PREPARATION OF A DIAGNOSTIC STUDY TO INFORM AN INTEGRATED COASTAL MANAGEMENT PLAN FOR TONGATAPU, TONGA

July 2014

This consultancy was supported by the Secretariat of the Pacific Community (SPC) through the European Union-funded Global Climate Change Alliance: Pacific Small Island States (GCCA: PSIS) project.

Deliverable 3: Final Coastal Characteristics and Issues Report (Tongatapu)

Prepared by Jonathan McCue

Presence of giant clam (Tridacnas) off Ha'atafu (Hihifo) – yet its overfishing remains a key issue on Tongatapu (picture taken by J McCue off Fafa island 12 May 2014).

Special Management Areas – a community regulatory approach for nearshore fisheries in Tongatapu (picture taken from Fafa Island by J MCue on 12 May 2014).

Fanga'uta Lagoon – its health is important for the livelihoods of many on Tongatapu (picture by J McCue on 10 May 2014).

Table of Contents

Executive Summary

Jonathan McCue (on behalf of Sustainable Seas Ltd) was contracted by the Secretariat of the Pacific Community (SPC) to complete the project entitled "***Preparation of a Diagnostic Study to inform an Integrated Coastal Management Plan for Tongatapu, Tonga***". The report represents Deliverable 3: Coastal Characteristics and Issues Report (Tongatapu)". It focuses on a categorized listing of key issues and available information plus a concise description of the major characteristics of the Tongatapu coast (see Appendix B). The evidence to support the recommendations presented in this report has been gathered from a literature review, interviews with key stakeholders of Tongan government agencies and consideration of existing institutional practices of coastal management planning from the international arena (see Deliverable 2).

Whilst preliminary at this stage, the report considers five possible aspects of a policy coordination framework that are most likely to be required during the creation of an Integrated Coastal Management (ICM) Policy Framework report, namely:

- A reporting and monitoring framework for ICM;
- An institutional framework for ICM;
- A capacity improvements framework for ICM;
- Creating an adaptive framework for ICM; and
- Creating a suitable stakeholder and public engagement framework for ICM.

It is concluded that there already exists the basic organisational platform for an effective ICM planning process to be established, however, the current move towards creating large "catch all" Ministries (such as the Ministry of Lands, Environment, Climate Change and Natural Resources - MLECCNR) may create real implementation challenges in the future unless robust and clear reporting and regulatory roles and responsibilities are set up. To realise this opportunity the report concludes that **there is no requirement to establish a new organisation or for specific ICM legislation in Tonga**. It is recommended that MLECCNR, PUMA and Ministry of Infrastructure, instead, establish a high-level committee supported by technical staff and the possible establishment of a 'Tongan Marine Community' (building on or supporting the existing JNAP Secretariat). What is now likely to be required is to make the current institutional situation work better. To this end, the report makes four (4) overarching recommendations for consideration (to be developed further later in the contract):

Recommendation 1 – Clearly reference ICM within the new Kingdom of Tonga Land Use Policy (2014) plus (if possible) Legal Statutes (National Infrastructure and Spatial Planning Act – 2014) and embed the principles of ICM and its formal documents within new MLECCNR planning and development processes.

Recommendation 2 – Implement ICM principles using existing institutional structures.

Recommendation 3 – Formalise a "Tongan Marine Community" (as an update to the JNAP Secretariat and to link to the outputs of the Fanga'uta Ridge to Reef project) and appoint a Coastal and Marine Advisor.

Recommendation 4 - Improve the visibility and benefit of developing ICM within Tongan civil society through improved stakeholder engagement education measures.

Document History

JOB NUMBER: SS14-006 – Tongatapu ICM			**DOCUMENT REF:** SS14-006 – Tongatapu ICM/Doc/002			
Revision	**Purpose Description**	**Originated**	**Checked**	**Reviewed**	**Authorised**	**Date**
1	Draft Coastal Characteristics and Issues Report	JMcC/F.Kitekai'aho	JSpeak	GC (SPC)	GC (SPC)	15/05/14
2	Draft Coastal Characteristics and Issues Report	JMcC/F.Kitekai'aho	JSpeak	GC (SPC)	GC (SPC)	2/06/14
3	Draft Coastal Characteristics and Issues Report (ii)	JMcC/F.Kitekai'aho	JSpeak	GC (SPC)	GC (SPC)	16/06/14
4	Final Coastal Characteristics and Issues Report (ii)	JMcC/F.Kitekai'aho	JSpeak	GC (SPC)	GC (SPC)	13/07/14

This consultancy was supported by the Secretariat of the Pacific Community (SPC) through the European Union-funded Global Climate Change Alliance: Pacific Small Island States (GCCA: PSIS) project.

Abbreviations

ADB	Asian Development Bank
AF	Adaptation Fund
CCA	Climate Change Adaptation
CMA	Coastal Management Area
CMP	Coastal Management Programme
DRM	Disaster Risk Management
EBA	Ecosystem Based Adaptation
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FADS	Fish Aggregating Devices
GCCA	Global Climate Change Alliance
GIS	Geographical Information System
GPS	Global Positioning System
GVA	Gross Added Value
ICM	Integrated Coastal Management
ICMSP	Integrated Coastal and Marine Spatial Planning
ICRM	Integrated Coastal Risk Management
JNAP	Joint National Action Plan
LMMA	Local Marine Management Areas
MLECCNR	Ministry of the Lands, Environment, Climate Change and Natural Resources
MHW	Mean High Water
MoW	Ministry of Works
MPA	Marine Protected Areas
MSP	Marine Spatial Planning
PIC	Pacific Island Country
POP	Persistent Organic Pollutants

PPP	Private Public Partnerships
PSIS	Pacific Small Island States
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
TDS	Tonga Defence Services
TOP	Tongan Pa'anga

SECTION 1 – INTRODUCTION

1.1 Project Overview

The objective of this consultancy (circa 50 man days in duration) is to prepare a diagnostic study that will inform the subsequent development of an integrated coastal management (ICM) plan for Tongatapu. The diagnostic study will (1) categorize the physical, biological and human features of the Tongatapu coastal management area as well as a review of policy and institutional arrangements; (2) identify the major issues facing the coastal management area; and (3) identify the extent of the coastal management area (CMA) to be addressed by the ICM plan.

The successful implementation of the project is expected to contribute to the development of an ICM plan (following this initial contract) using information based on this diagnostic study, that will inform the sustainable use of the CMA through the implementation of policies designed to maintain and enhance environmental quality and promote economic development, and taking into account climate change and climate variability.

Project Title

(RFP) no: 14/05: Preparation of a Diagnostic Study to inform an Integrated Coastal Management Plan for Tongatapu, Tonga.

Project Outputs

The following activities and outputs will be undertaken as part of this proposed consultancy:

a) Prepare a work plan and schedule of work to be undertaken *(Output 1: Work plan and schedule);*

b) Review coastal management plans in other parts of Tonga and other Pacific Island Countries and Territories. Circulate the draft to relevant stakeholders and prepare a final version. *(Output 2: Compilation of coastal management approached used elsewhere in the Pacific islands);*

c) Review and assess relevant literature including relevant unpublished reports and ongoing projects relating to activities and processes in the coastal area of Tongatapu (addressed in Appendix B of this report and includes a review of all available reports including those held by the SPC-Applied Geoscience and Technology Division). From this, prepare an issues paper concisely defining and discussing the major issues facing coastal areas in Tongatapu and identifying information gaps. Circulate the draft to relevant stakeholders and prepare a final version *(Output 3: Issues paper using the categorization list to outline information available and a description of the major characteristics of the coast);*

d) In collaboration with key stakeholders, and based on the foregoing delineate the extent of the coastal management area. Circulate the draft to relevant stakeholders and prepare a final version. *(Output 4: Short paper describing and justifying the selection of the coastal management area);*

e) Together with the Ministry of the Lands, Environment, Climate Change and Natural Resources (MLECCNR) hold a two day consultation with key stakeholders to discuss the finding of the diagnostic study and plan the framework of a future ICM plan for Tongatapu. *(Output 5: Report on the consultation);*

a) Prepare an annotated table of contents for an ICM plan for Tongatapu. Circulate the draft to relevant stakeholders and prepare a final version. *(Output 6: Fully annotated and detailed table of contents for an ICM plan).*

The timeline for the project is 50 working days. The Targeted Starting Date: was set as 21 April 2014 with a contracted completion date of 30 July 2014.

1.2 Purpose and Structure of the Report

This report introduces initial discussion on the following key sections/appendices:

- Analysis of Integrated Coastal Management issues (Section 2). Key references included in Appendix A and linked to Appendix B are presented here to help the reader cross refer to the more detailed back up information if required;
- Key observations and information gaps (Section 3).

Appendix A includes a list of references *(NB: these are presented as complete as possible though some references have been passed over to the consultancy team as incomplete or do not include correct referencing information)*.

The categorisation of coastal issues in Tongatapu is presented in Appendix B. The structure of that Appendix includes (for each sector or coastal "theme" of relevance) a summary description of the "theme" and commentary on key sources of information that may be interrogated or sourced further if this is believed to be readily available.

Appendix C outlines a list of all stakeholders Consulted upon (up to 1 June 2014) whilst Appendix D presents the approach and delivery for Workshop 1 help in conjunction with MLECCNR. Finally, Appendix E presents a summary list of Metadata GIS data that is available from the GIS Department of MLECCNR.

1.3 Project Mission 1 (May 2014)

1.3.1 Pre-visit Planning

Upon award of the contract (20 April 2014), a desk review of existing documents was compiled by Jonathan McCue. The list of documents compiled plus other documents/reports found on the internet that are of relevance to the project, are listed in Appendix A.

1.3.2 Mission Itinerary

The following represents the Mission 1 Programme to Tonga to capture existing information and to consult with key stakeholders on the projects intentions and outcomes.

- 6 May Arrival in Tonga (afternoon – 15.50);
- 7 May Inception meeting with MLECCNR. Workshop on Land Use Policy Event;
- 8 May Various stakeholder meetings: Coastal Issues Report writing;
- 9 May Meetings with CEO of Ministry of Agriculture, Forestry, Food and Fisheries (MAFFF), CEO of Infrastructure, CEO of MLECCNR;
- 10-11 May Site visit data collection field exercises; Coastal Issues Report writing;

- 12 May Stakeholder Meetings;
- 13 May (am) Project workshop with JNAP Technical Committee (10-12am);
- 13 May (pm) Departure from Tonga for Fiji (16.55);
- 14 May Mission Debrief with Gillian Cambers (SPC Suva) – 10am.

1.3.3 Stakeholders Contacted

A list of stakeholders visited during the Mission 1 period is presented in Appendix C.

1.3.4 Workshop 1: Coastal Issues Event

The first Project Workshop was held on 13 May 2014 with the JNAP Technical Committee. Details of the event, plus all handout questionnaires used are presented in Appendix D. The key outcome of the event was commentary on the following aspects:

a) There is poor inter-ministerial working on ICM issues;

b) Committees need to be refocused to address ICM issues – the existing JNAP ToR for members could be reviewed and updated in this context.

c) ICM needs to have a clear and workable financial "model" associated with it, to ensure that "livelihood alternatives" are set out to help communities adopt any new coastal policy regulation that maybe set for community fisheries, sand mining, cutting of mangroves and sub division of their lands for economic return.

d) MLECCNR must have a mandate to set up clear coastal indicators and a monitoring and evaluation (M&E) framework to make ICM work.

e) ICM must be "community focused" in Tongatapu. Without having the "buy in" of the local coastal community, ICM will fail as nobody will comply with any regulation being set unless they can see some kind of economic benefit of doing so.

f) The definition of the CMA should take into consideration land ownership problems (nobles etc). The current Land Act (1903) definition of being 50ft inland from high water (15.24m) was discussed for its appropriateness by the Tongan stakeholders, though this needs to be "climate assessed" so that an extra buffer distance is included to account for climate change.

g) Need to ensure that existing Village Disaster Management Plan "evacuation zones" are considered where appropriate.

Details of the institutional arrangement aspects of the questionnaire are currently being compiled and the results shall be communicated back to stakeholders at the second workshop event scheduled for 17 July 2014.

SECTION 2 – ANALYSIS OF INTEGRATED COASTAL MANAGEMENT ISSUES

2.1 Overview

The following issues have been derived from a review of existing documentation (see detailed coastal characteristics section in Appendix B), stakeholder consultation and field visits carried out around Tongatapu during May 2014. The section is kept as brief as possible to comply with the client recommendations. To assist in differentiating between issues of local and national significance, the issues are divided into the following subsections:

- Sectoral issues of national relevance;
- Geographic specific issues (around Tongatapu);
- Cross sectoral issues.

All issues were presented for initial discussion to the JNAP Technical Group at Workshop 1 on 13 May 2014 (see Appendix D). Subsequent updates and revisions (if appropriate) were subsequently made to the appropriate sub-sections. The following "issues" are thereby presented as being relevant for specific attention when preparing an ICM Policy Framework for Tongatapu in the future.

2.2 Sectoral Issues of National Relevance

2.2.1 Land Tenure, Settlement Patterns and Development Issues

There are no areas owned communally by resident communities in Tonga (Malm 2001). Large areas of coastal land belong to the Royal Family and Nobles (or chiefs), or is government land. The rest is held under lease from the Nobles by individual Tongan males who are granted a parcel of land for small scale agriculture (from 2 to 4 ha) when they reach the age of 16. On Tongatapu, there is now a shortage of land and the granting of land may not, as a result, be automatic.

Land (including coastal lands) cannot be sold to non-Tongans, although it can be leased (Malm 2001). The non-tradability of land under the existing tenure system (except leasehold) may contribute to sub-optimal land distribution. The shortage of suitable land for residential and non-residential purposes in and around the Nuku'alofa urban area has led the large number of urban migrants of recent years to settle in the swampy and low-lying areas of Sopu and Popua, and the mangrove areas of the Fanga'uta Lagoon. The increased pressure on land use is mainly related to population growth and socio-economic developments including commercial agriculture.

Evidence from the national Census (2012) suggests clearly that the size of the coastal population has been growing for decades. In addition, urbanisation has developed almost exclusively along the coastal margins reflecting the close ties with the marine environment and the resources it is able to provide. Historically Tongans lived in dispersed homesteads and it is only relatively recently after the civil war that ended in 1852 that a village system has developed (Malm 2001). Urbanisation due to people moving into Nuku'alofa area from other areas of Tongatapu and from outer islands is now causing pressure on terrestrial and marine biodiversity around Patangata and Popua coastal areas. The development of villages around the coastal areas of Tongatapu has also coincided with an increase in population and a consequence of this has been that more land has

been converted to plantation/agriculture use and greater exploitation of the marine environment has occurred. Aside from issues such as fertiliser use and run-off that can impact adjacent ecosystems, and in particular the marine environment, land conversion is likely to be reducing the capacity for the natural environment to accommodate change in either the short or longer terms. Of importance to future human settlement planning is that any reduction in wetland and mangrove areas is most likely to result in land being more susceptible to flooding.

The key focus of development pressure undoubtedly is felt in the greater Nuku'alofa area which is increasing as a result of population growth. The existing urban infrastructure is already deemed insufficient to meet the demands of the current urban population. Upgrading of existing infrastructure is being undertaken through the Nuku'alofa Reconstruction Project and the Integrated Urban Development Sector Project, however, the scope of these projects is inevitably limited and will not meet all immediate infrastructure needs. Further investment in urban infrastructure is therefore required with particular focus on coastal lands as areas for urban expansion of Nuku'alofa is limited to peripheral agricultural and ecologically sensitive areas.

Development of residential subdivisions on the fringes of Nuku'alofa is also constrained by large areas of un-drained surface water, requiring substantial filling of properties and raising of roads (e.g.: in Popua to the east of Nuku'alofa). The sensitive topic of community relocation (away from high risk areas prone to flood inundation) now needs to be considered quite seriously in the coming decade and any future ICM Plan needs to be acknowledge this in terms of its policy setting over the next 30 years (see Section 2.2.2).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
- ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
- Malm, T. The tragedy of the commoners: The decline of the customary marine tenure system of Tonga. Paper presented at the Symposium and Workshop on Managing Common Resources – What is the Solution? Lund University, Sweden, 10–11 September 2001
- Netatua Pelesikoti (2003). Sustainable Resource and Environmental Management in Tonga: Current Situation Perceptions and a proposed new Policy Framework - A thesis submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy.
- Kingdom of Tonga National Strategic Planning Framework February 2009
- Kingdom of Tonga National Land Use Policy: Kingdom of Tonga (Draft 1) 2014.

2.2.2 Coastal Vulnerability and Flood Risk

Tongatapu is flat and low-lying, the highest elevation being 70 meters above sea level. Most of the urban area of Nuku'alofa is only 1–2 meters above sea level and is subject to periodic flooding during heavy rain. The risk of coastal inundation and erosion is often, intensified by social behaviour patterns and preferences. For example, local communities in Tongatapu tend to live in topographically low (higher flood risk) areas. Owing to sea level rise and flooding induced by a

higher water table, it is anticipated that people currently living in these locations may have to move to higher ground or to other islands in the future.

The vulnerability of north coast settlements (greater Nuku'alofa), in addition to sea level rise and climate change, is exacerbated by the geological tilting of Tongatapu to the northwest due to subduction of the Pacific Plate under the Indo-Australian Plate which causes ongoing earthquake activities in the vicinity of the Tonga Trench over the last 200 years (SOPAC 2010). The northwest tilt is causing land subsidence to the west of Tongatapu and most of the northern coastline, increasing risk of inundation to settlements such as the villages in Hihifo (e.g.: Kolovai – see Section 2.3).

With regard to rapid onset disasters (e.g.: tsunamis), consideration and attention is now being placed on the more likely approach of a tsunami to Tongatapu from the east and NOT the north (as previously anticipated – Packham 1978). The direction of a tsunami impacting on Tongatapu is still being estimated, but its direction approach is critical in the future strategic planning of Nuku'olofa. Poor settlements to the east of the Nukual'ofa wharf (Anana and Popua) are built on reclaimed areas, and their vulnerability is seen to be high, especially if tsunami approach is from the east. Community relocation away from such locations needs to be considered, or at the very least, the cessation of new development taking place in such locations. To this end, planning proposals are being considered to build "evacuation bridges" across the Fanga'uta lagoon (using Chinese money). Large reclamation proposals are also being discussed to increase vacant land area for Nukual'ofa (ADB 2013).

Eua Island (close to Tongatapu), with a resident population of about 9000 people, does not experience the same level of vulnerability to tsunami due to its more elevated topography. Despite this, current roads have been built within "risk areas" to storm inundation. Moving roads or property inland is, however, unlikely due to land negotiations and land rights. Government buildings are also seen to be at risk from coastal erosion (ADB 2013).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
- ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
- CTL, 2013b. MECC Consultancy to Conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the eastern side of Tongatapu: Report of Coastal Design and Costing March 2012.
- DOS (2011) Tonga 2011 Census of Population and Housing, Volume 2: Analytical Report Kingdom of Tonga, Department of Statistics.
- Government of Tonga, National Climate Change Policy, 2006.

