamamau (French Polynesia), umog (Guam); manienie ali‘i (Hawaii); mahkwekwe (Kosrae); katejukjuk (Marshall Islands); mosie fahitalo (Niue); deskim, keteketarmalk (Palau); reh takai (Pohnpei); takataka, takataka ‘a leala, mohuku siamane (Tonga); te uteute (from Ecoport, source not given)	Poaceae	grass
Ficus benjamina	English: weeping fig, baka, Java fig, weeping fig ; Other: ‘ovava fisi (Tonga)	Moraceae	tree

Flemingia strobilifera	English: luck plant; French: sainfoin du bengale; Other: besungelaiei (Palau)	Fabaceae	shrub
Furcraea foetida	English: Mauritius hemp, sisal, maguey, giant cabuya; French: aloès vert, chanvre de Maurice; Other: toua (Niue); lautalotalo papalagi (Samoa); faumalila, fau malila (Tonga)	Agavaceae	succulent
Grevillea robusta	English: silk oak, silky oak, she-oak, silver oak, spider flower; Other: oke' (Tonga)	Proteaceae	tree
Hedychium coronarium	English: white ginger, butterfly lily, ginger lily, garland flower; Other: tunun, sinser (Chuuk); sinter pwetepwet (Pohnpei); tolon (Puluwat); thevunga, ndrove, cevuga vula, dalasika (Fiji)	Zingiberaceae	herb
Hemigraphis alternata	English: metal leaf; red ivy, cemetery plant (Fiji)	Acanthaceae	herb
Hyptis pectinata	English: comb hyptis, comb bushmint, mint weed, purple top; French: fausse menthe; Other: mumutun lahe, mumutun palaoan, mumutan ademelon (Guam); tamole ni veikau, tamoli ni vavalangi, timothi ni vavalangi, wavuwavu, ndamoli, ben tulsia (Fiji)	Lamiaceae	herb
Impatiens balsamina	English: impatiens, balsam, garden balsam, rose balsam, spotted snapweed; French: balsamine des jardins, impatience; Other: kamantigi (Guam), polosomo (Tonga)	Balsaminaceae	succulent
Indigofera suffruticosa	English: indigo; Other: aniles (Guam); ‘iniko, inikoa, kolu (Hawai'i); la‘au mageso (Samoa); ‘akau veli (Tonga)	Fabaceae	shrub
Ipomoea spp.	English: morning glory (non-native)	Convolvulaceae	herb
Jatropha curcas	English: physic nut, purging nut, Barbados nut; French: médicinier, pignon d'Inde, purghère; Other: wiriwiri, wiriwiri ni vavalangi, uto ni vavalangi, banidakai, mbanindakai, manggele, maqele, ndrala (Fiji); fiki (Fiji, Tonga); tuba-tuba (Guam); laupata (Samoa)	Euphorbiaceae	shrub
Kyllinga nemoralis	English: white kyllinga, whitehead spikesedge; Other: kili‘o‘opu (Hawai‘i), ta‘a ta‘a, ta‘a ta‘a vili taliga, matie upo‘o, matie tahiti, mo‘u upo‘onui, mo‘u upo‘o, tuise (Samoa); pakopako, pakopako ‘ae kuma (Tahiti); tuise (Tonga)	Cyperaceae	sedge
Lablab purpureus	English: hyacinth bean, lablab, bonavist, Egyptian kidney bean, dolichos; French: dolique, dolique d'Egypte, pois nourrice; Other: ndralawa, natomba, tomba (Fiji); cheribilla apaka, chuchumeko (Guam); papapa, pi (Hawai'i); pini lae puaka (Tonga)	Fabaceae	vine
Lantana camara	English: lantana; Other: landana, rantana, rahndana, tukasuweth (Pohnpei); ros fonacni (Kosrae); kauboica, kaumboitha, mbonambulumakau, mbona ra mbulumakau, tokalau, waiwai, lanitana (Fiji); latana (American Samoa and Samoa); latora moa, tatara moa (Tahiti); lakana (Hawai'i); talatala, talatala talmoa (Tonga); te kaibuaka, te kaibuaja (Kiribati); taramoa (Cook Islands); migiroa (Nauru), taratara hamoa, taratara moa (French Polynesia)	Verbenaceae	shrub
Leonurus japonicus	English: lion’s tail, Chinese motherwort	Lamiaceae	herb
Leucaena leucocephala	English: leucaena, wild tamarind, lead tree; French: graines de lin, faux-acacia, faux mimosa (New Caledonia); Other: koa haole, lili-koa, ekoa (Hawaii); tangantangan, tangan-tangan, talantayan (Guam, CNMI, Marshall Islands); talntangan (CNMI); ganitnityuwan tangantan (Yap); tuhngantuhngan, rohbohtin (Kosrae); telentund (Palau); lopa Samoa (American Samoa and Samoa); fua pepe (American Samoa and Samoa); lusina (Samoa); pepe (Niue and Samoa); tavahi kaku (Niue); nito, toromiro (Cook Islands); siale mohemohe (Tonga); vaivai, vaivai ni vavalangi, vaivai dina, balori (Fiji); atiku (Marquesas); cassis (Vanuatu); te kaitetua (Kiribati); namas (from Ecoport, source not given)	Fabaceae	tree
Macroptilium atropurpureum	English: siratro, purple bushbean	Fabaceae	
Melia azedarach	English: Chinaberry, pride-of-India, indian lilac, Persian lilac, white cedar, margosa tree, tira; French: lilas des Indes, arbre à chapelets; Spanish: jazmin (Galapagos Is.); Other: paraiso, para'isu (Guam); lelah (Pohnpei); prais (Yap);sili, tili (Niue); dake, bakain (Fiji), sita (Tonga)	Meliaceae	tree
Melinis repens	English: Natal redtop, Natal grass, red Natal grass, Holme's grass, blanketgrass; French: herbe du Natal, herbe rose, herbe pappangue; tricholène (New Caledonia); Other: salapona (Tonga)	Poaceae	grass
Merremia peltate	English: merremia; Other: wachathal (yap); lohl, iol, yol (Pohnpei); kebeas (Palau); lagon, lagun (Guam); fitau, fitaw (Chuuk); pala, pul, puhlah (Kosrae); fue, fue vao, fue kula (Niue); fue lautetele (American Samoa and Samoa); fue mea (Tonga); abui, grobihi, arosumou (Solomon Islands); wa mbula, wa bula, wa damu, wa ndamu, viliyawa, wiliviwa, veliyana, wiliao (Fiji); pohue (French Polynesia)	ae	vine

Mimosa pudica	English: sensitive plant, sleeping grass; French: sensitive; Other: la‘au fefe, vao fefe, vao tuitui, tuitui (American Samoa and Samoa); ra kau pikikaa, rakau pikika (Cook Islands); tho ngandrongandro, tho kandrodandro, cogadrogadro (Fiji); betguen sosa (Guam); memege (Niue); mechiuaiu (Palau); limemeihr (Pohnpei); pohe ha‘avare, pope ha‘avare (Tahiti); mateloi (Tonga)	Fabaceae	herb
Momordica charantia	peria; French: momordique, margose (Réunion, Mauritius Islands), margose amère, momordique amère, concombre amer, concombre africain; Spanish: achoccha silvestre; Other: almagosa, atmagosu (Guam); atmagoso (Guam, CNMI); markoso (Palau); kerala (Fiji); meleni 'ae kuma, vaine 'initia (Tonga)	Cucurbitacea e	vine
Murraya paniculate	English: orange jessamine, satin-wood, Chinese box, Hawaiian mock orange	Rutaceae	shrub/tre e
Neonotonia wightii	English: glycine; French: soja pérenne	Fabaceae	vine
Operculina ventricosa	English: paper rose, St. Thomas lidpod; Other: alalag (Guam); palulu (Samoa); fue hina (Tonga)	Convolvulace ae	vine
Panicum maximum	English: Guinea grass, green panic, buffalograss; French: herbe de Guinéa, panic élevé, capime guiné, fataque; Other: saafa (Tonga)	Poaceae	grass
Paraserianthes falcataria	English: Molucca albizia; Other: tamaligi palagi (American Samoa); tuhke kerosene, tuhkehn karisihn (Pohnpei); ukall ra ngebard (Palau); tamaligi uliuli (Samoa)	Fabaceae	tree
Paspalum conjugatum	English: T grass, ti grass, sour grass; sour palpalum, buffalo grass, carabao grass, Hilo grass (Hawaii); French: herbe sure, herbe créole; herbe de tauère (New Caledonia); Other: fetin wumwune (Chuuk); muhsrasre (Kosrae); udel ra ngebei (Palau); rehn wai (Pohnpei); moise vailima, motie vailima (Niue and Tonga); vao lima (American Samoa and Samoa), vailima matafao (Samoa); vailima, (Samoa, Tonga, Niue)	Poaceae	grass
Paspalum orbiculare	English: rice grass; ditch millet (Fiji); Other: co duru levu, tho nduru levu, tho ndina, tho ni ndina (Fiji); karasi (Solomon Islands)	Poaceae	grass
Passiflora edulis	English: passion fruit, yellow passion fruit, purple passion fruit, qarandila, purple granadilla; French: grenadille; Spanish: maracuya (Galapagos Is.); Other: liliko‘i (Hawai‘i), pompom (Pohnpei); pasio (Samoa); vaine (Tonga)	Passifloracea e	vine
Passiflora foetida	English: love-in-a-mist, wild passion fruit, passionflower, stinking passionflower; French: passiflore; Spanish: bedoca (Galapagos Is.); Other: pasio vao (American Samoa and Samoa); bombom (Chuuk), sou, loliloli ni kalavo, qaranidila (Fiji); pohapoha (Hawai‘i); tea biku (Kiribati); vine vao (Niue); kudamono (Palau); pompom, pwomwpwomw (Pohnpei); kinahulo‘ atdao, dulce (Saipan); vaine ‘initia (Tonga); tomates (Yap)	Passifloracea e	vine
Passiflora maliformis	English: hard-shelled passionfruit, sweet calabash, sweet cup; French: pomme calabas; Other: pasio (Samoa), vaine Tonga, vaine kai (Tonga)	Passifloracea e	vine
Passiflora quadrangularis	English: granadilla, giant granadilla; French: barbadine; Spanish: badea (Galapagos Is.); Other: parapotina maata (Cook Islands); para pautini (French Polynesia); palasini, palatini, vine fua lalahi, vine palasini, tinitini (Niue); kudamono (Palau); pasio (Samoa); pasione (Tonga)	Passifloracea e	vine
Passiflora suberosa	English: wild passionfruit, devil's pumpkin, indigo berry, corky passionflower, corkstem passionflower; French: passiflore, grenadille; Spanish: uvilla (Galapagos Is.); Other: huehue haole (Hawai'i)	Passifloracea e	vine
Pimenta dioica	English: pimento, allspice; Other: sipaisi (Tonga)	Myrtaceae	tree
Pinus caribaea	English: Caribbean pine, Bahamas pine; Other: paina (Samoa), paini (Tonga)	Pinaceae	tree
Piper auritum	English: eared pepper, anise piper, Veracruz pepper; Spanish: hoja santa, anisillo, hinojo, sabalero, hoja de la estrella; Other: Hawaiian sakau, false sakau, false kava (Pohnpei)	Piperaceae	shrub
Psidium guajava	English: guava; French: goyavier; Spanish: guayaba, guayabo; Other: ku‘ava, ku‘avu, tu‘avu (American Samoa and Samoa); kuafa (Chuuk); kuava (Cook Islands, Tonga, Fiji, Samoa); quwawa, nguava, ngguava ni India, amrut (Fiji); tuava, tumu tuava, tuvava (French Polynesia); abas guayaba (Galapagos); (Guam, Saipan-Chamorro, Yap); kuawa (Hawai‘i); kuhfahfah (Kosrae); te kuawa (Kiribati); guabang, kuabang (Palau); guahva, kuahpa (Pohnpei); kuwawa (Nauru); kautoga, kautonga, kautoga tane, kautonga tane (Niue); apas (Saipan); abwas (Saipan-Carolinian); tu‘ava (Samoa)	Myrtaceae	tree
Pueraria montana var. lobata	English: kudzu, Japanese arrowroot; Other: deday (Yap); aka (American Samoa, Tonga, Niue, Wallis and Futuna); a'a (American Samoa and Samoa); yaka , wa yaka, nggariaka (Fiji); akataha, fue’aepuaka (Tonga); acha, nepalem	Fabaceae	vine

Ricinus communis	English: castor bean, castor-oil plant; French: ricin; Spanish: higuerilla; Other: agaliya (Guam); gelug, maskerekur, uluchula skoki (Palau); tuitui, tuitui fua ikiiki (Niue); koli (Hawaii); lama palagi, lama papalagi (American Samoa and Samoa); lepo, lepohina (Tonga); mbele ni vavalagi, toto ni vavalagi, utouto (Fiji)	Euphorbiaceae	shrub
Rivina humilis	English: baby pepper, bloodberry, coral berry, rouge plant; Other: polo (Tonga)	Phytolaccaceae	herb
Samanea saman	English: monkeypod, rain tree, saman; French: arbre de pluie; Other: tronkon mames, trongkon-mames (CNMI-Chamorro); filinganga (CNMI-Carolinian); gumor ni spanis (Yap); 'ohai (Hawaii); vaivai ni vavalangi, vaivai ni vavalagi (Fiji), malapa (Samoa); kasia (Tonga)	Fabaceae	tree
Sambucus mexicana	English: elderberry, Mexican elder	Caprifoliaceae	small tree
Senna tora	English: foetid cassia, stinking cassia, Java-bean, sickle senna, sicklepod, Chinese senna, peanut weed, sickle senna; French: cassier sauvage, pois puant, séné; Other: kaumoce, kaumothe, pini, tarota (Fiji); mumutun admelon, mumutun palaoan, amot-tumaga carabao (Guam), vao pinati (Samoa); te'epulu, tengafefeka (Tonga)	Fabaceae	shrub
Setaria pallide-fusca	English: foxtail, garden bristle grass, yellow bristlegrass, Queensland pigeon grass (Australia), cat's tail grass (Fiji); French: sétaire glauque	Poaceae	grass
Solanum capsicoides	English: cockroach berry, devil's apple, soda apple; Other: kikania kei, akaaka, akaka (Hawai'i)		herb
Solanum mauritianum	English: bugweed, wild tobacco, tree tobacco; Other: pua nana honua (Hawai'i), pula (Tonga)		shrub
Solanum torvum	English: prickly solanum, devil's fig, turkeyberry, terongan; French: fausse aubergine, aubergine sauvage épineuse; Other: piko (Vanuatu); tisaipale (Tonga); kausoni, soni, kauvoto-votua, kaisurisuri, katai, bhankatiya, soni ni vavalagi (Fiji)		shrub
Solenostemon scutellarioides	English: coleus; Other: lata, lau lata (Fiji); weleweka (Hawai'i); selevese (Niue); koramahd, koaramahd (Pohnpei); pate, patiale, la'au fai sei (Samoa)	Lamiaceae	herb
Sorghum halepense	English: Johnson grass, Aleppo grass, Aleppo milletgrass; French: sorgho d' Alep, sorgo de Alepo, herbe de Cuba; Other: kola (Tonga); gumai (Russia); zacate Johnson, grama China, cañuela, Don Carlos	Poaceae	grass
indicus	English: smutgrass, wiregrass, Indian dropseed; Other: fisihina (Tonga)		grass
cayennensis	English: blue rat's tail, dark-blue snakeweed, false verbena, nettleleaf velvetberry; French: herbe bleue; Other: ouchung, sakura (Chuuk), louch beluu (Palau); mautofu tala, mautofu vao, matofu fualanumanoa (American Samoa and Samoa); te uti (Kiribati); mautofu Samoa, motofu Samoa (Niue); hiku 'i kuma, hiku'kuma, 'iku 'i kuma, iku 'ikuma (Tonga); turulakaka, tumbutumbu, serakawa, lavenia, se karakarawa (Fiji)	Verbenaceae	herb
Syngonium podophyllum	English: arrowhead plant, goosefoot plant	Araceae	climber
Tecoma stans	English: yellow bells, yellow-elder, yellow trumpetbush; Other: peeal (Puluwat), piti (French Polynesia, Tonga)	Bignoniaceae	small tree
Thunbergia fragrans	English: white lady, white thunbergia, sweet clock-vine; Other: fue hina (Tonga)	Acanthaceae	vine
Toona ciliata	English: Australian red cedar, toon; Other: tuna (Samoa), sita kula (Tonga)	Meliaceae	tree
Tradescantia spathacea	English: oyster plant, boat plant, boat lily, moses in a boat; Other: talotalo, laupapaki (Niue)	Commelinaceae	herb
Triumfetta rhomboidea	English: Chinese burr, paroquet burr, burr bush; Other: dadangsi, masiksik lahe (Guam); mo'osipo (Tonga); mosipo (Niue); manutofu, mautofu, mautofu vao (American Samoa and Samoa); qatima (Fiji), urio (French Polynesia)		shrub
Triumfetta semitriloba	English: Sacramento bur; Other: dadangsi, masiksik lahe (Guam)		shrub
Urena lobata	English: hibiscus burr, aramina, caesarweed, pink Chinese burr, urena burr, bur mallow; French: jute africain, cousin urène; Other: dadangsi, dadangsi apaka, dadangsi machingat, dádangse (Guam); chosuched e kui, osuched a rechui (Palau); karap, korop (Pohnpei); nognuk, ocher (Chuuk); motipo, mosipo (Niue); mautofu, manutofu (American Samoa and Samoa); qatima, gataya, nggatima (Fiji); mo'osipo Tonga (Tonga), piripiri (French Polynesia)	Malvaceae	shrub

Annex 6. Invasive and potentially invasive species present on the Ha'apai Groups

Scientific Name	Common Names	Family	Habit	Location
Acacia auriculiformis	English: Papuan wattle, auri, earleaf acacia, northern black wattle, ear-pod wattle; Other: tuhkehn pwelmwahu (Pohnpei)	Fabaceae	tree	Lifuka
Adenanthera pavonine	English: Coral bean tree, red sandalwood tree, red bead tree, lopa, bead tree, false wiliwili, peacock flower-fence; French: bois de condori; Other: kaikes (Pohnpei); mwetkwem (Kosrae); colales, culalis, kolales, kulales, kulalis (Guam, CNMI); metekam, metkam, metkem, (Kosrae); telengtúngd, telentundalel (Palau); pomea (Fiji, Niue), lera, lere ndamu, vaivai, vaivai ni vavalangi (Fiji), lopa, la'au lopa (American Samoa, Samoa and Tonga); paina, pitipitio (French Polynesia)	Fabaceae	tree	Lifuka/Foa, 'Uiha
Aleurites moluccana	English: candlenut, Indian walnut; French: bancoulier, bancoulier, noyer de bancoul, noyer des Moluques; Other: lumbang (Guam), raguar (Caroline Islands); sakan, shakan (Pohnpei); lama (American Samoa and Samoa); kukui (Hawai'i); tuitui (Cook Islands, Niue, Tonga), 'ama (Marquesas); lauci, lauthe, lauthi, toto, tuitui, tutui, waiwai, sekeci,sikethi, sikeli, nggerenggere (Fiji); tahii tiairi, ti'a'iri, tutui, tahiri (French Polynesia)	Euphorbiaceae	tree	Late, Lifuka/Foa, Tofua
Allamanda cathartica*	English: yellow trumpet vine, golden trumpet, allamanda, brownbud allamanda, golden allamanda, golden cup; French: monette jaune, li'ane s'aime; Other: pua taunofo (American Samoa and Samoa), lani-ali'i (Hawai'i)	Apocynaceae		Lifuka
Annona muricate	English: soursop, prickly custard apple; French: corossolier, cacheimantier épineux, cachiman épineux, corossol épineux; Other: saasaf, sasaf (Chuuk); tapotapo papaa (French Polynesia); laguana, laguaná, laguanaha, laguanaba, labuanaha (Guam); sosap (Kosrae); jojaab (Marshall Islands); syasyap (Northern Mariana Islands), talapo fotofoto (Niue), sausab (Palau); sei, sae, truka shai (Pohnpei); sasalapa (Samoa); 'apele 'initia (Tonga); sausau (Yap)	Annonaceae	tree	Ha'ano, Lifuka/Foa, 'Uiha
Annona squamosa	English: sugar apple, sweetsop, custard apple, sugar apple; French: annone écailleuse, pomme-canelle; Other: atis, ates (Guam); ngel ra ngebard (Palau), 'apele papalangi, 'apele Tonga (Tonga), tapotapo (French Polynesia)	Annonaceae	tree	Lifuka/Foa
Antigonon leptopus*	English: Mexican creeper, mountain rose, Confederate vine, chain-of-love, hearts on a chain, love-vine, coral bells, coral vine, queen's jewels, kadena de amor, corallita; Other: rohsapoak (Pohnpei)		vine	Lifuka/Foa
Arundo donax	English: giant reed, Spanish reed, wild cane; French: canne de Provence, grand roseau; Other: ngasau ni vavalangi (Fiji); fiso papalagi (Samoa); kaho folalahi (Tonga)		grass	Lifuka
Asparagus densiflorus	English: asparagus fern, sprengeri fern, smilax, regal fern	Liliaceae	herb	Lifuka
Asparagus setaceus	English: ornamental asparagus, climbing asparagus fern, plumosa; French: asperge plumeuse; Other: taupo 'ou (Tonga)	Liliaceae	vine	Lifuka/Foa, 'Uiha
Asystasia gangetica	English: Chinese violet, Philippine violet, coromandel	Acanthaceae	herb	Lifuka
Bauhinia monandra	English: orchid-tree, St. Thomas-tree, Napoleon's plume; flamboyant (Pohnpei), flores mariposa (CNMI); mariposa (Guam); pink butterfly tree (Fiji); Other: pine fua loloa (Niue), vae povi (American Samoa and Samoa)	Fabaceae	tree	Ha'ano, Lifuka/Foa
Bidens pilosa	English: beggar's tick, Spanish needle, cobbler's pegs; French: piquants noirs, bident hérissé, herbe d'aiguille, herbe villebague (Mauritius); Other: fisi'uli (Tonga); kofe tonga, kofetoga (Niue); piripiri (Cook Islands); tae puaka (Futuna); batimadramadra, mbatimandramandra, mbatikalawau, matakaro, matua kamate (Fiji); ki, ki nehe, ki pipili, nehe (Hawai'i)	Asteraceae	herb	Ha'ano, Lifuka/Foa, 'Uiha, Tofua and probably all islands
Brachiaria mutica	English: California grass, para grass, buffalo grass, Mauritius grass, signal grass; French: herbe de Para; Other: puakatau (Tonga) (Swarbrick, 1997)	Poaceae	grass	Lifuka/Foa

Brachiaria subquadripara	English: brachiaria, green summer grass, tropical signalgrass, cori grass	Poaceae	grass	Lifuka
Breynia disticha*	English: snowbush, snowbush breynia, sweetpea bush, foliage-flower	Euphorbiaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha
Bryophyllum pinnatum	English: life plant, air plant, resurrection plant, Canterbury bells, cathedral bells, Mexican love plant; Spanish: hoja del aire; Other: kibilia (Marshall Islands); bulatawamudu (Fiji); tupu he lau, tupu noa (Niue); teang (Kiribati)	Crassulaceae	herb	Lifuka/Foa, 'Uiha
Cananga odorata	English: perfume tree; French: canang odorant; Other: ilang-ilang, alang-ilang (Guam, Philippines); ylang-ylang, lengileng (CNMI); chiráng, irang (Palau); ilanlang, ilahnglahng (Kosrae); pwanang, pwuur, pwalang (Chuuk); pur-n-wai, pwurenwai, sair-n-wai, seirin wai, seir en wai (Pohnpei); ilanilan, ilañlañ (Marshall Islands); motoi (Niue); makasoi, makosoi, makusui, mokohoi, mokosoi (Fiji); moso'oi (American Samoa and Samoa); mohoki, mohokoi, mohokoi (Tonga); moto'oi, mata'oi (Cook Islands, Niue, Tahiti); moto'i (Tahiti); lanalana (Hawai'i)	Annonaceae	tree	Lifuka/Foa
Canna indica	English: canna, canna lily, Indian shot; French: balisier comestible, tous-les-mois; Other: mongos halum-tano (Guam); luiuenwai (Pohnpei); apeellap, oruuru (Puluwat); fanamanu, fagamanu, fa'i masoa (American Samoa and Samoa); gasau ni ga (Fiji); te riti (Kiribati), misimisi (Tonga); fagafaga (Futuna); ali'ipoe, li'ipoe, poloka (Hawai'i); pia-raroto'a (French Polynesia)	Cannaceae	herb	Ha'ano, Lifuka/Foa
Ceiba pentandra	English: kapok, kapok tree, silk-cotton tree, pacae; French: kapokier, capoc, bois coton; Spanish: ceibo; Other: koton (Chuuk); algodon de Manila, atgodon di Manila, algidon, atgidon de Manila (Guam); koatoa, atagodon, arughuschel (Saipan), batte ni gan' ken (Yap); bulik, kotin (Marshall Islands); cottin, koatun, koatoa (Pohnpei); kuhtin, cutin (Kosrae); kalngebard, kalngebárd, kerrekar ngebard (Palau); vauvau ni vavalangi, semar (Fiji); vavae (American Samoa, Samoa, Niue, Tonga); vavau ni lokoloko (from Ecoport, source not given)	Bombacaceae	tree	Ha'ano, Lifuka/Foa, 'Uiha
Cenchrus ciliaris	English: buffelgrass, African foxtail grass, anjan grass; French: cenchrus cilié	Poaceae	grass	Lifuka/Foa
Cenchrus echinatus	English: burgrass, sand-bur, southern sandbur, Mossman River grass (Australia); French: herbe a cateaux (Mauritius); Other: tuitui, vao tuitui, vao papalagi (American Samoa and Samoa); se mbulabula (Fiji); piri-piri, pipiri (French Polynesia); konpeito-gusa, 'ume'alu (Hawai'i); te anti, te kateketeke (Kiribati); cram-cram (New Caledonia); motie vihilago, mosie vihilango (Niue); loklok, lellik, lekelik, liklik, karmwijmwij (Marshall Islands); cauit-cauitan (Philippines); hefa (Tonga)	Poaceae	grass	Ha'ano, Lifuka/Foa
Centrosema pubescens	English: centro, butterfly-pea; French: fleur-languette, pois bâtard; Other: pi ni ndola (Fiji)	Fabaceae	herb	Lifuka/Foa
Cestrum diurnum	English: inkberry, day jessamine, day cestrum, China berry; Other: thauthau (Fiji); tinta 'n-China, tentanchinu, tintan China (Guam, CNMI); sugi vao, suni vao (Samoa); vaitohi (Tonga)	Solanaceae	shrub	Lifuka/Foa
Chamaecrista nictitans	English: partridge pea, Japanese tea senna; Other: kobo-cha, nemu-cha (Japan)	Fabaceae	small shrub	Lifuka/Foa
Chrysopogon aciculatus	English: Mackie's pest, lovegrass, seed grass, golden beardgrass, seedy grass (Solomon Islands); French: herbe plate, herbe à piquant; Other: inifuk, palaii (Guam); iul (Palau); manienie 'ula (Hawai'i); mutia tai, mutia vao (Samoa); mosie fisi (Niue); matapekepeke, matapekapeka matapekepeka (Tonga); herbe plate (Vanuatu), papapa (French Polynesia)	Poaceae	grass	Late, Tofua
Clerodendrum buchananii var. fallax	English: red clerodendrum, pagoda-flower; Other: talufe (Niue); amo'ula, amo'ule (Tonga), lau'awa (Hawai'i)	Verbenaceae	shrub	Lifuka/Foa
Clitoria ternatea*	English: butterfly pea, Asian pigeonwings; French: honte; Other: buikike, bukike, paokeke, bukike paokeke, capa de la reina, kapa de la raina (Guam); putitainubia (CNMI); pepe (Niue); latoela, nawa (Fiji), paipa (Tonga)	Fabaceae	vine	Nomuka
Coffea arabica*	English: coffee; French: café, caféier d' Arabie; Spanish: café, cafeto; Other: kove (Fiji); kofe (Fiji, Niue, Samoa), kofi (Tonga); kafe (Marquesas); taofe (Tahiti)	Rubiaceae	tree	