- Government of Tonga National Strategic Planning Framework, 2009–2014.
- Ministry of Environment and Climate Change, Vulnerability and Adaptation Assessment on Tonga's Initial National Communication on Climate Change, 2005.
- Nobuo Mimura (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change. Center for Water Environment Studies, Ibaraki University, Hitachi, Ibaraki 316-8511, Japan, Climate Research Journal, Vol. 12: 137–143.
- Oliver. J and Reddy, G.F. (1982). Tropical Cyclone Isaac, Cyclonic impact in the context of the society and economy of the Kingdom of Tonga; Centre for Disaster Studies, James Cook University of North Queensland.
- Pacific Adaptation Strategy Assistance Program Assessing Vulnerability and Adaptation to Sea-Level Rise Lifuka Island, Ha'apai, Tonga (2010).
- Packham, G.H., 1978: Evolution of a simple Island Arc ; Lau-Tonga Ridge. In Coleman, P.J. (ed) Second Southwest Pacific Earth Science Symposium. IGCP project 110, Sydney, December 1977. Bull.Aust.Soc. Explor.Geophys. 9(3)G2: 133-140.
- Prescott N., Mimura N. & Hori N. (1992). Assessment of the Vulnerability of the Kingdom of Tonga to Sea Level Rise, Nuku'alofa, Kingdom of Tonga.
- Statistics Department (2006). Kingdom of Tonga Population Census 2006: Administrative Report and Basic Tables, Government of Tonga, Nukulofa.

2.2.3 Road Design and Drainage Issues

The most significant change to the land environment in Tongatapu has been the conversion of main coastal roads from dirt tracks to more permanent and fixed tarmac structure; this effectively acts as a seawall separating the marine and coastal environment and land environment (e.g.: on east and west coastal areas of Tongatapu – at Hahake and in Hihifo). This has implications for coastal evolution as the coastal margin is fixed creating the phenomena of coastal squeeze[1] and increasing erosional pressures. A further consequence of the tarmacking of these roads (by foreign investors such as the Chinese in many parts of Tongatapu including the new road to Hihifo District) has been that its design level has been raised such that any flooding on the landward side cannot drain seaward as often there is no provision of drainage across the barrier formed by the road and so the absence of adequate road drainage and the poor maintenance of existing drains remain a constant problem (due to poor initial road design) and this often results in frequent flooding of roads (Sustainable Seas 2014; CTL 2012a). The piecemeal raising of road levels and filling of properties has also altered the natural drainage patterns close to the coast or Fanga'uto Lagoon, which has created additional swamps and open water bodies, causing flood damage to property and a loss of access to unfilled properties.

The surfaces of most local residential access roads are gravel, and they are often impassable during wet weather. Limited provisions for pedestrians (i.e., footpaths) result in pedestrian–vehicular traffic conflicts, particularly after heavy rainfall, when roadside flooding forces pedestrians onto the main roadways. Despite this, there are some good examples of where new

[1] Where the coastal margin is squeezed between the fixed landward boundary (artificial or otherwise) and rising sea level.

walkways have been introduced which include the 2km stretch of new concrete walkway along Vuna Road to the west of Nuku'alofa.

In addition to road design, there has been significant increase in vehicular usage over the past 15 years in Nuku'alofa which has resulted in congestion of the main approach roads to the urban area and roads in the town centre (ADB 2006/2013. Hahake District (eastern Tongatapu) is receiving new SPCR funds to construct new tsunami evacuation transport routes for the villages of Manuka, Navatoka and Kolonga (eCoast 2013). The same approach is need for a number of other villages including Popua where communities are particularly poor and vulnerable to a tsunami strike (see Section 2.2.2).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
- ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
- eCoast (2013) "Review of Historical and Recent Studies Pertaining to Erosion of Eastern Tongatapu, Tonga. Prepared for SPC – GCCA:PSIS.
- Government of Tonga, National Climate Change Policy, 2006.
- Government of Tonga National Strategic Planning Framework, 2009–2014.
- SOPAC (2006) National Integrated Water Resource Management Diagnostic Report, Tonga, Miscellaneous Report 646.
- SOPAC, Pacific Islands Forum Secretariat and UNDP Pacific Centre (2009) Guide to Developing National Action Plan: A Tool for Mainstreaming DRM Based on Experiences from Selected Pacific Islands Countries, SOPAC, Suva, Fiji.SPC (2008) TONGA Country Profile September 2008 (FINAL DRAFT).
- Statistics Department (2006). Kingdom of Tonga Population Census 2006: Administrative Report and Basic Tables, Government of Tonga, Nukulofa.
- Sustainable Seas Ltd (2014) PACC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Western side of Tongatapu: Report of Coastal Feasibility Studies January 2014.

2.2.4 Climate Change Related Issues

According to latest climate change prediction work set out in the Pacific Climate Change Data from BOM and CSIRO (2014), projected change in annual and seasonal mean climate for Tonga is presented under four emissions scenarios and this is shown in Figure 2.1 below. These are RCP2.6 (very low emissions, in dark blue), RCP4.5 (low emissions, in light blue), RCP6 (medium emissions, in

orange) and RCP8.5 (very high emissions, in red). Projected changes are given for four 20-year periods centred on 2030, 2050, 2070 and 2090, relative to a 20-year period centred on 1995. Values represent the multi-model mean change, with the 5–95% range of uncertainty in brackets. Confidence in the magnitude of change is expressed as *high*, *medium* or *low*. Surface air temperatures in the Pacific are closely related to sea-surface temperatures (SST), so the projected changes to air temperature given in this table can be used as a guide to the expected changes to SST. 'NA' indicates where data are not available.

Variable	Season	2030	2050	2070	2090	Confidence (magnitude of change)
Surface air temperature (°C)	Annual	0.5 (0.3–0.9)	0.6 (0.4–1)	0.6 (0.3–1)	0.6 (0.2–1.1)	*High*
		0.6 (0.3–1)	0.9 (0.6–1.4)	1.1 (0.7–1.6)	1.2 (0.8–2.1)	
		0.5 (0.3–0.8)	0.8 (0.6–1.3)	1.2 (0.8–1.8)	1.6 (1.2–2.4)	
		0.7 (0.4–1)	1.2 (0.8–2)	1.9 (1.4–2.9)	2.6 (1.8–4.1)	
Maximum temperature (°C)	1-in-20 year event	0.6 (0.2–0.9)	0.7 (0.1–1)	0.7 (0–1)	0.7 (-0.1–1.1)	*Medium*
		0.6 (0.2–0.9)	0.9 (0.2–1.2)	1.1 (0.4–1.7)	1.3 (0.6–1.8)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.7 (0.2–1.2)	1.4 (0.7–2)	2.2 (1.3–3)	2.9 (1.7–4.2)	
Minimum temperature (°C)	1-in-20 year event	0.5 (0.1–0.8)	0.6 (0–0.9)	0.7 (0.4–1)	0.6 (0.1–0.9)	*Medium*
		0.6 (0–0.9)	0.9 (0.5–1.3)	1.1 (0.7–1.5)	1.3 (0.7–1.9)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.7 (0.3–1.1)	1.3 (0.7–1.9)	2.1 (1.6–2.7)	2.9 (2.1–4.2)	
Total rainfall (%)	Annual	2 (-7–7)	3 (-5–12)	0 (-11–10)	1 (-7–8)	*Low*
		1 (-12–10)	-1 (-12–10)	2 (-11–18)	3 (-10–16)	
		1 (-8–8)	3 (-8–14)	5 (-8–19)	6 (-7–25)	
		1 (-11–10)	2 (-10–15)	3 (-16–24)	6 (-15–35)	
Total rainfall (%)	Nov-Apr	3 (-9–12)	5 (-6–16)	1 (-11–13)	1 (-11–12)	*Low*
		2 (-14–14)	1 (-13–16)	4 (-10–21)	4 (-9–22)	
		4 (-6–13)	4 (-9–16)	6 (-7–23)	8 (-8–30)	
		2 (-10–12)	3 (-9–18)	6 (-13–35)	11 (-10–53)	
Total rainfall (%)	May-Oct	1 (-8–7)	3 (-5–12)	-1 (-14–8)	1 (-6–10)	*Low*
		0 (-9–9)	-2 (-11–9)	0 (-15–12)	1 (-11–13)	
		-1 (-11–5)	3 (-7–12)	3 (-9–14)	4 (-5–17)	
		0 (-11–12)	0 (-12–11)	-1 (-17–13)	1 (-22–23)	
Aragonite saturation state (Ωar)	Annual	-0.3 (-0.6–0.0)	-0.4 (-0.7—0.1)	-0.4 (-0.7—0.1)	-0.3 (-0.7–0.0)	*Medium*
		-0.3 (-0.6—0.1)	-0.6 (-0.8—0.3)	-0.7 (-1.0—0.4)	-0.8 (-1.0—0.5)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		-0.4 (-0.7—0.1)	-0.7 (-1.0—0.5)	-1.1 (-1.4—0.9)	-1.5 (-1.8—1.2)	
Mean sea level (cm)	Annual	13 (8–18)	22 (14–30)	31 (19–43)	40 (23–58)	*Medium*
		13 (8–18)	23 (15–31)	35 (22–48)	47 (29–66)	
		12 (7–17)	22 (14–31)	34 (21–47)	48 (30–67)	
		13 (8–18)	25 (17–35)	42 (28–58)	63 (41–88)	

FIGURE 2.1: PROJECTED CHANGE IN ANNUAL AND SEASONAL MEAN CLIMATE FOR TONGA UNDER 4 SCENARIOS (BOM CSIRO 2014).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
- BoM / CSIRO (2014) "Report: Climate Variability, Extremes and Change in the Western Tropical Pacific 2014 - Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports 2014" http://www.pacificclimatechangescience.org/publications/reports/climate-variability-extremes-and-change-in-the-western-tropical-pacific-2014

- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
- Government of Tonga, National Climate Change Policy, 2006.
- 5th IPCC Assessment Report (2014) Chapter 13 "Sea Level Change" Coordinating Lead Authors: John A. Church (Australia), Peter U. Clark (USA)
- Intergovernmental Panel on Climate Change. "Climate change 2007"; Fourth Assessment Report (AR4), Cambridge University Press, United Kingdom.
- Intergovernmental Panel on Climate Change. 2000. "Emission Scenarios"; Cambridge University Press, Cambridge, United Kingdom.
- Ministry of Environment and Climate Change, National Assessment Report, 2004.
- Ministry of Environment and Climate Change, Vulnerability and Adaptation Assessment on Tonga's Initial National Communication on Climate Change, 2005.
- Ministry of Environment and Climate Change, Climate Change Thematic Assessment Report under National Capacity Self Assessment Project, 2007.
- Ministry of Environment and Climate Change, Joint Community consultations on Climate Change, Biodiversity and National Capacity Self Assessment Projects, 2006.
- Nichols, RJ. & Mimura, N. (1998). Regional issues raised by sea-level rise and their policy implications. Clim. Res. 11:5-18.
- Nobuo Mimura (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change * Center for Water Environment Studies, Ibaraki University, Hitachi, Ibaraki 316-8511, Japan, Climate Research Journal, Vol. 12: 137–143.
- SimCLIM Model Software 2008, CLIMsystems Ltd., Hamilton, New Zealand.
- Sea Level Data Archives CD-ROM June 2008, South Pacific Sea Level and Climate Change Monitoring Project.SOPAC (2002). COASTAL EROSION SURVEY VISIT TO TONGATAPU, KINGDOM OF TONGA (27 April – 4 May 2002), Andrick Lal (South Pacific Sea Level & Climate Monitoring Project Phase III).
- Thompson, C. S. 1986. "The climate and weather of Tonga"; Miscellaneous Publication, New Zealand Meteorological Service, Wellington, New Zealand.

2.2.5 Coastal, beach and soil erosion issues

Although no monitored evidence is available to confirm or refute this, it is most likely that human activities are contributing to beach erosion that is being experienced in Tongatapu. For example, in many places, mangroves are cleared for fuel wood and the resulting space is being used (amongst other things) for land reclamation (CTL 2012a). Beach sands are intensively being mined and used as construction material and for decoration of tombs as a social tradition. Another possible reason for beach erosion is the acceleration of sea level rise (see references in Section 2.2.4 above) which is contributing to the wave overtopping being experienced on coastal roads mostly running along the coast around Tongatapu. This latter aspect is being trialled using GCCA:PSIS and ADB funds

for eastern Tongatapu (eCoast 2013a, b and c) between Navutoka and Manuka) where a combination of hard defence construction and soft littoral planting (in sheltered areas created by the defence) is being proposed under the GCCA: PSIS project and the ADB funded SPCR project as a measure to "buy time" before longer term planning options can be considered using separate funding streams.

With regards to soil erosion, agricultural activities in Tonga are exhausting the fertility of the soil and attempts at reforestation have had limited success. The clearing of land in Tongatapu has inevitably contributed to land degradation in the form of soil erosion. Soil erosion is though more profound in islands that have a steep land formation like Vava'u and 'Eua. Studies have shown that topsoil is eroded off the land and transported to other nearby ecosystems, which in turn affect that ecosystem's health and the sustainability of living organisms that inhabit it.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
- eCoast (2013) "Review of Historical and Recent Studies Pertaining to Erosion of Eastern Tongatapu, Tonga. Prepared for SPC – GCCA:PSIS.
- Ellison, 1998. First Report on Development of Mangrove Environmental Management Plan for Tongatapu.
- Howarth R (1982) TECHNICAL REPORT 32 on COASTAL RECLAMATION STUDY, NORTHWEST TONGATAPU, TONGA. 10 October to 22 October 1983, SOPAC.
- MAF/ Statistics Dept/ FAO (2002). Agricultural Census 2001. Kingdom of Tonga.
- MEC, 2013. Environmental Impact Assessment of Four Proposed Coastal Engineering Interventions for Five Communities on Eastern side of Tongatapu, June 2012.
- Nichols, RJ. & Mimura, N. (1998). Regional issues raised by sea-level rise and their policy implications. Clim. Res. 11:5-18.
- Sea Level Data Archives CD-ROM June 2008, South Pacific Sea Level and Climate Change Monitoring Project. SOPAC (2002). COASTAL EROSION SURVEY VISIT TO TONGATAPU, KINGDOM OF TONGA (27 April – 4 May 2002), Andrick Lal (South Pacific Sea Level & Climate Monitoring Project Phase III).
- SOPAC, 1989. High Resolution Seismic Survey for Lagoonal Sand and Gravel Resources in Tongatapu, Kingdom of Tonga. SOPAC Technical Report 85, April 1989.
- SOPAC, 1991a. Assessment of Sand Resources North Tongatapu, Nuku'alofa, Tonga. SOPAC Technical Report 123, May 1991.
- SOPAC, 1991b. Volume of Sand in Basin A, Northwest of Fafa Island, Nuku'alofa Lagoon, Tonga: Results of High Resolution Seismic Survey. SOPAC Technical Report 133, September 1991.

- SOPAC, 1994. Coastal Protection in the South Pacific. SOPAC Technical Report 190, March 1994.
- SOPAC, 1995a. Monitoring Coastal Changes on Tongatapu, Kingdom of Tonga.
- SOPAC Technical Report 218, December 1995.
- SOPAC, 2005. Environmental Impact or Sand Resource Extraction North of Tongatapu. SOPAC Technical Report 387, February 2005.
- Sustainable Seas Ltd (2014) PACC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Western side of Tongatapu: Report of Coastal Feasibility Studies January 2014.
- Tappin, David R.; Lal, Andrick,; Forstreuter,; Mafi, Kelepi,; 2002.: Coastal Erosion in Western Tongatapu, Tonga- human input, natural process or both?? SOPAC Report.

2.2.6 Coastal Habitat Degradation Issues

The nearshore and intertidal areas off Tongatapu consist of a wide range of habitats including mangroves; rock terraces; sand beaches; saline wetlands; estuary and mudflats; reef flats and coral reef (barrier, fringing and submerged) (4th Review Biodiversity Strategy and Action Plan). Most coastal (landward) habitats have been significantly altered by humans either through conversion to agriculture/plantation use and urban development of the villages that border the coastline (NBSAP 2012). The only land habitat that is not significantly altered in places is low lying swamp and wetland that remain behind the villages of Navutoka and Manuka and extending to close to Kolonga village (Hahake District –CTL 2012a).

Mangrove species biodiversity and extent is of concern in Tongatapu and this represents a key natural resource issue (Pelesikoti 2003, Aholaho 2013). For example, *Lekileki – Xylocarpus moluccensis* (Lamarck) is one of the mangroves species which has almost reached its extinct level, (Ellison 1998) especially in northern and eastern areas of Tongatapu. This mangrove species is culturally unique for Tongans as its bark is utilized for medicine as a treatment for internal bleeding, injuries, etc. However, this species is subject to destruction for fire wood, similar to *Lumnitzera lottorea (Hangale)*. The bark of another two mangrove species, Tongo Lei *(Rhizophira mangle)* and Tonga Ta'ane *(Brugueira gymnorrhiza)* are mostly harvested by local people for making tapa cloth (Ngatu) but recently, a replacement product for these mangrove species' bark has proven very effective. However, Lekileki and Hanagle species are at a very critical to endangered level, while the other two indicated species are still at endangered level (Ellison, 1998). In the area around the main town of Nuku'alofa urbanization is the main cause, as the town expands towards swampy areas and edges of the lagoon.

The response to the local impacts of coastal habitat degradation and flood inundation risk in the coastal zone of Tongatapu is to slowly focus on adaptation, risk and hazard management. Hihifo District, for example, is experiencing coastal erosion, exacerbated in part by the existing poor seawall design that currently exists (Sustainable Seas Ltd 2014). Efforts are currently underway to introduce a more Ecosystem Based Adaptation (EBA) approach to addressed coastal risk in Hihifo by introducing a managed realignment defence, designed to allow storm waves to overtop defences but coupled with created topographically higher areas in between the low stand areas. Use of bamboo and brushwood to create natural "breakwaters" are also proposed and being designed at present (under the PACC project – Sustainable Seas Ltd 2014). In addition, the role of casuarina trees (and not necessarily mangroves) are being proposed as important wave and wind

breaks to storm waves in the region, based on evidence from Indonesia (tsunami of 2004) which showed that casuarina trees are most likely to still be present after a tsunami (coconut trees are not robust enough). Despite this, casuarina trees can have deleterious impacts on local terrestrial biodiversity by inhibiting the growth of local grasses etc.

In an attempt to learn more and to identify EBA based mitigation strategies, the MESCAL (Mangrove Ecosystems Community Adaptation and Livelihoods) project was initiated in July 2011 and finished in December 2013. As a Regional Programme focusing on mangrove conservation and protection, climate change adaptation and livelihood security, it focused only on Tongatapu. An activity completed was a Mangrove Audit Review, carried out to identify gaps and weaknesses in the current system. A strong conclusion of the MESCAL project suggests that EIA regulation and enforcement plus weak links to strategic land use planning approvals are the key challenges for managing coastal habitats in Tonga. Adding to the challenge is that Tonga has no national mangrove management plan, though guidelines do exist through an AUSAID funded "Lafanga'uta Management Plan" which is being used as a guide document where examples of mangrove zoning for different uses (recreation/conservation etc) are included in that plan.

The coral reefs in the Hahake District (CTL 2012a) are found to be in poor health primarily because of the regime shift towards brown algae and a consequence of this is that there is evidence that they are less able to recover from extreme events. Furthermore, it may be that there is a wider issue with environmental quality as where coral cover was found to be high coincides with mono-species growth suggesting that few species are able to grow under the prevailing conditions. This is in contrast to observations made at a control site on the north coast near to Nuku'alofa (measured by CTL 2012a) where the reef health and condition is showing evidence of recovery from extreme event episodes (storms/bleaching events etc),. In addition the control site showed a well-marked zonation from the reef edge to the beach that included sea grass beds and low levels of brown algae.

There are community concerns over the decline of two seaweed species (Angle-hair and Grape) which are thought to be very vulnerable in abundance due to their acute sensitivity to biotic factors that may reduce their growth. The Grape seaweed *Claurepa sp* is no longer abundant in Fanga'uta lagoon, perhaps as a response to some environmental changes in the lagoon. Kaly *et al* (2000) suggested a possible response to increasing sedimentation from runoff as the likely cause. This edible seaweed used to be abundant in the local market however is no longer a regular item, indicating a marked decline in the abundance of this species in the wild. The Angle-hair seaweed *Cladosiphon sp,* which is known locally as 'Limutanga'u', is one of the commercial export commodities developed in the late 1990s. It has provided an excellent cash crop for many local fishers especially coastal communities. The harvesting season takes place from August to November annually. The production in term of export has been varied. When export of the seaweed commenced in 1996, 36 tonnes was exported. This increased to 403 tonnes in 1997, then decreased to 79t in 1998 and increased to 200t in 1999, (Fisheries Annual Report, 2001). The fluctuation of the production is due to the combination of factors such as climate change (i.e. water temperature variation) and bad weather/rough seas (i.e. reduced growth rate by dispersal of the spores to unfavourable habitat).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
- Cruickshank, M.J. & Morgan, C.L., (1996). Final Environmental Impact Assessment on the Proposed Sand Dredging in Basin A offshore from Nuku'alofa, Kingdom of Tonga, Ministry of lands, Survey and Natural Resources, Nuku'alofa.
- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
- Dept of Environment (2006). KINGDOM OF TONGA, National Biodiversity Strategy & Action Plan.
- Ellison, J.C (1998): First Report on Development of Mangrove Environmental Management Plan for Tongatapu,Tonga. WP 5, Hassal and Associates in association with AMSAT.
- Hoifua 'Aholahi. 2013. Mangroves of Tonga. http://www.livingoceansfoundation.org/mangroves-of-tonga/
- Lovell, E.R. and Palaki, A, 2001. Tonga Coral Reefs: National Status Report. In "Status of Coral Reefs in Southeast and Central Pacific- Polynesian Mana Network," B. SALVAT ed, Foundation Naturalia Polynesia: pp101–124.
- MEC, 2013. Environmental Impact Assessment of Four Proposed Coastal Engineering Interventions for Five Communities on Eastern side of Tongatapu, June 2012.
- Netatua Pelesikoti (2003). Sustainable Resource and Environmental Management in Tonga: Current Situation Perceptions and a Proposed new Policy Framework - A thesis submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy.
- SOPAC, 1995a. Monitoring Coastal Changes on Tongatapu, Kingdom of Tonga.
- SOPAC, 2005. Environmental Impact or Sand Resource Extraction North of Tongatapu. SOPAC Technical Report 387, February 2005.
- Sustainable Seas Ltd (2014) PACC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Western side of Tongatapu: Report of Coastal Feasibility Studies January 2014.
- Van Katwijk, M.M., N.F. Meier, R.van Loon, E.M. van Hove, W.B.J.T. Giessen, G. van der Velde, and C. Hartog. 1993. Sabaki River sediment load and coral stress: correlation between sediments and condition of the Malindi-watamu reefs in Kenya (Indian Ocean). Marine Biology: (Berlin). 117(4):675-683.
- Zann, L.P. 1994. The Status of Coral Reefs in South Western Pacific Islands. Marine Pollution Bulletin. 1994. 29(1-3): 52-61.
- Zann, L.P., Kimmerer,W.J. and Brock,R.E.(1984) The Ecology of Fanga'uta Lagoon,Tongatapu, Tonga International Sea Grants, University of Hawaii/ Institute of Marine Resources, USP 100pp

2.2.7 Coastal and Marine Resource Use Issues (living resources)

NB: the following sub-section refers to living resources that are extracted for economic benefit only.

Historically, Tonga's inshore and intertidal areas, has been subject to heavy fishing mainly because Tonga's marine tenure system is an open system, with the coastline open to everyone and not restricted to any particular group of people (Malm 2001). As a result, all types of fishing have been used in this zone, ranging from commercial, artisanal to subsistence fishing. There is the common view that areas around the reef slope and flats are overfished. This is reflected in a decrease in the number of species observed in nearshore waters (*pers comm* Dept of Fisheries). Fishing is now more often undertaken further out to the seas towards submerged reefs and seamounts. This trend is indirectly emphasized by the rising cost of reef fish in the local market.

Overfishing, in particular, occurs around the reef flat slope and nearby barrier reefs. The increased use of three types of dangerous fishing methods over the past decade (dynamite, poison and fine net) have also resulted in reduced fish stocks as these types of fishing are not selective but tend to kill all sizes of fishes. CTL (2012a) observed during marine survey work at Hahake, that there was an almost total absence of fish over the reefs in the study area and reefs had become dominated by brown algae. This observation is mirrored by the Department of Fishery who advised of a lack of coastal fisheries studies around Tongatapu and on outer islands. Department of Fisheries stress the need for baseline studies on coastal fisheries in Tonga.

Within Fanga'ota Lagoon, since 1975, commercial fishing in the lagoon was banned in an attempt to reduce fishing pressure, but without strict enforcement. The existing lagoon fishery is broadly classified as subsistence, but includes commercial elements, as many fishers sold at least part of their catch in local markets or by the side of the road as a source of income, or to cover costs of fishing gear. There has still been a dramatic decline over the years with fishers near the mouth of the lagoon reporting a decrease in both sizes and weights of catches (MESCAL 2013).

Marine aquarium fisheries has become the second highest export revenue earner for the Kingdom. However, in 2008, the Fisheries Department banned the removal and export of live rock. Allocated harvesting areas have been established though in recent years, the monitoring of this fishery has been very poor due to lack of funds. A management plan and specific regulations are in place and the future of this fishery lies in encouraging people to export live rock currently being farmed through artificial propagation (such as around fish aggregating devices (FADS) etc).

The Marine Protected Areas (MPAs), including Marine Reserves, have been a vital fisheries management control tool established at selected areas. These have, however, failed to achieve their objectives due to a lack of compliance. In all MPAs established around coastal areas of Tongatapu (e.g.: off Fafa island and off Ha'atafu), there is no difference between other fishing areas adjacent to these areas in term of species richness, coral cover percentages, etc. MPAs are covered under MLECCNR whereas no fishing zones are declared as spatial management areas under Fisheries Legislation.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.

- Dept of Environment (2006). KINGDOM OF TONGA, National Biodiversity Strategy & Action Plan.

- Lovell, E.R. and Palaki, A, 2001. Tonga Coral Reefs: National Status Report. In "Status of Coral Reefs in Southeast and Central Pacific- Polynesian Mana Network," B. SALVAT ed, Foundation Naturalia Polynesia: pp101–124.
- MAF/ Statistics Dept/ FAO (2002). Agricultural Census 2001. Kingdom of Tonga.
- Malm, T. The tragedy of the commoners: The decline of the customary marine tenure system of Tonga. Paper presented at the Symposium and Workshop on Managing Common Resources – What is theSolution? Lund University, Sweden, 10–11 September 2001
- PROCFISH, (2009). Tonga country report: profiles and results from survey work at Ha'atafu, Manuka, Koulo and Lofanga (November and December 2001; March to June 2002; April to June, September and October 2008). Secretariat of the Pacific Community, Noumea, New Caledonia.
- Van Katwijk, M.M., N.F. Meier, R.van Loon, E.M. van Hove, W.B.J.T. Giessen, G. van der Velde, and C. Hartog. 1993. Sabaki River sediment load and coral stress: correlation between sediments and condition of the Malindi-watamu reefs in Kenya (Indian Ocean). Marine Biology: (Berlin). 117(4):675-683.
- Zann, L.P. 1994. The Status of Coral Reefs in South Western Pacific Islands. Marine Pollution Bulletin. 1994. 29(1-3): 52-61.
- FAO (2010) Fishery and Aquaculture Country Profile (Tonga) http://www.fao.org/fishery/facp/TON/en

2.2.8 Coastal and Marine Resource Use Issues (non-living)

With regards to "non-living" coastal resources, the management of marine sands (aggregates) is an important issue which is focused on the activity of sand mining around the shores of Tongatapu. Whilst this activity is banned on Tongan beaches, there are still areas where authorities appear to turn a blind eye to such activities. There continue to be many examples of sand mining where truck access permits (notably on the west facing coast of Hihifo, along the southern shores of Tongatapu and along the outer islands). With regards to offshore extraction, permits are needed (from the MLECCNR), however, regulation of the permit (where sand should be taken from and how much) is very difficult. The impact of sand mining on local beach dynamics is uncertain through likely to be impacting on local coastal erosion situations.

Based on the above aspects, the lack of knowledge associated with sand resources around Tonga is very obvious. The results of the PASAP LiDAR project (GHD 2011), which extended to cover all of Tongatapu and Lifuka Island (Haapai Group – see Figure B3 in Appendix B) should be used to help identify "possible" sources of material which could be surveyed through more conventional techniques and approaches. A national "Sand Resources Management Strategy" study should be initiated for Tongatapu, to enable clear advice on the amounts of sand to be mined, the locations of sustainable sand resources for construction AND beach replenishment projects and also the financial amount for each tonne of sand extracted for private and public projects.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- Cruickshank, M.J. & Morgan, C.L., (1996). Final Environmental Impact Assessment on the Proposed Sand Dredging in Basin A offshore from Nuku'alofa, Kingdom of Tonga, Ministry of lands, Survey and Natural Resources, Nuku'alofa.

- Dept of Environment (2006). KINGDOM OF TONGA, National Biodiversity Strategy & Action Plan.

- EU EDF 8 (2005). SOPAC Project 38: Reducing Vulnerability of Pacific ACP States Tonga Proposed Guidelines and Monitoring Procedures for Aggregate Extraction north of Tongatapu. EC (2008). Country Strategy Paper for Tonga and National Indicative Programme (2008 – 2013).

- EU EDF 8(2005) SOPAC Project Report 39: Reducing Vulnerability of Pacific ACP States Tonga Technical Report on Aggregate Dredging and Proposed Plan of Action for Offshore Aggregate Extraction in Tongatapu.

- Furness, L, J. (1993). Location of fresh-water supplies on Lifuka, Ha'apai Group, Kingdom of Tonga, *Hydrology of Warm Humid Regions* (Proceedings of the Yokohama Symposium, July 1993). IÂHS PiSl.no. 216.

- Howarth R (1982) Technical Report 32 on Coastal Reclamation Study, NW Tongatapu, Tonga. 10 October to 22 October 1983, SOPAC

- Lovell, E (2005). Environmental Impact Assessment of Sand Resource Extraction North of Tongatapu (February 2005) Biological Consultants, Fiji, SOPAC Technical Report 387.MECC (2010).

- SOPAC, 1989. High Resolution Seismic Survey For Lagoonal Sand and Gravel Resources in Tongatapu, Kingdom of Tonga. SOPAC Technical Report 85, April 1989.

- SOPAC, 1991a. Assessment of Sand Resources North Tongatapu, Nuku'alofa, Tonga. SOPAC Technical Report 123, May 1991.

- SOPAC, 1991b. Volume of Sand in Basin A, Northwest of Fafa Island, Nuku'alofa Lagoon, Tonga: Results of High Resolution Seismic Survey. SOPAC Technical Report 133, September 1991.

- SOPAC Technical Report 218, December 1995.

- SOPAC, 2005. Environmental Impact or Sand Resource Extraction North of Tongatapu. SOPAC Technical Report 387, February 2005.

- SURVEY REPORT OF SAND AND AGGREGATE RESOURCES AT VAVA'U, KINGDOM OF TONGA Geon-Hong Min and Sung-Rock Lee March 1999 SOPAC Technical Report 277.Tiffin, D (1982) KOLOVAI RIDGE SAND SURVEY KINGDOM OF TONGA, 11-22 February 1982, SOPAC Project, WORK PROGRAMME CCSP-I/TG.6.

2.2.9 Water Resources, Degradation and Groundwater Pollution Issues

All Tongan island groups (including Tongatapu) are thought to sit on a single freshwater aquifer, which provides a primary source of water for domestic, agricultural, industrial and commercial purposes. Rainwater harvesting is practiced to a varying extent from island to island (depending on quality and quantity of groundwater resources). Future availability of freshwater resources,

both from groundwater and rainwater, is likely to decline under the predicted regime of climate change (BoM/CSIRO 2014). Declining volumes of groundwater in Tongatapu will undermine the integrity of aquifer and become susceptible to intrusion of seawater from the transition zone underneath.

Degraded water quality (especially in the Fanga'uta Lagoon) is compounding the problem as excess nutrients and sediments result in eutrophication in coastal waterways, in seagrass beds and on coral reefs. Additional pollution of groundwater has occurred through the accidental or deliberate release of persistent organic pollutants (POPs) such as agricultural pesticides and PCBs used in electrical transformers and various industries. The lagoon is an important habitat and a spawning place for some marine organisms. However, this ecosystem is being systematically degraded due to unsustainable land use (deforestation) and use of fertilizers and pesticides. Run off from surrounding farms pollute the lagoon whilst removal of mangroves and the creation of direct access to the lagoon (sub division of lands) is encouraging direct littering and allowing pollution from septic tanks through leakages to reach the lagoon.

Existing levels of contaminants, in association with their persistence and trends in agrochemical usage, could compromise the future of the ecosystem including sustainable fisheries and the potential for developing aquaculture. Sewage treatment predominantly is carried out through the extensive use of domestic and small scale septic tanks, but these are poorly maintained and frequently leak sewage into soils and groundwater. Little data pertaining to the types and amounts of pollutants affecting the lagoon areas are available in Tongatapu.

With reference to groundwater recharge from rainfall projections over the next few decades, the estimated annual recharge displays a downward trend over time. By 2095, a 5-25% decrease in groundwater recharge is predicted. If this projection from Tongatapu is reasonably similar for other outer islands, then it means that all communities in Tonga will face shrinking groundwater resources in the future.

The quality of the freshwater lens also depends on a number of factors such as the thickness of the water lens, level of extraction of groundwater, the amount of recharge that generally pushes down the transition zones which insulates groundwater from seawater, proximity of the lens to shorelines and overtopping of saltwater due to higher wave actions or storm surges. Tongatapu experienced less-than-average annual rainfall during the large part of the 1960s, heavy rainfalls during the 70s, and low rainfalls from the early 80s to late 90s. It is also suggested that salinity level of groundwater is also highly correlated with tidal movement, which amplifies the emerging risk of sea level rise and storm surges on the quality of groundwater.

In addition, the level of salinity in a given well varies considerably depending on the location of the well. Whilst there are only eight monitoring wells (all located on Tongatapu) and more systematic analyses are needed to fully understand the combined impacts of sea level rise, shrinking water lens during the dry seasons and extreme climate events on the salinity of groundwater, available evidence suggests that wells located closer to the shore or wells that are less well insulated from seawater movement underground are more susceptible to such changes.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.

- ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
- BoM / CSIRO (2014) "Report: Climate Variability, Extremes and Change in the Western Tropical Pacific 2014 - Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports 2014" http://www.pacificclimatechangescience.org/publications/reports/climate-variability-extremes-and-change-in-the-western-tropical-pacific-2014.
- Damlamian, H. 2008. Hydrodynamic Model of Fanga'uta lagoon: Water Circulation and Applications. EUEDF-SOPAC: Reducing Vulnerbility of Pacific ACP States. Project Report 135.
- Dept of Environment (2006). KINGDOM OF TONGA, National Biodiversity Strategy & Action Plan.
- Groundwater Assessment Report (1999) Kingdom of Tonga February 1999.
- Falkland, A. (1999). Tropical Island Hydrology and Water Resources: Current Knowledge and Future Needs. Second International Colloquium on Hydrology and Water Management in the Humid Tropics, Panama City, 21–26 March.
- Falkland A. & Woodroffe C. D (1997). Geology and hydrogeology of Tarawa and Christmas Island, Kiribati, Chapter 19, in Geology and Hydrogeology of Carbonate Islands, Developments in Sedimentology 54 (editors Vacher, H.L. and Quinn, T.M., Elsevier, Amsterdam, 577–610.
- Fielea, Q. (2012) Hihifo Water Distribution Report, Hihifo, Tongatapu. Water Supply Improvement Project, PACC. Kolomotu'a, TONGA.
- Furness L.J & Helu S.P (1993). The Hydrogeology and Water Supply of the Kingdom of Tonga, Ministry of Land Survey and Natural Resources, Kindom of Tonga, February 1993.
- Kula, T. (2009) An Investigation of the Feasibility of Rainwater Harvesting Systems for Water Supply in the islands in the Kingdom of Tonga, Spatial Research Project, University of Sydney, AUSTRALIA.
- SOPAC (2006) National Integrated Water Resource Management Diagnostic Report, Tonga, Miscellaneous Report 646.
- Taaniela Kula. An Investigation of the Feasibility of Rainwater Harvesting Systems for Water Supply in the islands of the Kingdom of Tonga Author:, SID: 309033594. GEOG5005 Spatial Research Project.

2.2.10 Tourism Development Issues

Tourism on small island states is highly dependent on the quality of the coastal environment. If the coast is managed correctly, it could be a major contributor to a nations' economy, and this situation certainly applies to Tonga. The tourism sector currently provides Tonga with an estimated annual $13 million TOP (US$7.2 million) in gross revenues (Tonga Visitors Bureau Annual Report 2000). In 2010-11, Gross Value Added (GVA) for recreational, cultural and sporting activities

rose by 5.9 percent, due to increased tourist expenditure[2]. Tourism expenditure in Tonga was estimated to be worth approximately 56 million TOP in 2013[3]; this equates to approximately 1,200 TOP per visitor.