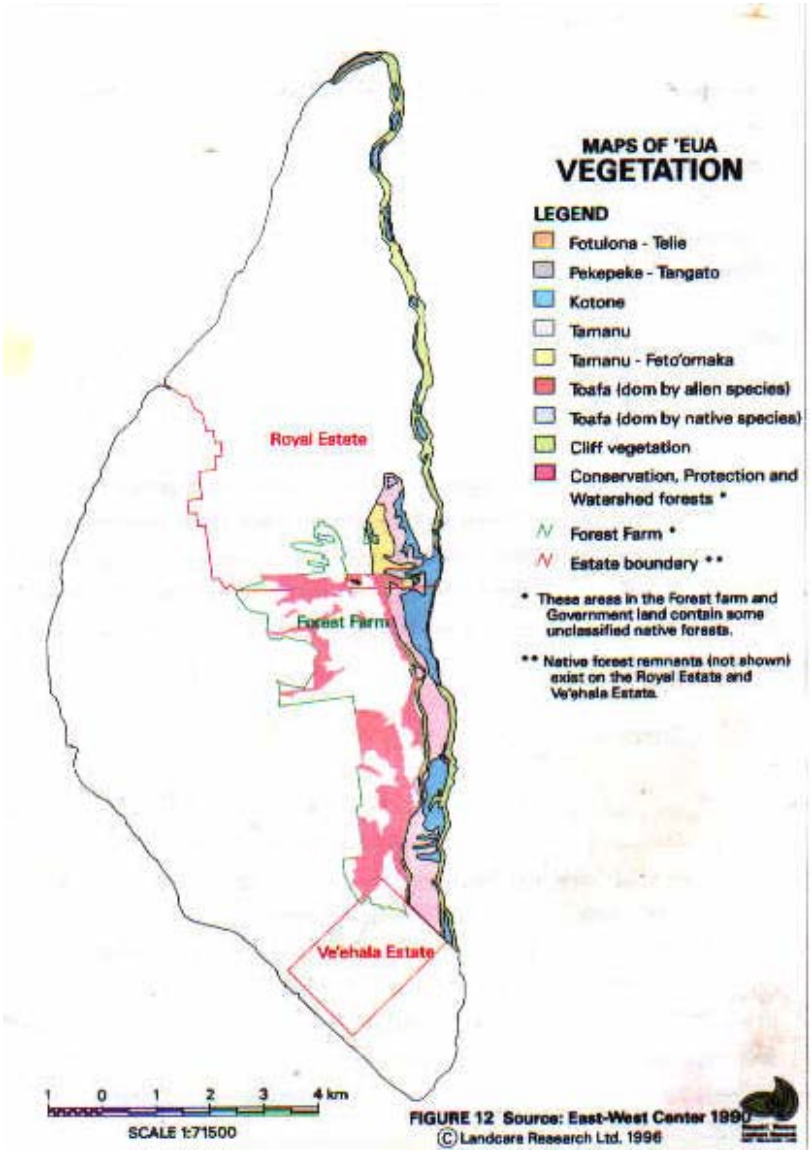
Commelina diffusa	English: commelina, dayflower, wandering Jew, spiderwort; Spanish: chiriyuyo; Other: semprebiban-damalong (Guam); honohono (Hawai'i); mau'utoga, mau'u Tonga (American Samoa and Samoa); mohuku vai, musie matala pulu (Tonga); ai rorongi, ai rongorongo, airogorogo, cobulabula, rongomatailevu, thombulambula, matembulambula, drano,duludauwere, ndrano, ndulandauwere, luna, tho nggalonggalo (Fiji), ma'apape (French Polynesia)	Commelinaceae	herb	
Costus speciosus	English: crepe ginger, crape ginger, wild ginger, Malay ginger, canereed; Other: isebsab (Palau)	Zingiberaceae	herb	Lifuka/Foa
Crassocephalum crepidoides	(American Samoa and Samoa); maraburubo (Solomon Islands); fisi puna (Tonga); se vuka (Fiji)	Asteraceae	herb	Late
Digitaria ciliaris	English: Henry's crabgrass, smooth crabgrass, tropical crab grass, large crab grass, southern crabgrass, fingergrass, summer grass; French: digitaire ciliée; Other: kukaepua'a (Hawai'i); Saulangi (Niue)	Poaceae	grass	Late
Duranta erecta	'olive (Tonga)	Verbenaceae	shrub	Lifuka/Foa
Elephantopus mollis	English: elephantopus, elephant's foot, tobacco weed; French: faux tabac; Other: papago' vaca, papago' halom tano, papago' baka, papago' halomtano' (Guam); lata hina, lau veveli (Tonga); tavako ni veikau, jangli tambaku (Fiji); tapua erepani (Cook Islands)		herb	Lifuka/Foa
Eleusine indica	French: pied de poule; Other: fahitalo, lau ta'a ta'a, ta'a ta'a (American Samoa and Samoa); kavoronaisivi, vorovoroisivi, ghoraya (Fiji); tamamau (French Polynesia), umog (Guam); manienie ali'i (Hawaii); mahkwekwe (Kosrae); katejukjuk (Marshall Islands); mosie fahitalo (Niue); deskim, keteketarmalk (Palau); reh takai (Pohnpei); takataka, takataka 'a leala, mohuku siamane (Tonga); te uteute (from Ecoport, source not given)	Poaceae	grass	Late, Lifuka/Foa, Tofua
	English: weeping fig, baka, Java fig, weeping fig ; Other: 'ovava fisi (Tonga)	Moraceae	tree	Ha'ano, Lifuka/Foa, 'Uiha
Flemingia strobilifera	English: luck plant; French: sainfoin du bengale; Other: besungelaiei (Palau)	Fabaceae	shrub	Lifuka/Foa
Hyptis pectinata	English: comb hyptis, comb bushmint, mint weed, purple top; French: fausse menthe; Other: mumutun lahe, mumutun palaoan, mumutan ademelon (Guam); tamole ni veikau, tamoli ni vavalangi, timothi ni vavalangi, wavuwavu, ndamoli, ben tulsia (Fiji)	Lamiaceae		Ha'ano, Lifuka/Foa, 'Uiha
Indigofera suffruticosa	English: indigo; Other: aniles (Guam); 'iniko, inikoa, kolu (Hawai'i); la'au mageso (Samoa); 'akau veli (Tonga)	Fabaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha
Ipomoea spp.	English: morning glory (non-native)	Convolvulaceae	herb	Ha'ano, Lifuka/Foa
Jatropha curcas	English: physic nut, purging nut, Barbados nut; French: médicinier, pignon d'Inde, purghère; Other: wiriwiri, wiriwiri ni vavalangi, uto ni vavalangi, banidakai, mbanindakai, manggele, maqele, ndrala (Fiji); fiki (Fiji, Tonga); tuba-tuba (Guam); laupata (Samoa)	Euphorbiaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha
Kyllinga nemoralis	English: white kyllinga, whitehead spikesedge; Other: kili'o'opu (Hawai'i), ta'a ta'a, ta'a ta'a vili taliga, matie upo'o, matie tahiti, mo'u upo'onui, mo'u upo'o, tuise (Samoa); pakopako, pakopako 'ae kuma (Tahiti); tuise (Tonga)	Cyperaceae	sedge	Lifuka/Foa
Lablab purpureus	English: hyacinth bean, lablab, bonavist, Egyptian kidney bean, dolichos; French: dolique, dolique d'Egypte, pois nourrice; Other: ndralawa, natomba, tomba (Fiji); cheribilla apaka, chuchumeko (Guam); papapa, pi (Hawai'i); pini lae puaka (Tonga)	Fabaceae	vine	Lifuka/Foa
Lantana camara	English: lantana; Other: landana, rantana, rahndana, tukasuweth (Pohnpei); ros fonacni (Kosrae); kauboica, kaumboitha, mbonambulumakau, mbona ra mbulumakau, tokalau, waiwai, lanitana (Fiji); latana (American Samoa and Samoa); latora moa, tatara moa (Tahiti); lakana (Hawai'i); talatala, talatala talmoa (Tonga); te kaibuaka, te kaibuaja (Kiribati); taramoa (Cook Islands); migiroa (Nauru), taratara hamoa, taratara moa (French Polynesia)	Verbenaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha

Leonurus japonicus	English: lion's tail, Chinese motherwort	Lamiaceae	herb	Ha'ano, Lifuka/Foa, 'Uiha
Leucaena leucocephala	faux-acacia, faux mimosa (New Caledonia); Other: koa haole, lili-koa, ekoa (Hawaii); tangantangan, tangan-tangan, talantayan (Guam, CNMI, Marshall Islands); talntangan (CNMI); ganitnityuwan tangantan (Yap); tuhngantuhngan, rohbohtin (Kosrae); telentund (Palau); lopa Samoa (American Samoa and Samoa); fua pepe (American Samoa and Samoa); lusina (Samoa); pepe (Niue and Samoa); tavahi kaku (Niue); nito, toromiro (Cook Islands); siale mohemohe (Tonga); vaivai, vaivai ni vavalangi, vaivai dina, balori (Fiji); atiku (Marquesas); cassis (Vanuatu); te kaitetua (Kiribati); namas (from Ecoport, source not given)	Fabaceae		Ha'ano, Lifuka/Foa, 'Uiha, Nomuka
Lonicera japonica*	English: Japanese honeysuckle, Hall's honeysuckle; Other: honekakala (Hawai'i)	Caprifoliaceae		Lifuka/Foa
Macroptilium atropurpureum	English: siratro, purple bushbean	Fabaceae	herb	Lifuka/Foa
Mimosa pudica	English: sensitive plant, sleeping grass; French: sensitive; Other: la'au fefe, vao fefe, vao tuitui, tuitui (American Samoa and Samoa); ra kau pikikaa, rakau pikika (Cook Islands); tho ngandrongandro, tho kandrodandro, cogadrogadro (Fiji); betguen sosa (Guam); memege (Niue); mechiuaiu (Palau); limemeihr (Pohnpei); pohe ha'avare, pope ha'avare (Tahiti); mateloi (Tonga)	Fabaceae	herb	Ha'ano, Late, Lifuka/Foa, 'Uiha
Momordica charantia	English: balsam-apple, bitter-melon, bitter gourd, balsam pear, squirting cucumber, cerasee, peria; French: momordique, margose (Réunion, Mauritius Islands), margose amère, momordique amère, concombre amer, concombre africain; Spanish: achoccha silvestre; Other: almagosa, atmagosu (Guam); atmagoso (Guam, CNMI); markoso (Palau); kerala (Fiji); meleni 'ae kuma, vaine 'initia (Tonga)	Cucurbitaceae	vine	Lifuka/Foa, Tofua
Murraya paniculate	English: orange jessamine, satin-wood, Chinese box, Hawaiian mock orange	Rutaceae	shrub/tree	Ha'ano, Lifuka/Foa
Ocimum gratissimum	English: wild basil, clove basil, tree basil; French: basilic, menthe gabonaise; Other: la'au sauga (Samoa)	Lamiaceae	herb	Lifuka/Foa
Operculina ventricosa	English: paper rose, St. Thomas lidpod; Other: alalag (Guam); palulu (Samoa); fue hina (Tonga)	Convolvulaceae	vine	Ha'ano, Lifuka/Foa, Tofua
maximum	English: Guinea grass, green panic, buffalograss; French: herbe de Guinéa, panic élevé, capime guiné, fataque; Other: saafa (Tonga)	Poaceae		Lifuka/Foa
Paspalum orbiculare	English: rice grass; ditch millet (Fiji); Other: co duru levu, tho nduru levu, tho ndina, tho ni ndina (Fiji); karasi (Solomon Islands)	Poaceae	grass	Kao, Late, Lifuka/Foa
Passiflora edulis	English: passion fruit, yellow passion fruit, purple passion fruit, qarandila, purple granadilla; French: grenadille; Spanish: maracuya (Galapagos Is.); Other: liliko'i (Hawai'i), pompom (Pohnpei); pasio (Samoa); vaine (Tonga)	Passifloraceae	vine	Ha'ano
Passiflora foetida	English: love-in-a-mist, wild passion fruit, passionflower, stinking passionflower; French: passiflore; Spanish: bedoca (Galapagos Is.); Other: pasio vao (American Samoa and Samoa); bombom (Chuuk), sou, lolilol ni kalavo, qaranidila (Fiji); pohapoha (Hawai'i); tea biku (Kiribati); vine vao (Niue); kudamono (Palau); pompom, pwomwpwomw (Pohnpei); kinahulo' atdao, dulce (Saipan); vaine 'initia (Tonga); tomates (Yap)	Passifloraceae	vine	Lifuka/Foa, Nomuka, 'Uiha
Passiflora maliformis	English: hard-shelled passionfruit, sweet calabash, sweet cup; French: pomme calabas; Other: pasio (Samoa), vaine Tonga, vaine kai (Tonga)	Passifloraceae	vine	Lifuka/Foa
Passiflora quadrangularis*	English: granadilla, giant granadilla; French: barbadine; Spanish: badea (Galapagos Is.); Other: parapotina maata (Cook Islands); para pautini (French Polynesia); palasini, palatini, vine fua lalahi, vine palasini, tinitini (Niue); kudamono (Palau); pasio (Samoa); pasione (Tonga)	Passifloraceae	vine	Lifuka/Foa
Persea americana*	English: avocado, alligator pear; French: l'avocat; Spanish: aguacate; Other: apoka (Cook Islands); pea (Fiji); avoka (Niue, Tonga); aviota (Samoa); avota (Samoa and Tahiti); bata (Palau); alageta (Chamorro, Guam)	Lauraceae	tree	Lifuka/Foa

Pimenta dioica*	English: pimento, allspice; Other: sipaisi (Tonga)	Myrtaceae		Lifuka/Foa
Pimenta racemosa*	English: bay tree, bay rum tree, bay oil tree, malagueta; Other: sinamoni (Tonga)	Myrtaceae	tree	Lifuka/Foa
	English: Caribbean pine, Bahamas pine; Other: paina (Samoa), paini (Tonga)	Pinaceae	tree	Ha'ano, Lifuka/Foa
Piper auritum	English: eared pepper, anise piper, Veracruz pepper; Spanish: hoja santa, anisillo, hinojo, sabalero, hoja de la estrella; Other: Hawaiian sakau, false sakau, false kava (Pohnpei)	Piperaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha
Plectranthus amboinicus	English: Mexican mint, Spanish thyme, Cuban oregano; French: oreille; Other: rhaivoki, sage (Fiji); pasiole (Niue, Tonga); la'au tai'e, lau tai'e, militini (Samoa); kaloni (Tonga)	Lamiaceae	herb	Lifuka/Foa, Nomuka
Psidium guajava	English: guava; French: goyavier; Spanish: guayaba, guayabo; Other: ku'ava, ku'avu, tu'avu (American Samoa and Samoa); kuafa (Chuuk); kuava (Cook Islands, Tonga, Fiji, Samoa); quwawa, nguava, ngguava ni India, amrut (Fiji); tuava, tumu tuava, tuvava (French Polynesia); abas guayaba (Galapagos); (Guam, Saipan-Chamorro, Yap); kuawa (Hawai'i); kuhfahfah (Kosrae); te kuawa (Kiribati); guabang, kuabang (Palau); guahva, kuahpa (Pohnpei); kuwawa (Nauru); kautoga, kautonga, kautoga tane, kautonga tane (Niue); apas (Saipan); abwas (Saipan-Carolinian); tu'ava (Samoa)	Myrtaceae	tree	Ha'ano, Lifuka/Foa, 'Uiha
Pueraria montana var. lobata	English: kudzu, Japanese arrowroot; Other: deday (Yap); aka (American Samoa, Tonga, Niue, Wallis and Futuna); a'a (American Samoa and Samoa); yaka , wa yaka, nggariaka (Fiji); akataha, fue'aepuaka (Tonga); acha, nepalem	Fabaceae	vine	Ha'ano, Lifuka/Foa, Tofua
communis	English: castor bean, castor-oil plant; French: ricin; Spanish: higuerilla; Other: agaliya (Guam); gelug, maskerekur, uluchula skoki (Palau); tuitui, tuitui fua ikiiki (Niue); koli (Hawaii); lama palagi, lama papalagi (American Samoa and Samoa); lepo, lepohina (Tonga); mbele ni vavalagi, toto ni vavalagi, utouto (Fiji)		shrub	Lifuka/Foa
Samanea saman	English: monkeypod, rain tree, saman; French: arbre de pluie; Other: tronkon mames, trongkon-mames (CNMI-Chamorro); filinganga (CNMI-Carolinian); gumor ni spanis (Yap); 'ohai (Hawaii); vaivai ni vavalangi, vaivai ni vavalagi (Fiji), malapa (Samoa); kasia (Tonga)	Fabaceae	tree	Lifuka/Foa
mexicana	English: elderberry, Mexican elder	Caprifoliaceae	small tree	Lifuka/Foa
Schefflera arboricola*	English: dwarf brassia, dwarf schefflera, Hawaiian elf schefflera	Araliaceae	shrub	Lifuka/Foa
Senna alata	English: candle bush; candelabra bush, Roman candle tree, emperor's candlesticks, ringworm bush (Australia), alcapulco; French: epis d'or, bois dartre, dartres; Other: arakak (Chuuk); akapuku, andadose, candalaria, take-biha (Guam); kerula besokel, yult (Palau); rakau honuki, truke-n-kili-n-wai, tuhkehn kilin wai, tirakahonuki (Pohnpei); flay-n-sabouw (Yap); mulamula (Niue); bakau plant (Solomon Islands); mbai ni thangi (Fiji); fa'i lafa, la'au fai lafa (American Samoa, Samoa and Tonga); te'elango (Tonga)	Fabaceae	shrub	Lifuka/Foa
Senna tora	English: foetid cassia, stinking cassia, Java-bean, sickle senna, sicklepod, Chinese senna, peanut weed, sickle senna; French: cassier sauvage, pois puant, séné; Other: kaumoce, kaumothe, pini, tarota (Fiji); mumutun admelon, mumutun palaoan, amot-tumaga carabao (Guam), vao pinati (Samoa); te'epulu, tengafefeka (Tonga)	Fabaceae	shrub	Ha'ano, Lifuka/Foa, 'Uiha
Setaria pallide-fusca	English: foxtail, garden bristle grass, yellow bristlegrass, Queensland pigeon grass (Australia), cat's tail grass (Fiji); French: sétaire glauque	Poaceae	grass	Ha'ano, Nomuka
Solanum mauritianum	English: bugweed, wild tobacco, tree tobacco; Other: pua nana honua (Hawai'i), pula (Tonga)	Solanaceae	shrub	Nomuka
Sorghum halepense	English: Johnson grass, Aleppo grass, Aleppo milletgrass; French: sorgho d' Alep, sorgo de Alepo, herbe de Cuba; Other: kola (Tonga); gumai (Russia); zacate Johnson, grama China, cañuela, Don Carlos	Poaceae	grass	Lifuka/Foa
Stachytarpheta cayennensis	English: blue rat's tail, dark-blue snakeweed, false verbena, nettleleaf velvetberry; French: herbe bleue; Other: ouchung, sakura (Chuuk), louch beluu (Palau); mautofu tala, mautofu vao, matofu fualanumanoa (American Samoa and Samoa); te uti (Kiribati); mautofu Samoa, motofu Samoa (Niue); hiku 'i kuma, hiku'kuma, 'iku 'i kuma, iku 'ikuma (Tonga); turulakaka, tumbutumbu, serakawa, lavenia, se karakarawa (Fiji)	Verbenaceae	herb	Ha'ano, Lifuka/Foa, 'Uiha

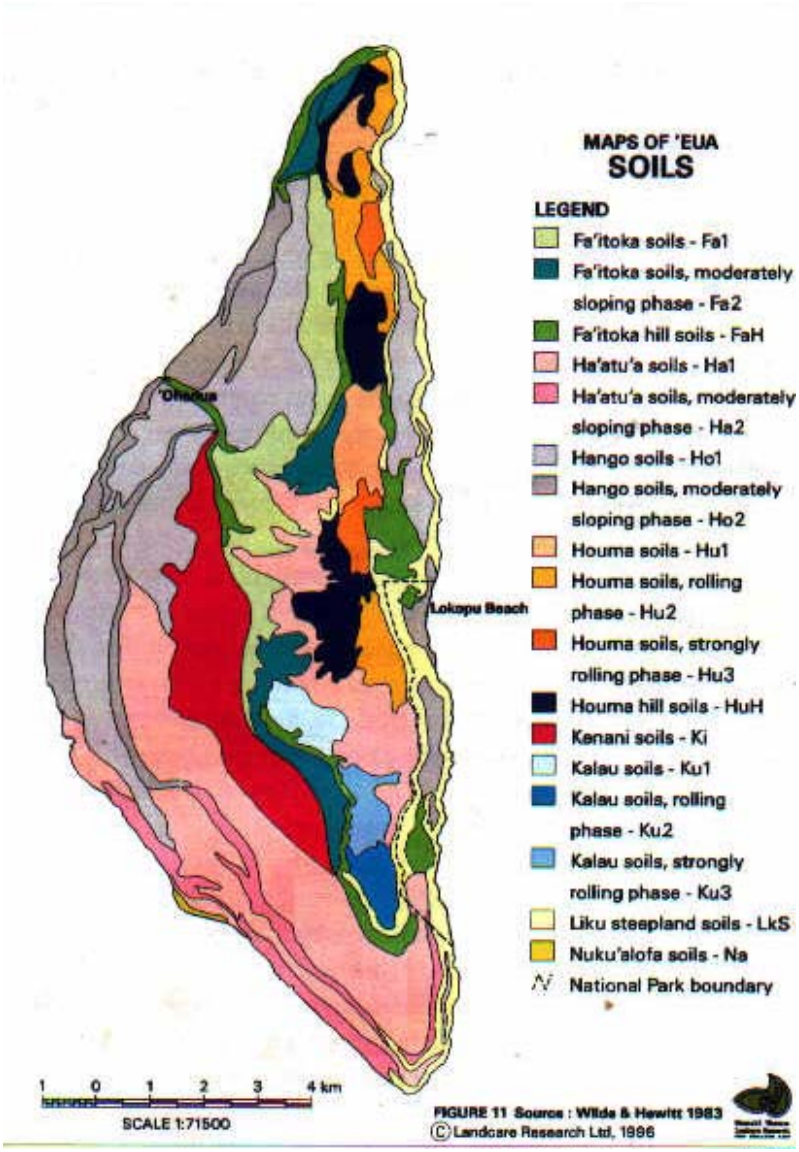
Tecoma stans	English: yellow bells, yellow-elder, yellow trumpetbush; Other: peeal (Puluwat), piti (French Polynesia, Tonga)	Bignoniaceae	small tree	Lifuka/Foa
Thevetia peruviana*	English: yellow oleander, be-still tree, lucky nut; French: oléandre jaune; Other: koneta (Chuuk); nohomalie (Hawai'i); irelepsech (Yap)	Apocynaceae	small tree	Lifuka/Foa
Thunbergia fragrans	English: white lady, white thunbergia, sweet clock-vine; Other: fue hina (Tonga)	Acanthaceae	vine	Lifuka/Foa, Ha'ano
Tradescantia spathacea	talotalo, laupapaki (Niue)	Commelinaceae	herb	'Uiha
Triumfetta rhomboidea	English: Chinese burr, paroquet burr, burr bush; Other: dadangsi, masiksik lahe (Guam); mo‘osipo (Tonga); mosipo (Niue); manutofu, mautofu, mautofu vao (American Samoa and Samoa); qatima (Fiji), urio (French Polynesia)		shrub	Lifuka/Foa, 'Uiha

Figure 4.1 Map of 'Eua Vegetation



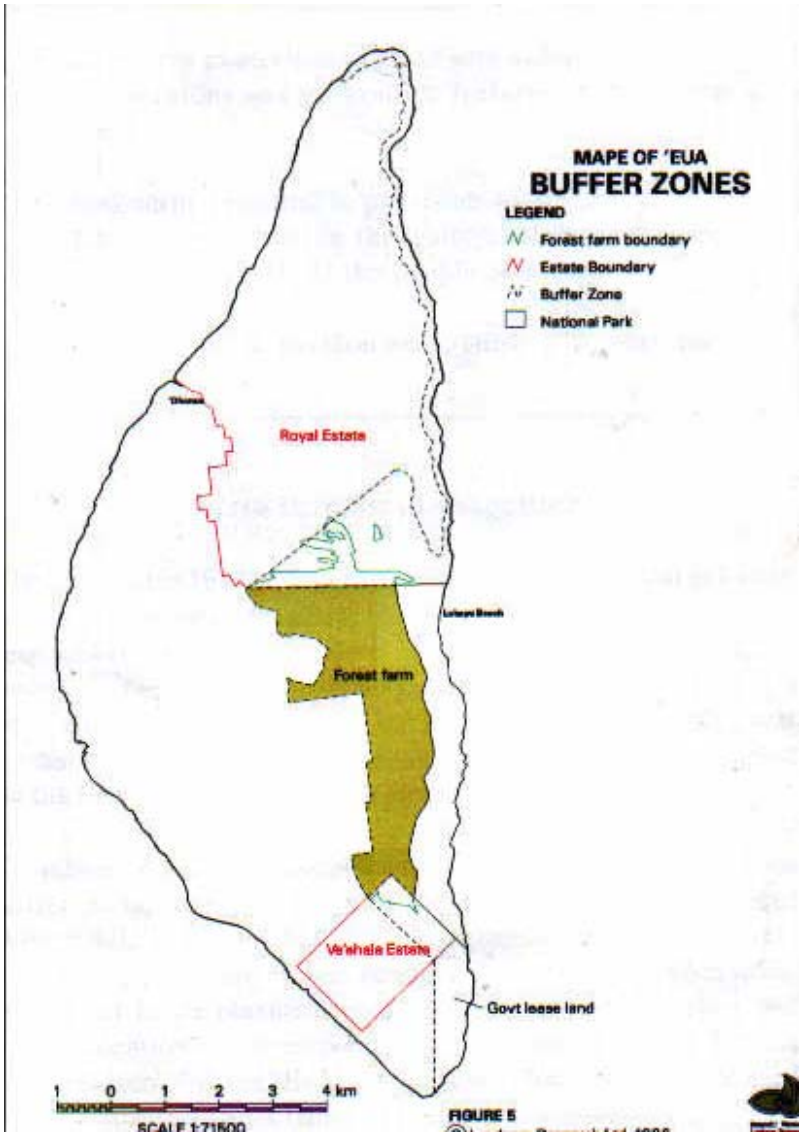
Source: Landcare Research PO Box 40, Lincoln 8152, New Zealand

Figure 4.2 Map of ‘Eua Soils



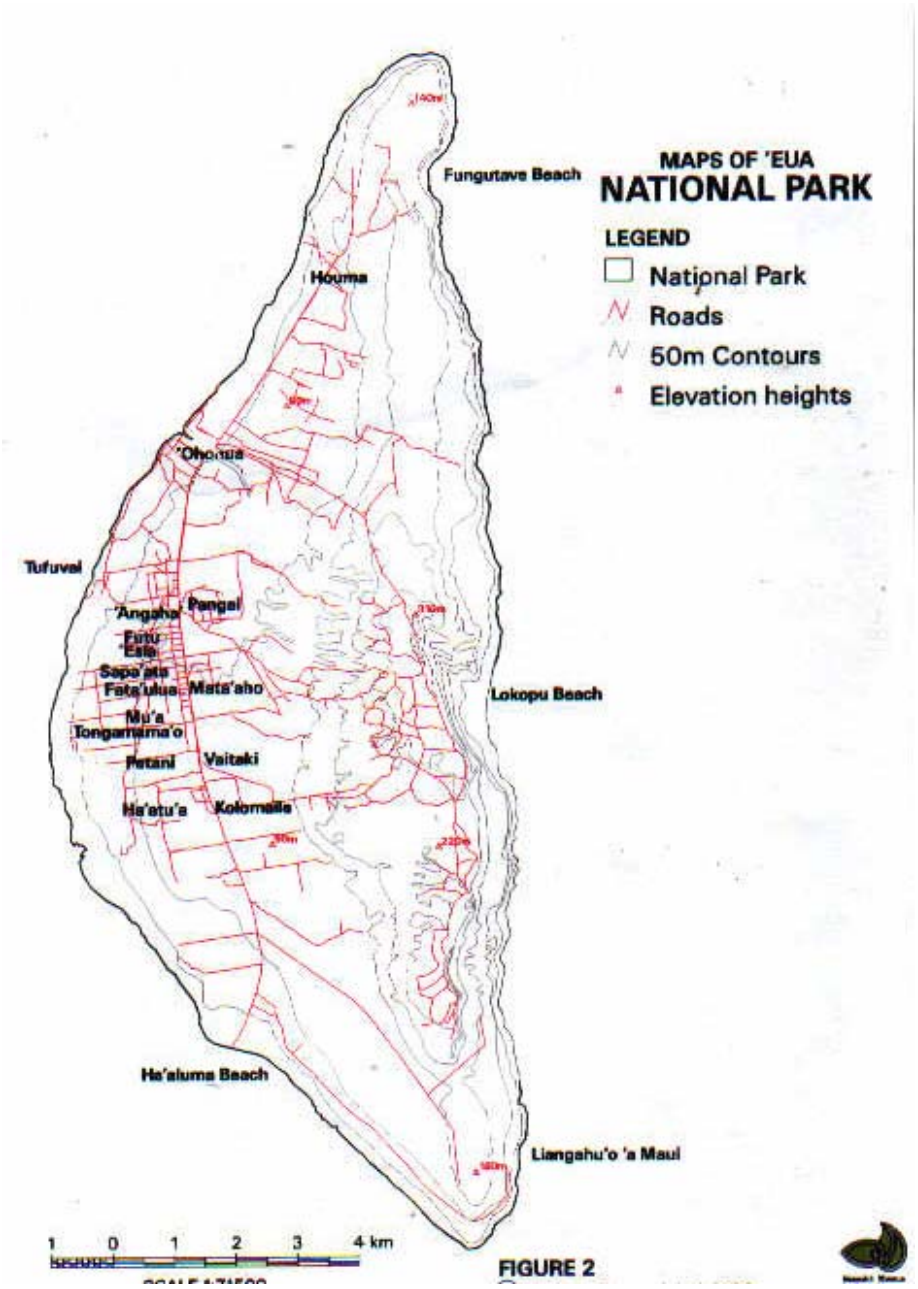
Source: Landcare Research PO Box 40, Lincoln 8152, New Zealand

Figure 4.3 Map of ‘Eua Buffer Zones



Source: Landcare Research PO Box 40, Lincoln 8152, New Zealand

Figure 4.4 Maps of ‘Eua National Park



Source: Landcare Research PO Box 40, Lincoln 8152, New Zealand

CHAPTER FIVE

MARINE – PELAGIC BIODIVERISTY AND CONSERVATION

(Poasi Ngaluafe[10])

5.0 Introduction

The marine pelagic[11] sector in the Kingdom of Tonga covers an area of approximately 700,000 km^2 (EEZ territory), (Figure 5.1) as compared to about 395,000 km^2 under the 1887 Royal Proclamation. The control, development and management of this resource (Fisheries) are the responsibility of the Ministry of Fisheries.