Tonga's tourism offers the most immediate potential for generating economic growth and income, but the level of growth for the tourism sector needs to be accelerated, as the growth rate has been low compared to many other Pacific countries. The Government of Tonga has finalized its "Tourism Sector Roadmap 2014-2018" which will pave the way to improve the profile of Tonga's tourism products and its stepped up destination marketing initiatives. The Roadmap has projected, by 2020, tourism in Tonga will become the main source of income for Tongans generating over 100 Million Tongan pa'anga (TOP) for the economy, representing over 30 percent of national GDP and increasing the number of those employed in the workforce through tourism to 4,000 persons . To realize the development goal of the tourism sector, the main areas of governmental focus for the Roadmap include marketing, investment and business enabling environment.

At present, coastal and beach tourism is focused on the Hihifo District where 6 privately owned beach front resorts are situated on the west coast of the peninsula. In additional outer islands off Tongatapu (such as Pangamotou and Fafa Island) provide two separate types of beach experience. Eco-tourism does occur around the lagoon with kayak tours popular, though this activity is still in its infancy with only a few private companies providing services to visitors.

Tourism expenditure in Tonga was estimated to be worth approximately 56 million TOP in 2013[4]; this equates to approximately 1,200 TOP per visitor.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

1. ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
2. Dickenson, W.R., 2007, Paleo-environment of Lapita sites on Fanga'uta Lagoon, Tongatapu, Kingdom of Tonga. In Bedford, S., Sand,C., and Connaughton, S.P., eds.,Oceanic Explorations: Lapita and Western Pacific Settlement [Terra Australia 26]: Canberra, ANU Press, pp. 177-186.
3. Govt. Tonga. A BILL for AN ACT TO PROVIDE A FRAMEWORK FOR PLANNING THE USE, DEVELOPMENT, MANAGEMENT AND PROTECTION OF LAND IN THE KINGDOM IN THE INTEREST OF ALL TONGANS AND FOR RELATED PURPOSES.
4. Government of Tonga National Strategic Planning Framework, 2009–2014.

[2] The services sector (including hotels and restaurants, recreational, cultural and sporting activities) makes up more than 50 percent of GDP (783.4 millions TOP, 2010-11 preliminary estimate), although its contribution has decreased in the past two years due to the higher construction activity. In 2010-11 the service sector contribution to GDP (as measured in current prices) was 53.2 percent.

[3] Based Ministry of Tourism estimates – Summary of Tourism Arrivals Report – 2010. Ref: TRIP Consultants. 2013. Tonga Tourism Sector Roadmap: Situation Analysis and Tourism Sector Framework.

[4] Based Ministry of Tourism estimates – Summary of Tourism Arrivals Report – 2010. Ref: TRIP Consultants. 2013. Tonga Tourism Sector Roadmap: Situation Analysis and Tourism Sector Framework.

5. TRIP Consultants (2013). Tonga Tourism Sector Roadmap: Situation Analysis and Tourism Sector Framework.

2.2.11 Dredging and Reclamation Issues

Land reclamation around the Tongatapu coast and lagoon is the main threat to land based coastal habitats such as mangrove ecosystem. Unauthorized encroachment and reclamation of land, including removal of parts of the ecosystem, is contributing to the degradation of the coastal and lagoon ecosystems in Tongatapu. Any reclamation above mean high water (MHW) needs Government of Tonga consent and permissions. Any reclamation activity below MHW is likely to require an EIA.

In 1999, major dredging was undertaken to create the approach channels and wharf areas needed for the port. No significant dredging has occurred since that time. Vuna Wharf is the most recent development in Tongatapu (Nuku'alofa). Previous areas of extraction (prior to 2002) used to be close to Atata Island. Erosion was reported on the island and so dredging sand programmes were terminated. A new area was proposed to the north of Fafa Island (Basin "A").

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE APPENDIX A AND MORE DETAIL SUPPORTING THE POINTS RASIED IN APPENDIX B)

- Cruickshank, M.J. & Morgan, C.L., (1996). Final Environmental Impact Assessment on the Proposed Sand Dredging in Basin A offshore from Nuku'alofa, Kingdom of Tonga, Ministry of lands, Survey and Natural Resources, Nuku'alofa.
- EU EDF 8 (2005). SOPAC Project 38: Reducing Vulnerability of Pacific ACP States - Tonga Proposed Guidelines and Monitoring Procedures for Aggregate Extraction North of Tongatapu.EC (2008). Country Strategy Paper for Tonga and National Indicative Programme (2008 – 2013).
- EU EDF 8(2005) SOPAC Project Report 39: Reducing Vulnerability of Pacific ACP States Tonga Technical Report on Aggregate Dredging and Proposed Plan of Action for Offshore Aggregate Extraction in Tongatapu.Furness, L, J. (1993). Location of fresh-water supplies on Lifuka, Ha'apai Group, Kingdom of Tonga, *Hydrology of Warm Humid Regions* (Proceedings of the Yokohama Symposium, July 1993). IÂHS PiSI.no. 216.
- Howarth R (1982) Technical Report 32 on Coastal reclamation Study, NW Tongatapu, Tonga. 10 October to 22 October 1983, SOPAC.
- Lovell, E (2005). EIA of Sand Resource Extraction North of Tongatapu (February 2005) Biological Consultants, Fiji, SOPAC Technical Report 387.MECC (2010).
- SOPAC, 1989. High Resolution Seismic Survey For Lagoonal Sand and Gravel Resources in Tongatapu, Kingdom of Tonga. SOPAC Technical Report 85, April 1989.
- SOPAC, 1991a. Assessment of Sand Resources North Tongatapu, Nuku'alofa, Tonga. SOPAC Technical Report 123, May 1991.
- SOPAC, 1991b. Volume of Sand in Basin A, Northwest of Fafa Island, Nuku'alofa Lagoon, Tonga: Results of High Resolution Seismic Survey. SOPAC Technical Report 133, September 1991.

- SOPAC, 2005. Environmental Impact or Sand Resource Extraction North of Tongatapu. SOPAC Technical Report 387, February 2005.

- Survey Report of Sand and Aggregate Resources at Vavau, Tonga Geon-Hong Min and Sung-Rock Lee March 1999 SOPAC Technical Report 277.Tiffin, D (1982) Kolovai Ridge Sand Survey, Tonga, 11-22 February 1982, SOPAC Project, WORK PROGRAMME CCSP-I/TG.6.

2.3 Geographic Specific Issues

The Tongatapu coastline has been classified into 5 Coastal Units (Figure 2.2) based on their coastal characteristics, exposure to wind, cyclone and tsunami, offshore bathymetry and coastal topography. *NB: These divisions are designed to help present some of the initial key coastal issues of relevance to key locations around Tongatapu. More precise divisions and recommendations for a more formal delineation of the Tongatapu coastal zone shall be prepared through a separate participatory consultative process (arranged for 17 July 2014).*

	Coastal Unit 1: North Coast (Nuku'alofa urban area westwards to Masilamea)
	Coastal Unit 2: Low lying west coast (Hihifo Peninsula – lagoon side villages)
	Coastal Unit 3: Low lying north east coast (Hahake Peninsula: Nukuleka to Afa Village)
	Coastal Unit 4: Fanga'Uta Lagoon
	Coastal Unit 5: Raised coast (Ha'atafu (Hihifo) to Afa (Hahake)

FIGURE 2.2: FIVE COASTAL UNITS OF TONGATAPU ISLAND.

2.3.1 Coastal Unit 1: North Coast (Nuku'alofa urban area westwards to Masilamea)

This Coastal Unit includes all coastal communities that comprise the greater Nuku'alofa urban area (from Tukutonga on the east) extending westwards to the village of Masilamea. The Coastal Unit represents the most populated out of all the five (5) Coastal Units defined, with an estimated

30,000 people inhabiting the coastline or nearby hinterland areas along the extent of the Coastal Unit. Most inhabitants live or work on coastal land that is below the 4 meter topographic contour. The northwest tilting of Tongatapu coupled with accelerated sea level drop about 20,000 years ago has caused land subsidence to most of the northern coastline of Tongatapu, making all land and human development along this Coastal Unit vulnerable to sea inundation and flood risk. The coastline also faces northwards, which coincides with prevailing wind and also cyclone directions.

In addition, recent tsunami modelling studies and maps (produced by MLECCNR in 2013) along this coastline clearly demonstrated that, under the scenario of a magnitude 9.0 Richter scale earthquake originating towards the east (from the Tonga Trench), coastal communities, properties and businesses located within this Coastal Unit are identified as being the most vulnerable to a rapid onset tsunami related disaster event.

The Coastal Unit includes, outside of the greater Nuku'alofa urban development areas, more rural settlements towards the western part of the unit. A number of assets and coastal community populations at risk from flood inundation as set out below:

- Masilamea village (36 households (254 people));
- Nukunuku (292 households (1613 people));
- Matafonua (37 households (222 people)).

More information on the coastal vulnerability of this Coastal Unit is presented in Section B6 of Appendix B.

2.3.2 Coastal Unit 2: Low lying west coast (Hihifo Peninsular – lagoon side village)

This Coastal Unit extends northward from Masilamea village, northwards past Fo'ui village towards the village of Ha'atafu village. The Coastal Unit faces north eastwards and often experiences easterly and north easterly storm wind events. Large waves generated by these two wind directions are forced to break further offshore by a large barrier reef that extended almost parallel to this coastline.

Recent tsunami modelling studies and maps (produced by MLECCNR in 2013) along this coastline of Coastal Unit 2 has, of interest, "downgraded" the original perceived risk to coastal communities, with increased risk being placed more on communities and assets in Coastal Unit 1 (see above in Section 2.3.1). Despite this, under the scenario of a magnitude 9.0 Richter scale earthquake originating towards the east (from the Tonga Trench), the villages of Kanokupolu, Ahau and the northern part of Kolovai village are identified as being the most vulnerable to a rapid onset tsunami related disaster event. The northern section of this Coastal Unit (towards Ha'atafu village is topographically higher than the southern parts of the unit.

The Coastal Unit includes a number of assets (over 400 households) and coastal community populations (approx. 2353) at risk from flood inundation as set out below:

- Ha'atafu village (39 households (236 people));
- Kanokupolu village (53 households (324 people));
- Ahau village (57 households 367 people))
- Kolovai village (124 households (607 people));

- Ha'avakatolo (44 households (235 people));
- Fo'ui (84 households (584 people))

NB: FIGURES TAKEN FROM LATEST TONGA CENSUS OF 2012.

Detailed information on the coastal characteristics of this Coastal Unit can be found in the work by Sustainable Seas Ltd (2014). More information on the coastal vulnerability of this Coastal Unit is presented in Section B6 of Appendix B.

2.3.3 Coastal Unit 3: Low lying north east coast (Hahake Peninsula: Nukuleka to Afa Village)

This Coastal Unit extends from Afa village through Manuka, Navutoka, Talafo'ou, Makaunga and Nukuleka at the western end. The coastline along the whole Coastal Unit is protected by a mostly submerged fringing reef during high tide with the reef edge being less than 80m from low water mark at Afa village, increasing to over 550m further west.

The Coastal Unit to the east (towards Afa Village) is a limestone raised platform facing NE directional waves with limited littoral beach present. The topography from west Kolonga towards Nukuleka reduces in a westerly direction. The six villages frontages are all less than 3m above sea level rendering them highly vulnerable to the impacts of climate change, disaster risks (e.g.: tsunami), sea level rise, storm surge and coastal erosion issues.

Recent tsunami modelling studies and maps (produced by MLECCNR in 2013) along this coastline clearly demonstrated that, under the scenario of a magnitude 9.0 Richter scale earthquake originating towards the east (from the Tonga Trench), coastal communities, properties and businesses located within this Coastal Unit are identified as being the very vulnerable to a rapid onset tsunami related disaster event. All villages within the unit could be inundated from such an event, though the most vulnerable is Nukuleka village, mainly as it is only accessible via single track road.

Aerial photography indicates that the coast has been subject to coastal erosion of up to 50m to 70m since the 1960s (CTL Consult 2012). Coastal erosion has been arrested by the coastal road, which is holding the line and acts as a sea wall. However, despite upgrading in 2011, the coastal road is itself under threat in many places and recent cyclone activity has uprooted trees whose root systems have been undermined by continuing erosional pressures). Attempts have been made in places to arrest erosional pressures, but these have been unsuccessful and, furthermore, failure to understand the dynamics of coastal processes has meant that attempts to put in place coastal protection have led to enhanced erosional pressures downstream. The coastal road is a critical feature as both preforming a role as a coastal protection feature and also as the only route for the peoples of the villages of Nukuleka, Talafo'ou, Navutoka and Manuka and the capital (Nuku'alofa) to escape the area in the event of an extreme event (e.g. super-cyclone, tsunami)

The Coastal Unit includes a number of assets (over 400 households) and coastal community populations (approx. 2353) at risk from flood inundation as set out below:

- Navutoka village (127 households (797 people));
- Manuka village (42 households (282 people));
- Navutoka, (127 households (797 people));
- Talafo'ou, (74 households (381 people));

- Makaunga (66 households (416 people));
- Nukuleka (50 households (292 people)).

NB: FIGURES TAKEN FROM LATEST TONGA CENSUS OF 2012.

It can therefore be seen that within this Coastal Unit, over 500 properties, housing over 3367 are potentially at risk from coastal inundation. The issue of coastal erosion and flood inundation is potentially exacerbated through the continuation of sand mining activities which is believed to be impacting on beach levels throughout the Coastal Unit.

Detailed information on the coastal characteristics of this Coastal Unit can be found in the work by CTL Consult Ltd (2012) and eCoast (2013). More information on the coastal vulnerability of this Coastal Unit is presented in Section B6 of Appendix B.

2.3.4 Coastal Unit 4: Fanga'Uta Lagoon

This Coastal Unit extends along the shores of the Fanga'Uta Lagoon from the Vaiola Hospital location (west shore), eastwards to include the villages of Pea, Ha'ateiho, Veitongo, Nukuhetula, Longoteme, Vaini, Holonga, Alaki, Mua and Hoi.

The Coastal Unit, therefore, represents a quite unique lagoonal environment. It is a shallow, and includes the almost completely closed Fanga'uta and Fangakakau Lagoons (hereinafter referred to as "the Fanga'uta Lagoon") which are both important breeding ground for birds and fish as they live within the mangroves growing around the lagoon's shores. The lagoons were declared a Marine Reserve in 1974 by the government. It has a mean depth of about 1.4 m and a maximum of 6 m, excluding the entrance channel (Zann *et al.*, 1984), and the total volume of the lagoon is 38,000 megalitres. The lagoon is composed of two branches: the Nuku'alofa (or the western) branch and the Mu'a (or the south-eastern) branch. The lagoon also contributes to the sustainability of the Tongatapu Island's coastal fisheries.

Since late 1980s, sewage-related problems and pollution entering the lagoon were increasingly reported. Pollution in the lagoon system comes through direct dumping, groundwater, and run-off from the land and pollution that is made inside the lagoon as a result of human disturbance. Direct dumping and littering involves cans, paper, plastic, car tires, batteries, timber, masonry and other rubbish, that are thrown into the lagoon or dumped in its mangroves. Some items are thrown along the shores of the lagoon and then washed into it during storms. Other items such as gillnets and floats, may be lost by fishermen. Approximately 26,000 m^3 of freshwater are flowing into the lagoon every day from the groundwater reservoir around the lagoon. This water falling as rain on the land can collect pollution and carry it into the groundwater. The pollution may be sewage from leaking septic tanks, pesticides and chemical fertilizers from agricultural areas, waste oil, asbestos roofing, or a cocktail of chemicals found in garbage dumps (e.g. Popua).

All wastewater is managed by on-site systems, with supervision by the Ministry of Health (MOH) when resources permit. In this respect wastewater management is in the hands of the community. Poorly constructed or inappropriate sanitation systems are common, resulting in the potential for pathogens and nutrients being introduced into the surrounding environment, including ingress to groundwater. Excess nutrient loads appear to be impacting the environmental health of the near shore reef in the Nuku'alofa area, and the lagoon in general. Algal growth can be seen in both areas. In addition, there are concerns that fish harvested in these areas, particularly shellfish, may be contaminated.

The shoreline of the Fanga'uta Lagoon is bounded by a main road that acts as a sediment trap. Urban development and illegal cutting have markedly decreased the stands of mangroves during

the past decades. Pigs are commonly found living on wastes in the mangroves and cause local areas of erosion and mangrove loss. There are high levels of human impact on the mangroves of the lagoon system (Ellison, 1999[5]). The most common of mangrove destruction in the lagoon system are the cutting of trees, dumping of rubbish, sewage discharge, and reclamations for the construction of houses. A significant area of mangroves has been lost from two areas within the lagoon system. These losses have been recorded at the Mu'a and Pe'a/Ha'ateiho areas of the lagoon through examining old aerial photographs.

Detailed information on the coastal characteristics of this Coastal Unit can be found in the work by MESCAL (2013), Kaly et al (2000), Ellison (1999) and UNDP (2014).

2.3.5 Coastal Unit 5: Raised coast (Ha'atafu (Hihifo) to Afa (Hahake)

This Coastal Unit is (geographically) the longest proposed Coastal Unit on Tongatapu. It extends to include the open coast area tourist resort stretch from Ha'atafu Beach (Hihifo District), southwards to cover the low populated raised plateau coast and extending eastwards and then northwards up to Nuitoua and Afa Village (Hahake Disctrict).

This Coastal Unit is characterised by higher limestone terraces and high cliffs (mainly at Fua'amotu and Vaini areas) with moderate terraces at Ha'ateiho to Houma. The cliffs, whilst still significant in reducing flood risk, do become topographically lower towards Hihifo. The coastline is further characterised by an uplifted fringing reef with height higher at the south east (SE) part of the island at Fua'amotu and decreasing in height towards Hihifo, where most of the fringing reef is submerged during high tide. These two coastal features offer evidence for the northwest tilt suggested for the island of Tongatapu due to subduction process at the Tonga Trench.

The southern coastline faces high energy waves from the predominantly SE wind. Because this coastline is highly elevated than the northern coastline, this coastline is predicted to be protected against a tsunami waves from the east.

Tourism is a developing industry along the west coast of Hihifo and also at specific locations such as Oholei Beach Resort. Sand mining activities are impacting on beach levels throughout the Coastal Unit where vehicular access is possible.

2.4 Cross Sectoral Issues

2.4.1. Policy Integration between Sectors

The difficulty perceived in Tonga is that the mandate to each and every piece of legislation, of relevance to ICM, is divided among the many government ministries. The long list of existing legislations dealing with coastal and marine related matters (direct or indirect) indicates the current difficulty of administering coastal controls in a cohesive and coordinated manner. This is because each Ministry implements its own initiatives on a sector by sector basis (coastal road projects to housing projects to water supply projects). A more integrated approach towards delivering environmental legislation and policy measures is required.

Management of the coast in Tongatapu, as identified above, is therefore characterized by its ad hoc nature and the sectoral perspective from which upon different environmental problems are dealt with. This piecemeal design is not helpful when also trying to address climate change, climate variability and sea level rise.

[5] Ellison, J. 1999. *Second Report on Development of a Mangrove EMP for Tongatapu*. TEMPP Report. n.p.

The country's priorities have shifted with time, assisted by the increasing global focus on sustainable development and the environment, yet predominantly a regulatory system remains. For a small country with very limited natural resources, sustainable development should be the key objective for the government, and this is now being addressed through the new draft Tonga Land Use Policy (2014) which does appear to focus on more cross sectoral issues such as climate change and disaster risk reduction. In this context, it is evident that there is some clear progress at the policy decision level, to better integrate economic development with environment awareness and sustainable development.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE ALSO APPENDICES A AND B)

- Laws of Tonga – (found at http://crownlaw.gov.to/cms/)
- Kingdom of Tonga (2009) National Strategic Planning Framework 2010-2014, February 2009
- Kingdom of Tonga (2014) National Land Use Policy: Kingdom of Tonga (Draft 1) 2014.

2.4.2. Co-operation/Co-ordination of activities

There is little co-operation and co-ordination of enforcement activities across Government which means that there are opportunities for efficiencies that are not being realised. This is largely a behavioural issue, the consequences of which are the issues associated with data and information sharing (see Section 2.4.8). The abilities of the government to address the interrelated issues of coastal and groundwater protection, in a manner that enhances the resilience of natural ecosystems, is constrained by the lack of a strong and forward thinking policy or legislative framework. Currently, coastal resilience to climate change is not being factored into land, water and coastal planning, development activities and investment decisions in different economic sectors.

Land use decisions (prior to the implementation of the new Tonga Land Use Policy in 2014) are made primarily with a view to optimizing yields and incomes from production activities. Consequently, land, groundwater and coastal use planning has lacked a focus on managing coastal areas and habitats to reduce vulnerability to climate change, irrespective of the adaptation benefits. Underlying reasons for this are knowledge barriers, or insufficient awareness on climate change impacts and the necessity of addressing coastal ecosystem restoration and resilience as an adaptation measure. These are related to an insufficient knowledge base pertaining to shoreline and coastal processes and groundwater resource dynamics under conditions of climate change, threshold (tipping points) and values, cumulative impacts of different land and water use, as well as the impacts of development activities.

Coordination challenges when attempting to implement environmental management programmes appear to be apparent, and this is something for any future ICM plan to be aware of, For example, the Fanga'Uto Lagoon Environmental Management Plan (EMP) was approved by the Cabinet in 2003 (Morrison and Kay 2010), though no details on its actual implementation (including financial and administrative commitments) were provided. Due to serious budgetary constraints and other circumstances (i.e., lack of a coherent management approach, insufficient skilled manpower and unclear institutional arrangement), implementation of the EMP has been a challenge (Kingdom of Tonga 2011).

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE ALSO APPENDICES A AND B)

- Morrison, R. John & U. L. Kaly (2010) "Chapter 15 Coastal lagoon management in three Pacific island situations: – is scientific knowledge used effectively?" In Saving Small Island Developing States: Environmental and Natural Resource, edited by Shyam Nath, John L. Roberts and Yeti Nisha Madhoo. Commonwealth Secretariat, United Kingdom, page 178.

- Kingdom of Tonga. 2011. *Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas.* Submitted to the Secretariat of the Convention on Biological Diversity.

- Kingdom of Tonga (2014) National Land Use Policy: Kingdom of Tonga (Draft 1) 2014.

2.4.3 Regulatory Procedures and Standards

Regulatory procedures and standards do exist to provide a partial framework for management of some activities in the coastal and marine environment in Tonga. For example, an environmental impact assessment (EIA) is required for major reclamation projects and there are environmental standards for sand dredging (e.g. limits on total suspended solids), and a requirement for monitoring and the use of silt/ sediment traps.

Procedures and processes may be applied without adequate or well-defined time limits/response times. This can lead to projects becoming delayed and/or progressing in the absence of some responses. Development projects that require dredging and reclamation are mostly carried out for and by the private sector with little involvement of or benefit to local communities. For example, dredged sand in waters off Tongatapu attracts no levy so is effectively 'free' to the developer, who only has to cover dredging costs, although in economic and environmental terms sand (as a resource) is a capital and national asset. Given the future pressure for space and land development in Tongatapu, reclamation and sand dredging is likely to become of critical strategic importance to the development of the island.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE ALSO APPENDICES A AND B)

- Laws of Tonga – (found at http://crownlaw.gov.to/cms/)

- Kingdom of Tonga (2009) National Strategic Planning Framework 2010-2014, February 2009

- Kingdom of Tonga (2014) National Land Use Policy: Kingdom of Tonga (Draft 1) 2014.

2.4.4. Definitions of Land and Sea – the need for integration

Of relevance to ICM in Tongatapu, "land" (as defined in the "Lands Act 1903") means the total area of the Kingdom of Tonga defined in Tongan law, which includes Kingdom's maritime zones. This Policy applies to the Kingdom's land and all its natural resources – being the "*areas of the earth's surface, nutrients, and minerals in the soil and deeper layers of the earth's crust, water, wild and domesticated plants and animals, air and other resources produced by the earth's processes*". Sand resources and dredging permits are also included in Act. The new National Spatial Planning and Management Act (2014) covers marine areas (below mean low water) and so the inclusion of a marine spatial planning component (in the future) as part of an Integrated Coastal and Marine Spatial Planning (ICMSP) Framework may need to be reviewed.

The Royal Proclamation of 24 August 1887 declared the sea boundary of Tonga, whereas the *Land Act 1903* defined the coastal area as the land adjacent to the sea, alternatively covered and left dry by the ordinary flow and ebb of the tides and all areas adjoining this and lying within

15.24 metres (50 feet) of the high water mark of ordinary tides (ibid. s. 2). On Tongatapu, the coastal area is the area starting from 15.24 m above high water mark (*Land Act 1903*) to the outer edge of the reef or where no reef exists.

There is therefore a need to ensure planning continuity across the land /sea interface. At present there is no spatial planning for coast or sea areas in Tonga, and the pressure for sustainable management and conservation of offshore resources (living and non-living) are likely to grow with the onset of deep offshore mining projects. In the future there is a need to link with the new MACBIO (Marine and Coastal Biodiversity Management in Pacific Island Countries) as proposals are being made for the production of a Marine Spatial Plan (MSP) for Vavau and Tongatapu.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE ALSO APPENDICES A AND B)

- Land Act 1927 (http://crownlaw.gov.to/cms/)

2.4.5 Sectoral Legislation

In terms of the built structures in the coastal zone, the Environment Impact Assessment Act of 2003 is important and provides for the application of environmental impact assessment to the planning of development projects within Tonga.

The Land Act of 1927 is important for the protection of coastal resources and regulation of activities in coastal areas. Importantly it states that the foreshore is the property of the Crown and the Minister with the consent of the Cabinet may grant permits to erect stores or wharves or jetties on the foreshore, or to reside on any portion of the foreshore. A linked act is the Land (removal of sand) Regulations of 1936 aimed to manage the practice of removing sand from foreshores in Tonga.

The mandate to each and every piece of legislation (as illustrated in Appendix B2) is divided among the many government ministries and Statutory Boards. At present environmental management (and coastal management) in Tonga is characterized by ad hoc and sectoral constraints.

KEY REFERENCES THAT ADDRESS POINTS RAISED IN THIS SUB-SECTION (SEE ALSO APPENDICES A AND B)

- Laws of Tonga – (found at http://crownlaw.gov.to/cms/)
- Land Act 1927 (http://crownlaw.gov.to/cms/)

2.4.6 Bureaucracy and Administration

There is a high level of hierarchical and administrative bureaucracy in Tonga that requires a considerable vertical passage of permissions and authorities. For example, requests for information and co-operation have to be made via letter from a high level official (see Section 2.4.5 – "Sharing of Information"). There is little evidence of, for example, effective data-sharing protocols with guidance that allows responsibility/decisions to be devolved to an operational level. This leads to delays, and the risk of poor decisions being made because of inadequate evidence to support them. This is particularly ineffective and inefficient when making a cross-Departmental / Ministerial request, as requests have to be made (often in writing) up the chain of command, to a high level official before crossing by letter to an equivalent level in the receiving Department/Ministry where the outcome is communicated down the chain of command, again in writing, to the appropriate operational level. Though typical of administrations in the South Pacific region, this 'rectangular' pathway of communication is very inefficient and wasteful of precious

time both in terms of the people involved and in operational efficiency . Cross-sectoral operational committees could be considered as an alternative approach.

2.4.7 Coastal Engineering Capacity Issues

In Tonga, the Ministry of Works (MoW) have limited capacity in coastal engineering works. Most engineers are civil engineers and they have not had the opportunity for coastal engineering training or capacity support. Capacity within the MoW has been scaled down by Government. All engineering works are undertaken from the Tongatapu head office. Local offices in outer islands only have administrative and maintenance engineering capacity. There is no "best practice" coastal protection guidance document produced and this would be a welcome support document to help deliver any future ICM Plan.

SECTION 3 – KEY OBSERVATIONS AND INFORMATION GAPS

3.1 Observations

The outcome of the rapid consultation exercises, held in Tonga during May and June 2014, coupled with a thorough desk review of available information, suggests that there is recognition of the need for ICM, and awareness of the pressures faced by the coastal and marine systems of Tongatapu. However, there is also frustration that appropriate arrangements are not in place to ensure that the efforts made by individual organisations lead to the better overall management of the coastal and marine space. In some cases there is also a perception that efforts made by one organisation are negated by those of other organisations.

The assessment shows that while for any given activity in the coastal and marine space there is an identified organisation with management responsibility, it is also the case that in some instances (e.g. sustainable land management), there are multiple organisations that are involved in the management of that activity. An assessment of the laws and regulations currently governing coastal and marine activities indicates that these are adequate but implementation is a major issue.

The greatest barriers to implementing ICM in Tongatapu were the following:

1. That there is an **absence of co-ordination and co-operation** between organisations involved in elements of ICM;
2. That there is a **lack of awareness** (with a focus on clarity about who is responsible for what, for example, monitoring and/or enforcing) of either the needs of ICM or the benefits that can accrue from an ICM approach.

It is proposed that 3 key environmental principles are taken forward in any future ICM Policy Framework for Tongatapu. These are:

- "Compliance",
- "Improved Integration" and
- "Appropriate Scientific Background.

These principles are as believed to be pivotal for the effective implementation of ICM in Tongatapu. It is proposed that instead of focusing purely on ICM, that a new focus on producing a Policy Framework for Integrated Coastal **and Marine Spatial Planning** (ICMSP) is considered to help capture national vision statements, objectives and associated policies in the marine area as well.

A separate discussion paper shall be prepared to take forward this suggestion later in the contract (July 2014).

3.2 Key Information Gaps

3.2.1 Existing Data Availability

There does not appear to be any effective mechanisms to routinely or automatically share data and proposals within and between Ministries, either as raw data, analysed outputs and/or as some

form of metadata. The only form of geographical information system (GIS) related metadata layer listing made available is presented in Appendix E.

The following table 3.1 is designed to capture a clear summary overview of the availability and format of any relevant published or digital related data which could be used in the production of a future ICM Plan (or ICMSP – see above). The various issues have be categorised into 6 appropriate "Themes" headings which may be taken forward for use within a future Tongatapu ICM Plan production ***(NB: should the recommendation be accepted to take forward ICMSP, then the same Themes can be used to reflect data "seaward" of the Coastal Management Area as well). Data gaps are also clearly defined (based on knowledge at the time of writing)***.

3.2.2 Sharing of information

There appears to be a challenge relating to the sharing of coastal related information/data (formal or informal) between Ministries. In some cases there is even an absence of routine sharing of information between Departments within the same Ministry. This can lead to lack of co-ordination of coastal related actions and/or duplication of effort. A good example of this is linked to the availability of beach profile information which has been collected by the Department of Natural Resources (part of MLECCNR), though is not used within a collective databank of information at a national scale.

MLECCNR currently own Arc GIS version 9.2. They intend to purchase version 9.3 if possible in the future. It is not clear which Ministries would be geared up to make use of this data in this format. Quickbird imagery is available for all islands (2004) with aerial imagery available from 1961 and 2004, however the topographic variance of these images have an approximate 5-10m accuracy. The 1961 images also have not been ortho-rectfied.

There is no updated land use data available within the GIS, which is held nationally at MLECCNR who hold the national metadata file structure (see Appendix D). No well or borehole data is available from MLSNR though borehole and well mapping has just started, using global positioning system (GPS) to identify exact locations. Specific information on beach change (beach profile information) is not available from an island wide perspective. Capacity issues and training are key reasons for this lack of data.

TOPICS OF RELEVANCE	DATA AVAILABILITY AND STATUS (FORMAT ETC)
THEME 1 – ACCESSING THE COASTAL MANAGEMENT AREA	
Coastal hydrodynamics;	Separate consultancy reports and EIAs. PASAP project completed coastal modelling for Ha'apai but not Tongatapu. Most of the coastal hydrodynamic data are within the Geology Department and in SOPAC in Technical reports form. Tonga Defence Services conduct most of coastal hydro graphic surveys
Residential development;	Ministry of Lands, Environment, Climate Change and Natural Resources (MLECCNR) in maps form. Standards and permit for residential houses are controlled by Ministry of Infrastructures
Coastal structures;	The information are shared between Port Authority, Ministry of Infrastructure and Ministry of Lands, Environment , Climate Change and Natural Resources (MLECCNR) - in maps
Beach/waterfront management and recreation (public space);	MLECCNR-in maps
Water based recreation (and facilities);	Ports Authority and MLECCNR- not well developed
Tourism facilities;	Ministry of Commerce, Tourism and labour- maps
Development Guidance (Building Controls in the CMA)	Urban Planning & Ministry of Lands- under development
Foreshore ownership and land use zonation;	MLECCNR-maps
Piers and docks.	Ports Authority- maps
THEME 2 - Transportation in the Coastal Management Area	
Commercial ports;	Ports Authority- maps
Fishing harbours;	Ports Authority. Ministry of Fisheries- maps
Shipping routes;	Ports Authority- maps
Coastal navigation and waterways;	Ports Authority, Tonga Defence Services (TDS)- maps
Leisure boating (permits/services etc)	Ports Authority
Water taxis etc.	Ports Authority
Coastal roads	MLECCNR- maps
THEME 3 – Protecting and conserving habitats in the Coastal Management Area	

TOPICS OF RELEVANCE	DATA AVAILABILITY AND STATUS (FORMAT ETC)
Water pollution (storm water and effluent disposal);	Port Authority, Fisheries, MLECCNR, Tonga Water Board (TWB)- maps
Marine ecology/ habitat;	Fisheries, MLECCNR- various reports
Shoreline features	MLECCNR, Ports Authority- in maps and soft copies
Marine protected areas	Fisheries, MLECCNR- maps
Open space preservation;	MLECCNR, Fisheries- SMA, maps
Fishery exclusion zones	Fisheries, MLECCNR- not well developed
THEME 4 - Resource management in the Coastal Management Area and offshore	
Pelagic fisheries;	Fisheries- reports
Shellfisheries;	Fisheries- various reports
Aquaculture/mariculture.	Fisheries- various reports
Deep Sea Mineral Exploration;	MLECCNR- under development
Sand resources;	MLECCNR, SOPAC- various reports
Water resources (groundwater aquifers);	MLECCNR, Tonga Water Board (TWB) .-water quality data is available in report and soft copies
Offshore water aquifers.	MLECCNR, Tonga Water Board (TWB)- maps, reports and soft copies
Agricultural resources	Ministry of Agriculture- reports, maps
THEME 5 - Safety and security in the Coastal Management Area and offshore	
Disaster risk reduction (natural hazards);	Ministry of Infrastructure, MLECCNR- maps
Homeland security	Ministry of Police, Prime Minister's Office
Offshore communication cables;	TCC- maps
Search and rescue (SAR);	Tonga Defence Service (TDS)
Critical infrastructure and "sensitive areas";	MLECCNR, Ministry of Infrastructure, Ministry of Fisheries, Ministry of Health, Prime Minister's Office
Critical utilities;	Prime Minister's Office, Tonga Power Board (TWB)
Commercial and light industry development;	Ministry of Labour and Commerce
Military use areas;	TDS, MLECCNR- under development
Coastguard requirements.	TDS- under development
THEME 6 - Cultural heritage in the Coastal	

TOPICS OF RELEVANCE	DATA AVAILABILITY AND STATUS (FORMAT ETC)
Management Area	
Heritage tourism issues;	Ministry of Tourism, MLECCNR- not well developed
Offshore cultural issues -	Ministry of Tourism, MLECCNR, Ministry of Fisheries- not well developed
“Noble” owned areas and Customary lands.	MLECCNR- maps

TABLE 3.1 – DATA AND INFORMATION GAPS AND AVAILABILITY

APPENDIX A REFERENCES

1. ADB, 2013. TA-8307 TON Preparing the Strategic Program for Climate Resilience (SPCR). Nukaleka-Maneka-Kolonga Shore Protection, Draft for Discussion. Asian Development Bank, May 2013.
2. ADB (2006). Tonga Integrated Urban Development Project - Final Report Volume 2 – Appendices.
3. Aholahi, H.(2013) Mangroves of Tonga. http://www.livingoceansfoundation.org/mangroves-of-tonga/
4. Bataille-Benguigui, M.-C., 1989. La peche artisanale aux ˆ ˆıles Tonga: antagonisme entre projets de developpement et traditions. Aquat Living Resour. 2, 31–43.
5. Bataille-Benguigui, M.-C., 1992. Pecheurs de mer, p ˆ echeurs de terre, ˆla mer dans la pensee Tongienne. Etudes Rurales 127-128, 55–73.
6. BoM / CSIRO (2014) "Report: Climate Variability, Extremes and Change in the Western Tropical Pacific 2014 - Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports 2014"
7. Cruickshank, M.J. & Morgan, C.L., (1996). Final Environmental Impact Assessment on the Proposed Sand Dredging in Basin A offshore from Nuku'alofa, Kingdom of Tonga, Ministry of lands, Survey and Natural Resources, Nuku'alofa.
8. CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.
9. CTL, 2013b. MECC Consultancy to Conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the eastern side of Tongatapu: Report of Coastal Design and Costing March 2012.
10. Damlamian, H. 2008. Hydrodynamic Model of Fanga'uta lagoon: Water Circulation and Applications. EUEDF-SOPAC: Reducing Vulnerbility of Pacific ACP States. Project Report 135.
11. Dept of Environment (2006). KINGDOM OF TONGA, National Biodiversity Strategy & Action Plan.
12. Dickenson, W.R., 2007, Paleoenvironment of Lapita sites on Fanga'uta Lagoon, Tongatapu, Kingdom of Tonga. In Bedford, S., Sand,C., and Connaughton,bS.P., eds.,Oceanic Explorations: Lapita and Western Pacific Settlement [Terra Australia 26]: Canberra, ANU Press, pp. 177-186.
13. DOS (2011) Tonga 2011 Census of Population and Housing, Volume 2: Analytical Report Kingdom of Tonga, Department of Statistics.
14. eCoast (2013) "Review of Historical and Recent Studies Pertaining to Erosion of Eastern Tongatapu, Tonga. Prepared for SPC – GCCA:PSIS.
15. eCoast (2013) "Final Design of Two Coastal Erosion Options for Eastern Tongatapu, Tonga". Prepared for SPC – GCCA:PSIS.
16. eCoast (2013) "Monitoring and Evaluation Plan for Two Coastal Erosion Options for Eastern Tongatapu, Tonga, Prepared for SPC – GCCA:PSIS.