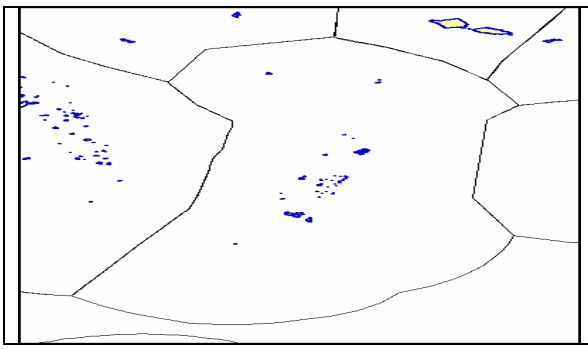


Figure 5.1 Tonga Exclusive Economic Zone (EEZ)

The pelagic organisms are the fisheries, which spent their life in water column either in coastal or oceanic water away from the bottom (Bone and Marshall, 1992; Castro and Huber, 2000).

The Ministry of Fisheries is responsible for the controlling fisheries activities in Tonga's EEZ in complying with *Fisheries Act 1989*, *Fisheries Regulation 1994*, *Fisheries Management Act 2002* and *Aquaculture Act 2003* also collaboration with relevant government ministries. The *Fisheries Act 1989* is the main fisheries law in Tonga, which defines fisheries water as the territorial waters of the Kingdom that claims sovereign rights or jurisdiction with respect to the marine living resources by legislative enactment or by Royal Proclamation. On the other hand, the new *Fisheries Management Act 2002* provides the condition for foreign fishing vessels if kept in Tongan water also the conditions for licensing structure.

[10] Poasi Ngaluafe is a fisheries expert

[11] Worm *et al*., (2003) reported that the oceanic pelagic ecosystem is by far the largest on earth, covering >70% of the planet by area and even larger percentage by volume.

Pelagic species abundance and diversity are mostly found at the epipelagic zone (Table 5.1.1 and Chap 5 – Appendix 1, 2 & 3), however there some of tuna species (horse mackerel) can be found both at coastal and oceanic water.

Table 5.1.1: Identified Pelagic Species found in Pelagic Zone (Coastal and Oceanic)

Common name	Family name	No. of species recorded in Tonga	Coastal orOceanic
Finfishes 1. Tuna, mackerel and horse mackerel	Scombridae	7	Tuna – Both Mackerel - Both
2. Mackerel	Carangidae	1	Coastal
3. Barracuda	Sphyraenidae	3	Coastal
4. Dolphin fish, mahimahi	Coryphaenidae	1	Oceanic
5. Flying fish	Exocoetidae	4	Oceanic
6. Garfish	Hemiramphidae	1	Coastal
7. Anchovies	Engraulididae	1	Coastal
8. Herring. Sprat. sardine	lupeidae	8	Both
9. Scad, trevally	Carangidae	6	Both
10. Billfish, swordfish, wahoo, sailfish		6	Oceanic
Marine mammals Whales	Cetacea	12	Both
Marine turtles Turtle		6	Both
Mollusc Octopus and cuttlefish		Unknown species	Octopus – both Cuttlefish – oceanic
Marine plants Marine microscopic algae (phytoplankton)		Unknown species	Both
Crustaceans Prawns and krill	Crustacea	Unknown species	Oceanic

Sources: Bone and Marshall 1992, Castro and Huber 2000, Bell et al. 1997, King 1995).

5.1 Marine – Pelagic Biodiversity

5.1.1 Endangered and Threatened Species

* Endangered pelagic species found in Tongan waters included humpback and blue whale
* Hawksbill turtle reported by Wilkinson (1977) is endangered in the South Pacific Island including Tonga, (www.cites.org/eng/append/appendices.shtml).

Donoghue et al., (1996) listed bottlenose whale as highly threatened. However, overfishing of the pelagic species will be driven to dangerously low levels, either target catch or bycatch especially tunas, billfish, sea turtle, shark and whale fisheries resources.

5.1.2 Cultural Significance Species

Special importance of pelagic species is link to Tongan culture such as skipjack tuna, turtle and shark. Skipjack is regarded as ***ika eiki*** at the ***Fakapangai*** when compare to other fishes brought to the ***Fakapangai*** at the Palace to the King. On the other hand, major tuna fishery such as bigeye, albacore and yellowfin are targeted species exploited by the long-liner due to their high price in the international market apart from blue fin tuna, which regarded as the highest price in tuna fish market world wide especially at the Japanese market (sashimi market) but there is no confirmation that found in Tongan water or just only the high sea area.

Sharks form an important role in the culture and folklore of many South Pacific island states, which included Tonga (Nichols, 1993). This mythology could be linked to the story of 'Eueiki people who's never killed by shark at the ocean, which also continues to this day but there is no evidence from the people recently.

In Tongan pelagic water, poisoning from eating cooked meat of a 2' 4" long and 1' 4" wide hawksbill turtle was reported from Nomuka Island in March 1983 (Latu, letter dated 13 October 1983, cited in Bell *et al*., 1993). The turtle was caught at Hakaufisi Reef was thought to be linked to ciguatera poisoning caused by dinoflagellate toxin. Of the twenty-one people who ate the meat, 18 became very sick and 3 died. The three that died and those who became very sick ate part of the viscera (Muli, letter dated 7 February, 1984). This was the only time poisoning from eating turtle meat has been reported from Nomuka or elsewhere in Tonga. However, after short consultation with Latu (Senior Fisheries Officer), the cause of the death could be associated with toxic from shark gall bladder that accidentally mixed with the turtle meat during processing procedure.

5.2 Priorities for Pelagic Biodiversity Conservation

Apart from whale and turtle fisheries (protected here in Tonga), deep slope fishery is the first priority to conserve in the pelagic biodiversity. King (1992) reported that snapper and grouper fisheries (refer list below) are fragile and easily susceptible to overfishing. Tuna fishery is regarded as highly migratory and it's hard to predict the stock population.

Priority list for Consevation:

1. Palu tavake (Long-tailed snapper)
2. Palu malau (Short-tailed snapper)
3. Mohuafi (Convict grouper)

These species are found at the offshore seamount at depths of more than 200 meters. This is the target species in deepwater fishing for export. Regulating deepwater fishery in view for sustainable harvesting is important.

5.2.1 Unique Aspects of the Pelagic Ecosystem

Marine pelagic or offshore ecosystems are not well documented due to the lack of appropriate equipment and manpower resources to conduct appropriate research. Most of the research works found are in the epipelagic zones, however, concentration on highly migratory species (i.e. tuna, whale and shark fisheries resource) while other pelagic species are unidentified especially deeper pelagic zones. MPAs news (September, Vol. 5, No. 3, 2003) reported that new research by a team from German and Canadian scientists suggested that tunas, sharks, sea turtles, and other large oceanic predators concentrate in diversity hotspots much like those that exist on land. The distinct locations at which these hotspots occur at intermediate latitudes close to habitat features like coral reefs, shelf breaks, and seamounts could provide the basis for open-ocean marine reserves to protect threatened species, say the researchers.

5.2.1.1 Seamounts

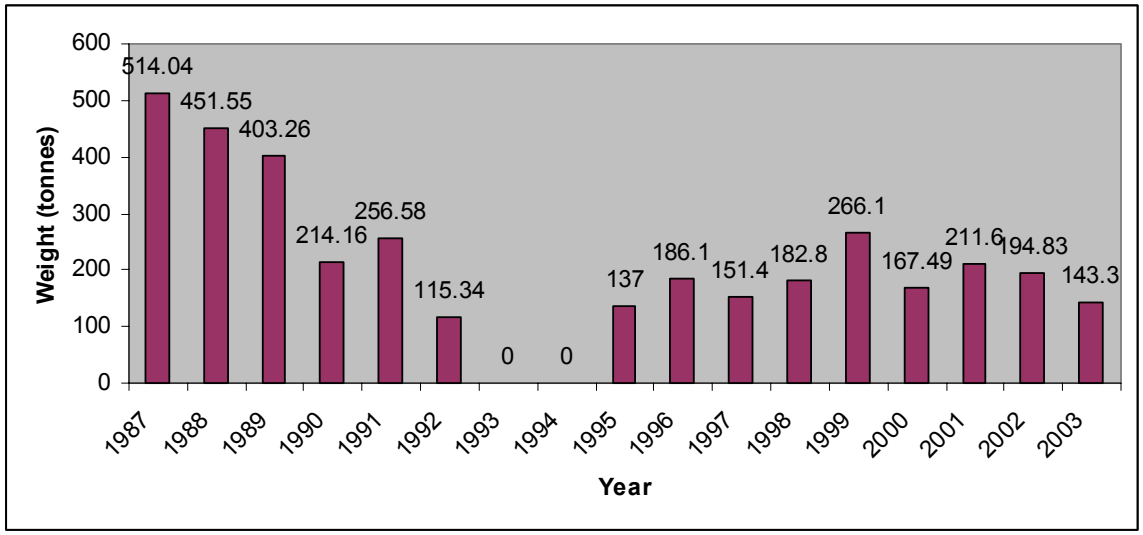
A chain of volcanic seamounts occurs on the Tonga ridge regarded as the fishable habitat for deep slope species following exploratory fishing by the South Pacific Commission (SPC) Fisheries programme (Langi and Langi, 1987; Langi *et al*., 1988; MRAG, 1994). The catch from bottomfishery is derived from both shallow water coastal shelves and banks, and offshore seamounts (Mead, 1979), (refer Table 5.1.2 & Chap 5 Appendix 2 & 4).

Table 5.1.2: Species Recorded on Offshore Seamounts (Depth > 200 meters)

Common name	Local name	Scientific name
Long-tailed snapper	Palu tavake	*Etelis coruscan*
Short-tailed snapper	Palu malau	*Etelis carbunculus*
Comet grouper	Ngatala pusi	*Epinephelus morrhua*
Convict grouper	Mohuafi	*Epinephelus octofaciatus*
Other important species		
Rusty jobfish	Palu polosi	*Aphareus rutilans*
Green jobfish	'Utu	*Aprion viresces*
Sea bream	Palumutumutu	*Paracaesio kusakarii*
Emperjack	Palumoana/Paluvai	*Seriola sp*
Species recorded at shallow coastal shelf and bank		
Golden eye jobfish	Palu sio'ata	*Pristopomoides flavipinnus*
Crimson jobfish	Palu hina	*Pristopomoides filamentosus*
Sweetlip emperor	Manga	*Lethrinus chrysostomus*

The Deep Water Snapper Fishery has been one of Tonga's main commercial fisheries since the 1980s. Landings data are available from 1987 to the present with a 2-year gap in data for 1993 and 1994. Total landing catch peaked in 1987 with 563 tonnes (Latu and Tulua, 1992) then settled to around 200 – 300 tonnes per year (MOF, 2001) for most of the 90s (refer Figure 5.2). It is the country's most profitable commercial fishery, with over T$2 million of export revenue (MOF, 2001), and employs over 200 people in fishing, marketing and other ancillary services. Tonga exports more snapper than any other Pacific Island country and the development of this fishery has been cited by some fishery experts as the most successful fisheries in the region (King, 1992).

Figure 5.2: Average Landing Catch main export Species from Deepwater Fishery (1987 – 2003).



(Source: Ministry of Fisheries Bottom-line Database - updated annually)

5.2.2 Economic and Cultural Importance of Documented Fisheries Resource

5.2.2.1 Tuna Fisheries Resource

Traditional fishing for skipjack in Tonga was carried out by trolling from canoes (***popao***), some with sails, using pearl-shell lures (***tofe***) and bamboo pole. This method was typical of Polynesian tradition. Bonito trolling is known as ***hi 'atu*** in Niuatoputapu where the ***'atu*** is still considered the king of fish (Dye, 1983).

Fishing as a communal effort was common, and catches in this case were distributed among the participants. Dye (1983) describes five mechanisms for catch distribution on Niuatoputapu, of which three (first listed below) were said to be the "Tongan way" of distribution of fish. The five mechanisms include ***vahevahe***, ***tufatufa***, ***kole***, donation to church feasts and sales. ***Vahevahe*** was most common and involved apportionment of fish to participants. ***Tufatufa*** is the distribution of fish to people outside the fishing party, to include church ministers, government representative, relatives and the neighbours. ***Kole*** is a request for fish either before or after the fishing expedition and adult's requests were always honored. The three "Tongan" mechanisms clearly indicate the nature of fishing in the old times was wholly subsistence. Schuh (1981) writes that the ***kole*** system in Tongan society is a constant barrier to developing commercial fishing, making it difficult for a private fisherman to own or maintain fishing gear, outboard engines and tools.

With the introduction and utilization of modern fishing gear including powered boats, tuna has become an important resource in the artisanal fishery for the local market. The fishing method employed is trolling, targeting skipjack, yellowfin, dogtooth tuna, marlin, barracuda, wahoo and dolphin fish.

The involvement of the government of Tonga in commercial tuna operating started in 1969 (on experimental basis) with is long-liner 'Ekiaki'[2]. A second and a third 'Tavake'[2] and 'Lofa'[12] arrived in 1976 and 1982 respectively. It was only with the arrival of Lofa that the tuna operations in Tonga become profitable. Catches were mostly exported, thus earning foreign exchange for the kingdom. Long lining has been mainly targeting albacore and yellowfin for the export market. Currently, more than 20 long-liner vessels have been licenced to exploit tuna fisheries resources with a total of 4000 tonnes per year as a total allowable catch (TAC) for only main target species (bigeye, albacore, yellowfin) annually for each licensed longline vessels.

In June, 1989 Tonga entered the Multilateral Treaty on Fisheries between the Governments of Certain Pacific Islands States and the Government of the United States of America. This allows US purse seiners to fish in EEZs of those Pacific Island States that sign the treaty for a set fee. Recently there is no report from SPC that US purse seiners fished at Tongan EEZ based on the information from SPC observer programme.

5.2.2.2 Small Pelagic Fisheries Resource

Some small pelagic species (refer Table 5.1.3) formed an important portion of the subsistence fishery in Tonga prior to the introduction of modern fishing methods such as gillnets, fish weirs and dynamites. No information could be located that documents traditional catching of flyingfish in Tonga. Dye (1983) reported that absent from the Niuatoputapu repertoire are such widely distributed fishing strategies as snaring, flying fish netting, dip netting and shark noosing. However, ***tau 'otule*** is practised. This is the catching of the scad, S. *crumenophthalmus*, using baited hooks and a pressure gas lamp suspended above the boat anchored at depths of about 17 fathoms. The bait is normally the intestines of small goatfishes and the lamp light attracts the '***otule***. The halfbeaks is one of the fishes caught in the ***kupega fakamamaha,*** which involves setting a seine net in the shape of a "C" with each

[12] Tavake, Ekiaki and Lofa were all donated by Japanese government in 1967, 1976 and 1982 respectively. Tavake maximum storage capacity of 40 mt whereas Lofa could reach to more than 70 mt.

end anchored near the shore or on a shallow spit of reef rock at high tide (Dye, cited above). The net is often set at night in anticipation of an early morning low tide. As the tide goes out, the net acts as a barrier to fish trying to flee. The fish are harvested at low tide. ***Fakapoa*** is a method that utilizes a net and bait (grated coconut) to specifically catch halfbeaks (***hu'ila***). The method is employed just off the windward reef where the bait is used to attract halfbeaks. The seine net is set surrounding the feeding fish and is scooped up at will.

Apart from their use at the subsistence level, the small pelagic fishes, although mostly seasonal in abundance, form a significant contribution in the artisanal fishery. Dye (cited above) listed ***'otule*** as one of the polytypic ***ika*** taxa that is economically important on Niuatoputapu. On 'Eua, ***'otule*** is also used as bait for pelagic hand-line night fishing for the large tunas, jacks and jobfish (Schuh, 1982). The ***'otule*** caught in the ***tau 'otule fishery method mentioned above is*** often used as live bait for catching larger predator fish species, such as trevallies, snappers, barracuda and sharks. The revised of landing catch species for the Ministry of Fisheries Inshore Fisheries Statistics project, targeting inshore fish landed in Nuku'alofa at Vuna and Faua landing sites, indicated ***'otule*** (horse mackerel) as one of the most important fish species (Class 1). Landing catch in all species type in 1994 was less than the landing catch in 1993 except for the barracuda ('Ono) and 'anga (sharks) considering there was more recorded in 1993.

Table 5.1.3: Total landing Catch of some Pelagic Species from Artisanal Fishery (kg).

year	'Atu Skipjack	'Anga Shark	'Ono Barracuda	'Otule Scud	Takuo Bigeye	V/Tonga Dogtooth	Mahimahi Dolphinfish
1993	17987		379	19281	14107	98	1337
1994	13833.1	160.2	950.4	7529.4	8707.2	51.5	162.7

(Source: Tulua *et al*, 1994 and 1995)

Attempts have been made to assess the availability of live baitfish resources in Tonga for use in the commercial pole-and-line fishery for skipjack. Locally caught live bait has been used both by the Ministry of Fisheries operated and research fishing vessels. The recent baitfish research examined the availability and suitability of the same resources for longlining of tunas, especially bigeye tuna but also albacore and yellowfin tuna. However, after the termination of this research, there is no more fishing boat to continue catching of bait fish.

5.2.2.3 Other Tuna Pelagic Fishes

The oceanic pelagic species form a portion of the catches made in the troll and longline fisheries for tuna, in both the artisanal and commercial operations. They are an important component of the FAD catch. Sportfishing occurs in Tonga and it specifically targets billfish and ***mahimahi***. On Niuatoputapu, barracuda (*Sphyraena* sp.) is one of the species caught in the traditional ***tau 'otule***. In addition, wahoo is one of the fish species caught in the ***fakatele***, one of the indigenous trolling methods (Dye, 1983), (refer Chap 5 Appendix 4).

5.3 Cartilaginous Fishes

Shark fisheries resource:

In the past, shark meat seems to have had an important role and contributed substantially to the fish portion of the local diet in Tonga, especially in the outer islands. Traditional fishing for shark also appears to have been more frequent then. An interview with an 81-year old fisherman (Tafakula Vaiangina) on 'Eua in 1980 indicated that local people used to catch and eat a lot more shark than at present (Schuh, 1981). ***Siu'anga*** (***tau 'anga***), the traditional shark fishing, was believed to have come to 'Eua from 'Euaiki.

Similar to other Polynesian traditions, e.g. Samoa, shark fishing in Tonga is only performed by certain specialized fishermen within a community. Traditionally, sharks are captured using a noose after being enticed alongside a boat by a coconut rattle which consists of a metre-long loop of twine from which several halved coconut shells were suspended (Zann, 1981). "The first shark to show up is always given great respect and is named after the most beautiful lady “Hina”. She is given flower laurels as well as a bowl of ***kava*** before she is asked to go and return with all her friends from the deep. A little while after Hina disappears; more sharks come up near where the boat is. Bait is then thrown out on a line, and as the shark approaches, it is drawn back to the boat. As the shark follows the bait alongside the boat, a noose is thrown around the bait and is drawn up and slipped round the shark's neck. The shark is then pulled on board and killed. If the first shark disappears from the water with little disturbance, the next can be caught in exactly the same way" (Vaea and Straatmans, 1954).

Modern methods are now used in shark fishing, e.g. on 'Eua "a No.1 shark hook secured with a chain leader to about 50 meters of strong nylon rope. Two 50 cm floats are attached to the line as tethers to

tire the shark out. Baits used are skipjack, tuna heads or a dog" (Schuh, 1982). The same author noted that "many fishermen were reluctant to add gear and confusion to their boats by shark fishing in conjunction with troll and bottom fishing, yet a single shark can make the difference between a marginal fishing trip and a profitable one". Together with bottom-fish species, shark was reported by the same author as one of the main species caught in bottom handline fishing on 'Eua at depths of 80-250 m. During the 2-year project, the largest shark caught was a 4.6 m tiger shark in July, 1981.

At the subsistence and artisanal levels, hand-lines, gill nets and spear diving are the main methods by which sharks are now caught (Fuka, 1979). Blue and mako sharks are not utilized as food in Tonga (JICA, 1977).

In longlining operations by long-liners have licensed to exploit tuna fisheries, shark forms a fair portion of the catch and has been included in its commercial exports with tuna especially targeted shark fin.

5.4 Reptiles

Turtle fisheries resource:

In the past, turtle's meat was a common source of protein for the Tongan people whereas turtle shell provided material for local crafts (Anon, 1974). Nets made specifically for catching turtles were made of twine spun from coconut husks. Mesh sizes of these nets were 1ft 4 inches (Fuka, 1979). Small stones were used as sinkers while breadfruit timber served as floats. Nets were carried to the fishing grounds on a canoe or sailboat. The nets were hung across areas frequented by turtles, usually the green turtles, *C. mydas*, which become entangled in the net (Zann, 1981). Fishing for turtles at night was also practised where 2-3 fishermen take a canoe out, using lit dry coconut leaves as a torch, held by one fisherman standing in the front of the canoe. A spear was used when a turtle was sighted. Periods of rough seas near the beach were believed to be the best time to find turtles. When fishing in the sea was not fruitful, the fishermen would wait on the beach for turtles coming to lay eggs. Cotton multifilament and monofilament nets have replaced the traditional fibre nets, and then spear gun is a recent additional gear. On Tongatapu, there is a group of fishermen who specializes in spearing green turtles, using hand spear and spear gun (Anon, 1990). They search for turtles swimming on the surface of reef lakes or around the reef skirts. Special turtle fences made of chicken wire were also used to catch turtles (Pritchard, 1981).

By definition, the people of Niuatoputapu, as is common in other Polynesian cultures, include turtles as fish (***ika***) (Dye 1983).

Collection of turtle eggs at the subsistence level has been, and still is, a practice on islands where turtles nest. Nesting site surveys conducted in the early 1970's on uninhabited islands where turtle nesting is believed to take place indicated that the practice of turtle egg collecting by nearby islands inhabitants was very common. Shell of the hawksbill is used for the production of tortoiseshell jewellery, which includes combs, bracelets and hooks. Whole shells of both species are used for indoor decorations.

5.5 Molluscs

Octopus fisheries resource:

Octopus are a Tongan delicacy (Zann, 1981) and are normally hooked out of crevices at low water using a steel hook, or are caught from canoes with a hook on a pole, which is used to probe holes below the tide mark (Zann, 1981). However, the best-known method of octopus fishing is the ***makafeke*** (octopus rat lure baiting).

One of the important components of canoe fishing activities on Ha'apai is the octopus-lure fishing. This is confined to the reefs; a good catch of octopus means a good source of income (Halapua, 1981). Dried octopus and salted fish that are often sold in Nuku'alofa market, usually originate from Ha'apai.

Thomas (1978) noted that the outer-island groups offer export potential for several marine species from Tonga, including frozen packed octopus.

In addition to the consumption of octopus locally, they also form an important part in the handline fishery, as octopus is one of the main baits used. On most of the islands surveyed in the Ha'apai group in 1973 by the Fisheries Division, fish, octopus and clams are used as bait for handline fishing, which is the most important fishing method that occurs there. This fishery normally occurs in the coastal waters but sometimes the fishermen go out in the deeper waters. It can be conducted in day or nighttime. Sometimes the fishermen do not use canoes but walk through the sea while fishing during

low tide. Schuh (1982) also reported octopus as one of the most commonly used baits for bottom handline fishing (***taumata'u***) on 'Eua.

5.6 Squid and Cuttlefish Fisheries

Squid (*Ngufeke*) is not a very popular fishery here in Tonga but is believed to be one of the bycatch in trawler, longline, and even deepwater dropline fisheries. There is no information about the species diversity and also there is no commercial value nationally. However, squid is used as bait which currently imported from overseas to use by both deepwater dropline and longline fisheries.

5.7 Marine Mammals

Whale fisheries resource:

Whale meat is one of the protein sources of Tongan people in the past especially humpback whale. Currently, whale bone is one of the most important products for the jeweler trader here in Tonga.

The Tongan people hunted humpback whales from the 1890s using open boats and hand harpoons. Whaling was small scale; with annual catches prior to the early 1960s probably not exceeding 30-40 whales (cited by Donoghue *et al*., 1996 from Dawbin 1966 report which unavailable). This subsistence hunting persisted until the cessation of whaling by Royal decree in 1978 (Donoghue *et al*., 1996). Extrapolation from whaling logbooks suggested more than 3,000 humpbacks killed in Oceania from 1905-1909, mostly in Tonga (South Pacific Humpback Whale Research Project, 2003).

Donoghue *et al*., (1996) suggested that a major wintering aggregation of the eastern migratory component of the Group V humpback stock occurs in the waters around Tonga. South Pacific Humpback Whale Research Project (2003) reported that humpback whales are found in Tongan waters from late June to early November but the greatest densities are observed during August and September with an apparent peak in early September

5.8 Marine plant - Phytoplankton

Phytoplanktons are the most important primary producer in pelagic ecosystem especially epipelagic zone. Epipelagic zone is often defined as the zone from the surface down to a given depth, commonly 200 meter. The epipelagic is therefore similar the photic zone, the zone from the surface to the depth where there is no longer enough light for plants to grow by photosynthesis as phytoplankton do.

5.9 Threats and Pressures of Pelagic Biodiveristy

Long-line fishing method using modern gear technology is the major pressure on tuna fisheries resource here in Tongan water plus the demand from the tuna market especially Japanese's sashimi market. In the past decade, few long-line vessels participated on exploitation of tuna fisheries resource compare to about more than 25 vessels currently have a license to exploit tuna resources.

The night/day divers are the major pressure for the turtle fisheries, which the most common fishing method had practiced on the last decade (Halapua, 1982). Using net made from coconut husk (Kafa fonu) is only traditional fishing method employed by Tongan people in the past but very rare to use nowadays (Bell *et al*., 1997).

5.10 How and by Whom Marine Biodiversity are being Used

Tuna Fishery:

In the past two decades, most fishing was concentrated on the deep-water slope fishery, which exploited bottomfishes on the nearshore slope of the archipelago and numerous seamounts (King, 1992). The tuna fishery has developed recently, with one majority owned government company (Sea Star Fishing Co.) and a number of private Tongan companies becoming involved in the fishery over the past decade. Over the past 5 years, the size of the domestic fleet has grown 5 to 16 active vessels, with a move from smaller (under 15 meters) to larger vessels (over 15 meters) over the past few years (refer Table 5.1.4).

Table 5.1.4 Number of Longline Vessels and Company which participated on Exploitation of Tuna Fisheries Resources

Company or Owner	No. of vessels	Length (meters)
Alatini Fisheries Co. Ltd	2	18 to 19
Friendly Islands Fishing	1	20
Sea Star	2	29
Maui Pacific	1	18
Fung Shing	3	23 to 37
Tokaikolo	1	23.27
R.I.O.T Unifi Ltd	4	32 to 39.25
Southern Seas Fishing	5	27.17
Ministry of Education	1	39.39
Ministry of Fisheries	1	28

(Source: Ministry of Fisheries, 2003)

Sport fishing is very important occasion here in Tongan water, which hosted by Tongatapu and Vava'u annually, targeting billfish such as marlin and mahimahi. Game and sport fishing operators target tourists and some brought their own vessels. In the mean time about 8 operators have been issued with license to operate in Tongan waters (www.tongaholiday.com), (Table 5.1.5).

Table 5.1.5 Current Game and Sports Fishing Operators

Operators	Location
Dora Maria	Vava'u
Hakula Lodge	Vava'u
Ika Lahi Gamefishing Lodge	Vava'u
Kiwi Magic	Vava'u
Mounu Island Gamefishing	Vava'u
Target One	Vava'u
Lady Di	'Eua
Royal Sunset Island Resort	Tongatapu

Source: Tonga Holiday: www.tongaholiday.com

5.11 Sustainable Use of Pelagic Biodiversity

5.11.1 Tuna Fishery

The new Tuna Management Plan, which endorsed by Minister for Fisheries in 2003 provides measures for a sustainable of tuna fishing in Tonga. The regulatory measures are applied in this Plan is to ensure the sustainable harvest of the resource and provide for the orderly development of the fishery, include:

i) limits on the level of catch of one or more species[13];

[13] Total allowable catch for each vessel annually is 4000 mt.

ii) limits on the level of fishing effort, including vessel numbers[14], types and sizes[15];
iii) controls on fishing activities, including gear restrictions[16] and deployment of fish aggregative devices (FADs);
iv) size limits for individual species[7]; and
v) area or seasonal closures[17].

This regulatory measure can be revised from time to time, in consultation with the Tuna Consultative Committee, as circumstances in the fishery change or as information on the status of the resource received. At this development stage of the fishery, the harvest target level comprises all the main tuna species. In the future, it is likely that each of these species will require a separate harvest level to minimize the loss of biodiversity from overfishing strategy. It is recognised that vessel limits constitute an inexact means of controlling fishing effort, however, at the current stage of the development of the industry, with inadequate catch data, as well as the current capacity of the Ministry, it is considered to be appropriate. Consideration will be given in future to developing closer proxies for fishing effort, such as hook limits.

5.11.2 Whale and Turtle Fishery

Whale and marine turtle fisheries (hawksbill turtle) are currently protected here in Tongan water, which stressed by Fisheries Regulation, 1994. Apart from hawksbill turtle, which totally banned from fishing, closed season is applied to other species (November to February) and size limitation[18] to maintain the population.

5.11.3 Bottom-line Fishery

Available data on the deepwater snapper fishery are consistent with a resource that is fragile and easily susceptible to over fishing (King, 1992). The species are slow growing and long lived; initial catches of large-sized, older fish rapidly give way to those of younger, smaller fish (Langi and King, 1994). Langi *et al.,* (1992) reported that many seamounts are very small, which support-limited populations that could be easily depleted. Since 1986, the total annual catch of all deepwater snapper throughout

[14] The tuna fishery is initial limit to 25 vessels but will be reviewed in line with any future development of an alia fleet, with a view to introducing licence categories for different classes of vessels.
[15] Size of the vessels should not be more than 50 meters.
[16] Only longline fishing method is allowed.
[17] Not applicable in this stage due to not enough data base on biology of tunas.
[18] Illegal size for the turtle (Hawksbill turtle not included) is 45 cm.

the Kingdom is estimated to have peaked in 1987 at 514 tonnes, and subsequently to have declined to the 1999 level of 266 tonnes.

Regulatory measures for deepwater snapper fishery:

1. Limit fleet size 15 meters
2 Limit licensed to 25 vessels
3 Total allowable catch of 210 tonnes per year for only export species[19]
4 Licenses are to be permitted only for locally owned fishing vessels
5 Only fishing reel allowed to use for exploit of deepwater fishery

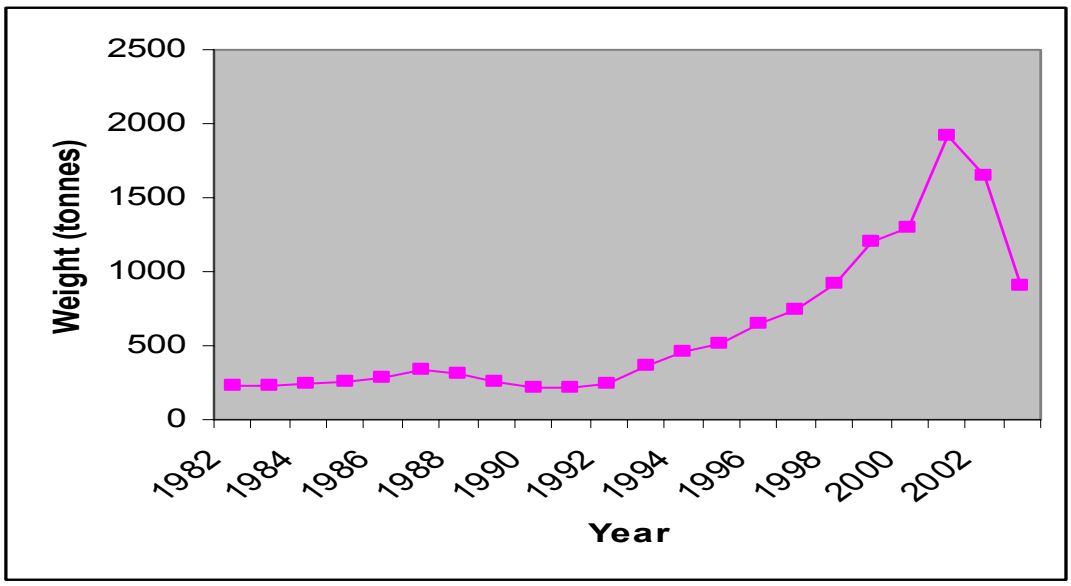
The above control measures can be revised from time to time, in consultation with Deepwater Fishery Management Committee.

5.12 Trends in Threats, Pressures

Total production of tuna fisheries in this day are varied according to the data being collected by Ministry of Fisheries since 1982 (refer to Figure 5.3). The highest landing catch was recorded in 1997 to 2002, which ranged from 923 to 1919 tonnes. During 1980s most of the catch is landed from only Lofa long-liner, which owned by the government. In late 1990s more fishing vessels are involved at exploitation of tuna resources after successfully development of the market to tuna fisheries especially fresh tuna market. Currently more longline fishing vessels are tied up at the wharf due to the declining of the stock but there is no scientific evidence to prove that the stock is overexploited.

[19] Export species for deepwater fisheries are Long-tailed and short-tailed snapper, comet and convict grouper, and golden eye and crimson jobfish

Figure 5.3. Total landing catch for Tuna Fisheries for 1982 to 2003.



Estimated landing catch for tuna fisheries as from 1982 to 2003 as shown in Fig 5.3.

Year	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	
Catch	229	232	244	260	280	333	306	261	212	
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Catch	217	250	367	454	515	647	739	923	1202	1291
Year	**2001**	**2002**	**2003**							
Catch	1919	1647	904							

Source: Ministry of Fisheries Tuna Database

5.12.1 Causes of Threats and Pressures for Unsustainable Uses

The most direct causes of threat to the pelagic biodiversity are human activities (fishing activities). Many company invested in modern gear technology to compete with other fishers, which ended up with overfishing. Improving of technology contributes to the ability of both subsistence and commercial fishers to exploit stocks without large increases in fishing effort. In regard to turtle fisheries, Wilkinson (1979) wrote that even with the cessation of human predation, potential threats to turtle populations in the Pacific include pigs, dogs, rats, several crab species, sea birds, rock shores and reef fishes. In regard to shark fishery, longline fishing has great impact on shark population because most fishers targeted tunas so shark as bycatch, and some fishers just cut the fins and released the rest of the body.

The increased fishing pressure driven by improvement access to markets and rising price for major commercial species resulting in marked declines of the resources, or unsustainable uses of the resources. This is one of the indirect pressures that lead to the overexploited of resources. As a result little incentive exists for individuals to practice conservation. A fisher leaving a fish in the sea for tomorrow simply gives his competitors a chance to catch that fish today.

5.13 Equitable Sharing of Benefits

5.13.1 Indigenous Knowledge

Indigenous skill and knowledge on exploiting of the pelagic resources were 'freely' shared and passed on through word of mouth or practice, such as using pearl oyster shell as a lure for trolling skipjack are not used in these days. Same issue for ***kafa fonu*** and ***no'o 'anga*** methods due to many commercial companies have invested in modern technology just as longline fishing. Thus, there is no benefit for the local fishers in these days. However, many commercial fishing companies use local fishers due to their local knowledge and experienced.

5.13.2 Beneficiaries from Multilateral Treaty

Under the Multilateral Treaty on Fisheries between the governments of Certain Pacific Island States and the government of the United States of America, an annual amount of US$18 million is paid to Forum Fisheries Agency (FFA), as the Treaty Funds Administrator (Table 5.1.6). This amount is then shared amongst the Pacific Island States who are party to the Treaty based on an agree formula. Tonga, as a party to the Treaty has received the following amounts since 1997. These funds were paid directly to the Government's general revenue (MOF, 2002).

Table 5.1.6 Total revenue collected from Multilateral Treaty

Licensing period (year)	11th 1998	12th 1999	13th 2000	14th 2001	15th 2002
US$	148,446.53	148,661.22	148,131.22	147,682.00	147,321.72
T$	2118,818.59	230,947.99	284,584.02	310,388.29	309,564.45

Source: Ministry of Fisheries Annual Report, 2002

Employment is one of the beneficial option from pelagic resource due to more than hundred local people currently employed by the tuna industries company, ecotourism (whale watching), and Game and Sport Fishing operators here in Tonga, which included fishermen, marine engineer, marketing people, fish processor, and also graduated people from local and international institutions in different carrier (Tuna Conference hosted by Ministry of Fisheries, 2003).

Approximately more than 50% of the total exports from fisheries come from pelagic species resources (tuna **and** shark dried fin, snapper) also the largest contribution to the economy in term of foreign exchange when compared to other fisheries (refer Table 5.1.7). The revenue collected from Whale Watching and Game and Sport Fishing activities is not included here.

Table 5.1.7. Total Export for Fisheries Product 2000 - 2002.

Year	Tuna*	Snapper**	Aquarium rock	Live fish, clams and soft coral	Dried* shark fin	Seaweed and others	FOB value ($T in million)
2000	786.1 mt	140.12 mt	137.46 mt	217,951 pc	1.62 mt	310 mt	14.8
2001	1202.04 mt	186.2 mt	259.72 mt	245,653 pc	4.33 mt	121.92 mt	10.4
2002	730.13 mt	174.71 mt	318.96 mt	296,951 pc	6.8 mt	285.84 mt	15.2

N.B. * indicated the pelagic production. ** indicated deepwater fishery production
Source: Ministry of Fisheries Annual Report 2000 to 2002

5.13.3 Equitability of Exploitation

Unlike most Pacific Island nations, coastal communities in Tonga traditionally do not have preferential access to adjacent marine areas. That is, the situation is one of open access, where everyone can access any fishing grounds. Simlarly, with regard to pelagic biodiversity, no individual/group or company has exclusively property right. Thus, each individual fishery is motivated to compete for a maximum share of the common resource. Little incentive exists for individuals to practice conservation. However, the Ministry of Fisheries has prepared regulations to monitor exploitation level of most important fisheries resource. Tuna fishery is one of the most important commercial fisheries in Tongan waters especially at the oceanic pelagic zone, which also attract the foreigner company to invest in this fishery. As a result the ministry issued a licensing structure for the longline fishery to protect the property right of the national business.

Table 5.1.8 Summary of Licensing Structure for the Longline Fishery

Type of Company	Licence type	Type of vessel that can be licensed
Tongan company	5 year; subject to annual endorsement Transferable (subject to conditions)	Local fishing vessel Locally based foreign fishing vessel
Foreign-owned local company	3 year; subject to annual endorsement Non-transferable	Local fishing vessel Locally based foreign fishing vessel
Foreign company or fishing association	Subject to access agreements Non-transferable	Foreign fishing vessel

Source: Tuna Management Plan, Ministry of Fisheries, 2003

Licences granted to Tongan companies will be transferable to a third party on a permanent basis if party would qualify in his/her own right as a Tongan company (Table 5.1.8). The transferred licences will only be valid for the balance of the five years remaining, but shall be renewable subject to the licence holder complying with the terms and conditions of the licence.

A Foreign-owned local company, subject to approval from the Secretary, may charter or lease a foreign fishing vessel to fish against its licence. Such a vessel must comply with the rules governing a locally-based foreign fishing vessel. Foreign company or fishing associations shall be granted licences according to the terms of access negotiated and agreed with the Government of Tonga. Licenced issued such as access agreement will be of no more than one year's duration.

In addition to any licence conditions specified by the Government of Tonga, the conditions attached to licences issues to foreign fishing vessels shall conform to the *Harmonised Minimum Terms and Conditions for Foreign Fishing Vessel Access* as amended from time to time by the Forum Fisheries Committee.

5. 14 Institutional Framework and Human Resource Base

5.14.1 Current Institutional Responsibilities

The Ministry of Fisheries is responsible to control development and management of the oceanic fisheries resources. The Ministry of Land, Survey and Natural Resource coordinated policy making and new establish Environment Department is responsible for environmental impact assessment.

5.14.2 Institutional Strengths and Weakness

These strengths and weakness are only focused on human resources at Ministry of Fisheries.

Strengths:

- Preparation of legislations to control and monitoring the pelagic ecosystem.
- Development of fishing industries for tuna fisheries.
- Supply technical advice for the fishers who participated on harvesting the resources.
- Preparation of management plan (e.g. Tuna Management Plan) to implement acts and regulations.
- Conducted workshop, training and conference.
- Participated on international convention and treaty.

Weakness:

- Lack of enforcement.
- Lack of co-ordination between government agency that involved in management and conservation of the pelagic biodiversity.
- Lack of skills and knowledge to conduct scientific research to identify species abundance of the pelagic resources (e.g. Fish taxonomy).

The whale watching industry is one of the conservation strategies to protect this fishery. The Visitors Bureau issues the licences for whale watch operators whereas Ministry of Fisheries is not involved. This is an issue raised in a workshop on whale conservation in 2003. The Ministry of Fisheries is responsible for the control of all fisheries resource under the *Fisheries Act, 1989*.

5.14.3 Adequacy of Funding

The Ministry of Fisheries annual recurrent budget for the management of tuna is very minimal apart from the salary of staff. However, SPC allocated fund for monitoring tuna fisheries resources, which used to pay for data collection and observers programme each year since 1994. The average amount ranged from T$5000 to T$10,000 per year.

5.15 Legal and Policy Framework

5.15.1 Legislative and Policy Framework

Royal Proclamation 1887: The proclamation defines the extent and boundaries of the Kingdom of Tonga within the latitudes 15°S and 23.5°S and longitudes 173°W and 177° W from the Meridian of Greenwich.

Royal Proclamation 1972: This proclamation defines the islands of Teleki Tokelau (North Minerva Reef) and Teleki Tonga (south Minerva Reef) and all islands, rocks, reefs, foreshores and waters lying within a radius of twelve miles thereof as part of the Kingdom of Tonga.

The Continental Shelf Act of 1970 [CAP. 63]: The Act provides for the protection, exploration and exploitation of the continental shelf, the prevention of pollution in consequence of works in connection with the shelf, and for matters connected with those purposes. It empowers the King, by Order-in-Council, to delineate the boundaries of the Continental Shelf. No order has been made in exercise of this power (Campell and Lodge, 1993).

The Territorial Sea and Exclusive Economic Zone Act 1978: This Act is not in force. But if it will be, it would establish a twelve nautical mile territorial sea and a 200 nautical mile exclusive economic zone (Campell and Lodge, 1993). The total area of the EEZ would be about 700,000 km^2 as compared to approximately 400,000 km^2 covered by the Royal Proclamation 1887.

The Fisheries Act 1989: The Act provides for the management and development of fisheries in Tonga and other matters incidental thereto and repeals the Fisheries Regulation Act, 1923, the Fisheries Protection Act, 1973, and the Whaling Industry Act, 1935.

Section 2 of the Act defines fisheries waters as the territorial waters of the Kingdom, internal waters, including lagoons, and such other waters over which the Kingdom of Tonga claims sovereign rights or jurisdiction with respect to the marine living resources by legislative enactment or by Royal Proclamation.

Part II of the Act deals with Fisheries Conservation, Management and Development. Section 3 requires the Secretary of Fisheries to progressively prepare and keep under review plans for the conservation, management and development of the fisheries in the fisheries waters of Tonga. The Secretary is required to consult with local government authority and local fishermen concerned in the preparation and review of each fishery plan. The Minister approves these plans. The same part of the Act includes sections on:

- Registration of Local Fishing Vessels
- Local Fishing Vessel Licenses
- Local Committees
- Commercial Sports Fishing
- Foreign Investment in Fisheries.

Part III: Foreign Fishing, and includes sections on:

- Foreign Fishing Vessel Licenses
- Other Agreements and Arrangements
- Stowage of Fishing Gear
- Marine Scientific Research Operations

The Act clarifies that the kingdom may enter into bi-lateral or multi-lateral access agreements or arrangements providing for the allocation of fishing rights. Foreign fishing vessels require a fishing license to fish in Tongan fisheries waters under the Act. Section 28 requires that anyone engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed. Section 59 of the Act empowers the Minister to make regulations for the implementation of its purposes and provisions.

Part V: General Provisions, including:

- Prohibited Fishing Methods
- Reserved Fishing Areas
- Fish Processing Establishments
- Leasing of Land for Aquaculture
- Import and Export of Live Fish
- Controls over the Export of Fish and Fish Products
- Statistics

Under Section 59 of the same Act the Minister may make regulations not inconsistent with the Act for the implementation of its purposes and provisions.

Parks and Reserves Act 1976: The following Parks and Reserves were established under this Act:

* Hakaumama'o Reef
* Pangaimotu Reef Reserve
* Monuafe Island Park and Reef Reserve
* Ha'atafu Beach Reserve
* Malinoa Island Park and Reef Reserve.

Fisheries Regulations: Three separate sets of Fisheries Regulations have been proposed by the Ministry of Fisheries and are currently under review to implement the Fisheries Act 1989. The main

objectives of these regulations are regarded as rules or direction for fisheries conservation and management, foreign fishing and local fishing issues in comply with main fisheries law (Fisheries Act 1989).

The Fisheries (Conservation and Management) Regulations 1994.

The Fisheries (Foreign Fishing) Regulations 1992.

The Fisheries (Local Fishing) Regulations 1995.

***Fisheries Management Act 2002*:**

The new 2002 Fisheries Management Act is to amend the Fisheries Act 1989. For instance, fishing licences in Fisheries Act 1989 was very general but Fisheries Management Act 2002 categorized into detail. Part IV of the new Fisheries Management Act 2002 has detailed the requirements and conditions for local fishing vessel licences, commercial sport fishing licences, locally based foreign fishing vessel licences, and fishery scientific research and test fishing operations or survey licences.

Further, the new 2002 Fisheries Act requires conservation, management, sustainable utilization and development of fisheries resources in the Kingdom and the fisheries waters through the consideration of the following:

(a) the need to ensure the long term conservation and sustainable use of fishery resources, and to this end adopt management measures which promote the objective of optimum utilization and to achieve economic growth, human resource development, employment creation and sound ecological balance;

(b) the need to ensure that management measures are based on the best scientific evidence available;

(c) the application of the precautionary approach at no less standard than set by criteria in the Fish Stocks Agreement or any other fisheries management agreement;

(d) the need to conserve aquatic living resources and protect biodiversity in the marine environment for present and future generations;

(e) the need to protect the ecosystem as a whole and the general aquatic environment and adopt, where necessary, conservation and management measures for species belonging to the same ecosystem or associated with or dependent upon target stocks;

(f) the need to take measures to prevent or eliminate over-fishing and access fishing capacity and to ensure that the levels of fishing effort do not exceed those commensurate with sustainable use of fishery resources;

(g) the need to collect and share in a timely manner and in accordance with fisheries management agreements and inte a lia, vessel position, catch of target and non target species and fishing effort, as well as information from national and international research programmes;

(h) the need to promote and conduct scientific research and develop appropriate technologies in support of fishery conservation and management;

(i) the interests of artisanal and subsistence fishers;

(j) any relevant obligations of Tonga under applicable rules of international law and international agreement.

5.15.2 Tuna Exploitation Policy

His Majesty's Cabinet approved this policy on 28 October, 1993 and is as follows:

1. That with the exception of activities carried out under regional treaties, foreign-based fishing vessels be not allowed access to the tuna resources of Tonga and that only locally-based vessels working through local companies are allowed to harvest tuna;

2. That the Ministry of Fisheries be initially responsible for grading tuna for export;

3. That the Ministry of Fisheries is responsible for the implementation of this policy and assistance is to be provided by all Ministries/Departments as required.

The Territorial Sea and Exclusive Economic Zone Act 1978: This Act defines Tonga's territorial sea and EEZ. Under the Act, a license is required for a foreign fishing vessel to engage in fishing within Tonga's EEZ. In addition, the Minister is empowered to determine allowable catch with respect to every fishery within the EEZ. However, this Act has not come into force because a date has not been appointed by the King in Privy Council for its coming into force as required under the Act.

Recommended legislation/policy regarding exploitation: Three separate sets of Fisheries Regulations have been proposed. These are the Fisheries (Foreign Fishing) Regulations, Fisheries (Conservation and Management) Regulations and Fisheries (Local Fishing) Regulations.

The current rate of exploitation of tunas in Tonga is low relative to the resource abundance present. Thus the potential for further development is substantial and the Ministry of Fisheries may need to encourage exploitation along the lines provided by DP 6, which is, to create an environment conducive to the development of private sector involvement in fisheries. Compliance with Section 28 of the

Fisheries Act 1989 needs to be improved by the fish operators and exporters in order to obtain more accurate figures on the resource in Tonga.

Shark:

Current legislation/policy regarding exploitation: There is currently no regulation that specifically deals with the shark resource.

Recommended legislation/policy regarding exploitation: No regulation seems necessary except FAO and UN trying to stopped catch and release or bycatch fishery from seine and trawler fisheries, which shark is included but in Tonga.

Turtle:

Current legislation/policy: A closed season from 1 December to 31 January was introduced in 1967. This was subsequently changed to also include November. In addition a license was required to put up a fence to catch turtles. The minimum mesh size was 1.5 in. across and fence width and length was limited to 450 ft. (Braley, 1973).

Recommended legislation/policy: The Fisheries (Conservation and Management) Regulations 1994 include the following, specifically for sea turtles:

No person shall -

(a) disturb, take, have in his possession, sell or purchase any turtle eggs;
(b) interfere with or disturb in any way any turtle nest;
(c) sell, purchase or export any turtle or the shell thereof of the species Eretmochelys imbricata, known as the hawksbill turtle;
(d) use a spear or spear gun for the purpose of capturing, destroying or taking any species of turtles;
(e) closed seasons: All turtle species except leatherback - 1 November to 31 January;Leatherback - 1 January to 31 December.

Establishment of some islands as reserves for turtles and other animals seems possible especially those that are government owned. Introduction of minimum size limits has been successfully applied in some countries as a step towards management of the turtle resource. Involvement of communities in the management of these resources and the enforcement of regulations is probably the most practical means towards attaining goals in this area.

Whale:

Whale fishery is currently protected here in Tongan water since Royal degree in 1978 and so there is no current legislation in term of management and conservation except new *Fisheries Management Act 2002*. One of the considerations included the need to implement and conduct scientific research and develops appropriate technologies in support fishery conservation and management, which applicable to protect whale fishery.

5.16 Relevant Programs and Projects

(1) Project Title: Vessel Monitoring System for Tracking of Fishing Vessels Operating in Tonga

Goals and objective: To ensure and monitor compliance with fisheries management and conservation rules by licenced fishing vessels (Tuna longline fishing vessels).

Donor: Tonga Fisheries Project (AusAID), Fishing Industry, Ministry of Fisheries

Implementing agencies: Monitoring and Surveillance Section, Ministry of Fisheries

Starting date and duration: Nov. 2003 to 2006

Budget: US$150,000

Summary of strategies employed:

* Ensuring the sustainable use of the fisheries resource
* Improve monitoring
* Control and surveillance capacity and effectiveness
* Enhance safety at sea and emergency response capacity
* Enable and enhance collection or near real time fisheries catch data
* Enable vessel owners to increase productivity and profitability of fishing activities through a capacity to track vessels and monitor real time activities

Summary of results to date: 5 VMS had been installed into 5 licenced fishing long-liner vessel included 2 exploratory fishing vessels owned by GJ fishing company.

Evaluation: Good management tool to control the exploitation of the pelagic biodiversity in a sustainable manner.

(2) Project title: Mini Longline Trial and Bait

Goals and Objectives: Diversify inshore fisheries to deepwater fisheries resources

Donor: RDA, USA

Implementing agency: Research Section, Ministry of Fisheries

Starting date and duration: 1990 – 1993
Budget: Unknown but likely around US$5 to 10 million

Summary of strategy employed:

* Diversify inshore fisheries to deepwater fisheries (using longline techniques).
* Research on how efficiency of bait production.
* Pin point the perfect fishing ground for tunas.
* Conduct scientific research on tuna's migration pattern.

Summary of results to Date: More local fishers are involved in longline fisheries but unfortunately bait production is not very convenient to use commercially.

Evaluation by local consultant of the soundness of the project or programme:

Baitfish was successfully exploited in Vava'u area but never used by the commercial tuna long-liner due to lower production to accommodate the need from Tuna Company. After the mini longline trial, about 20 tuna longline the Ministry of Fisheries both domestic and international was monitored by the MOF in relation to Tuna Management. However, the cost of this project was relatively high and most of the local fishers were not able to participate due to the running cost was too high. International companies own most of the companies with local fishers benefiting from being shareholders (49% go to international company while 51 % go to the local shareholder).

(3) Project Title: Tonga Fisheries Project (AusAID)

Goals and Objectives: Providing assistance to small-scale fishers and developing commercial tuna longline fishing.

Implementing agencies: Ministry of Fisheries

Starting Date and Duration: 1998 – 2002 then extended to another 4 years.

Budget: FADs $797,858 approximately

Summary of strategies employed:

* Extending the original proposals for fish aggregating devices (FADs) to increase the number, make them more suitable to the needs of small-scale fishers, addressing environmental and safety issues and finding innovative ways of making them self-funding.
* Refurbishing the MV Ekiaki.
* Developing cost-effective and innovative approaches to asset management, in relation to MV Takuo and five fishing vessels recently donated by the Korean government.

Summary of result to date: 2 Korean fishing vessels were conducted exploratory fishing in Tongan water plus more than 10 FADs had been deployed throughout the Kingdom.

Evaluation by local consultant of the soundness of the project or programme: Deploying of FADs is an effective way to improve the catch production for commercial fisher plus reducing cost (running cost) in regarding to reduce time spends on seeking fishing ground. On the other hand, the master fisherman of the project should provide technical advisory services and practical assistance to tuna fishing vessel operators and crews in response to request. He will also work with Ministry of Fisheries counterparts to upgrade their ability to identify and source specialized advice and assistance to commercial tuna fishing through regional and international fisheries agencies and bi-lateral technical exchange programs.

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www.cites.org/eng/append/appendices.shtml

www.holidaytonga.com

Annexures:

Appendix 1

Table 1. List of most species found in Tongan pelagic zones.