17. Ellison, 1999. First Report on Development of Mangrove Environmental Management Plan for Tongatapu.

18. EU EDF 8 (2005). SOPAC Project 38: Reducing Vulnerability of Pacific ACP States Tonga Proposed Guidelines and Monitoring Procedures for Aggregate Extraction north of Tongatapu. EC (2008). Country Strategy Paper for Tonga and National Indicative Programme (2008 – 2013).

19. EU EDF 8(2005) SOPAC Project Report 39: Reducing Vulnerability of Pacific ACP States Tonga Technical Report on Aggregate Dredging and Proposed Plan of Action for Offshore Aggregate Extraction in Tongatapu.

20. Furness, L, J. (1993). Location of fresh-water supplies on Lifuka, Ha'apai Group, Kingdom of Tonga, *Hydrology of Warm Humid Regions* (Proceedings of the Yokohama Symposium, July 1993). IÂHS PiSl.no. 216.

21. FIELEA, Q. (2012) Hihifo Water Distribution Report, Hihifo, Tongatapu. Water Supply Improvement Project, PACC. Kolomotu'a, TONGA.

22. Govt. Tonga. A Bill for an Act to provide a Framework for Planning the use, development, management and protection of land in the Kingdom of al Tongans and for related purposes.

23. Government of Tonga, Emergency Management Act 2007.

24. Government of Tonga, National Climate Change Policy, 2006.

25. Government of Tonga National Strategic Planning Framework, 2009–2014.

26. Falkland, A. (1999). Tropical Island Hydrology and Water Resources: Current Knowledge and Future Needs. Second International Colloquium on Hydrology and Water Management in the Humid Tropics, Panama City, 21–26 March.

27. Falkland A. & Woodroffe C. D (1997). Geology and hydrogeology of Tarawa and Christmas Island, Kiribati, Chapter 19, in Geology and Hydrogeology of Carbonate Islands, Developments in Sedimentology 54 (editors Vacher, H.L. and Quinn, T.M., Elsevier, Amsterdam, 577–610.

28. FAO (2010) Fishery and Aquaculture Country Profile (Tonga) http://www.fao.org/fishery/facp/TON/en

29. Furness L.J & Helu S.P (1993). The Hydrogeology and Water Supply of the Kingdom of Tonga, Ministry of Land Survey and Natural Resources, Kindom of Tonga, February 1993.

30. Hawkins, J.W. 1974: Geology of the Lau Basin: A marginal sea behind the Tonga Arc; pp. 505-20in Burk, C. A.; Drake, C.L (eds.) : "The Geology of Continental Margins". Springer Vevlag, New York 1976.

31. Herzer, R.H.; Exon, N.F. 1985: Structure and Basin analysis of the southern Tonga forearc. In Scholl, D.W. and Vallier, T.L. Geology and Offshore resources of Pacific Council for Energy and Mineral Resources Earth Science Series, V. 2: Tulsa, Oklahoma, American Association of Petroleum Geologists.

32. Howarth R (1982) Technical Report 32 on Coastal Reclamation Study , NW Tongatapu, Tonga. 10 October to 22 October 1983, SOPAC.

33. 5th IPCC Assessment Report (2014) Chapter 13 "Sea Level Change" Coordinating Lead Authors: John A. Church (Australia), Peter U. Clark (USA)

34. Intergovernmental Panel on Climate Change. "Climate change 2007"; Fourth Assessment Report (AR4), Cambridge University Press, United Kingdom.

35. Intergovernmental Panel on Climate Change. 2000. "Emission Scenarios"; Cambridge University Press, Cambridge, United Kingdom.

36. Kouwenhoven, P. et al. (2006). Capacity Building to enable the Development of Adaptation Measures in Pacific Island Countries (CBDAMPIC) - ECONOMIC ASSESSMENT OF PILOTS - - FINAL REPORT -To SPREP - International Global Change Institute (IGCI) University of Waikato, Hamilton, New Zealand.

37. Kingdom of Tonga. 2011. Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas. Submitted to the Secretariat of the Convention on Biological Diversity.

38. Kingdom of Tonga (2009) National Strategic Planning Framework 2010-2014, February 2009

39. Kingdom of Tonga (2014) National Land Use Policy: Kingdom of Tonga (Draft 1) 2014.

40. Kula, T. (2009) An Investigation of the Feasibility of Rainwater Harvesting Systems for Water Supply in the islands in the Kingdom of Tonga, Spatial Research Project, University of Sydney, AUSTRALIA.

41. Larue, B. M. ; Pontoise, B.; Malahoff, A.; Lapouille, A.; Latham, G.V. 1982: Bassins Marginaux Actifs du Sud-Quest Pacifique: Plateau Nord – Fidjien, Bassin de Lau (Active marginal basins of the south – west Pacific: North Fiji Basin, Lau Basin). In Equipe Ge'ologie – ge 'ophysique ' ORSTOM Noumea Contribution 'a l'etude ge'odynamique du Sud- Quest Pacifique' Trav. Doc. ORSTOM 147: 3636-406.

42. Lovell, E.R. and Palaki, A, 2001. Tonga Coral Reefs: National Status Report. In "Status of Coral Reefs in Southeast and Central Pacific- Polynesian Mana Network," B. Salvat ed, Foundation Naturalia Polynesia: pp101–124.

43. Lovell, E (2005). Environmental Impact Assessment of Sand Resource Extraction North of Tongatapu (February 2005) Biological Consultants, Fiji, SOPAC Technical Report 387.MECC (2010).

44. MAF/ Statistics Dept/ FAO (2002). Agricultural Census 2001. Kingdom of Tonga.

45. Malm, T. The tragedy of the commoners: The decline of the customary marine tenure system of Tonga. Paper presented at the Symposium and Workshop on Managing Common Resources – What is theSolution? Lund University, Sweden, 10–11 September 2001

46. MEC, 2013. Environmental Impact Assessment of Four Proposed Coastal Engineering Interventions for Five Communities on Eastern side of Tongatapu, June 2012.

47. Ministry of Environment and Climate Change, National Assessment Report, 2004.

48. Ministry of Environment and Climate Change, Vulnerability and Adaptation Assessment on Tonga's Initial National Communication on Climate Change, 2005.

49. Ministry of Environment and Climate Change, Climate Change Thematic Assessment Report under National Capacity Self Assessment Project, 2007.

50. Ministry of Environment and Climate Change, Joint Community consultations on Climate Change, Biodiversity and National Capacity Self Assessment Projects, 2006.

51. Morrison, R. John & U. L. Kaly (2010) "Chapter 15 Coastal lagoon management in three Pacific island situations: – is scientific knowledge used effectively?" In Saving Small Island Developing States: Environmental and Natural Resource, edited by Shyam Nath, John L. Roberts and Yeti Nisha Madhoo. Commonwealth Secretariat, United Kingdom, page 178.

52. Mulder, C.J.; Niuewenhuizen, C.V.D. 1971. : Appraisal of the Tonga concession and recommendations for future work. Bataafse Internationale Petroleum Maatschappij N.V. Rep. G2 EP-42347. (unpubl. Rep.) Open File, Tonga Govt. Petrol. Rep. 15. (Include paleontological data sheets, offshore seismic sections.)

53. Netatua Pelesikoti (2003). Sustainable Resource and Environmental Management in Tonga: Current Situation Perceptions and a Proposed new Policy Framework - A thesis submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy.

54. Nichols, RJ. & Mimura, N. (1998). Regional issues raised by sea-level rise and their policy implications. Clim. Res. 11:5-18.

55. Nobuo Mimura (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change * Center for Water Environment Studies, Ibaraki University, Hitachi, Ibaraki 316-8511, Japan, Climate Research Journal, Vol. 12: 137–143.

56. Oliver. J and Reddy, G.F. (1982). Tropical Cyclone Isaac, Cyclonic impact in the context of the society and economy of the Kingdom of Tonga; Centre for Disaster Studies, James Cook University of North Queensland.

57. Pacific Adaptation Strategy Assistance Program Assessing Vulnerability and Adaptation to Sea-Level Rise Lifuka Island, Ha'apai, Tonga (2010).

58. Packham, G.H., 1978: Evolution of a simple Island Arc ; Lau-Tonga Ridge. In Coleman, P.J. (ed) Second Southwest Pacific Earthscience Symposium. IGCP project 110, Sydney, December 1977. Bull.Aust.Soc. Explor.Geophys. 9(3)G2: 133-140.

59. Prescott N., Mimura N. & Hori N. (1992). Assessment of the Vulnerability of the Kingdom of Tonga to Sea Level Rise, Nuku'alofa, Kingdom of Tonga.

60. PROCFISH, (2009). Tonga country report: profiles and results from survey work at Ha'atafu, Manuka, Koulo and Lofanga (November and December 2001; March to June 2002; April to June, September and October 2008). Secretariat of the Pacific Community, Noumea, New Caledonia.

61. Salinger. J. 2000. "The effects of the inter-decadal Pacific oscillation on the South Pacific Convergence zone"; National Institute of Water and Atmospheric Research, Auckland, New Zealand.

62. Sclater, J.G.; Hawkins, J.W. ; Mammerickx, J.; Chase, C.G.: 1972: Crustal extension between the Tonga and Lau Ridges; petrologic geophysical evidence: Bull. Geol. Soc. Am. 83: 505-518.

63. SimCLIM Model Software 2008, CLIMsystems Ltd., Hamilton, New Zealand.

64. Sea Level Data Archives CD-ROM June 2008, South Pacific Sea Level and Climate Change Monitoring Project.SOPAC (2002). COASTAL EROSION SURVEY VISIT TO TONGATAPU, KINGDOM OF TONGA (27 April – 4 May 2002), Andrick Lal (South Pacific Sea Level & Climate Monitoring Project Phase III).

65. Smith, R.B. 1991. Volume of Sand in Basin A, Northwest of Fafa Island, Nuku'alofa, Tonga. South Pacific Applied Geoscience omission (SOPAC) Technical Report 133. 59p.

66. SOPAC (2006) National Integrated Water Resource Management Diagnostic Report, Tonga, Miscellaneous Report 646.

67. SOPAC, Pacific Islands Forum Secretariat and UNDP Pacific Centre (2009) Guide to Developing National Action Plan: A Tool for Mainstreaming DRM Based on Experiences from Selected Pacific Islands Countries, SOPAC, Suva, Fiji.

68. SOPAC, Pacific Islands Forum Secretariat and UNDP Pacific Centre (2009) Guide to Developing National Action Plan: A Tool for Mainstreaming DRM Based on Experiences from Selected Pacific Islands Countries, SOPAC, Suva, Fiji.SPC (2008) TONGA Country Profile September 2008 (FINAL DRAFT).

69. SOPAC Technical Report 286.HA'APAI DEVELOPMENT MASTER PLAN 2011/12 – 2020/21 (2010) MINISTRY OF FINANCE AND NATIONAL PLANNING.JOINT NATIONAL ACTION PLAN ON CLIMATE CHANGE ADAPTATION AND DISASTER RISK MANAGEMENT for Tonga 2010–2015 (July 2010).

70. SOPAC, 1989. High Resolution Seismic Survey For Lagoonal Sand and Gravel Resources in Tongatapu, Kingdom of Tonga. SOPAC Technical Report 85, April 1989.

71. SOPAC, 1991a. Assessment of Sand Resources North Tongatapu, Nuku'alofa, Tonga. SOPAC Technical Report 123, May 1991.

72. SOPAC, 1991b. Volume of Sand in Basin A, Northwest of Fafa Island, Nuku'alofa Lagoon, Tonga: Results of High Resolution Seismic Survey. SOPAC Technical Report 133, September 1991.

73. SOPAC, 1994. Coastal Protection in the South Pacific. SOPAC Technical Report 190, March 1994.

74. SOPAC, 1995a. Monitoring Coastal Changes on Tongatapu, Kingdom of Tonga.

75. SOPAC Technical Report 218, December 1995.

76. SOPAC, 2005. Environmental Impact or Sand Resource Extraction North of Tongatapu. SOPAC Technical Report 387, February 2005.

77. Statistics Department (2006). Kingdom of Tonga Population Census 2006: Administrative Report and Basic Tables, Government of Tonga, Nukulofa.

78. Sustainable Seas Ltd (2014) PACC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Western side of Tongatapu: Report of Coastal Feasibility Studies January 2014.

79. SURVEY REPORT OF SAND AND AGGREGATE RESOURCES AT VAVA'U, KINGDOM OF TONGA Geon-Hong Min and Sung-Rock Lee March 1999 SOPAC Technical Report 277.Tiffin, D (1982) KOLOVAI RIDGE SAND SURVEY KINGDOM OF TONGA, 11-22 February 1982, SOPAC Project, WORK PROGRAMME CCSP-I/TG.6.

80. Taaniela Kula. An Investigation of the Feasibility of Rainwater Harvesting Systems for Water Supply in the islands of the Kingdom of Tonga Author:, SID: 309033594. GEOG5005 Spatial Research Project

81. Talanoa Fuka Kitekei'aho and Poasi Ngaluafe (Dec 2010).EIA for the PROPOSED REPLACEMENT CAUSEWAY FOR FOA ISLAND, KINGDOM OF TONGA.

82. Tappin, David R.; Lal, Andrick,; Forstreuter,; Mafi, Kelepi,; 2002.: Coastal Erosion in Western Tongatapu, Tonga- human input, natural process or both?? SOPAC Report.

83. Taylor, F.W.: Bloom, A.L; 1977: Coral Reefs on tectonic blocks, Tonga island arc: Proc. 3rd Int. Coral Reef Symp. Miami 3(2) G2: 276-81

84. Taylor, F.W. 1978: Quaternary tectonic and sea- level history, Tonga and Fiji, Southwest Pacific: Unpubl. Ph. D Thesis, Connell University, Ithaca, New York.366p.

85. The Kingdom of Tonga. (2010). Fourth report: Review of Tonga National Biodiversity Strategy and Action Plan.

86. Thompson, C. S. 1986. "The climate and weather of Tonga"; Miscellaneous Publication, New Zealand Meteorological Service, Wellington, New Zealand.

87. Tonga Meteorological Services Ministry for Transport Tonga Tsunami Report 11-12 March 2011 PROJECT "SUSTAINABLE URBAN AND ENVIRONMENTAL MANAGEMENT ENVIRONMENTAL PROTECTION" - TONGA - Reference: TG/001/07 EDFIX Contract Service n° TON001/09 Quarterly Monitoring Report 1 September 2010 – November 2010.

88. TRIP Consultants (2013). Tonga Tourism Sector Roadmap: Situation Analysis and Tourism Sector Framework.

89. UNDP (2014) Project Docment for the Ridge to Reef LDCF/GEF proposal for Fanga'Uta Lagoon.

90. Van Katwijk, M.M., N.F. Meier, R.van Loon, E.M. van Hove, W.B.J.T. Giessen, G. van der Velde, and C. Hartog. 1993. Sabaki River sediment load and coral stress: correlation between sediments and condition of the Malindi-watamu reefs in Kenya (Indian Ocean). Marine Biology: (Berlin). 117(4):675-683.

91. Zann, L.P., Kimmerer,W.J. and Brock,R.E.(1984) The Ecology of Fanga'uta Lagoon,Tongatapu, Tonga International Sea Grants, University of Hawaii/ Institute of Marine Resources, USP 100pp

92. Zann, L.P. 1994. The Status of Coral Reefs in South Western Pacific Islands. Marine Pollution Bulletin. 1994. 29(1-3): 52-61.

93. http://legislation.to/cms/home.html

94. http://crownlaw.gov.to/cms/

95. Assessing the vulnerability of fisheries and aquaculture in the tropical Pacific to climate change – an update: http://www.spc.int/fame/doc/meetings/7thHOF/HOF7_IP3.pdf.

96. Preliminary assessment of the Effects of climate change: http://www.spc.int/sppu/images/stories/preliminary%20assessment.pdf

97. The Contribution of Fisheries to the Economies of PICs (ADB report): http://www.adb.org/documents/reports/contribution_fisheries_pacific_economies/contribution_fisheries.pdf

98. Assessing the vulnerability of rural livelihoods in the Pacific to climate change: http://www.sprep.org/att/IRC/eCOPIES/Pacific_Region/583.pdf

PEIN Country Profile and Virtual Environment Library for Tonga: http://www.sprep.org/publication/pein_tonga.asp

APPENDIX B – COASTAL CHARACTERISTICS OF TONGATAPU

NB: where appropriate, reference is made throughout Appendix B to the proposed Coastal Units for Tongatapu as identified in Section 2.3. The reader should be aware of these Coastal Units and in particular, Figure 2.2.

B1 General Country Information

SUMMARY DESCRIPTION

There are four main groups of islands that forme the Tonga Group. Arranged in a north to south direction, are the two Niuas, followed by the Vava'u Group, the Ha'apai Group and further south is the Tongatapu Group of islands (Figure B1). Tongatapu is the largest of these islands and contains about 60% of its 120,000 population (World Bank and CIA Factbook). The capital Nuku'alofa lies on the northern leeward coast of Tongatapu island.

FIGURE B1: THE KINGDOM OF TONGA SHOWING THE LOCATION OF TONGATAPU.

B2 Institutional Arrangements, Policy and Legislation

Institutional Arrangements

SUMMARY DESCRIPTION

The primary public sector stakeholder responsible for the future implementation of ICM in Tongatapu is most likely to be the Ministry of Land, Environment, Climate Change & Natural Resource (MLECCNR). As the core government agency responsible for providing '*the fundamental basis for the achievement of high standard of living and quality of life for the people of Tonga at present and into the next generation, through sustaining the integrity of the ecosystems of Tonga to support life and livelihoods*,' MLECCNR will play a role of bridging and ensuring the collaboration and close communication between ministries and public entities having the mandate for biodiversity conservation and sustainable management of coastal resources within the Coastal Management Area (CMA). At present, there is a range of Departments and Ministries with prospective roles in enforcing current legislation. Key Ministries and other stakeholders with important roles to play shall include Ministry of Agriculture, Forestry, Food and Fisheries (MAFFF), Ministry of Tourism, Ministry of Foreign Affairs and the Aid Management Division of the Ministry of Finance and National Planning and NGOs including Tonga Trust whose role would be to ensure that the voices of communities, especially women, are heard in project determination and in participation to gain benefits from any coastal project.