Common name	Local name	Scientific name	Fishing method	References
Fin fish				
Tuna				
Skipjack	‘Atu	*Katsuwonus pelamis*	Trolling, long-line, purseine net,	***Klawe 1978, Collette and Nauen 198***
Yellow-fin	Takuo	*Thunnus albacares*		
Albacore	Alapakoa	*T. alaunga*		
Bigeye	Piki’ai	*T. obesus*		
Mackerel or little tuna	Kavakava	*Euthynnus affinis*		
Frigate tuna	Kahikahi	*Auxis thazard*		
Dogtooth tuna	Valu tonga	*Gynosarda unicolor*		
Small pelagic (Bait-fishes)				
Anchovies		*Stolephorus devisi*		***Dalzell, 1993***
Flying-fish	Malolo/Longovuka	*Cheilopogon unicolor, C. antoncichi, C. spilonotopterus, C. atrisignis*		
Fusiliers		*Caesio diagramma, C. chlorus*		
Half-beaks	Hu’ila	*Hermirhamphidae Herklotsichthys quadrimaculatus, Allanetta forskali,*		
Herrings	‘Ulukau (gold spot herrings)	*Harengula ovalis*		
	Huli (round herrings)	*Rastrelliger kanagurta*		
	‘Ulukau (herring)	*Dussumieri acuta*		
	Nga’a	*Amblygaster sirm*		
Mackerels		*Sardinella sp*		
Round herrings	Satini (spotted sardinella)	*Selar crumenopthalmus*		
Sardines	Satini (blacktip sardine)	*Atule mate*		
	‘Otule matafolahi (bigeye scad)	*Decapterus macrosoma, D. macarellus, D. russeli*		
Scads	‘Otule (yellowtail scad)	*Athrinomorus lacunosus*		
	‘Otule kau (scad)	*Hypoatherina ovalaua, Spratelloides delicatulus, S.*		
	Helii (broad-band silverside)			
Silversides				

Sprats		*gracilis, (S. japonicus?).*		
Other oceanic pelagic fishes		*Coryphaena hippurus*		
Dolphin fish	Mahimahi	*Elegatis bipinnulatus*		
		Makaira nigricans		
	Lupo-umata	*M. indica*		
Rainbow runner		*Tetrapturus audax*		
	Hakula	*Xiphias gladius*		
Blue marlin	Hakula	*Istiophorus*		
Black marlin	Hakula	*platypterus*		
Striped marlin	Hakula puaka	*Acanthocybium*		
Broadbill swordfish	Hakula	*solandri*		
Sailfish		*Sphyraena sp.*		
	Valu louniu			
Wahoo				
	Hapatu, ‘Ono,			
Barracuda	Momoto			
		Mola sp		
Others finfish		*Luvarus sp*		
	Moa, Toengamounu-‘amaui	*Caranx sp*		***Dye, 1983***
Sunfish				
Louvar	Lupo, Lupolupo, Sipesipa			
		Lepidocybium		
Travelly		*flavobrunneum*		
Opah*	Sifisifi	*Tylosurus sp*		
Moonfish	Ihe	*Luvettus pretiosus*		
Garfish	Palutalatala	*Taractichtys*		
	Valu maka	*steindachneri*		
Oily fish	Lapila moana/			
	Tutuku moana			
Blue-nose				
Pomphrets and breams				
Cartilaginous Fishes				
Shark				
White-tip shark	‘Anga	*Triaenodon obesus*		*Friendlander, 1984*
Grey shark		*Carcharhinus amblynchos*		*Vaea and Straatmans, 1954*
White-tipped reef shark		*C. albimarginatus*		
Black-tipped reef shark		*C. melanopterus*		
Great white shark		*Carcharondon carcharias*		

Hammerhead Mako shark (short fin) Tiger shark Blue shark Hiragashira Smooth hammer shark Thresher shark Sting ray	 Fai	*Sphyrna lewini* *Isurus oxyrinchus* *Galeocerdo cuvier* *Prionace glaucal* *Rhizoprionodon acutus* *S. zygaena* *Alopias pelagicus* *Raja sp, Bathyraja sp.*		 *JICA, 1977* *Vaea and Straatmans, 1954*
Reptiles **Turtle** Green turtle Hawksbill turtle Olive Ridley turtle Eastern Pacific green turtle Leatherback turtle **Mollucs** **Octopus** Epipelagic octopus Squid or cuttle fish **Mammals** **Whales** Humpback whale Blue whale Bryde's whale Minke whale Sperm whale Killer whale Short-ginned pilot whale False killer whale Bottlenose dolphin Spinner dolphin	 Fonu tu'a'uli Fonu koloa Fonu tu'aleta Feke Ngufeke Tofua'a	 *Chelonia mysdas* *Eretmochelys imbricate* *Lepidochelys olivacea* *C. agassizii* *Dermochelys coriacea* *Argonauta argo* *Abraliopsis sp.* *Megaptera novaeangliae* *Balaenoptera musculus* *M. edeni* *B. acutorostrata* *Physeter macrocephlus* *Orcinus orca* *Globicephala macrorhynchus* *Pseudorca crassidens* *Tursiops truncates* *Stenella longirostris*		 *Wilkson, 1979* *Zann, 1981* *Patenaude, et.al., 1996.*

Appendix 2. Recorded pelagic species especially deeper ocean (*1000 – 10,000 meters*).

Zones (refer to figure 1).	Common name	Scientific name	Local name
Mesopelagic Zones	Myctophid	*Electrona*	
	Myctophid	*Lampanyctus*	
	Stomiatoid	*Bonapartia*	
	Adult paralepid	*Paralepis*	
	Melamphaeid	*Melaphaes*	
	Lancetfish	*Alepisaurus*	Haku
	Alepocephalid	*Xenodermichthys*	
Bathypelagic	Gulper	*Eurypharynx*	Tuna/Toke
		Gyclothone braueri	Tuna/Toke
	Gulper eel	*Sacchopharynx*	Tuna/Toke
	Whalefish	*Cetomimus*	
	Angler	*Linophryne*	
	Snipe eel	*Cyema*	Tuna/Toke

Appendix 3

Notes:1

Epipelagic zone is often defined as the zone from the surface down to a given depth, commonly 200 meter. The epipelagic is therefore similar to the photic zone, the zone from the surface to the depth where there is no longer enough light for plants to grow by photosynthesis. Most of the primary production process take place at epipelagic zone, which accommodate high diversity of organisms when compare to other pelagic zones. On the other hand, the epipelagic supplies food to other communities. It has been discovered that large amounts of organic matter sink out of the epipelagic to feed the organism that live below. Without a steady supply of food from above, there could be little life below the sunlight layer of the sea (Castro and Huber, 2000). In the same time many fish species, which lived below the epipelagic zones can migrate up to the ocean surface to feed on zooplankton while the non-migrators have the jaws and capacity to take large meals which last for long period of time – most fish species below 1000m have larger head and big jaw to accommodate larger meal at a single time). In regard to bathypelagic zone, this is the most deserted part of the ocean which fishes are not known to migrate upward in search for food (Bone and Marshall, 1992). They are organized naturally to conform to their food-poor surroundings zone (bioluminescence common used to attract prey).

Notes:2

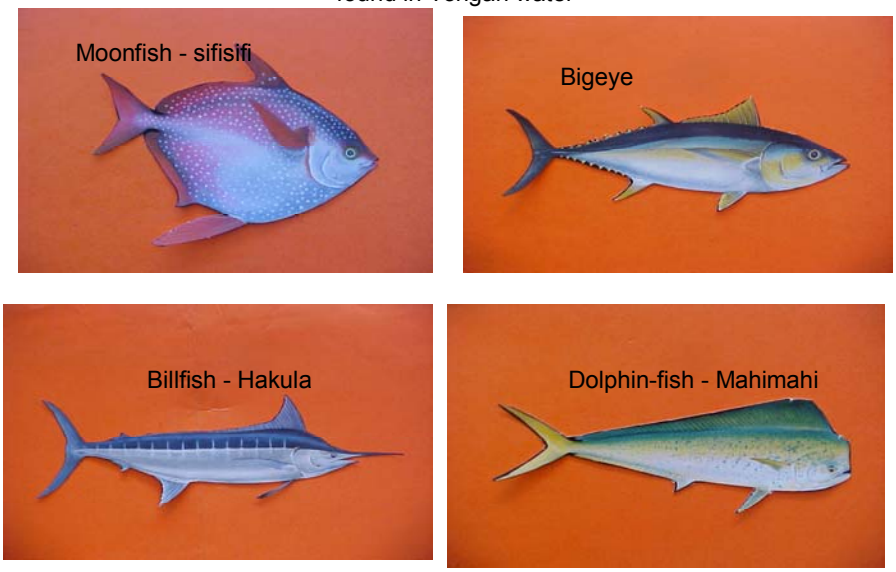
It has been noted that, because physical and chemical condition changes from place to place, different parts of the ocean harbor very distinct communities (Bone and Marshall, 1992 and Castro and Huber, 2000). Benthic organisms, or the benthos, are those that live or buried in the bottom whereas pelagic organisms live up in the water column. Pelagic organisms are further subdivided according on how well they swim. Marine organisms swim only weakly or not at all called plankton. The animal planktons are called zooplankton while planktonic algae and other autotrophs are collectively called phytoplankton. Phytoplanktons are the most important primary producer in pelagic ecosystem (Marine Biodiversity, 1996). Animals that can swim well enough to oppose the currents are called nekton.

Notes:3

The pelagic environment is divided with reference to continental shelf. The pelagic environment that lies over the shelf is called neritic or coastal zone. Pelagic waters beyond the shelf break are the oceanic zone. However, the pelagic is divided vertically into depths zone that correspond to the amount of light. In the shallowest, the epipelagic zone, there is plenty of light for photosynthesis, at least for part of the year. Below the epipelagic lies the mesopelagic zones, which there is not enough light to support photosynthesis, so plants cannot grow. The deepest parts of the ocean are bathypelagic, abyssopelagic and hadopelagic zones. Although each of these zones supports a different community of animals, they share many similarities.

Appendix 4

Most commercialized pelagic species found in Tongan water




Wahoo - Valulouniu


Trevally - Iupo


Albacore


Marlin


Humpback whale


Marlin

CHAPTER SIX

COASTAL BIODIVERSITY AND CONSERVATION

('Asipeli Palaki[20])

6.0 Introduction

The lives of the people of Tonga are closely related or intertwined with the ocean. In its vast marine areas of approximately 400,000 sq km, Tonga continues to depend heavily on the marine life of coastal waters for food and income. The culture – its way of life, traditional beliefs and recreation is linked directly to the coastal waters.

In the Pacific Island Nations including Tonga, there is no clear-cut definition or boundary drawn to differentiate coastal from oceanic zones. Despite the fact that the definition of coastal waters in Tonga is yet to be cleared, the context of this report may use the definition in Munro and Fakahau (1993); ESCAP & GOT, (1990); Thistlethwaite et al. (1993) cited in Prescott (2003) which defined coastal resources to include all non-living and living components of the area of waters from the shoreline to the outer edge of the reef or where no reef exists, the open ocean for which it is practical for small craft to operate and usually not exceeding 30 km from land.

While the human population continues to increase in an exponential rate, and the land mass and marine areas are so small, it is vital that biodiversity must be well managed for the future. Coastal areas, however, are facing several challenges and problems. Overpopulation and the need for cash income have driven the coastal marine resources to deplete in a rate faster than to replenish.

This report however aims at documenting the stock on hand in Tonga as far as the coastal resources is concerned, as well as identifying threats and also existing legal framework and indigenous that are currently used in the country.

Ecosystem:

Ecosystem is defined as a dynamic complex of plant, animal, and microorganism communities and the nonliving interacting as a functional unit (World Resource Institute, 2003).

For the context of this report, Coastal Marine Sector has four identified ecosystems that fall under the definition given above: coral reefs, seagrasses, mangroves, and mudflats.

6.1 Coastal Biodiversity and Conservation

6.1.1 Coral Reef Ecosystem

Coral reefs are the most diverse of all marine ecosystems. They contain at least a million species, but very little have been described. In the simplest sense, coral reefs are wave-resistant piles of limestone and calcareous sediments built by a thin veneer of living organisms-individual living coral animals termed polyps. These piles are of great ecological and resource significance for their habitat heterogeneity, extremely high biodiversity, and distinct trophic structure and primary production.

Coral reefs are widely distributed through the island groups of Tonga (Figure 6.1) with three major reef types; fringing reef, barrier reef, and submerge reef. Lovell and Palaki 2001 also estimated the number of reefs in each reef type; 37 fringing reefs, 7 submerged reefs, and 6 barrier reefs.

6.1.1.1 Species Richness

Corals:
Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia

Corals depend on light and warmth. Reef corals grow best in brightly lighted water about 5 to 10 meters deep. They prefer clear water because turbidity prevents light penetration, which the zooxanthellae need for photosynthesis, and because suspended inorganic particles interfere with feeding by the polyp tentacles. Thus, reefs grow most prolifically in clear, warm, shallow, and nutrient-poor waters. Table 6.1.1 lists the number of species found in Tonga.

[20] ‘Asipeli Palaki is marine biologist and coastal ecosystem expert. Sections were written by Lupe Matoto and Tupe Samani.

Figure 6.1: Coral Reef distribution in Tonga

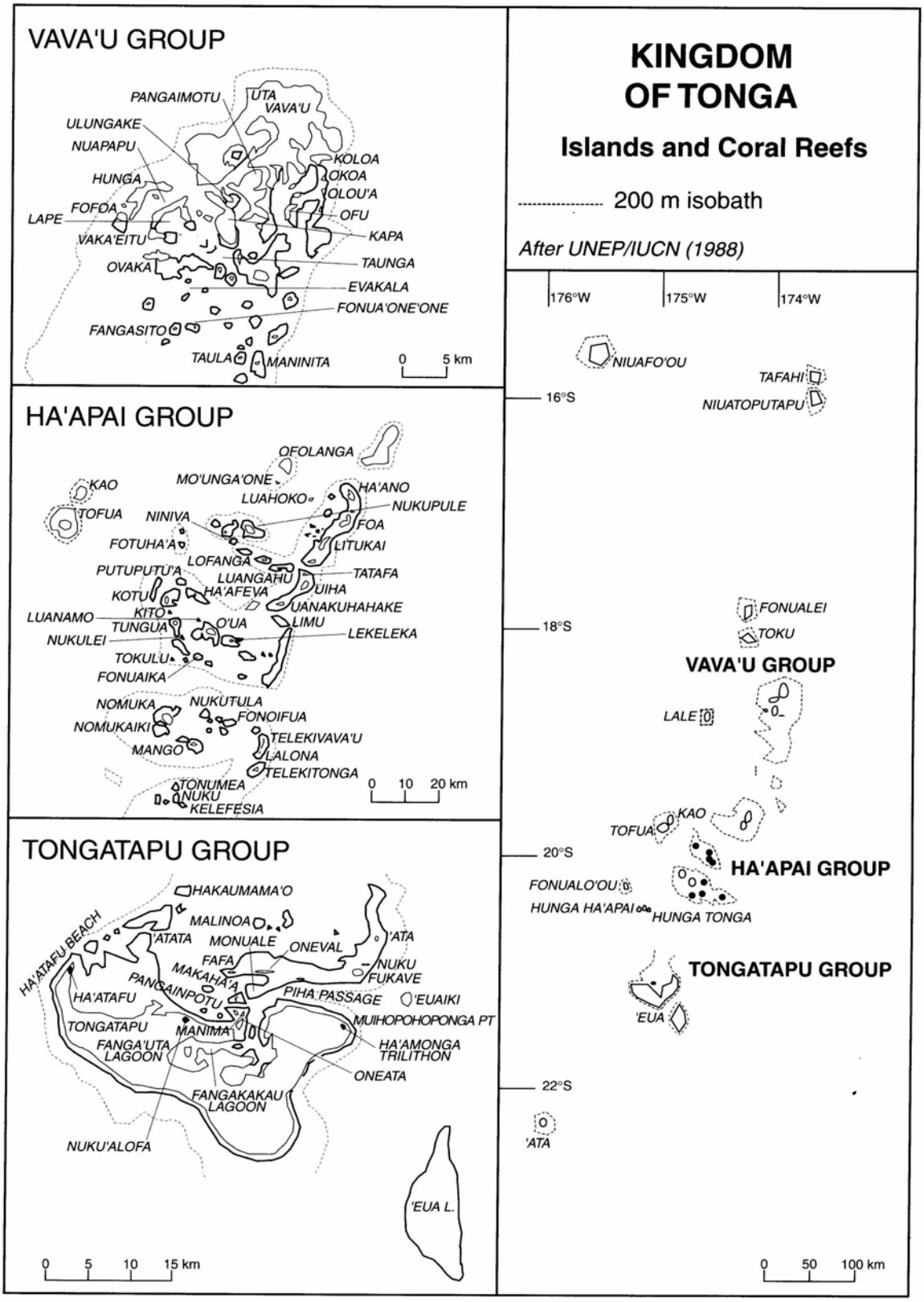


Table 6.1.1 Corals Species in Tonga

Species	Species number	Family Number	Sources of information	Dominant Family
Scleractinian Corals	192	39	JICA/environment in 1996 Holthus 1991	Acroporidae
Soft Corals	7	1	JICA	Alcynacea
Black Corals	3	1	Chesher	Antipathes
Non Scleractenian Reef Building corals	3	1	JICA 2001	Milleporidae

Class *Scyphozoans*:

The Class Scyphozoan (Phylum Cnidarians), commonly known as jelly fish and locally called (*kolukalu*) frequently inhabits most coastal waters of Tonga. *Cassiopea sp* (*kolukalu*) is harvested for consumption and is very common in the Nuku'alofa areas.

Reef Fish:

One of the major inhabitants of the coral reef ecosystem is reef fishes (Table 6.1.2). In Tonga there has been very little study on the reef fish richness and abundance even though data collection on catch at the local market was well documented by several studies (Table 6.1.3).

Table 6.1.2 Reef Fish of Tonga

Species	Species number	Family number	Dominant Family	Sources of information
Finfish	229 300 plus	39	Labridae	Marine Parks Center of Japan Smithsonian Institute Fenn 1972
Elasmobranch	16	3		Thaman et.al 1996 Mann 1987 Fenn 1972
Muraenidae	7	1		Thaman et.al 1996 Mann 1987 Fenn 1972

Table 6.1.3 Most common Reef Fishes in Tonga

Family	Species Number	Commom Name
Labridae	41	Wrasses
Pomacentridae	35	Damsel Fish
Chaetodontidae	24	Butterfly Fish
Scaridae	19	Parrotfish
Acanthuridae	12	Surgeon fish
Mullidae	10	Goatfish
Blennidae	9	Blennies
Gobbidae	8	Gobies

Mollusc:

Phylum Mollusca inhabits most of the coral reef ecosystem in the island groups of Tonga. Some of the molluscs has not been invented or described. Very few studies have fully documented the stock on hand for most of the major Class and Family of Phylum Mollusc, even though edible molluscans were well described. Table 6.1.4 lists major class of mollusc found in Tonga

Table 6.1.4 Mollusc found in Coral Reef of Tonga

Major Class	Species Number	Location	Common Name
Bivalve	57	To	Shellfish
Gastropoda	85	To	Shellfish
Cephalopoda	7	To	Squids, octopus, cuttlefish
Polyplacophora	1	To	Chitons

Source: Marine Parks Center of Japan 1997, Ministry of Fisheries Mollusc of Tonga, Thaman 1996

Echinoderms:

Echinoderms are bottom dwellers. They often found inhabiting coral reef ecosystem through out Tonga (Table 6.1.5)**.**

Table 6.1.5 Echinoderms found in Coral Reef of Tonga

Major Class	Species Number	Common Name	Sources of information	Tongan Name
Asteroidea	5	Sea star or star fish	Personal obs	Mangamangaatai
Echinoidea	4	Sea urchin	P.obs	Vana
Holothuroidea	19	Sea cucumber	Okamoto 83 and 84 Thaman et.al 1996	Lomu
Cronoidea	2	Feather Star	P.obs	Fulufului
Ophiuroidea	3	Brittle stars	P.obs	Mangamanga

Crustaceans:

Crustacean is one of the major class of the Phylum Arthropods. Very few documentation was done on major families of crustacean in Tonga except for the economic important fisheries (Table 6.1.6).

Table 6.1.6 Crustaceans found in Coral Reefs of Tonga

Common Name	Family Name	Tongan Name	No. of Species	Sources of information
Crabs	Decapodia	Paka	20	Thaman et al 1996
Lobsters	Panularis	Uo	4	Lovell and Palaki 2001
Prawn	Penaeus	uloulaavai	2	

Sponges:

Sponges, which constitute the phylum Porifera, are the most primitive of the multicellular animals, and one of the most abundance organisms found in most coral reefs in Tonga. Several studies have described the abundance of sponges on coral reefs in terms of percentage coverage, but detail study on their richness is still vague.

Plankton:

Plankton richness in coral reefs in Tonga has not been well documented. Very little or no study has been conducted on this commodity although their ecological importance as a primary producer is very vital.

This is just a personal observation on samples that had been taken from the coastal waters of Tongatapu and recognised that there are some major planktonic organisms worth noticing (Table6.1. 7).

Table 6.1.7 Major Class of planktonic organisms found in Tonga.

Major Class	Phytoplankton	Zooplankton
Ctenophore		1
Chaetonath		1
Copepods		1
Diatoms	1	
Plankton Larvae		4
Dinoflaggelate	2	
Foraminifera	1	

Phytoplanktons are those that mostly enhance eutrophication, red tide, and algal bloom. Some of the ciguatera poisoning from fish and mollusc are cause by dinoflagellates. On the sandy beach areas, diatoms and foraminifera shells are found in abundance.

Larvae of many vertebrates and invertebrates in their planktonic stage are also found in the coastal waters of Tonga.

Algae and Annelids:

Algae a primary producer is a marine plant that often found in all coral reefs in Tonga. Some of them are Tongan delicacy and some have potential market value especially overseas market (Table 6.1.8). Polychaete worms, of the Class Annelids, are also found of which some are of Tongan delicacy (Table 6.1.9).

Table 6.1. 8 Algae species found in Tonga.

Species/No.spp	Tongan name	Sources of information
Caulerpa (4)	Limu fua	Kaly at.al 2001 Thaman at.al 1996 Palaki and Nakaya 2002 P.obs
Halimeda (5)		Above
Turbanaria (1)	Limu fetuu	Above
Sargassum(2)	Limu fua	Above
Podium (1)	Limu teemoa	
Padina (1)	Limu talinga	
Hypnea (1)		
Turf algae	Limu	
Cladosiphon (1)	Limu tangau	Lovell 1996

Annelids:

Table 6.1.9 Number of polychaete worm species found in Tonga.

Species name	Number of species	Number of Family
Polychaete worms	54	19

Source; Baily Brock 1987

6.1.2 Endemism

The only recorded endemic species that inhabits the coral reef in Tonga is the giant clam *Tridacna tevoroa* that is endemic to the Lau Groups and Tonga. However, coral species Halimitra was seen at one of the reef around Tongatapu, which is also endemic to Tonga.

6.2 Endangered and Threatened Species

Two giant clam species *Tridacna derasa* and *Hippopus hippopus* were considered and believed to be extinct from the Tongan water (Mckoy 1980). They were both reintroduced in 1990 and 1991.

Three species of black corals (Genus Antipathes) were also depleted to such an extent that they are endangered in the Tongan waters (Chesher 1986)

Two species of Marine turtle, green and hawksbill turtles were threatened in Tonga during the 70s (Braley 1973 a,b; 1974) and cited in Lovell and Palaki 2001.

Sea-cucumber or Bes-der-mer has been over fished during the early 90s because of their high market value was considered threaten. They are sandfish, holothuria scabra and teatfish.

Thaman at.el., (1996) listed rare or endangered coastal species at Ha'apai as a result of a survey conducted as part of the activities for the Haapai Conservation Areas Project. It is important to take note that only highly threatened species is listed here in Table 6.2.1.

Table 6.2.1 List of Rare or Endangered Coastal Species

Tongan	English Name	Scientific name
Fai pala	Black-spotted stingray	Taeniura melanospila
Tenifa	Tiger shark	Galeocerdo cuvier
Toketuna	Black-edged conger eel	Conger cinereus
Toke pokulu	Marbled moray eel	Uropterygius marmoratus
Tukuku	Damsel and angelfishes	Stegates spp
Ngatala	Rock cod	Cephalopholis, Epinephelus
Sikatoki	Steephead parrotfish	Scarus mocrorhinos
Kuku	Mussels	Modiolus
Tridacnae	Smooth giant clam	Tridacna derasa
Elili	Turban shells	Turbo spp
Mokohunu	Black teatfish	Holothutia nobilis
Holomumu	Greenfish	Stichopus choronotus
Telehea	Deepwater redfish	Actinopyga echinites
Matamata	Brown sandfish	Bohadschia argus
Tukumisi	Cake sea urchin	Tripneustes gratilla
Tapatapa	Slipper lobster	Scyllarides squamosas
Uo	Lobster	Panularis
Veeuli	Dark-finger coral crab	Etisus dentatus
Umana	Sea anemones	Actiniidae
Limu tangau		Cladosiphon spp

Source: Thaman et al., (1996)

Unique Aspects of the Coral Reef Ecosystem:

The coral reef ecosystem is still the most diverse ecosystems on earth. The ecosystem supports millions of species from different phylum in both the plant and animal kingdoms. The roles that this ecosystem plays ecologically, biologically, and physically make it unique and one of the most valuable ecosystem on earth.

Coral reefs provide habitat for millions marine organism in the world. They provide shelters, feeding grounds, breeding grounds, and place for preys to hide from the effect of predators. Physically, coral reefs act as barrier to stop the impacts of wave action, current and storm surges on the coastal areas. Corals reefs also provide and still the main sources for aggregates and sands deposited on the coastal areas around every island groups in Tonga.

Economic, cultural, and historical Importance of the Ecosystem:

Economic

Subsistence and market value

Coral reef is one of the most diverse ecosystems in the world, which support millions of species, and most of which have very high market value Coral reef is probably the only ecosystem that you can find representatives from different Phylum from both Animal and Plant Kingdoms. Tables 6.2.2 and 6.2.3) show the economic values of some of the edible reef resources recorded in Tonga.

Table 6.2.2 Subsistence and Commercial Fisheries (Annual mean production – 1989-1992)

Subsistence fishies production (mt)	Nominal Value (US$)	Commercial fisheries production (mt)	Value (US$)	Total fisheries producton (mt)	Nominal Value (US$)
933	1,901,208	1,429	2,806,641	2,362	4,707,849

Source: MOF Annual Reports

Table 6.2.3 Catch Landings (tones). FAO Digital Atlas, 1998

Plance of Landings	Commercial	Subsistence	Total
Nuku'alofa	1,000	375	1,375
Vavau	250	280	530
Haapai	100	180	280
Other	79	98	177
Total	1,429	933	2,362

Aquarium

Development of the Aquarium fish trade since the 80s is another major industry for Tonga. This industry is one of Tonga's most valuable export fisheries. There are currently 5 licensed operators operating in Tonga. According to the Ministry of Fisheries Annual Report, the following were given in terms of money value (Table 6.2.4).

Table 6.2.4 Total value of aquarium fisheries per year

Year	TOP$
1998	485,402
1999	794,729
2000	1,520,530
2001	1,555,527
2002	2,725,650

Tourism

Ecotourism is another major income earner industry in Tonga. Increasing number of tourists to Tonga mainly for diving, snorkeling, and coastal marine activities contribute around 19 million *pa'anga* per year.

Cultural

Coral reefs in Tonga are always associated with the Tongan culture. Traditional fishing practices, games, food, dancing, *fakapangai* and etc are always affiliated with the reefs system. Constructions for cultural monument and buildings are also important thus using coral reef ecosystem for materials.

Extent, effectiveness and representation of Protected Area System:

Under the Parks and Reserves Act of 1976, Tonga has been able to designate five marine parks and reserves (Tonga Government Gazette 1979). The five Marine Parks and Reserves in Tonga are all located in the main island Tongatapu. There has been no marine park and reserve establish on the outer island groups, even though few surveys on the potential marine protected areas on those islands have been conducted.

Ha'apai group was declared as a conservation area under the SPBCP Program. This conservation area encompasses all the Ha'apai group, both marine and terrestrial environments. Of the 5 marine parks and reserves established in 1979, the total coral reef areas is approximately 290 ha, which is almost 10 % of the total coral reef areas in Tonga.

The concept of parks and reserves has been developed in Tonga since 1946, when the park reserve at Haveluloto was gazetted. The effectiveness of such approach has not been analysed socially and economically, however its biological implications has been proved an advantages. An inventory marine resources survey that was conducted by Marine Parks of Japan in 1997 on marine parks and reserves in Tonga showed that species richness and abundance in most established marine reserves are very high compared to other reef areas. This is a clear indication of the effectiveness of such conservation approach.

However, MPAS have not been appropriately managed due to lack of management plan and awareness program (Nakaya and Palaki 2003). It was also noticed that community consultation and involvement of community on every phase is vital for the effectiveness of the MPAs.

6.3 Mangrove Ecosystem

Mangroves are a diverse assemblage of tropical tree species that inhabit the intertidal range of sheltered shores (Ellison, 1998). They are found in a condition with low, muddy coasts in the tropical and subtropical areas.

Mangrove is a variety of life forms reflecting the diversity of their origins: some types of palms, shrubs, and ferns are all classed as mangroves. Thus, they can range from squat, scrubby stands on exposed flats, to few meters tall forests around the coastal areas.

Unique Aspect of the Mangrove Ecosystem:

Mangrove ecosystem assists in the stabilization and expansion of the other coastal wetlands. They also provide enormous and often under-valued coastal protection benefits (against storm surges, erosion, etc.).

The roots of mangrove plants are nearly impenetrable barrier, and so provide a safe environment for organisms around the base of the trees. They shelter many species of crabs, and because mangrove crabs are high economic value, they are harvested in large quantities. Mangroves also provide shelter for other marine invertebrates such as sponges, barnacles, oysters, and snails.

Mangrove ecosystem also serves as important breeding grounds for prawn and commercially valuable fishes, as well as providing a "nursery" for juveniles.

One other aspect of the mangrove ecosystem is to keep the surrounding water quality clean by sinking sediments load, nutrients and contaminants that find their ways to the water body.

Economic, Cultural and Historical Importance of the Ecosystem:

Economic

Performing its ecological role as a nursery for juveniles of some economic valuable species, it is no doubt that this ecosystem plays a vital role and has a potential and high economic importance. Snappers, mullets and prawns have high market value at both local and overseas markets. Handicrafts from mangrove materials also have high economic value locally and overseas market.

Cultural and Historical Importance

Tonga always has cultural and historical affinities with mangrove ecosystem. Long before the introduction of modern technology and industrial revolution, mangroves were part of Tongans life culturally and historically.

Mangrove areas are used in Tonga for fishing *(fishing ground), and for gathering of clams and crabs .It also a source of energy for cooking and light. Firewoods are occasionally collected for the family cooking and sometimes for light. Some of the mangrove species are used for buildings and other decoration goods such as chair, tables and etc. Whistler 1992 also stated that one other cultural importance of mangrove is for medicine. Bark from the Xylocarpus species are used by Tongans for treatment of internal breeding and injuries. Prescott 1989 studied the mangrove area conservation values and concluded with mangroves use traditionally in Tonga primarily for tapa dye, fishing gears, and medicines.

Species Richness:

In Tonga there are eight species of mangroves found and all are indigenous. Saenger et al 1983 described that Tonga has a total mangroves area of 1000 ha.

Table 6.2.5 and 6.2.6 listed the mangroves species and associated species found in the mangrove ecosystem in Tonga.

Table 6.2.5 Mangrove species Found in Tonga

Scientific name	Nomenclature	Tongan name
Rhizophora mangle	L (Rhizophoraceae)	Tongolei or tongo
Rhizo[hora stylosa	Griff. (Rhizophoraceae)	Tongolei or Tongo
Bruguiera gymnorrhiza	(L.) Lamk (Rhizophoraceae)	Tongo taane
Excoecaria agallocha	L. (Euphorbiaceae)	Fetaanu
Lumnitzera lottorea	(Jack) Voigt	Hangale
Heritiera littoralis	Dryand	Mamea
Xylocarpus granatum	Konig	Lekileki
Xylocarpus moluccensis	(Lamarck) Roemer	Lekileki

Table 6.2.6 Common species found within the mangrove ecosystem

Group	Species name	Common name
Finfish	Lethrinus sp	Snapper
	Mugil cephalus	Mullet
	Leiognathus sp	Bony fish
	Lethrinus harak	Black-blotched emperor
	Periophthalmus sp	Mud-skipper
	Laticauda colubrine	Sea snake
Crustacean	Penaeus sp	Prawn
	Sesarma sp	Crabs
Mollusks	Littorina sp	
Birds	Foulehaio carunculata	Wattled honeyeater
	Sgretta sacra	Pacific Heron
	Anas superciliota	Pacific black duck
	Sterna bergil	Crested tern
	Pluvialis fulva	Pacific golden plover
	Heterosceles incanus	Wandering Tattler
	Limosa lapponica	Bar-tailed God-wit

6.3.1 Mangroves Distribution in Tonga

Mangroves are widely distributed throughout Tonga, especially in the Tongatapu and Vavau groups. The largest mangrove areas in Tonga occur on the Fanga'uta Lagoon, Tongatapu (Figure 2).

Extent, effectiveness and representation of protected area system:

The mangrove ecosystem was protected under the Birds and Fish Preservation Act (Amendment) 1974, *"No person may within the protected area ……. temporary or permanent; cut, damage, remove or destroy any mangrove…."*. i.e the cutting of mangroves around the Fanga'uta and Fangakakau lagoon is totally prohibited under this act.

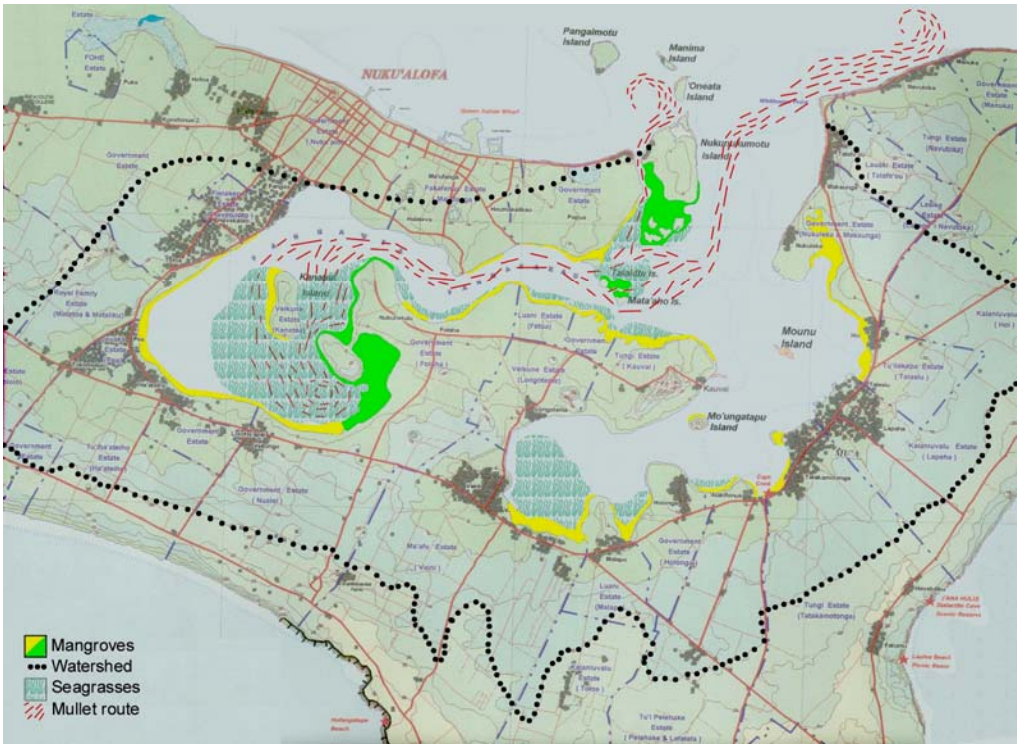
This only refers to the mangrove ecosystem around the lagoon not including those on other areas in Tonga. This mangrove forest covers a vast area of approximately 45 km of the total 58km of the lagoon coastline. It may be right to say that the Fangakakau and Fanga'uta lagoon mangrove forest takes up approximately 80% of the total mangrove forest in Tonga.

The effectiveness of this Act has not been proved, as the illegal cutting of mangroves is still a common practice. Land reclamation for settlement and development whereby mangroves are destroyed, are still exercising now and then totaling ignored the Act.

6.4 Lagoon Ecosystem

The lagoon comprises a shallow and almost enclosed estuarine embayment on the northern Tongatapu coastal line. There are two lagoons in Tonga both located on the main island Tongatapu, the Fangakakau and Fanga'uta lagoons (Figure 6.2). The total area of the lagoon as given by Wilkinson 1977 and Zann et.al 1984 are 2,835 ha and 3,423 ha respectively.

Figure 6.2 Ecological map of Fanga'uta and Fangakakau Lagoon.



This map shows the distribution of mangroves and the approximate distribution of seagrass beds in the lagoon. Mangrove areas in green are likely to be key habitats for fishes. The mullet spawning routes have been surmised from interviews with fishermen and information supplied by the Ministry of Fisheries.

Unique Aspects of the Lagoon Ecosystem:

Lagoon organisms often provide important ecological goods and services. For example, many fisheries target commercially valuable crabs and bivalves. Lagoon animals also recycle nutrients, detoxify pollutants, and represent important trophic linkages in coastal and lagoon ecosystems. As an illustration, some species such as worms and clams that live in the mud graze benthic algae and bacterial communities. In turn, the invertebrates are essential food for larger invertebrates (crabs, shrimps, and octopus), and fishes.

On exposed intertidal soft bottoms, birds and terrestrial mammals, including pigs and dogs, regularly forage. The profusion of benthic-pelagic and marine-terrestrial trophic links reveal that lagoon soft-sediment communities provide important energy pathways in the marine coastal ecosystems.

Extent, Effectiveness and Representation of Protected Areas System:

The lagoon was established under the Birds and Fish Preservation Act (Amendment) 1974, which was passed in the Legislative Assembly on 17 September 1974 and receiving Royal assent on June 1975. The Birds and Fish Preservation Act (Amendment), 1974, defines the boundaries of he site as the entire lagoon in Tongatapu, known as Fanga'uta and Fangakakau being the area lying to the south of a straight line drawn from Niutao to the northernmost point of Nukunukumotu and including the straits known as Holeva and all mangroves and foreshore.

Even though the lagoon is protected under the Birds and Fish Preservation Act of 1974, it has not been respect by the community, since it has been over fished for both subsistence and commercial purposes. The mangroves are removed; land reclamation and pollution have caused local disturbances

Species Richness:

Major group	No of species	Common name
FinFish	96	Fish
Algae	Caulerpa serratula	Seaweed
	C.racemosa	
	C.ashmeadii	
	Cladophora spp	
	Chorodesmos spp	
	Halimeda discoidea	
	Gracilaria spp	
Crustaceans	Alpheus mackayi	Alphaed shrimp
	Squilla sp	Mantis shrimp
	Lysiosquilla sp	
	Metapenaeus ensis	Prawn
	Penaeus sensculcatus	
	Scylla serrata	Crabs
	Thalamita prymna	
	Calappa hepatica	
	Xanthids spp	
Holothurians	Holothuria atra	Holothuria
	H.edulis	
	H.leucospilota	
	H.impatiens	
	Stichopus variegates	
	S.chloronotus	
	Archaster spp	Star fish
	Astropecten sp	
	Linkia laevigata	Blue starfish
	Tripnuestes gratilla	Sea urchin
	Toxopnuestes pileolus	
	Diadema setosum	
Bivalves	Grafrarium tunidum	
	Anadara maculata	
	Fragum unedo	
	Tellina spp	
	Periglypta spp	Cockle
	Lucina spp	
	Pecten spp	scallop
	Atrina spp	pinna
	Pinctado marginatifera	oyster
Gastropods	Cypreae annulus	Cowry
	C.moneta	
	C.vittelus	
	C.tigris	
	Lambis lambis	Spider shell
	Strombus gibberulus	Strom
	Conus pulicarius	Cone
Scyphozoans	Cassiopea spp	Jellyfish (kolukalu)

Economic,Cultural and Historical Importance of the Ecosystem:

Historically, Mu'a was the capital of Tonga for many centuries and of course located around the lagoon. The old harbour known, as the *Fangalongonoa* was also located at Mu'a around the lagoon. The Captain Cook landing area is located at 'Alaki Fonua which is around the lagoon areas. While several villages and Nuku'alofa areas are located around the lagoon, traditional foods, games, fishing techniques, and buildings are all associated with lagoon ecosystems.

The lagoon is valued as a nursery ground for many fisheries of very important commercial values. The lagoon is also a breeding ground for many commercially important fisheries such as snappers Lethrinus spp and Lutjanus spp. It also supports a juvenile population of grey mullet Mugil spp as well as Panaeus spp.

6.5 Seagrass

Seagrasses are angiosperms, i.e. vascular plants that reproduce with flowers and seeds. The life cycle of seagrasses is much like that of other angiosperms, but their pollen is distributed only by water. They occur in shallow soft-sediment habitats along the shores of coastal waters. The Fanga'uta and Fangakakau Lagoon, Nukuhetulu, Felemea and Tuanga are areas that seagrass coverage and state has been carried out (Refer to Prescott et al., 2001 and 2003). These studies found that seagrass in Fanga'uta Lagoon system is patchy and up to 100 % in some areas is covered by epiphytes (refer to Table 6.2.7).

Seagrasses create a habitat for many aquatic organisms. The root, stem and leaves provide protection prey from predators, and also shelters for many organisms from currents and wave action. Thus seagrasses are ecologically significant, both because of their high primary productivity and their value as habitat formers.

Organisms in every major Phylum occur within seagrass beds. They inhabit the mat of seagrass roots and rhizomes and live attached to or closely associated with the leaves. Other benthic and motile organisms such as snails, crabs, and fishes cruise through or above the leaf canopy. The majority of commercially valuable species are found in seagrass communities at some stage in their life histories.

The following seagrass species are found in Tonga:

- Halodule univatis
- Halophila ovalis
- Syringodium isoetifolium
- Thallasia spp
- Cymodocea sp

6.6 Analysis of Threats and Pressures

6.6.1 Anthropogenic

The increase of populations and economic activities in coastal areas is leading to an expansion of construction, which in turn leads to alterations to coastal zones and waters. Excavation, mining (such as sand and aggregate extraction, the building of ports and marinas and building of coastal defenses and reclamation linked to urban expansion are giving rise to alterations of coral reefs, mangroves and seagrass ecosystems. Important habitats are being destroyed. Wetlands are being transformed, into residential and commercial lands and other coastal development. As a result spawning grounds, nurseries and feeding grounds of major living marine resources of crucial importance to Tongan food security are being destroyed. This destruction of habitat exacerbates over harvesting of these living marine resources leading to a growing risk that they are being depleted. This is an increasing threat to the food security of coastal populations, including Tonga.

6.6.1.1 Pollution

Heavy metals:

Although heavy metals are natural constituents of the Earth's crust, human activities have drastically altered the biochemical and geochemical cycles and balance of some heavy metals. Heavy metals are persistent environmental contaminants since they cannot be degraded or destroyed. Therefore, they tend to accumulate in the sediments of most coastal environment. Excessive levels of metals in the marine environment can affect marine biota and pose risk to human consumers of seafood. Metals and their compounds, both inorganic and organic, are released to the environment as a result of a variety of human activities.

The main anthropogenic sources of heavy metals in Tonga are various industrial point sources, Electric Power Plant, quarries and mining activities, small industries, and diffuse sources such as piping, constituents of products, combustion by-products, traffic, etc. Heavy metals conveyed in aqueous and sedimentary transport (e.g., run-off) enter the normal coastal biogeochemical cycle and are largely retained within near-shore and shelf regions.

Morrison at.el., (2000) identifies trace metals contanmination in seashells and sediments from the Fanga'uta Lagoon even though the concentrations are unlikely to cause any major human health problems. The study also recommended that monitoring of this type be carried out on a regular basis (refer also to Table 6.2.7).

Pesticides

Pesticides have been and still extensively used to enhance agricultural production in the Kingdom. Few studies have been conducted showed that pesticide residues are occurred in the Fanga'uta lagoon and may posed further problems to the environment as well as the human health.

Velde et al., (2003) analysed 12 groundwater and sediment samples taken from sites around the lagoon and found the occurrence of pesticides dieldrin, diazinon and carbaryl. Morrison et al., (1999) indicated presence of carbaryl, chlorfluazuron, and flusilazole pesticides from sediment samples from Tongatapu coastal areas.

Litter

Litter threatens marine/coastal life through entanglement, suffocation and ingestion and destruction of habitats. It is widely recognized to degrade the visual amenities of marine and coastal areas with negative effects on tourism and general aesthetics.

Litter entering the marine and coastal environment has multiple sources. Sources include poorly managed or illegal waste dumps adjacent to coastal areas, windblown litter from coastal communities and dump sites. Marine litter is also caused by dumping of garbage into the marine and coastal environment by municipal authorities, individuals as well as recreational and commercial fishing vessels.

Uncontrolled burning of litter containing plastics may generate significant quantities of POPs, metals and hydrocarbons, which can reach the marine and coastal environment. The World Bank Report (1999) and Chesher 1984 identified littering as one of the major threat to the coastal environment from both point and non point sources.

Oils

Many oils are liquid and gaseous hydrocarbons of geological origin. While some oils are naturally occurring, a significant proportion of those in the marine and coastal environment have been derived from anthropogenic sources. Most oils from land-based sources are refined petroleum products or their derivatives. Some oils are volatile or easily degraded and disappear rapidly from aquatic systems, but some may persist in the water column or in sediments. Oils may be toxic to aquatic life when ingested or absorbed through skin or gills, interfere with respiratory systems, smother aquatic communities, habitats and bathing beaches, taint seafood and contaminate water supplies.

Land-based sources of oils include operational and accidental discharges and emissions from automotives, refining and storage facilities; urban, industrial and agricultural run-off; transport; and the inappropriate disposal of used lubricating oils.

Oils pollution from ships is an issue here in Tonga. Ships wrecks, accidental leakage of oils from ships as well as Oil tanker accident have reported in Tonga during the last few years. Last two years there was an accident on the Nuku'alofa harbour whereby an oil spill from oil tanker occurred. Even though it was just a minor accident but the spills cover vast areas around the Nuku'alofa harbour and the nearby coastal environment.

POPs

Persistent organic pollutants (POPs) are a set of organic compounds that are toxic, persistent, bioaccumulate, long-range transport and deposition, and can result in adverse environmental and human health effects. POPs are typically having low water solubility but high fat solubility. Most POPs are anthropogenic in origin. Anthropogenic emissions, both point and diffuse, are associated

with industrial processes, product use and applications, waste disposal, leaks and spills, and combustion of fuels and waste materials.

POPs have long environmental half-lives. Accordingly, successive releases over time result in continued accumulation and the ubiquitous presence of POPs in the environment. The transport routes into the marine and coastal environment include atmospheric deposition and surface run-off.

In Tongatau, the transformers at the Power station Popua contained 1000litres of PCB oil and it is more likely that PCB may find its way to the nearby coastal marine environment. The PCB inventory in Tonga as indicated in Morison and Palaki (1999); and O'Grady and Palaki (2001) found out few transformers that contained PCB oil at the Power Plant at Anana.

Morrison at.el., (2001) also found PCB in one sediment sample at one site in the Fanga'uta lagoon. Velde et.al., (2003) showed an occurrence of one POPs chemical dieldrin from groundwater and the Fanga'uta lagoon.

Nutrients

Eutrophication can result from nutrient inputs to coastal and marine areas as a result of human activities. Eutrophication is usually confined to the vicinity of coastal discharges but, because of both the multiplicity of such discharges and regional atmospheric transport of nutrients, such affected coastal areas can be extensive.

The effects of nutrients are not only to enhance productivity but also changes in species diversity, excessive algal growth dissolved oxygen reductions and associated fish kills and, it is suspected, the increased prevalence or frequency of toxic algal blooms.

Zann et al., (1984) and Zann and Muldoon, (1993), cited in Lovell and Palaki 1999 showed that in the Fanga'uta Lagoon, Tongatapu, an increase in seagrasses and mangroves and a decline in stony corals were to some extent attributed to eutrophication from urban nutrient run-off.

Fish kill that has been reported from the lagoon and Sopu in 1999 and 2001 areas indicated that they might be associated to eutrophication and dissolve oxygen limitation.

Radioactive Substances

Radioactive substances (i.e., materials containing radionuclides) have entered and/or are entering the marine and coastal environment, directly or indirectly, as a result of a variety of human activities and practices. In Tonga activities include military operations, nuclear testing, medical applications and other operations associated with the management and disposal of radioactive wastes and the processing of natural materials by industrial processes. Other activities, such as the transport of radioactive material, pose risks of such releases.

Radioactive materials can present hazards to human health and to the environment. Suspected radioactive contamination of foodstuffs can also have negative effects on marketing of such foodstuffs.

There wasn't any national study on radioactive substances found during this review.

Sediment Mobilization

Natural sedimentation and siltation are important in the development and maintenance of numerous coastal habitats. Habitats requiring sediment input include coastal wetlands, lagoons, estuaries and mangroves. Reduction in natural rates of sedimentation can compromise the integrity of these habitats, as can excessive sediment loads, which may bury benthic communities and threaten sensitive habitats such as coral reefs, mangroves, seagrass beds, and rocky substrates.

Contaminated sediments, whether they are fresh inputs or dredged, may also lead to pollution, the latter through resuspension or improper disposal.

Anthropogenic modifications to sedimentation are made by construction activities, forestry operations, agricultural practices, dredging activities, and coastal erosion.

Table 6.2.6 and 6.2.7 described the impacts of increased sedimentation on coastal biodiversity although a study and the actual sedimentation load or movement input into the coastal system has yet to be carried out.

Sewage

Domestic waste water that improperly discharged to coastal environments may have varieties of concerns. Waste water Run-off from land or un-point source may carry sewage into the coastal environment. Pathogens that may result in human health problems through exposure via bathing waters or through contaminated shellfish; suspended solids which may affect the photosynthetic process in the coastal environment nutrient inputs which may result in algal bloom biochemical oxygen demand (BOD).

Environmental effects associated with domestic waste-water discharges whether they may be point or non point source are generally local and concentrated in areas with high coastal population. Domestic waste-water discharges in Tonga are considered one of the most significant threats to coastal environments.

Kaly et. al., (2000) and Prescott, (2001) showed an elevated nutrients and Faecal coliform level in the lagoon due predominantly to sewage runoff. Kaly et al., (2001) showed that the Neiafu harbour areas are proned to pollution from sewage runoff as well as discharges from yachts and domestic ships. Chesher, (1984) reported the potential impact of sewage runoff into the reef system from hotels around the coast of Tongatapu and Vava'u.

Construction

Coastal construction has been reported as one of the major anthropogenic threat to the coastal environment whereby destruction of habitats and killing of marine organisms occurred. Siltations from construction and dredging have degraded the reefs and other coastal ecosystems adjacent to the constructed areas in Tongatapu, Neiafu and other island groups. Impacts of siltation on coastal biodiversity are reflected in Table 6.2.7.

Causeway construction in the Vava'u and Ha'apai caused degradation to the nearby reefs and lagoons. Most waterfront construction is carried out without precautions to prevent siltation of the marine environment during the activity. Chesher (1984) cited in Prescott, 2003 found evidence of deep-water pollution from a construction plume, and black coral being killed by siltation from the Queen Salote Wharf and Faua Boat Harbour projects.

Construction Material

Sand Mining

Sand is used in the production of concrete and it is also used traditionally as a ground cover around houses and to cover graves. The rapidly increasing rate of construction of houses and buildings, using primarily concrete blocks and concrete foundations, has resulted in increasing demand for sand.

On Tongatapu and Vava'u, sand is mined by the MLSNR and then sold to the public. In 1987, 3,564 tonnes of sand was sold to the public from the government's stockpile in Vava'u and 21,909 tonnes was sold from the Tongatapu stockpile while in 1999, 29,000 tonnes was sold from the Tongatapu stockpile (MLSNR 1988, 1999) cite in Prescott 2003.

Overfishing

When the rate of harvesting exceeds the carrying capacity of any resources, the over exploitation of such resources may occurre. Some of the coastal resources have been overfished to some extent.

A ban of beche-der-mer exporting during the 90s was due to serious overfishing. Giant clams were also overfished (Mckoy, 84) and two species were extinct from the Tonga. Some inshore fisheries were threatened due to increase fishing pressure (World Bank, 1999).

Lobster and mullet are currently fished and declining due to increase fishing pressure and being overfished (Lovell and Palaki, 1999). There are several factors that contribute to the overexploitation of the coastal marine resources in Tonga including increase population, improved fishing techniques/equipment, and high market values for most coastal fisheries both local and international markets.

Tourism and Recreational Activities

Game fishing and other marine related activites for tourists if not regulated properly could pose risks for biodiversity such as the whale watching industry, diving and fishing.

Diving industry both scuba and skin diving is now well developed in Tongatapu, Neiafu and Ha'apai. One of the most attracted recreational activities for many tourists is diving and for a result, coral

breakage may have occurred. Habitat lost through coral breakage, boat anchorage, and novice divers is a growing concerned. Pollution from hotels and tourist accommodations is another problem.

6.6.2 Natural Factors

The following natural phenomena that cause threats to the coastal ecosystems including volcanic activity, cyclones (waves, currents, storm surges), coral predators such as Acanthaster planci and drupella spp, disease and invasive species.

Few recorded events on volcanic activities at Niuafo'ou and formation of new volcanic islands in the Ha'apai and Vava'u are direct evidence of the threats to the coastal environment due to this natural phenomenon.

Destructive cyclones occurred in the years of 1961, 1978, 1982, 1995, 1997, 1999, 2000, and 2001. Coral reefs were destroyed; sedimentation and coral smothering were also identified (personal obs.).

Natural predators exerted threats to the corals during the outbreak of crown-of-thorns starfish as well as the drupella spp. Zann et al 1992 and Lovell 1999 recorded minor events of *Acanthaster planci* outbreaks in Vava'u and Tongatapu that cause coral mortality. Personal observation during the reef survey of the reefs around Tonga also indicated that *Acanthaster planci* is still a problem in the reefs areas. Gastropod species *drupella* is another coral predator that has been identified in reefs around Tongatapu and Ha'apai.

Disease is another natural phenomenon that may have great impacts and threats to the coastal ecosystems. There hasn't been any study on the issue but it is now becoming a potential threat to the marine environment.

Invasive species is a new issue that has been identified as a potential threat to the coastal ecosystems. Transboundary movement of invasive species to new areas through the ballast water could occur or through other forms of introduction such as ship's hull and floating woods, and point source species introduction for aquaculture purposes.

Climatic Change impacts

Global warming and sea level rise are of great concern to the coastal waters of Tonga, especially low islands, in terms of coastal processes, submergence, pollution of underground water and coral bleaching (Lovell et al., 1999). Mimura & Prescott (1997) carried out a vulnerability assessment of Tongatapu to sea level rise. Two scenarios were used for the assessment (0.3 m slr and a 1.0 m slr) combined with the local conditions (sea levels and chart datum).

Scenarios for Local Water Levels (Elevation is based on the chart datum. One metre contour corresponds to the high water level, i.e. the present coastline)

SLR = Sea Level Rise

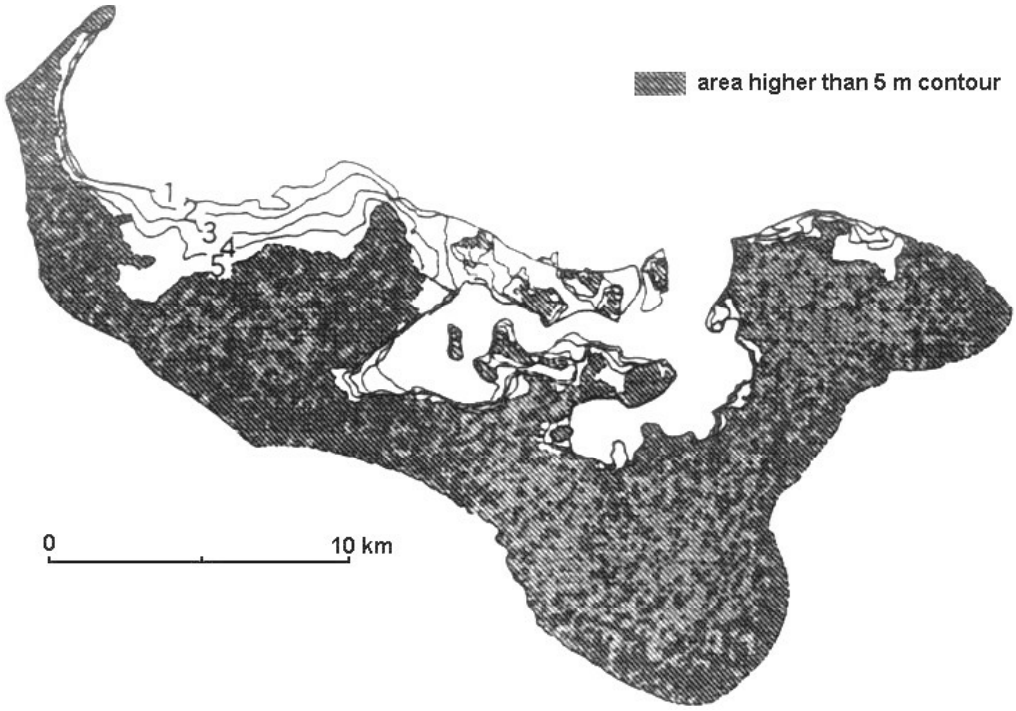
Cases	**Present Condition**	**SLR 1 (+0.3 m)**	**SLR 2 (+ 1.0 m)**
Ordinary Condition (High water level)	1.0 m	1.3 m	2.0 m
Extreme Event (Storm surge)	2.8 m	3.1 m	3.8 m

Source: Mimura, N., & Prescott, N., (1997)

The assessment found that Nuku'alofa would break into islands, 58 km^2 of coastal area would be inundated, and 10.7 km^2 of resdendial area and 63 % of the population of Tongatapu would be affected (Mimura & Prescott, 1997). This could mean disruption of habitats, creating 'new' environment and ecosystems and possible 'new species' (Refer to Fig. 6.3).

Figure 6.3 Map of Tongatapu with areas below 5 m contour that would be affected by a 3.8 m SLR

(Note: The chart datum is nearly 1 m below high water level, therefore 5 m contour corresponds to 4 m above the present coastline)



Source: Mimura, N., & Prescott, N., (1997)

Coral bleaching

Coral reef bleaching is a response to stress by increase in water temperature. Tonga has reported coral bleaching in February 2000. Observations from the Ha'atafu Reserve Tongatapu the bleaching event in 1999 following the El nino of 1998.

6.7 Coastal Biodiversity Use

The table below summarised the major uses of coastal biodiversity.