National Strategic Policy

SUMMARY DESCRIPTION

The Government of Tonga's development aims and program are presented in the Tonga Strategic Development Framework (TSDF). The TSDF specifically targets infrastructure and has four priority themes for economic infrastructure namely: (i) renewable energy and stable electricity prices, (ii) improved access to markets, (iii) improved management of the water and waste cycle, and (iv) improved asset management. The new National Spatial Planning and Management Act 2014 (NSPM) will provide the framework for land use planning and development. Urban planning objectives articulated in the NSPM include the creation of an urban structure with equitable access to employment, transportation, recreational and other opportunities, and to protect public utilities and other assets and enable the orderly provision and coordination of public utilities and other facilities for the benefit of the community.

Relevant Statutory Laws

SUMMARY DESCRIPTION

There are several species of legislation in Tonga, which have provisions for coastal/wetlands management and development or for their protection/conservation. Tonga could have the oldest piece of legislation for mangrove protection in the Pacific as in the 1934 Birds and Fish Preservation Act, amended in 1974, prohibits the cutting or removal of mangroves in any area. The key legislative framework of relevance to ICM consists of the following;

- Marine Pollution Act 2004 - Comprehensive provision is made in relation to marine pollution prevention and response.
- Aquaculture Management Act 2003 Notice must be given of an intention to use chemicals, pesticides, pharmaceuticals and bioremediation products, and such substances may be restricted or prohibited.

- Fisheries Management Act 2002 - This is a modern and comprehensive law dealing with all aspects of the conservation, management and sustainable utilisation and development of Tonga's fisheries.
- *Land Act (1903)* - makes provision for development within the littoral zone whereby under Section 22(1) (e), provisions are made to regulate the cutting and taking of timber, stone and sand from any holding (now superseded by the National Spatial Planning and Management (NSPM) Act (2014).
- *Parks and Reserves Act (1988)* - Provisions to regulate disposal of litter in public places but more importantly to set up Land and Marine Parks and Reserves. Considered one of the more important pieces of environmental legislation enacted in Tonga.
- *Land (Removal of Sand) Regulations (1936)* - prohibits taking of sand from the foreshore within the limits of the harbour, from Crown land or any holding without written permit from the Minister of Lands.
- Birds and Fish Preservation (Amendment) Act (1989) – Makes provision under Section 7 to prohibit within designated areas without prior consent any construction activity, discharge of effluent or the permanent cutting, damage, or removal of any mangroves.
- Fisheries Management Act (2002) - Makes provision under Section 59 for the Minister to make regulations, among other things, prescribing fisheries management and conservation measures, and schemes for limiting entry into all or only specified fisheries. The Ministry as well to progressively prepare and keep under review plans for the conservation, management and development of marine living resources;
- Environmental Management Act (2010).
- Environmental Impact Assessment Act (2003) - Provides a framework for development planning which aims to prevent the making of arbitrary decisions with regard to land, marine, coastal areas and resources use.

A number of Tonga's laws contain provisions relating to the protection, conservation and management of coastal waters. There are effective laws dealing with other matters of relevance to coastal zones, such as regulating the extraction of sand, rock and coral from such areas.

The Environmental Management Act (2005) established the Department of Environment to ensure the protection and proper management of the environment and the promotion of sustainable development. The objectives of the Act include:

- To coordinate the role of government in relation to environment management.
- To promote meaningful public involvement in relation to issues of environmental management.
- To ensure the observance of Tonga's international obligations in this context.
- To promote the concept of sustainable development.
- To facilitate assessments of environmental impacts.
- To promote understanding, management, conservation and protection of biological diversity.

In terms of built structures in the coastal zone, the Environment Impact Assessment Act of 2003 is important to enforce as it provides for the application of environmental impact assessment to the planning of development projects within Tonga.

The Land Act of 1927 (and as originated in 1903) is also important for the protection of coastal resources and regulation of activities in coastal areas. This is because it states that the foreshore is the property of the Crown and the Minister, with the consent of the Cabinet, may grant permits to erect stores or wharves or jetties on the foreshore, or to reside on any portion of the foreshore. A linked act is the Land (removal of sand) Regulations of 1936 aimed to manage the practice of removing sand from foreshores in Tonga.

As well as national legislation, there are relevant international conventions, protocols and regional agreements applying in the region would need to be considered in relation to the impacts of any changes in coastal management, namely:

- The Convention on Biological Diversity;
- Cartagena Protocol;
- World Heritage Convention;
- Framework Convention on Climate Change;
- Regional Seas Conventions;
- Convention to Combat Desertification;
- CITES (Convention on International Trade in Endangered Species).

A new Prevention of Marine Pollution Bill is now being processed dealing with prevention of marine pollution matters as prescribed under the International Convention for the Prevention of Pollution of the Sea by Oil (MARPOL) 73/78, the Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), London, Intervention, Fund and the United Nations Convention on the Law of the Sea. Finally, a new Ports Safety Bill deals particularly with pollution matters in a port area.

KEY SOURCES OF INFORMATION

All passed legislation (as mentioned above) can be downloaded from the following websites:
http://legislation.to/cms/home.html
http://crownlaw.gov.to/cms/

B3 Demographics

SUMMARY DESCRIPTION

The population of Tonga (all islands), as per the 2011 Census is 103,252. By island divisions, only Tongatapu population was increased by an annual growth of 0.8%, while all outer islands were decreased. The population of all Tongatapu districts has increased since the last census, except for Kolovai district which decreased by an annual rate of 0.1%. Tongatapu's population was 75,416, constituting 73% of Tonga's total population. This has increased from 71% in 2006.

The average population density in Tongatapu is 290 people/km2 compared to only 18 people/km2 in Ongo Niua. Figure B2 (referred also as Table G1) displays the 2011 census information for Tongatapu with comparisons with the 2006 census.

Table G1: Total population by sex, division and district (1996, 2006 and 2011)

Division/district	2011 Population & Housing Census			2006 Population & Housing Census			1996 Population & Housing Census		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
TONGA	**103,252**	**51,979**	**51,273**	**101,991**	**51,772**	**50,219**	**97,784**	**49,615**	**48,169**
Tongatapu	75,416	37,833	37,583	72,045	36,372	35,673	66,979	33,753	33,226
Kolofo'ou	18,957	9,526	9,431	18,463	9,273	9,190	16,953	8,482	8,471
Kolomotu'a	17,088	8,574	8,514	15,848	7,894	7,954	14,451	7,230	7,221
Vaini	12,949	6,500	6,449	12,594	6,397	6,197	11,180	5,681	5,499
Tatakamotonga	7,233	3,657	3,576	6,969	3,618	3,351	6,828	3,502	3,326
Lapaha	7,380	3,678	3,702	7,255	3,676	3,579	7,370	3,696	3,674
Nukunuku	7,733	3,861	3,872	6,820	3,462	3,358	6,160	3,128	3,032
Kolovai	4,076	2,037	2,039	4,096	2,052	2,044	4,037	2,034	2,003

FIGURE B2 TOTAL POPULATION OF TONGATAPU BY SEX, DIVISION AND DISTRICT (1996, 2006 AND 2011).

KEY SOURCES OF INFORMATION

The 2011 census for Tonga can be downloaded from the following website:

http://www.spc.int/prism/tonga/

B4 Socio-economy, Land Use and Infrastructure (coastal zone)

SUMMARY DESCRIPTION

Historically coastal fisheries determined the livelihood of Tongans. This is reflected by the fact that most of the population on the island of Tongatapu is distributed along this coastline. As a result fishers used to have higher status than farmers. This, however, changed in circa 1950 to agricultural production (Bataille-Benguigui 1988, 1992) which is marked by the introduction of copra and increased land cultivation. Despite this change government policies and projects are seen nowadays to focus on development and upgrading of coastal fisheries activities. Decline in coastal fisheries (FAO 2012) is experienced and most intervention is now directed towards development of commercial fishing such as duty free on fuel, baits and cheap loan.

Decline in coastal fisheries is related to the large coastal population and infrastructure built along the northern coastline. This includes the construction of wharves, fish processing and marinas. Building of wharves and coastal protection has changed the hydrodynamic in the Nuku'alofa urban area and has led to downdrift coastal erosion in the close proximity of the structures built..

KEY SOURCES OF INFORMATION

All EIAs must include key land use and socio-economic data. PACC project in Hihifo has good socio-economic assessments of the community to help devise the water supply project that has taken place. Other publications of relevance include the following:

Bataille-Benguigui, M.-C., 1989. La peche artisanale aux ˆ ˆıles Tonga: antagonisme entre projets de developpement et traditions. Aquat Living Resour. 2, 31–43.

Bataille-Benguigui, M.-C., 1992. Pecheurs de mer, p ˆ echeurs de terre, ˆla mer dans la pensee Tongienne. Etudes Rurales 127-128, 55–73.

B5 Coastal Protection and Sea Defence

SUMMARY DESCRIPTION

Most of Coastal Unit 1 (see Section 2.3 of this report) is protected by a rock revetment built in 1980s through the use of Japanese aid funds. Coastal Unit 2 (Hihifo) also has about two kilometres of rock coastal protection built in 1983 through a combined effort of the community and AuSAID funding. Coastal Unit 3 (Hahake) has evidence of an old rock protection built in 1972 on the eastern margin of this coastal zone. Also in this Coastal Unit, a more recent rock protection further to the west of the older protection was initiated in 1983 in response to storm damages to the coastline caused by Cyclone Isaac. Continuing erosion of the coastline, coupled with sea inundation on this coastline warranted the attention of the Tonga Government and this resulted in work by CTL Consult Ltd (from UK) to conduct a feasibility study in 2012 to produce a feasibility assessment of coastal protection options to minimise coastal inundation risks. An EIA study on the proposed engineering measures was completed (GeoCare 2013) and a plan is now underway for the proposed mitigating measures to be built along this coastline (eCoast 2013).

KEY SOURCES OF INFORMATION

CTL, 2013a. MECC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Eastern side of Tongatapu: Report of Coastal Feasibility Studies March 2012.

CTL, 2013b. MECC Consultancy to Conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the eastern side of Tongatapu: Report of Coastal Design and Costing March 2012.

eCoast (2013) “Review of Historical and Recent Studies Pertaining to Erosion of Eastern Tongatapu, Tonga. Prepared for SPC – GCCA:PSIS.

eCoast (2013) “Final Design of Two Coastal Erosion Options for Eastern Tongatapu, Tonga”. Prepared for SPC – GCCA:PSIS.

eCoast (2013) “Monitoring and Evaluation Plan for Two Coastal Erosion Options for Eastern Tongatapu, Tonga, Prepared for SPC – GCCA:PSIS.

Sustainable Seas Ltd (2014) PACC Consultancy to conduct Coastal Feasibility Studies, Coastal Design and Costing, of Six Communities on the Western side of Tongatapu: Report of Coastal Feasibility Studies January 2014.

NB: Most of the information can be sourced from feasibility studies and EIA reports conducted on the projects proposed on this coastline.

B6 Physical and Biological Characteristics

Coastal Geology

SUMMARY DESCRIPTION

The Tonga Group of islands is formed at the edge of the Australian Plate. Tongatapu is made up of Pliocene and Pleistocene limestone 130 – 250m thick overlying lower Pliocene and older volcaniclastics (Taylor 1978). The subduction zone or where the two plates meet is marked with the Tonga-Kermadec Trench which is the second deepest in the world. The numerous tiny islands north of Tongatapu Island are all sand cays that formed on the limestone platform.

Because the Tonga Island groups are on the edge of an active plate, strong uplift may occur. Taylor and Bloom (1976) have argued that there has been no net uplift or tilting of the Tongatapu Group at least in the last 125,000 years. However, on-going tectonically activity since 1853, may pose a possibility that uplift on the southern coast and at Tongatapu lowering on the northeast coast could contribute to the present vulnerability of the Tongatapu coastal zone to inundation.

KEY SOURCES OF INFORMATION

Maps and reports on all aspects of geology and hydrogeology of Tongatapu can be found at the Geological Services Unit of MLECCNR, Tonga. Appendix A and Table 3.1 provides an overview of data on this issue outlines key geological references of relevance to Tongatapu.

Coastal Topography

SUMMARY DESCRIPTION

The elevated limestone platform reaches a maximum topographic height of 65 – 70 m at the southern end of the island (Figure B3). This forms the high point of a narrow and irregular ridge (0.5 – 1.25km wide and mostly rising more than 20m above sea level) that extends to the northeast and northwest along the windward coast. The ridge encompasses a broad, low area in the central and northern part of the island that rises gently to the south.

The most appropriate source of information on topographic variance is linked to the 2011 LiDAR survey of the island (undertaken by GHD Ltd). This information provides accurate topographic data for the whole island and is stored within the MLECCNR. An example of the output is presented below (Figure B3):

FIGURE B3 EXTENT OF LIDAR COVERAGE FOR TONGATAPU (FROM GHD 2011): SAMPLE LIDAR PLOT OF HIHIFO DISTRICT

KEY SOURCES OF INFORMATION

Maps and report on all aspects of topography of Tongatapu can be found at the Geological Services Unit of MLECCNR, Tonga. Appendix A outlines key geological references of relevance to Tongatapu.

Soils

SUMMARY DESCRIPTION

The Tonga volcanic arc has been responsible for supplying the islands on the Tonga ridge with an andesitic tephra soil that has resulted in an extremely rich soil capable of supporting a high –yield, short fallow agricultural system. The soil of Tongatapu contains about 3m of volcanic ash that is supporting well the agricultural production at this island. With the exception of a few salt affected coastal areas (mainly salt spray on the south and south east coast of Tongatapu though saline intrusion is impacting on groundwater levesl in Hihifo District – Coastal Unit 2), soil are highly productive, easily cultivated and suited to a range of vegetable, root and trees crops as well as pastoral farming.

KEY SOURCES OF INFORMATION

Maps and report on all aspects of pedology and soils of Tongatapu can be found at the MAFFF (Ministry of Agriculture, Fisheries and Food) as well as at the GIS Department of MLECCNR, Tonga. Appendix A and Table 3.1 provides an overview of data on this issue.

Coastal Processes and Geomorphology

SUMMARY DESCRIPTION

Much of the northern coastline of Hahake (Niutoua to Nukuleka) is experiencing coastal erosion. However, there are no measured details of coastal erosion rates in this region. The villages of Kolonga, Manuka and Nukuleka, and a large part of the road are exposed to coastal erosion (CTL 2012a). A large number of ad hoc and poorly constructed seawalls in the area (all in a damaged state) provide little protection. A detailed study of erosion and inundation on the eastern coast of Hihifo (Kolovai to Ha'atafu) by Tappin (2003) showed that the erosion (loss of land) is linked to inundation of low-lying areas and episodic (tropical cyclone) events. Strong north-easterly winds (albeit infrequent) can also cause wave conditions at high tide which cause erosion along this coast. This is confirmed in more recent work undertaken by Sustainable Seas Ltd (2014)

KEY SOURCES OF INFORMATION

Although no relevant historic reports were identified, ortho-aerial photographs dating back to 1968 were available from the Ministry of Natural Resources, and include 1968, 1981, 1990, 1991, 2010 and 2011. Recent historical coastal change work has been completed by eCoast (2013) for the "Tonga Coastal Protection Works CC/13/95" study completed for SPC. A similar initiative is taking place for Hihifo District.

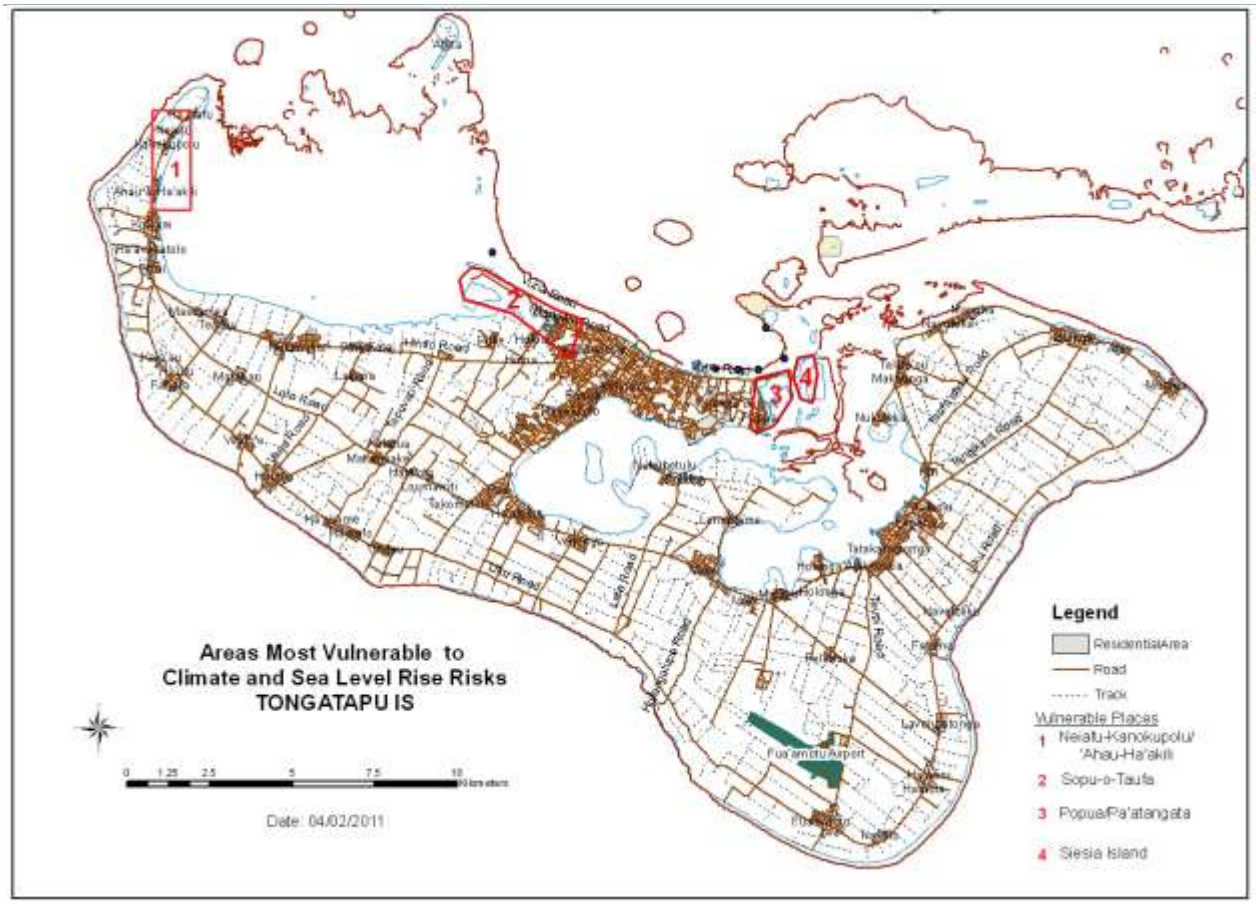
Other work completed by CTL Consult Ltd (2012a) and Sustainable Seas Ltd (2014) for Hahake and Hihifo districts represent the most comprehensive coastal assessment work in recent time for these two Districts. For the Lagoon area, the recent Ridge to Reef (R2R) Project Document work represents a good defining status report on the coastal processes operating within the lagoon (no formal copy of the Project Document is available at this time).