Biodiversity use	Ecosystems	How	Whom	Species involved/affected
Development	Coral reef Mangrove Seagrass Tidal flat/lagoon	Development such as construction of foreshores, hotels, wharves, jetties, buildings, causeways Housing, industries, jetties	Government Private sectors Oil companies Public, Defense Force	All coastal resources inhabiting the areas such as finfish, invertebrates Algae
Fishing	Coral reef Mangrove Seagrass Tidal falt/lagoon	Traditional fishing practices, Modern technology fishing techniques Illegal fishing practices	Fishing company Private sectors General public	Edible finfish, invertebrates Seagrass and algae, plankton
Aquaculture	Coral reef	Enhancement program of species of economic importance both native and introduced, seed production	Ministry of Fisheries, Private company such as Seastar Co.Ltd	Giant clam (T.teveroa, T.maxima,) Green snail (both native and introduced) Trochus
Mariculture	Coral reef	Enhancement program, seed production	Ministry of Fisheries, Private companies, General public	Cladosiphon species (limu tanga'u) Oyster (Tofe)
Aquarium trade	Coral reef	Export of live organisms to overseas market	5 companies in operation now in Tonga	Live fish mainly from families Gobidae, Blennidae, Chaetotondidae, Acanthuridae Pomacentridae Live corals, Live rocks, and few other invertebrates
Recreational	Coral reef Mangrove	Diving, snorkeling, whale watching, reef walking, mangrove walking, picnic, games	Tourists, General Public	Corals, invertebrates, Mangroves, seagrasses
Study and research	Coral reef Mangrove Seagrass Tidal flat/lagoon	School excursion, scientific research, studies and survey	School students Scientists, biologists, Universities, Government ministries	Species studies Corals, fish, invertebrates, algae, seagrass, Sediments, sand, mangroves
Handicrafts	Mangrove Coral reef	Harvesting mangroves for dye (for tapa), handicraft chairs and tables Corals for decoration, black	General public Small scale handicraft groups,NGOs	Mangroves, corals, black corals, cowrie shell, echinoderms, fish

		corals for necklace, cowrie, sea pens for curtains, etc		
Construction/cooking	Coral reef Mangrove	Mining for construction Firewood, building	Private companies, general publics	Sand, gravels mangroves
Sea transportation	All ecosystems	Cargo ships, oil tankers, patrol boats, fishing vessels, sea ferries, and small local domestics fishing and passenger boats all use the coastal ecosystem for transportation	Oil company Government Private ships Private Fishing company General Publics	Corals, benthic organisms, fish, and invertebrates

6.7.1 Sustainability of Coastal Biodiversity

Table 6.2.7 lists the major uses of coastal biodiveristy and impacts.

Table 6.2.7 Sustainability of the Coastal Ecosystem Use

Biodiversity uses	**Activities**	**Sustainability in terms of lost of biodiversity/productivity**
Construction	Construction of wharves, jetties, marinas Foreshore construction Hotels, industries, and buildings Causeways	Both species and productivity are degraded and lowered. Habitat are destructed due to dredging etc
Fishing	Illegal fishing techniques such as poisoning, dynamite, drift net (wall of death) i.e small mesh size nets Traditional fishing techniques such as gleaners turning, smashing rocks/corals searching for invertebrates and fish *Uloa* (fish herd), spearfishing Line fishing Trawling Traps and *pa*	Unsustainable, vast areas are destroyed and marine organisms are depleted. Juveniles and undersize Are also destroyed Corals are damage and in terms of productivity, resources are degraded Same as above sustainable unsustainable only when the mesh size is small and illegal because of undersize sustainable
Aquaculture	Mollusks enhancement program	Sustainable in terms of productivity and biodiversity loss. Seeds production for bivalves, and gastropods where millions of spats are produced and released in the wild
Mariculture	Mozuku (*limutanga'u*) farming	Sustainable, no major marine organisms is affected.

	Oyster (tofe)	This is also an enhancement program even though they are export.
Recreational	Diving and snorkeling Reef walking Whale watching	Sustainable, the DOE has developed code of practice for divers and if are followed no harm to biodiversity and productivity No a sustainable practice because damages to corals and other coastal organisms may occurred Code of conduct for whale watching was also developed by SPREP and Fisheries. If the code of conduct is to be followed, it is assumed that no further damage to the animal.
Aquarium Trade	Harvesting corals, fish, live rocks and invertebrates	The Ministry of Fisheries is currently developing a Management Plan for this industry. Management standards for collection, fishing, holding, handling, husbandry are also developed. Given the development of management standards, the industry in general is not sustainable as many species are depleted such as small fishes, and corals are breakage. No EIA has been conducted on the industry.
Study and research	Conducting survey and research	Sustainable, not target to destroy or harvest any resources
Handicraft	Collecting shells, cowrie,conch, spider shells, seapens, black corals, corals, etc Mangroves cutting, ring barking	Some are unsustainable such as black corals harvesting whereby the species is depleted and threatened in Tonga. Unsustainable both activities because the species are destroyed and some areas around the Fanga'uta lagoon has been degraded.
Building/cooking	Cutting mangroves	Sustainability depends on the degrees of harvesting. For firewood they are only harvesting dead branches and for building, plants are cutting. However, shifting from Tongan *fale* to modern house, very little exercise on buildings using mangrove branches.
Tansportation	Pollution such as oil spills, sewage, chemicals, and ballast water	Several conventions on Ships pollution on sea address this problem (MARPOL, UNCLOS, London convention, Basel and Waigani). In 2002 Marine Pollution Act, it addresses all pollution of the ocean. Given that, the pollution from ships is still not sustainable and as they all dumped to the seas. The effect is on all coastal ecosystems. A new convention on invasive species has just been started but not into force yet. Invasive species issue can be devastating to the coastal environment both local to species and productivity
Mining	Sand minig	Several benthic organisms inhabit the sand and mud environments. Mining can be devastating depleting the certain species but also the productivity of the ecosystems could be lowered.

6.7.2 Trends in Threats and Pressure

Coastal Development

Most developments in Tonga are either influenced by the sea or have impacted on the marine environment due to the geophysical characteristics of the Tonga archipelago. Public infrustructure development in most islands has increased rapidly in recent years and will in the future. Hotels, marinas, restaurants, diving operators, jetties, wharfs, and etc are growing and expanding in Vava'u. In Tongatapu, coastal developments are also planned to implement on it coastal environment. Demand for land in the Nuku'alofa areas and around the Fanga'uta lagoon is increasing settlement and industries development.

Cause of Threats

Most notable habitat destruction and modification are population pressure related. With increasing population relying on limited inshore resources that are open access for all people of Tonga (Prescott 2003). While Tonga's population is growing at .5% annually, the urban growth is 2.5%. There are evidences of coastal resources degration and biodiversity lost due to population demand and movement to the capital towns.

Improved fishing techniques and equipment has been reported to be one of the root causes of threats to the coastal environment of Tonga. Fishing gears improvement and the introduction of modern fishing techniques have triggered the overexploitation of coastal marine resources in the Kingdom. Spear gun, flippers, masks, SCUBA gears, hookah, and torch are modern equipment that assisted in the fast exploitation of most reef fishes and invertebrates.

Destructive Fishing Techniques

As recorded in many studies and anecdotal evidences described reef's gleaners using bush knives, iron poles and even hammers to pry loose living corals and smash them into small pieces in searching for octopus, fish, and invertebrates.

Dynamiting and fish poisoning from roots of *kava* plant damage vast areas of the reef and the lagoon. These two fishing techniques are currently used even though they are illegal in Tonga. Poisons are used to catch fish. Some of these are highly toxic to corals and small invertebrates and kill all the fish,

including the small juveniles. Natural toxins (*kava fisi*) and artificial poisons (bleach, pesticides, herbicides) cause long-term damage to corals and associated flora and fauna.

Table 6.2.8 summerised the status shaped by the threats and pressures described above.

Table 6.2.8 Status of some Coastal Biodiversity (copied from Prescott, 2003)

Biological Indicators	Status	Pressures and Potential Impacts	Source(s) of Information
Corals	Only 10-20% alive	Heavy sedimentation and poor water quality have killed off patch reefs and their associated fisheries	Kaly (1998, 1999, 2000)
Seagrasses	All seagrass beds in the lagoon are under stress and patchy in distribution Up to 100% cover by epiphytes	Heavy sedimentation, high nutrients and high turbidity are stressing seagrasses which are important habitats for fishes and productivity of the lagoon	Kaly (1998, 1999, 2000)
Mangroves (see also Table 3.5.6)	High human impact. Massive clearance and only narrow strip around the capital and villages with few remaining intact areas	Reduction in mangroves leads to loss of fisheries, habitats, foreshore protection and stabilization and resources for building, crafts and medicines.	Ellison (1991), Pelesikoti (1992a & 1992b)
	Land allocation and fragmentation	Most of the mangrove area between Nukuhetulu and Veitongo has been assigned for allotments. Losing this area of mangroves is likely to lead to major further damage to an already stressed lagoon.	MLSNR Land Records, Ellison (1991)
	Die back problem	Large area of mangrove die back from Pea to Mu'a	Ellison (1991) Prescott et al. (2001)
	Pig damage	Damages mangrove ecosystems, particularly the growth of young trees.	Ellison (1999) Prescott et al. (2001)
Fisheries	Declining Fish kill in the lagoon	Many of the fishes, shellfish and jellyfish are affected. Several species of silver biddies, tilapia, and craps were washed up on the shores from the National Centre to Veitongo during November 1998. Similar events have happened before Most recent incident of fish kill in a different area in brakish lakes in Sopu, west of Nuku'alofa, tilapia and eels were floating dead during December 2001	Lubett (2001), Spiller (2001) , ESCAP & GOT (1990) Kaly (1998) ESCAP & GOT (1990)

Biological Indicators	Status	Pressures and Potential Impacts	Source(s) of Information
Shellfish	No major contamination by metals	Concentrations of trace metals expected to cause health problems are either below the detection limits (< 2 mg/kg dry weight) or similar to values for shellfish in uncontaminated areas elsewhere. However, it was recommended that due to increasing urbanisation and industrialisation, such studies should be carried out on a regular basis (every 1-2 years) and other health problems such as microbiological contamination should be investigated on a regular basis.	Brown & Morrison (2000)

6.7.3 Equitable Sharing of the Benefits

Use of Indigenous Knowledge on Coastal Biodiversity

Some indigenous knowledge and understanding of the environment can lead to resource conservation although it is not documented. Many of the tradiotional fishing practices target centain species only in contrast to the use of nets where species that come across the path of the net are caught. Therefore, many of the traditional fishing practices and methods used are believed to lead to selective harvesting and to conservation and the harvest is usually shared among the expteded family or the whole viliage.

Many of our marine based indigenous knowledge are unique to Tonga and practiced nowhere else in the world. This includes examples like when practicing the traditional fishing practice of **No'o'anga.** Another is the mass migration of the female **'atu** or skipjack to the beaches of **Ha'ano**, this migration is culturally attributed to the relationship between the great chief of **Ha'ano** (the **Tu'i Ha'angana**) and the **'atu** (Tongilava, 1994) and the **makafeke.** The makafeke bait **(**Refer to Picture 1) is originated based on a popular folk story in Tonga telling the revenge of the octopus if it ever catches a mouse at sea again. It should be noted that a large amount of products sold in the handicrafts businesses use natural materials from the marine environment like coral, cowrie shells, black and white pearls, turtle shell, and other seashells that are mostly made into jewelry.

Picture 1: The "makafeke", traditional bait

The use of marine characters that feature in traditional folk stories or "**fananga**" on printed Look Sharp and Smart Look shirts is another use of indigenous knowledge. Designs of the turtle **Sangone, Hina** the shark, whales, or of tapa clothed men spear fishing are some popular characters that feature in these shirt designs.

Community fishing practices that requires the involvement of many people and sometimes the whole village, where catch are equally shared among the village, includes **Uloa** or **Pola** or Herding of the fish. The **Tolo** and **Faka'uvea** fishing methods are similar to the **Uloa** and only the people of Niuatoputapu carry out this type of fishery. This method targets certain inshore fishes such as mullet (**kanahe**) and goatfish (**vete**). The **No'o'anga** or Shark noosing is restricted to certain villages or the islands of **'Eueiki** and **Mo'unga'one** who have proclaimed this their traditional technique for catching sharks.

The lack of legislative rights imposed on the indigenous knowledge used for commercial interest is another factor that prevents beneficiaries been solely owned by the rightful holders. This is evident in the absence of legislative reference to traditional knowledge of Tonga's natural terrestrial or marine resources in the Industrial Property Rights Act (1994). Designs on Tongan Look Sharp and Smart

Look shirts that depict the characters of Tongan traditional folk stories are easily copied by overseas printing businesses, as it does not have any legislative protection.

Past documents have noted that the current Intellectual Property system in Forum Island Countries, which Tonga is a member, cannot protect traditional knowledge for three reasons. First the current system seeks to privatise ownership and is designed to be held by individuals or corporations, whereas traditional knowledge has collective ownership. Second, this protection is time-bound, whereas traditional knowledge is held in perpetuity from generation to generation. Third, it adopts a restricted interpretation of invention that should satisfy the criteria of novelty and is capable of industrial application, whereas traditional innovation is incremental, informal and occurs over time (Forum Secretariat, 1999).

Development of Biotechnology

As of present there has been no development in marine biotechnology in Tonga so far. A private company in Tonga, Pacific Biotechnology is a sign of such a development. However this company has not carried out any developments on the marine biodiversity instead focussing only on some terrestrial plants.

Legal basis for protecting Intellectual Property Rights (IPR)

It is widely recognised that an effective and efficient Intellectual system creates a confident and secure business environment, stimulates inventive ideas and innovative activities, deters unfair trade practices from infringements and therefore can lead to increase investment.

The importance of an Intellectual Property Rights system for trade and investments has been recognised in Tonga with the enactment of the recent Industrial Property Rights Act (1994) under the authority of the Ministry of Labour, Commerce and Industries. However this Act does not include a legal basis for protection or use of marine biodiversity at the level of the country and people, communities, national business and institutions.

Furthermore, the protection in this Act concentrates on core intellectual property issues such as the registrations and protection of New Inventions, Utility Models, Industrial Designs and Marks. Other

Intellectual Property legislations include Copyrights Act, Geographical Indication Act, Layout Designs Act and the Act of Unfair Competition has been passed by Parliament in 2002. However this Industrial Act excludes the other distinct aspect of Intellectual Property, that of Traditional Knowledge. Tonga like other Pacific communities have very fragile and unique biodiversity and very rich and diverse cultures, traditions, agricultural, medicinal, biodiversity related knowledge and expressions of folkstories in the form of music, dance, song, handicraft, and designs that is not protected in this Act from been exploited for commercial benefit.

In the absence of appropriate laws to govern access to biological resources and protect traditional knowledge, the Forum Islands countries will not derive any economic benefit and will continue to become an easy target for exploitation of this knowledge and genetic materials that are patented overseas (Forum Secretariat, 1999).

6.7.4 Beneficiaries of Present Use of Marine/Coastal Biodiversity

Table 6.2.9 summerises the benefeciaries of coastal biodiveristy use.

Table 6.2.9 Summary of the type of fishery and Benefeciary Groups

Type of Fishery or Marine activities	Beneficiary Groups	Names of existing beneficiaries in Tonga
Commercial Fishery **(with the sole purpose of use or sales of marine biodiversity for financial benefits)**	Fish Wholesale/ Retailers Fish exporters Handicrafts and Souvenirs businesses Supermarkets Restaurants, take away or food outlets Local village fishermen and women who exploit the inshore marine resources for sale in fish stands at Queen Salote wharf, Tu'imatamoana or by road sides Aquarium fishery business for export of live fish	Sea Star Fishing Co. Ltd. 'Alatini Fisheries South Seas Fishing co Ltd. Maritime Projects Tonga Ltd. Coral Kingdom Tonga Ltd. Friendly Islands Fishery Langafonua Handicraft South Seas Jewellery Tiani's Handicraft Souvenirs Fehoko Handicraft Kinikinilau, Morris Hedstrom, Si'i Kae Ola, Cold Store etc Sia Leka Takeaway, Bansal fish and chips, Tasty Café etc Dateline

	and corals	
Subsistence Fishery targeting Inshore resources	Local fishermen in village communities Local women in village communities	Inshore fishing and collection of marine resources mainly for family consumption only Exploiting resources for traditional handicraft practices for family collection
Game Fishing Recreational Sports	Game fishing Charter businesses	Tonga International Game Fishing Association affiliate Vava'u Sports Fishing Club has 5 gamefishing charter businesses: Hekula Lodge Fishing IWM Deep blue Kiwi Magic Charters Royal Sunset Game Fishing Target One
Ecotourism based fishery activities	Dive and Snorkeling Charter businesses Whale watching Charter businesses Dolphin watching Charter businesses	Dolphin Pacific Diving Friendly Island Kayak's Whale Discovery Hakula Lodge Whales in the Wild Kiwi Magic Charters Melinda Sea Adventures Sailing Safaris Whale Watch Vava'u Sea Taxi Nuku'alofa
Marine Scientific Investigations	Marine Scientific Investigations	
Aquaculture Fishery	Stock enhancement venture to increase species and also for business	Ministry of Fisheries Sea Star Fishery

6.7.5 Inequitable Sharing of Benefits.

According to findings by Kailola (1995), the Kingdom's fisheries resources can be classified into four habitat dependent groups, which are:

- offshore fisheries in oceanic waters for pelagic species such as tunas and "gamefish"
- offshore fisheries on reef slopes and sea mounts for deepslope bottomfish
- small scale nearshore pelagic fisheries from boats, including trolling around fish aggregation devices
- inshore subsistence and commercial fishing on shallow reefs or in nearshore waters and lagoons

These categories of fish resources are subjected to different levels of exploitation through fishing. However based on the findings by the Fisheries Sector and a joint FAO/AusAID team it was concluded that the INSHORE resources are the most over exploited both by subsistence and commercial fishing activities. The inshore area in Tonga is the shallow reef water including lagoon systems that is nearest

to land. Due to the narrow coastal shelves around the islands of Tonga, the inshore fisheries resources are limited. This resource limitation together with the easy accessibility to these areas lead to these resources been heavily exploited for many years. Evidence of this is noted in the Government of Tonga's Sixth Development Plan which estimated that 65% of all fish landing, including shell fish and crustaceans are caught in the inshore. The main fisheries resources in the zone which are also overexploited are mullet, sea cucumbers, giant clams, rock lobsters, beche de mer, finfish, slipper, turtles, octopus, sharks and edible shells (Kailola, 1995).

The development of the aquarium fish trade in Tonga has led to the exploitation, not only of small colourful reef fishes, but also juvenile giant clams, other shellfish species, corals and sea anemones. Export data submitted by the main aquarium exporter indicate that, in terms of the number of marine aquarium resources exported during 1993, corals made up about 60 per cent of the total export during the year (DOE, 2004).

Establishment of offshore bottomfish fishery that started in 1980 was initially aimed at relieving the pressure on the shallow inshore fisheries resources and to increase the production to meet the local demand. However in recent years the establishment of overseas markets for the more valuable bottomfish species has changed the nature of the fishery with most boats targeting the deep-water snappers and groupers for export.

Several measures have been developed to sustainably manage inshore resources. This includes the Fisheries Act 1989 section 59 that is the Fisheries (Conservation and Management) Regulations 1994. In Part II, III and IV of this Act which states General Conservation and Management Measures, Prohibited Fishing Methods and Species Conservation and Management respectively, where an offender can be fined up to TOP $ 10,000 for breaking the law.

6.7.6 Reinvestment in Sustainable Management of Coastal Biodiversity

The Vava'u Sports Fishing Club (VSFC) is affiliated with Tonga International Game Fish Association (TIGFA) that is affiliated with the International Game fishing Association (IGFA). The VSFC members are encouraged to Tag and Release Billfish that includes blue/black/striped marlin, sailfish and spearfish. There are five-gamefishing charter businesses in Vava'u and their customers are mainly international visiting anglers most of whom, want to also Tag and Release unless the billfish is a

potential record. In the statistics for 2003, 345 Billfish were caught of which 80% was tagged and released (URL// http://www.tongaholiday.com). The VSFC President is currently lobbying a proposal to put into effect a "Billfish Moratorium" which if accepted the commercial sale, battering and trading of any billfish species will be illegal.

Tonga Visitors Bureau has recognised the potential of ecotourism-based fishery that includes Whale watching, Diving and snorkeling, Dolphin watching activities to the tourism industry. In co-junction with Ministry of Fisheries, a brochure was produced to outline guidelines and code of practice for licensed whale watching charter businesses. This ensures protection of the marine environment from wastes that are detrimental to the health of the whales, but also includes practices that minimise disturbance to the whales that may leave the Tongan marine areas if they are under too much stress. Also the TVB have produced a code of practice for Diving and snorkeling operators that require them to comply with regulations and approved practices.

6.7.7 Equitability of the Exploitation

All foreign fishing vessels that are based locally have a license payment of US $10,000 per year whereas local fishing vessel license depends on the length of the boat. Currently local vessels pay TOP $50-00 for 6 metres and $5-00 for every meter, e.g. a 10 metre boat require a license of TOP $70-00.

Both local and foreign fishing vessels have equal rights to the exploitation of marine biological resources after they have obtained a license from the Ministry of Fisheries. However foreign vessels conduct mostly commercial long lining and do not carry out deep slope fishery because of the restriction of this type of fishery only for the locally owned fishing vessels. Currently, there are 10 locally based foreign vessels operating in Tonga, and 53 locally owned vessels.

Landing and export data are lacking from individual fish operators (DOE, 2004) however with the foreign fishing vessels may apply more effort to exploit a larger quantity of marine resources to make up for the expenses of license and other operational costs and therefore make a profit.

6.8 Institutional Framework and Human Resource Base

Present Institutional Responsibilities

The Department of Environment was previously a section of the Ministry of Lands, Survey and Natural Resources (MLSNR) known as the Environmental Planning and Conservation Section (EPACS). Responsibilities that were assigned to EPACS included implementing the legislative functions of the Ministry under the Parks and Reserves Act and other Government Policies. This included the research, development, implementation, monitoring and evaluation of suitable areas in the marine and land environment to be recommended as a Park or Reserve under the *Parks and Reserves Act 1976* (DOE, 2002). This Act gives authority to the Minister of Lands with advice from assessments carried out by EPACS to approve and declare an area on land or sea a park or reserve for the preservation of ecosystems and its biodiversity.

However, in 2001, Government restructuring resulted in the transfer of the Department to become an independent institution from the MLSNR. Yet, the Parks and Reserves Act and its authority remained under the Minister of Lands and the MLSNR even though the relevant skills, capacity and expertise have been transferred to the new DOE. The Departments responsibilities is still to advise and formulate management plans to forward to MLSNR on Marine Parks based on their surveys and assessments conducted but have no authority to enforce these plans.

Table 6.2.8 in Chap. 6 Appendices described in detail the institutional responsibilities.

6.8.1 Human Resources for Biodiversity Conservation

A weakness of the DOE in carrying out its responsibilities for marine biodiversity conservation is the limited number of skilled staff members. Currently there is 12 established staff with one Peace Corp who under volunteer contract for a period of 2 years. There is 6 project staff that is employed for the duration of the projects. Of the 12 staff members only 4 including the Peace Corp volunteer are assigned to the Technical and Sustainable Development Division (TASD) while the rest are either allocated under the Administration or Environmental Information Division. The TASD Division that has responsibility for environmental management and research involves planning and preparation of management plans that include MPA's, solid waste and pollution. Monitoring programmes are carried out to gather information together with assessing important ecosystems and habitats including

Fanga'uta Lagoon, MPA's, coral reefs around ***Nuku'alofa*** and wharfs in outer islands. The number of staff in this Division is a limiting factor and support from staff of other Ministries is sometimes employed to carry out marine and terrestrial assessment studies for this division.

The Ministry of Fisheries has 108 established and non-established staff. There is adequacy in staff numbers to carry out responsibility of the Ministry to conserve, manage and develop fisheries in Tonga and monitor and enforce these measures.

The MLSNR under the Division of Natural Resources, which includes a Mineral Resources Unit, has responsibilities regarding beach sand resources and employs 6 established and non established staff. However the Marine Parks and Reserves which has direct relation to marine resource conservation is only supervised by 1 staff member who is posted as a Parks Ranger and has responsibility of enforcing the laws stipulated under the Parks and Reserves Act 1976.

Tonga Visitors Bureau (TVB) plays a supportive role to other institutions in promoting ecotourism, promoting 'clean environment' campaigns and in producing brochures and guidelines in co-junction with MOF and DOE for Whale watching and Diving /snorkeling activities. There are about three staff members in TVB that have responsibility in this area.

6.8.2 Available Funding

Ministries that have responsibilities for biodiversity conservation as mentioned above are responsible for requesting government's funds through the Budgets for every financial year. Further, these institutions also have responsibility for seeking donor support to their biodiversity conservation role through projects developments. In the area of biodiversity conservation, government funds mainly covers staff salaries. Donor funding has been requested for relevant implementation, monitoring and education and awareness programmes, however sustaining these activities after the donor ends is a major problem in Tonga.

There are several projects that are presently been conducted and funded by either one or collaboration of several international organisations such as JICA, FAO, SPADP, SPREP, AusAID, SPC, FFA, and others as reflected in the ealier chapters of this report.

6.9 Legal and Policy Framework

There are several thematic programmes that fall under the CBD, which includes:

- Forest biological diversity
- Inland water biological diversity
- Agricultural biological diversity
- Marine and coastal biological diversity
- Dry and sub-humid lands

This report involves an analysis of the adequacy of the legal and policy framework for the conservation of coastal biodiversity. This will include:

- Analysing the strengths and weaknesses of the present legislative and policy frameworks as they affect coastal biodiversity conservation;
- Identify gaps, conflicts and areas of confusion, particularly attention will be given to coastal biodiversity conservation;
- Analyse the legal basis for institutional mandates; and
- Review of existing programmes and projects for coastal biodiversity conservation.

Existing Laws:

There is no separate Act that directly addresses biodiversity issues, however there are legislative provisions, under different Ministry's/Department's that could be used to address coastal biodiversity conservation. This section will review statutes that may address coastal biodiversity conservation.

Review of existing laws:

The following Acts were referred to for the purpose of compiling this report:

- The Land Act 1927
- Birds & Fish Preservation Act, amended in 1974
- Parks & Reserve Act 1976
- Fisheries Act 1989 (Discussed in Chapter 5)
- The Fisheries (Conservation and Management) Regulations 1994 (Discussed in Chapter 5)
- Fisheries Management Act 2002 (Relevant provisions for Coastal Biodiversity Management discussed here).
- Aquaculture Management Act 2003 (as above)
- Environmental Impact Assessment Act 2003

The Land Act

Section 2: "foreshore" means the land adjacent to the sea alternately covered and left dry by the ordinary ebb and flow of the tides and all the land adjoining thereunto lying within 15.24 meters of the high water mark of ordinary tides.

Section 113: The foreshore is the property of the Crown and the Minister of Lands, Survey and Natural Resources may with the consent of Cabinet grant permits to erect stores or wharfs or jetties thereon or to reside on any portion thereof or he may the like grant a lease for ay of the purposes aforesaid.

- This is the landward mark for coastal areas according to the law.

Birds & Fish Preservation Act, amended in 1974

Section 2: "protected area" means any area comprising land, or water, or land and water, as is specified in the Third Schedule hereto;

Part II – Protected Areas.

Section 6: The area specified in the third schedule to this Act is hereby declared as a protected area; and the Prime Minister may by Order with the consent of Privy Council amend the Third Schedule.

THIRD SCHEDULE – PROTECTED AREA

The following area is hereby declared to be a protected area:

All and whole of the lagoon in Tongatapu known as Fanga'uta and Fangakakau, being the area lying to the South of a straight line drawn from Niutao on the northernmost point of Nukunuku Motu and including the straights know as Holeva and all mangrove foreshore (refer to Figure 2).

7. (1) No person may, within a protected area, and without the prior consent in writing of the Prime Minister-

(iii) cut, damage, remove or destroy any mangrove;

(iv) erect any fish-fence, or set any fish trap; or trawl or fish (including shellfish) or engage in fishing for commercial purpose.

Parks & Reserve Act 1976

Provides for the establishment of a Park and Reserves Authority and establishing preservation and administration of Parks and Reserves.

- This legislation lies under the Ministry of Lands, Survey & Natural Resources mandate.

Fisheries Management Act 2002

The Act comprises of 105 sections. It establishes a new management framework for the sound conservation and management, and the sustainable utilisation of fisheries resources in the Kingdom. The Act lays down the basic requirements for fisheries management such as fishing effort control (through licensing), the use of closed and open seasons, and fishing gear controls. It also allows for future details regulations to be made to respond to different needs, times and situations. The Act proposes that the management of fisheries will be undertaken primarily by the Ministry of Fisheries through powers vested in the Minister and the Secretary for Fisheries and their designated agents. However, allowance is made through various institutions for the stakeholders to adequately participate in management activities or influence decisions in the interest of sound fisheries management.

Relevant sections for coastal biodiversity would include the following:

3. Provides for Responsibility of the Minister
7. Provides for Fishery management and development plans
8. Provides for Fisheries Management Advisory Committee
9. Provides for Co-opting members
12. Provides for Sub-Committees of the Committee
13. Provides for Special Management Areas
14. Provides for Designation of coastal communities
15. Provides for Regulation of fisheries in Special Management Areas
16. Provides for Protection of certain species
17. Provides for Fishing with poisons or explosives prohibited
19. Provides for Fishing and related activities subject to prohibition
29. Provides for Local fishing vessel licenses
101. Provides for Regulations

Aquaculture Management Act 2003

Provides for the management and development of aquaculture in Tonga and other matters incidental thereto.

Relevant sections under this Act may include:

4. The Minister shall prepare and keep under regular review a plan or the management and development of aquaculture which shall be published in the Gazette.

27(1) The Minister, may by notice in writing if he has reason to believe that any activity at any aquaculture premises may have a detrimental impact on the environment, require the holder of a license or other authorisation issued under this Act to –

(a) commission an assessment of the environmental impact of the existing aquaculture or related activities by an appropriately qualified independent person; and

(b) submit a report of the assessment to the Minister within the period specified in the notice and in accordance with the prescribed guidelines.

(2) The Minister may exempt an aquaculture development or related activity from the provisions of subsection (1).

29(1) No person shall import, possess, sell or culture any genetically modified fish or use any genetically modified fish in aquaculture or related activity without the written authorisation of the Secretary.

(2) An aquaculture officer may seize and destroy any genetically modified fish and may take possession of such fish in order to determine whether it is genetically modified and any expense shall be borne by the person who is in possession of such fish in contravention of subsection (1).

Environmental Impact Assessment Act 2003

Some of the key features relevant to this report include:

Section 2: "environment" includes all natural, physical and social resources, people and culture and the relationship that exists between these elements;

Section 6: All major projects shall be supported by an appropriate environmental impact assessment, conducted as required under this Act.

The EIA Act, recently passed in September 2003, provides a framework for development planning which aims to prevent the making of arbitrary land, marine & coastal areas resources use decision.

6.9.1 Strengths and Weaknesses of Existing Legislation

The land and the sea (and its resources) are the property of the Crown (The *Land Act 1927* & the *Territorial Sea and EEZ Act 1978*). Therefore, the rights to all natural resources are vested in the Crown, and the representative of the Crown is the government.

The Minister of Lands can authorise certain activities by issuing leases in specified marine and terrestrial areas. He also has the power for conservation and management of marine and national parks, and in all government land (*Parks & Reserve Act* and the *Land Act*). This creates a conflict with the *Birds and Fish Preservation Act (s. 6)* for protected areas, due to lack of enforcement. For instance, Fanga'uta and Fangakakau lagoon is the oldest protected area under the *Birds and Fish Preservation Act (s.7)*, prohibiting destruction of mangroves, however, the Minister has given authorisation to reclaim land for residential purposes, which breaches the *Act of the Constitution (s.109)* and the *Birds and Fish Preservation Act*.

The lack of implementation of the *Birds and Fish Preservation Act* is an example of 'unclear' management. This Act is considered the most important piece of legislation in Tonga to conserve biodiversity and wildlife (ESCAP, 1990). The Act was also amended in 1989 to offer protection for turtles during the breeding seasons, however, it lacked the protection for breeding sites. Than came the *Fisheries (Conservation and Management) Regulations 1994* under the *Fisheries Act 1989*, which offered the protection of turtles during breeding seasons and the protection of breeding sites. Therefore, there is an overlapping of some common elements between the two legislations of the Ministry of Lands, Survey & Natural Resources and the Ministry of Fisheries.

The *Fisheries Act 1989* provides for the management and development of fisheries in Tonga. There seemed to be a potential conflict with the *Parks & Reserve Act* and the *Land Act*, with regards to the regulation of fishing by the Minister of Fisheries in accordance with a fishery plan, licensing regime or declaration of a reserve (s.22) for subsistence fishing, however, this has been addressed by the *Fisheries Management Bill 2002*. The setting up of a Fisheries Management Advisory Committee (s.8), to advise the Minister and the Secretary on such matters relating to conservation, management,

sustainable utilisation of fisheries, has included the Secretary for Lands or his nominee as a member of this Committee. However, in the designating of coastal communities of the Bill, it is stated in s.11 that the Minister "may" consult the Committee, not "shall", so there may still be the potential for a conflict.

Tonga has five marine parks. These parks were established under the *Parks and Reserves Act of 1988*:

- Hakaumama'o Reef
- Pangaimotu Reef Reserve
- Monuafe Island Park and Reef Reserve
- Ha'atafu Beach Reserve
- Malinoa Island Park and Reef Reserve

The *Fisheries Management Bill 2002, s.2* defines "fisheries waters" the territorial waters of the Kingdom, internal waters including lagoons, and such other waters over which the Kingdom of Tonga from time to time claims sovereign rights or jurisdiction with respect to the marine living resources by legislative enactment or by Royal Proclamation.

S.3 (1) of the *Fisheries Management Bill* states: The Minister shall, subject to this Act, be responsible for conservation, management, sustainable utilisation and development of fisheries resources in the Kingdom and the fisheries waters.

There is no definition for "fisheries resources" in s.2 of the Bill. Does "fisheries resources" include mangroves? If yes, that would have an overlap of *s.3* of the *Fisheries Management Bill* under the authority of the Ministry of Fisheries and the *Birds and Fish Preservation Act, s.6* under the authority of the Ministry of Lands, Survey and Natural Resources. Fanga'uta and Fangakakau Lagoon would fall within the definition of "fisheries waters".

The *2002 Fisheries Management Act* is to repeal the *Fisheries Act 1989*. S.101 provides for Regulations, which states that the Minister may make regulations for the implementation of this Act. Currently, the Ministry of Fisheries is drafting a regulation for this Act, as well as the regulation for the Aquaculture Management Act 2003.

Guttenbeil, (2004) highlights overlaps between the *Aquaculture Management Act* and the Biosafety Protocol under the Convention. There is a potential overlap in the scope of the *Aquaculture Act (s.29)*

and Biosafety Protocol (Article 3), should an aquaculture product or fish qualify as a Living Modified Organism (LMO). The Aquaculture Management Act will need to be amended to include the definition of LMOs and a clause to state that it is essential that the Competent Authority for Biosafety should give their written authorisation in addition to the written authorisation of the Secretary of Fisheries.

S.27 of the *Aquaculture Management Act 2003* addresses EIA of an existing aquaculture or related activity. There is a need for a clause stating new applications for license to establish an aquaculture facility must be submitted to the Competent Authority (Department of Environment) for an EIA (s.6 of the *EIA Act*) before authorisation is given to proceed. Section 28 states that development activities of government agencies will be subject to the Act.

In addition to s.7 (3) of the *Fisheries Management Bill* that provides for fishery management and development plans, the Secretary shall, in preparation and review of each fishery plan, consult as appropriate with-

(a) other government departments and agencies, including any District, Town or local government body or authority concerned or affected by the fishery plan.

The Department of Environment should be consulted or included in the Committee, as the department will play a major role with regards to impact assessments of any development project. The use of the word "appropriate" is unclear. This implies that the Secretary may consult any agency he/she feels is suitable for that particular issue.

There is a need to ensure consultation and coordination among relevant government institutions and the general public, if not, measures to protect the environment will continue to be sector-based, fragmented, and in many cases ineffective.

Table 6.2.9 in Chap. 6 Appecdices summarises existing legislation that contain provisions relevant for coastal biodiversity conservation.

6.10 Existing Programmes and Projects

This section involves identifying and describing the present programmes and projects operating in Tonga in the area of biodiversity conservation.

(1) Tonga Fisheries Project:

Goals and objectives:

The Project is an integrated sectoral development and resource management project.

Its overall goal is to contribute to Tonga's economic growth and social well being of its people. The purpose of the Project is to improve the welfare of the people of Tonga through sustainable development and management of living marine resources, with attention to remote and disadvantaged communities.

Donor(s): AusAID

Executing agency: Ministry of Fisheries

Starting date and duration: January 2002; duration of 4 years

Budget:

Summary of strategies employed:

There are 4 components to this project:

1. Capacity building and enhanced stakeholder input. The following outputs would be:

    - Development of improved strategic planning capacity in MoF;
    - Advice on privatization of non-core functions of the Ministry - indicatively, boat building, engineering and market operation;
    - Human resource development strategies and a core of personnel equipped to deliver MoF's Strategic Plan;
    - Consultative network to ensure stakeholder input into fisheries development and management planning, work programming and review;
    - Improved capacity to disseminate information on fisheries issues and improved public perception of MoF and the fishing industry; and
    - Refurbishment of MoF's Sopu office, including construction of Project office space.

2. Assistance to small-scale fishers. Outputs would be:

    - Regular supplies of ice available at main centres in the Ha'apai group, on a sustained basis;

- Improved marketing opportunities in rural areas;
- A sustainable programme of FAD deployment, maintenance and replacement, with training in offshore fishing skills provided to improve catches of tuna and other pelagic fish;
- Increased awareness of small boat sea safety issues among small-scale fishers and improved radio communication in the outer islands; and
- Special initiatives fund operating to support sustainable small-scale fisheries.

3. Development of the commercial tuna longline fishery. Outputs would be:

- Tuna longlining trials conducted using two 9 m vessels for one year;
- Provision of practical advice to tuna exporters on processing and marketing options that will enable an increase in tuna export values in the absence of a significant increase in the availability of airfreight capacity;
- MoF has the resources to deliver responsive assistance and advice to commercial tuna fishing operators (particularly new entrants) on vessel selection, gear specification and procurement, fishing skills, vessel seaworthiness and safety at sea, and other matters; and
- Information on the credit-worthiness of the sector promulgated.

4. Community-based inshore resource management. Outputs are:

- A workable inshore resource management system based on increased coastal community involvement and ownership, initially in the Ha'apai area but with potential application elsewhere; and
- An extension service that will assist in the development and support of community based fisheries management and development.

Summary of results to date:

Components 1 - 3 are currently being implemented, and component 4 is to start this year 2004.

(2) National Biodiversity Strategy Action Plan and First Report to the COP

Goals and objectives:

The objective of this enabling activity is to formulate, through a participatory and analytical process, the strategies and actions necessary for the protection and sustainable use of the biodiversity in the Kingdom of Tonga and, to prepare a National Biodiversity Strategy and Action Plan for their implementation. Also the project will allow Tonga to meet its obligations under the Convention

Biological Diversity (CBD) by assisting the preparation of its first Country Report to the Conference of Parities (COP).

Donor(s): GEF financing

Implementing agencies*:* The GEF implementing agency is UNDP and the national executing agency is the Department of Environment.

Starting date and duration: June 2003; duration of 2 years

Budget*:* USD318,000

Summary of strategies employed:

1. Organisational phase – the creation of structures (such as the technical working group and national coordinating committee) to undertake the planning process

2. Stocktaking and assessment – this phase consists of:

    - Taking stock of the biodiversity within the country, (both wild and domestic)
    - Identification and assessment of the threats to this biodiversity
    - Identification and assessment of the causes of these threats
    - Gathering information on socio-economic issues and resource use regimes
    - Assessment of the sustainability of the present use of biological resources
    - Assessment of the equitability of the sharing of benefits from the use of biological/genetic resources
    - Assessment of the legal, policy and institutional framework governing the use and conservation of biological resources within the country

3. Definition of priorities and objectives – based on the results of the stocktaking phase, one must begin to define priorities for biodiversity conservation and to define the strategy objectives in a participatory manner

4. Identification and analysis of options for achieving objectives – this phase needs to be a strongly participatory phase involving those stakeholders that use biological resources, those that are involved directly or indirectly with the causes of biodiversity loss and those who have a stake in the sharing of the benefits from the use of biodiversity resources

5. Drafting of the national strategy – the final strategy must clearly define national priorities and objectives and those options that emerge from the planning process as the most effective for achieving the stated objectives

6. Preparation of the national action plan – the action plan must define, in much more concrete terms the following:

- Resources needed to implement the strategy and timetable for implementation
- Definition of roles and responsibilities of institutional and other stakeholders
- A monitoring and evaluation plan
- Calendar for implementation

Summary of results to date:

To date, the project is currently carrying out activity 1: Stocktaking and assessment.

(3) Development of the National Biosafety Framework for Tonga

Goals and objectives*:*

The main objective of this National Project is the preparation of a National Biosafety Framework in accordance with the relevant provisions of the Cartagena Protocol on Biosafety.

The main elements of this framework would be a regulatory system; an administrative system; a decision making system that includes risk assessment and management; and mechanisms for public participation and information.

Donor(s)*:* United National Environment Programme

Executing agency: Department of Environment

Starting date and duration: January 2003; duration of 18 months

Budget: USD148,000

Summary of strategies employed:

Phase one (1-6 months): consists of preparatory activities and the gathering of the necessary information.

Phase two (7-12 months): analysis for the preparation of the NBF.

Phase three (13-18 months): a draft NBF will be prepared.

Summary of results to date:
At this stage the project is currently executing phase two.

(4) International Waters Programme

Goals and objectives:

The goal of the action plan for this project is to achieve integrated sustainable development and management of International Waters.

The project purpose is to address the root causes of degradation of International Waters through a programme focus on improved Integrated Coastal and Watershed Management (ICWM) and Oceanic Fisheries Management (OFM).

Donor(s): GEF/UNDP/SPC/FFA/SPREP

Implementing agencies*:* SPREP

Executing agency*:* Department of Environment, Tonga

Starting date and duration: 4 February 2002, duration of 5 years

Budget: USD120,250

Summary of strategyies employed:
Outputs to be achieved are as follows:

- Enhance transboundary management regimes and create effective project coordination support;
- Achieve sustainable development and use of coastal living and non living resources;
- Achieve sustainable development and use of ocean living marine resources; and
- Effective project related community assessment participation and education.

Summary of results to date:

Currently, the project is implementing activities towards achieving output bullet point 2, on waste reduction demonstration project at Nukuhetulu, Tongatapu; and also towards output bullet point 4.

(5) ‘Eua Man and Biosphere Project

Goals and objectives:
The goal is to manage and protect the unique ecosystem of ‘Eua National Park with the support and assistance of the surrounding communities.

The primary objectives are to:

- Establish and continue an effective long-term management plan based on twin goals of economic sustainability of surrounding communities and National Park protection;
- Coordinate with international, national, and local agencies to develop long-term financing schemes to support EMB projects and activities and ensure the preservation of the EMB for future generations;
- Develop baseline scientific monitoring studies and research proposals to assess population size, diversity and composition of species and ecosystems of concern now and in the future;
- Establish a ‘Eua Man & Biosphere Coordinating Committee (EMBCC) with the DoE as the focal point;
- Coordinate among relevant Government Ministries, communities, and other public and private sector organizations concerning decisions on the EMB and the surrounding areas;
- Develop environmental education and awareness programmes to obtain support for EMB projects;
- Amend and create new legislation necessary for effective EMB projects and management plans;
- Promote sustainable community-based income generating programmes supported by the EMB management plan; and
- Plan, develop, and implement other EMB projects and activities as needs arise.

Donor(s): UNESCO

Implementing agency: Department of Environment, Tonga

Starting date and duration*:* mid-2004, one year

Budget: USD30,000

Summary of strategyies employed*:*

The EMB project is to be tentatively subdivided into three Strategic Areas to facilitate organization of the EMB management plan. These are:

- Strategic Area 1: Institutional strengthening and community capacity building mechanisms to develop in-country EMB management and administration skills, sustainable income generating activities, and public education and awareness campaigns.

- Strategic Area 2: Scientific assessment, monitoring, survey, research, and educational capacity building kills and programmes.

- Strategic Area 3: Fiscal, legal, and international obligations and mechanisms to ensure proper protection and management of EMB.

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The Land Act 1927

Parks & Reserve Act 1976

Territorial Sea and EEZ Act 1978

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URL//http://www.tongaholiday.com/stories/fishing/vavausfc.php

6.12 Annexures

Annex 1- Table 6.2.8: Summary of Existing Legislation that Contain provisions for Coastal Biodiversity Conservation

Responsible Ministry	Existing Legislation	Strengths and Weaknesses
Ministry of Lands, Survey & Natural Resources	The Land Act 1927	Weakness: conflicting roles of conserving swamp areas, weak enforcement.
	Birds & Fish Preservation Act, amended in 1974	Weaknesses: No regulation; list of protected species are outdated, lack of provision for habitat conservation, lack of pubic awareness
	Parks & Reserve Act 1976	Strengths: Provide for the establishment of conservation areas; establishment of Authority
		Weaknesses: No regulation, Authority inactive; lack of public participation
Ministry of Fisheries	Fisheries Act 1989	Strengths: provide for public participation; strong on monitoring, enforcement of conservation measures; penalties
		Weaknesses: Unclear management roles in marine reserves; lack of implementation; lack of coordination with relevant government organizations
	Aquaculture Management Act 2002	Strengths: provide for pubic participation; strong on monitoring, enforcement of conservation measures; penalties, establishing of Authority
		Weaknesses: no regulation
Department of Environment	Environmental Impact Assessment 2003	Strengths: Establishes Authority, provides for public participation; provides provisions for development planning and resource use
		Weaknesses: no regulation, implementation

Source: Prescott, N., 2003

Annex 2 - Table 6.2.9: Summary of the relevant institutional stakeholders with relation to marine biodiversity and their responsibilities for marine biodiversity conservation and weakness and strengths that exists within each institution

	RELEVANT INSTITUTIONAL STAKEHOLDERS			
	Department of Environment (DoE)	**Ministry of Lands, Survey and Natural Resources (MLSNR)**	**Ministry of Fisheries (MoF)**	**Tonga Visitors Bureau (TVB)**
Responsibilities for Marine Biodiversity Conservation	The Department plays an advisory role to other Ministries who have the mandates for marine biodiversity conservation. This advice is based from the Department's marine/coastal management research. The Environmental Planning and Assessment Division of the DoE is the body which carries out these surveys and assessment. Monitoring programmes have been established which are designed to assess and gather baseline information on important ecosystems and habitats, including Fanga'uta Lagoon, Marine Protected Areas, coral reefs. Other related responsibilities include: • Propose and recommend potential Marine Reserves sites for designation in accordance with the Parks & Reserves Act (1976) • Increase public/community awareness of environmental issues nationally like lagoon, coastal related issues, biodiversity) • Develop strategies for the conservation of biodiversity The DoE also stands as the coordinating organisation for all international donor funded projects in the environmental sector. It also handles compliance with the international conventions such as the United Nations Framework Convention on Climate Change	The responsibility of MLSNR that addresses marine biodiversity conservation is the authority of the Minister to declare an area in the coastal environment a Marine Protected Area (MPA)/Marine Reserve under the Parks and Reserves Act 1976 and Revised 1988. This Act is for the protection, preservation and control of any aquatic form of life and any other organic matter contained within this MPA boundary. The MLSNR with the authority of their Minister is charged with the responsibility to mine, bore, quarry, dig for, win and work all or any material under the Minerals Act 1949.	The responsibility for the conservation, management and development of fisheries in Tonga. The Fisheries Act, 1989 gives authority to the Minister and MoF to conserve endangered inshore marine resources by enforcing size limits on lobsters, giant clams, turtles, winged pearl oyster etc. This Act gives the MoF responsibility of enforcing the penalty if an offender is caught breaking the law	The Tonga Visitors Bureau do no have any direct responsibilities in protecting the marine resources which are mostly related with tourism for example whales and dolphins. However they have a supportive and enforcement responsibility to other relevant authorities like Ministry of Fisheries where a co-junction between TVB and MoF to introduce guidelines and codes of practice for whale watching operators. TVB also introduced code of practice for diving and snorkeling operators requiring them to comply with regulations and approved practices.

	(UNFCC) and Convention on Biological Diversity (CDB)			
Strengths of the institution or company	Qualified staff in the marine fields of study to carry out monitoring, assessment surveys. Adequate and reliable international assistance to fund monitoring, assessment, planning activities. For example AusAID funded study in Fanga'uta Lagoon. JICA funded consultant specializing in MPA management	Authority of Minister to declare an area a MPA for conservation of marine and terrestrial resources	Fisheries Management Act that was approved by legislative assembly in 2002 and endorse by the King have a section on Community Base Management where the conservation of marine resources to be enforced by the resource user. This will minimise the present open access nature system which does not support the conservation of marine resources	Support from other Ministries and Departments for conserving marine resources vital for ecotourism development
Weaknesses of the institution or company	The Department at present acts solely as a advisory body to other relevant institutions regarding marine resources because it has no authority in the matter as of yet. For example DoE have no authority with declaring an area a Marine Protected Area under the Parks and Reserves Act 1976 The Department been just established in 2001still have a low number of permanent staff. There are 11 staff permanent staff members and 1 Peace Corp Volunteer. Of these staff only 3 are assigned to the Planning and Assessment Division which oversees the bulk of the Marine based surveys, monitoring, assessment work.	In adequate funding Insufficient monitoring and weak enforcement Low public support and public participation where illegal sand extraction on beaches are still occurring and fishing in MPA No regulation for Parks and Assessment Act Lack of relevant capacity, skills, expertise and human resources for environment based requirements of MPA assessment	Lack of Human resources to enforce the Fisheries Regulation in remote islands Open access nature of fishing Industry is the main weaknesses Lack of Awareness programme MoF should develop a Management Plan for managing the resources that are endangered	The Tonga Visitor's Bureau has NO authority to protect any marine resources like whales, corals, turtles. The highest level of authority which they have regarding this area is supporting the core authority in setting up guidelines to protect the marine resources

Annex 3.

TERMS OF REFERENCE

ACTIVITY ONE: STOCKTAKING OF TONGA'S BIODIVERSITY

Biodiversity Assessment and Identification of Priorities for Biodiversity Conservation, Analysis of the Threats/Pressure on Biodiversity and on the Sustainability use of Biological Resources, Analysis of Equitable Sharing of benefits from the use of genetic/biological resources, and the Assessment of Agro-biodiversity genetic resources and the causes of its loss.

Background:

The Global Environment Facility has allocated a grant of USD 318, 000 to the Government of the Kingdom of Tonga, to enable them to prepare their Biodiversity Country Study, and National Biodiversity Strategy and Action Plan (NBSAP) and Country Report to the Conference of the Parties. All of these are required under the Convention on Biodiversity which the Kingdom of Tonga has signed and ratified. The implementing agency for this activity is UNDP. The project is implemented by the Government of the Kingdom of Tonga through its Department of Environment. The project began in July, 2003.

The National Biodiversity Strategic and Action Plan (NBSAP) Project of Tonga will be conducting Activity One – The Stocktaking of Tonga's Biodiversity. The Stocktaking of Tonga's Biodiversity activity is aimed at gathering existing information on the status, trends and needs of Tonga's biodiversity from all sectors, which includes Marine (pelagic and coastal), Forestry, Terrestrial Fauna and Agriculture. Local consultants from each of these sectors will be collecting information about the current status of Tonga's biodiversity based on the work described below.

Work Description:

- Assessment and identification of priorities for biodiversity conservation in the Kingdom of Tonga.
- Analysis of the threats/pressures on biodiversity and on the sustainability of the use of biological resources
- Analysis of the equitable of the sharing of benefits from the use of genetic/biological resources
- An analysis of the adequacy of the institutional framework and human resources base for biodiversity conservation.
- An analysis of the adequacy of the legal and policy framework for the conservation of biodiversity.
- Review of existing programs and projects for biodiversity conservation.

Assessment and identification of priorities for biodiversity conservation in the Kingdom of Tonga:

This will consist of a review of existing information and studies that have been done on the indigenous biodiversity, and will propose priorities for biodiversity conservation. Priorities will be based on the ecological criteria and the socio-economic criteria for priority-setting that will be established by the

NBSAP Technical Consultancy Group for the Stocktaking Activity. The assessment of biodiversity will be done by ecosystem.

The information to be gathered for each ecosystem will include the following:
- Location and a real extent (will include a compilation of existing maps);
- Species richness;
- Endemism;
- Presence of endangered and threatened species and of species of special importance;
- Unique aspects of the ecosystem;
- Spatial information of the degree of degradation of each ecosystem;
- Information on the economic, cultural, and historical importance of the ecosystem or certain parts of it.
- Extent, effectiveness and representation of protected area system.

After completing the review of available information on the country's coastal ecosystems the local consultant will apply the criteria for priority setting, and propose a ranking of ecosystems in terms of their priority for biodiversity conservation. The consultant will distinguish between global and national priorities for biodiversity conservation and clearly present his/her logic for the proposed priorities. Gaps in the information base will be identified.

An analysis of the threats and pressures on the sustainability of the use of biological resources:

The analysis of the biodiversity conservation will be closely linked to the analysis and the priority setting for the threats and pressures on the sustainability of the use of biological resources. Maps will be gathered to geographically identify the uses of the principal types of ecosystems and biological communities. Bibliographic research will complement this analysis. Particular attention will be paid to identifying trends indicative of unsustainable use, i.e., decreasing populations of plants and animals, of habitats, decreasing harvests of species, game, etc.

Specific tasks are the following:
- Identify the threats and pressures on the biodiversity of the different ecosystems. Rank in the order of importance;
- Identify the ways that coastal biodiversity is being used (what ecosystems? what species?), how and by whom;
- Assess the sustainability of these uses in terms of loss of biodiversity and in terms of maintenance of the productivity of the ecosystem;
- Assess the trends in the threats, pressures and sustainability of resource use over time and attempt to project future trends;
- Analyze the direct and indirect causes of the identified threats, pressures and unsustainable uses, especially of the most importance threats.

An analysis of the equitable of the sharing of the benefits from the use of genetic/biological resource:

The local consultant will perform the following tasks:
- Analysis of how indigenous knowledge on biodiversity is being used by national and international commercial interests and of how the holders of this knowledge are benefiting, if at all;
- Analysis of who benefits and who is negatively impacted by the development of biotechnology in the country. The analysis should include the effects within the country, of biotechnology

development both within the country and in other countries;

- Analysis of the legal basis for protecting the intellectual property rights for biodiversity at the level of the country and of people, communities, national businesses and institutions;
- Identify the beneficiaries of present use of l biological resources. Categorize them into groups. Identify and analyze cases of apparently inequitable sharing of benefits. Analyze to what extent benefits from resource use are reinvested in sustainable management.
- Analysis of the equitability of the exploitation of biological resources by foreign, commercial business interests.

An analysis of the adequacy of the institutional framework and human resource base for biodiversity conservation:

The analysis of the adequacy of the institutional framework and human resource base for biodiversity conservation will include:

- Analyzing the present institutional responsibilities for biodiversity conservation.
- Analyze the strengths and weaknesses of these institutions and the adequacy of their human resources.
- Analyze the clarity of mandate of institutions with responsibility in these fields.
- Identify any gaps there may be where no one institution has clear responsibility.
- Identify conflicting mandates and poorly defined mandates, etc.
- Analyze the adequacy and reliability of funding for the institutions involved.

An analysis of the adequacy of the legal and policy framework for the conservation of biodiversity:

The analysis of the adequacy of the legal and policy framework for the conservation of biodiversity will include:

- Analyze the strengths and weaknesses of the present legislative and policy frameworks as they affect biodiversity conservation.
- Identify gaps, conflicts and areas of confusion, particularly attention will be given to laws and policies governing access to resources
- Analyze the legal basis for institutional mandates.

Review of existing programs and projects for biodiversity conservation:

This will involve identifying and describing the present programs and projects operating in the area of biodiversity conservation. Summarize the status of each project/programs including the following points:

- Goals and objectives;
- Donor(s);
- Implementing agencies;
- Starting date and duration;
- Budget;
- Summary of strategy(ies) employed;
- Summary of results to date;
- Evaluation by local consultant of the soundness of the project or programme.

The local consultant will work in close collaboration with other local consultants of the Technical Consultancy Group and will participate in meetings organised by the Project Management Unit. The local consultant will present his/her findings to the National Biodiversity Advisory Committee and also at National Workshops. The local consultant will complete a full draft report prior to the presentation firstly to the National Biodiversity Advisory Committee (NBAC) and then to the National Workshops. The local consultant will modify and complete the report based on feedback from the National Biodiversity Advisory Committee (NBAC) and the National Workshops.

Outputs:

- Compilation of available maps showing location and a real extent of the country's ecosystems;
- Full report on:
  - The assessment of the country's biodiversity and identification of biological priorities for its conservation.
  - The analysis of the threats/pressures on the biodiversity and on the sustainability of the use of biological resources
  - Analysis of the equitable of the sharing of benefits from the use of genetic/biological resources.
  - An analysis of the adequacy of the institutional framework and human resources base for biodiversity conservation, sustainable use and equitable sharing of benefits of biological resources
  - An analysis of the adequacy of the legal and policy framework for the biodiversity conservation, sustainable use of resources and the equitable sharing of benefits of the coastal biological resources.
  - Review of existing programs and projects for biodiversity conservation, sustainable use and equitable sharing of benefits from biological resources

Qualifications:
The local consultant should have an advanced degree in the biological sciences. This person should have extensive field experience with the natural areas of the country. Good analytic and writing skills will be required.