Appendix A and C and Table 3.1 provides an overview of data on this issue.

Coastal Vulnerability

SUMMARY DESCRIPTION

There are 4 locations that are classified as the most vulnerable places in Tongatapu to coastal inundation. These include the villages of Kanokupolu (Hihifo District), Sopu (West of Nuku'alofa), Popua (east of Nuku'alofa) and Siesia island (east of Popua) (see Figure B4).



Location	Latitutude	Longitude	Elevation (m)
Kanokupolu	21.07441 S	175.33272 W	16.5
Popua	21.13937 S	175.20544 W	14.9
Sopu	21°07'26.68'' S	175°13'31.92'' W	15.3
Siesia Island	21°08'38.95'' S	175°09'02.36'' W	12.7

FIGURE B4 (TAKEN FROM AFUAFU KAUTOKE (UNIVERSITY OF SOUTH PACIFIC)).

Fig. B5 shows the areas below the elevation of 1 to 4 m above the present coastline (high-water level) in Togatapu Island, Tonga. Lowlands extend along the north shore, and the land is particularly low at Nuku'alofa, the capital. From the work of the University of the South Pacific (USP), increases of 0.3 and 1 m in mean sea level (MSL) would cause land loss of 3.1 and 10.3 km2, respectively, or 1.1 and 3.9% of the total area of Tongatapu Island. About 2,700 and 9,000 people would be affected under the 2 scenarios, corresponding to 4.3 and 14.2% of the total population of Tongatapu, respectively. In the case of an extreme

event, about 20,000 people currently live in the low-lying areas that can be flooded by a storm surge of 2.8 m, which was recorded during Cyclone Isaac in 1982.

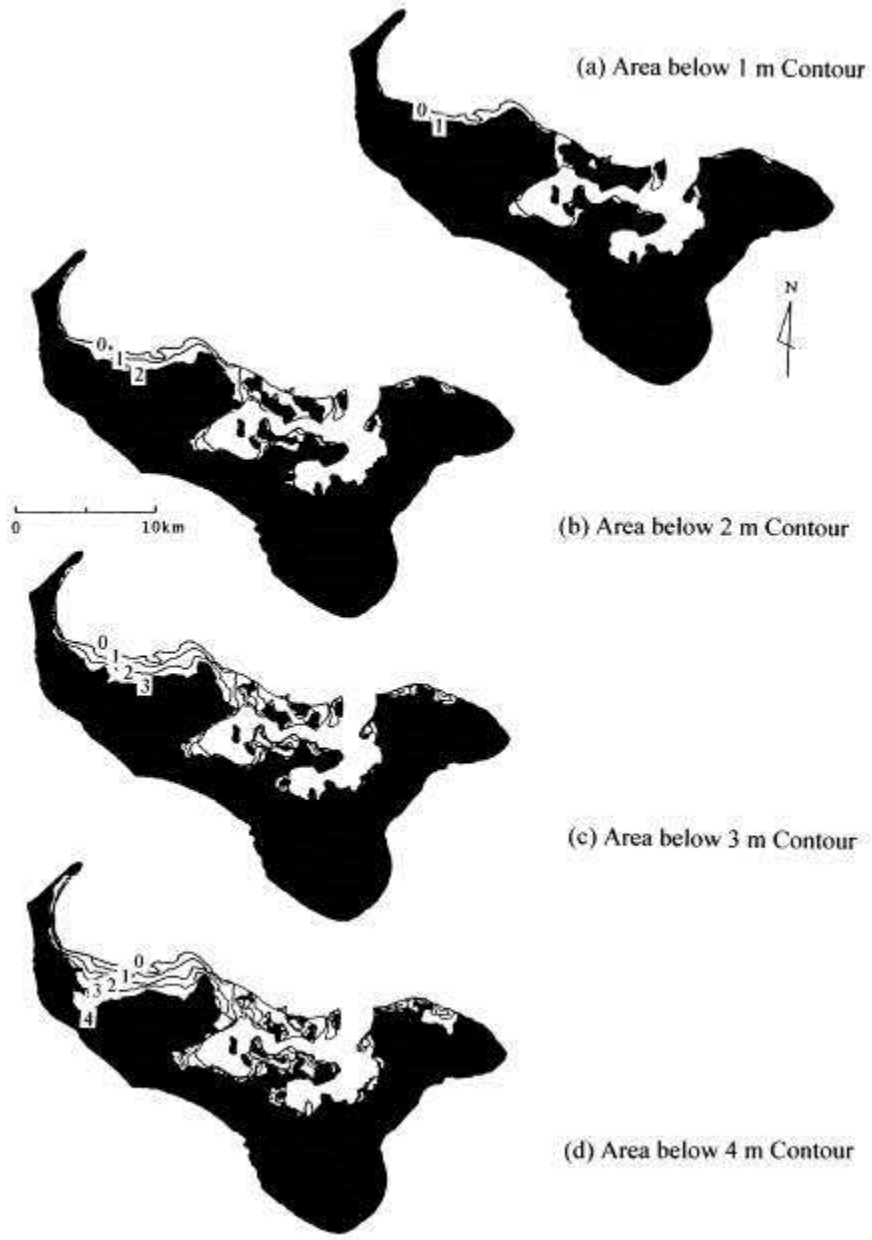


FIGURE B5 (TAKEN FROM AFUAFU KAUTOKE (UNIVERSITY OF SOUTH PACIFIC))

If a storm surge of the same degree occurs in conjunction with a 0.3 m sea level rise, 27.9 km2 (11% of the Tongatapu Island) and 23,470 people (37% of the Tongatapu population) would be at risk. These increase to 37.3 km2 (14%) and 29,560 people (46%) for a 1 m sea level rise. It should be noted that the impacts of sea level rise are not limited to simple inundation and that the danger of cyclone-induced storm surge increases significantly (Fifita *et al*. 1992, Mimura & Plesikoti 1997). The risk of inundation and flooding is further intensified by social factors. In recent years, many countries in the South Pacific have experienced the

migration of people from outer islands to the capitals, and a sharp increase in the population of the low-lying coastal areas.

Resort development construction and the destruction of mangroves have both contributed to increasing coastal vulnerability in locations such as Kanokupolu (Sustainable Seas Ltd 2014). Interventions have included coastal vegetation clearance, sand mining and land reclamation, which have all contributed to coastal erosion, coastal habitat destruction and an increase in coastal community risks to natural disasters. Mangrove cutting is often carried out by communities for medicines, fishing tools, dye and firewood. No alternative solutions are provided to coastal communities and so the practice continues despite education programmes being carried out.

KEY SOURCES OF INFORMATION

Appendix A and Table 3.1 provides an overview of data on this issue.

Coastal Vegetation

SUMMARY DESCRIPTION

Coastal forest in Tongatapu is important in providing natural protection against coastal erosion. The coastal plants of Tongatapu consisted mainly of medicinal and coastal plants that are very effective in providing protection against storm surges and tsunami waves. Most of the plants noted to grow on Tongatapu's coastline are shown in the Table B1 below.

TONGAN NAMES	SCIENTIFIC NAMES
Volovalo	*Prenma asiatica*
Touhuni	*Centella Asiatica*
Toa	*Casuarina equisetifolia*
Lala Tahi	*Vitex trifolia*
Milotahi	*Thespesia populnea*
Fau	*Hibiscus tiliaceus*
Fa	*Pandanus tectoricus*
Feta'u	*Callophyllum inphyllum*
Ovava	*Ficus oblique*
Tepilo a Maui	*Geniostoma rupestre*
Tongo	Mangroves (different species)

TABLE B1: LIST OF MEDICINAL AND COASTAL PLANTS FOUND IN ABUNDANCES ALONG TONGATAPU'S COASTLINE

KEY SOURCES OF INFORMATION

Appendix A and Table 3.1 provides an overview of data on this issue.

B7 Oceanographic Characteristics

Wave Climate

SUMMARY DESCRIPTION

No nearshore wave information is available for Tongatapu, though some offshore wave information exists for a location close to the Tonga Ridge. Understanding wave diffraction effects are perhaps the most significant issue to consider and this is most likely to be experienced over the reef system before diffracting onto the coastline of Tongatapu. The actual extent of this has not been calculated anywhere on Tongatapu and remains an uncertainty. New modelling studies are needed to better ascertain this uncertainty, though some initial modelling work has been completed by eCoast for the Hahake coastal frontage (Coastal Unit 3). The use of the new LIDAR bathymetry work (for PASAP) will prove beneficial in this way to help create inshore wave coefficients so that inshore wave conditions can be calculated for this coastline (See Figure B6).

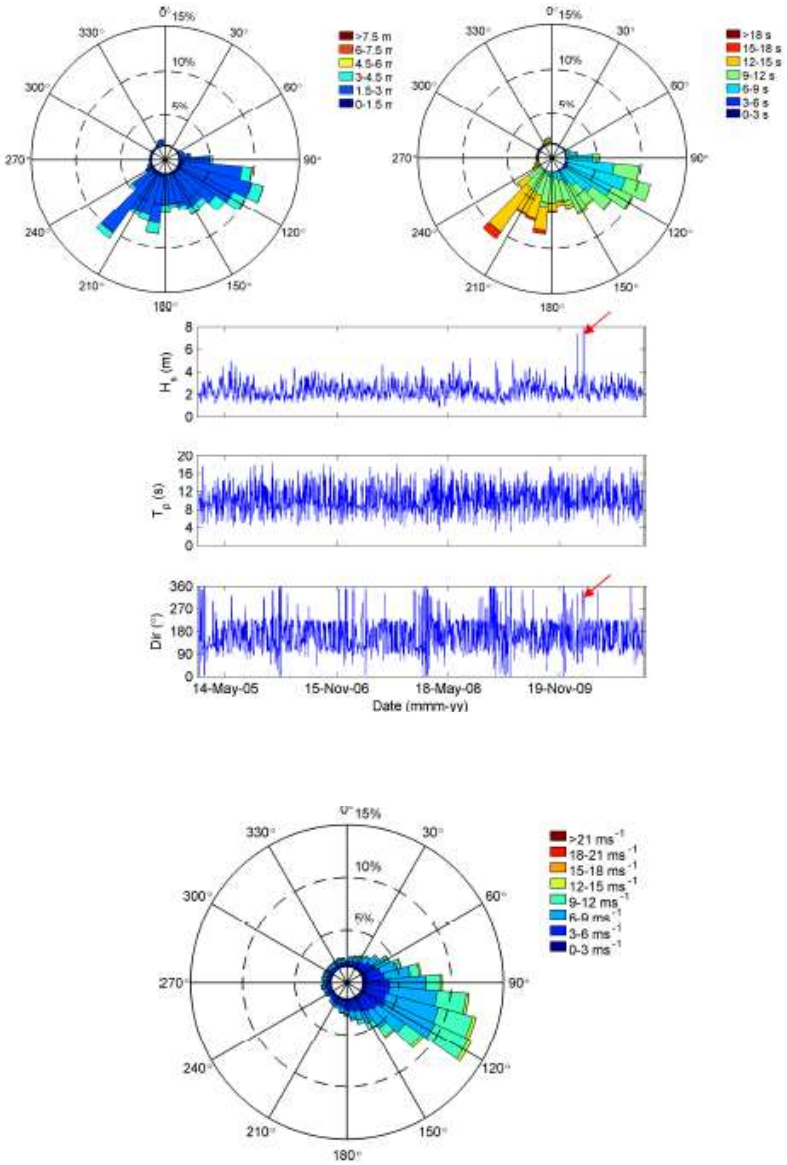


Figure 2.11. Wind rose for northeastern Tongatapu.

(FIGURE B6: TAKEN FROM ECOAST 2013)

KEY SOURCES OF INFORMATION

Wave data information (offshore wave information) exists for a location close to the Tonga Ridge. Data exists for wave duration and period, height, wind speed and direction at this location. Upon initial review of the data, the maximum wave heights recorded (during cyclone events) have exceeded 5m, though contemporary wave height at this locations often averages at 2 to 2.5m with most waves coming mostly from a south easterly direction.

Water Level and Tides

SUMMARY DESCRIPTION

Tides operating in Tongatapu are semi-diurnal, with neap tidal range being circa 0.9m whilst spring tides are close to 1.9 m according to tide gauge measurements at Nuku'alofa. There is only one tide recording gauge available in the country (at Kuini Salote Wharf in Nukualofa, Tongatapu). The sea level trend on Tongatapu suggests that there is a general increase in sea level in order of 6.4mm/yr since records started in 1993 up to 2007. (TMS, Tonga, 2007). An analysis of sea level rise indicates the vulnerability associated with flooding of coastal areas around Tongatapu (Hahake and Hihifo in particular).

Satellite data indicated that sea level has risen near Tonga by about 6mm per year since 1993 (PCCSP 2011). This is larger than the global average of 2.8-3.6mm per year. The higher rate of rise may be partly related to natural fluctuations that take place year to year or decade to decade caused by phenomena such as El Nino Southern Oscillation. This variation in sea level can be seen in Figure B7 which includes the tide gauge record and satellite data since 1993.

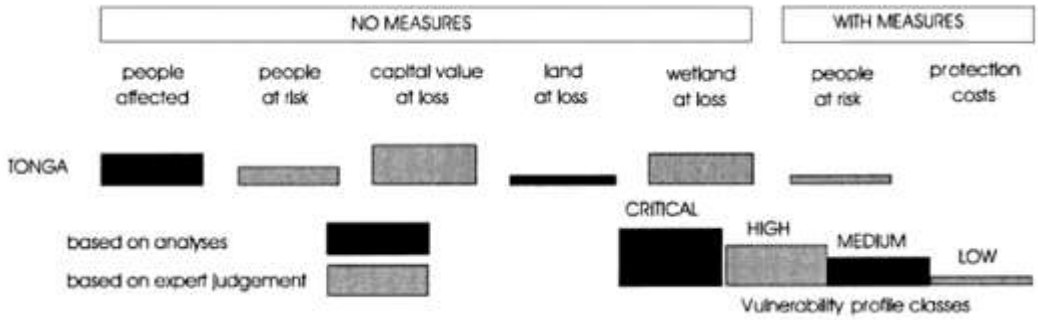


FIGURE B7. VULNERABILITY PROFILE FOR TONGA FROM SEA-LEVEL RISE (SOURCE: NICHOLS & MIMURA 1998).

KEY INFORMATION SOURCES

There is only one tide gauge located at Queen Salote Wharf. This gauge is part of the South Pacific Sea Level Rise and Climate Monitoring Project funded by AusAid. The data from this gauge goes directly to the Australian Bureau of Meteorology which in turn provides near real time data. Data can also be accessed via internet. Three coastal gauges located in the Tonga are managed by the JATWC. These are Nukualofa, Tonga Trench (west) and South of Minerva Reef.

Bathymetry

SUMMARY DESCRIPTION

The sea bed on the island's windward (south) coast slopes steeply to depths of 200m but the northern part of the Tongatapu block comprises a shallow lagoon (mostly 50m water depth) and are about 600 km in area. Figure B8 shows the extent of the new LIDAR programme for Tongatapu.

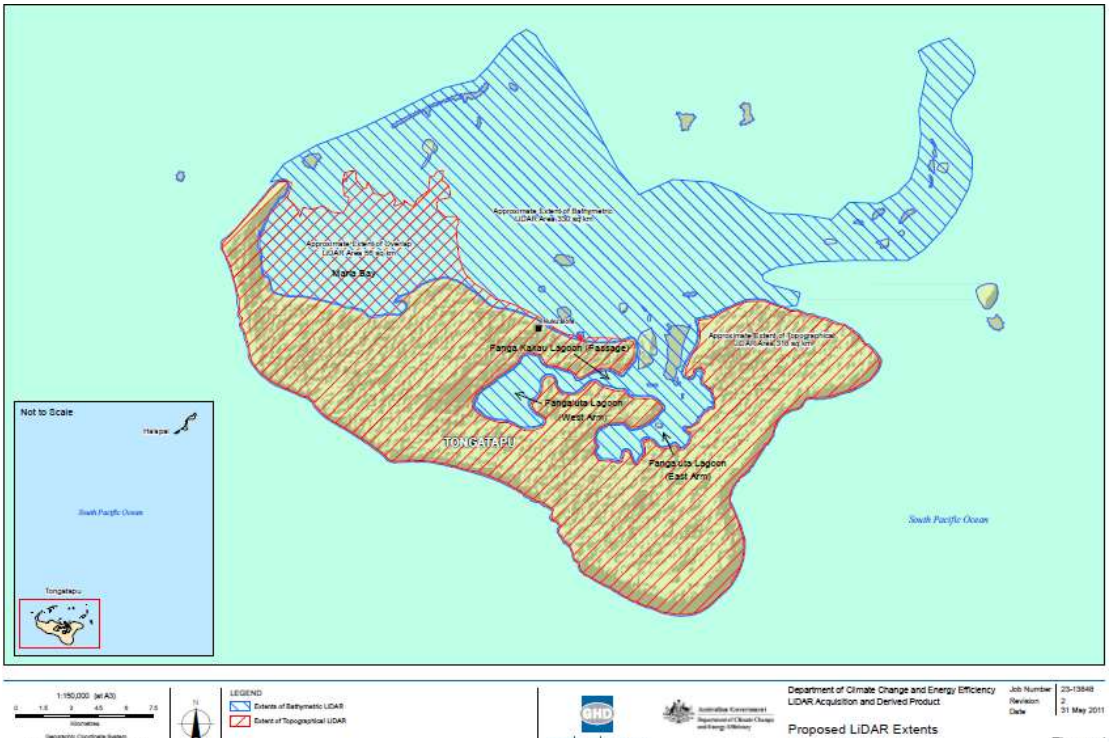


FIGURE B8. EXTENT OF LIDAR SURVEY CARRIED OUT IN 2011.

KEY SOURCES OF INFORMATION

Apart from the LiDAR data (2011), the only other available information relating to bathymetry is from published Admiralty Charts (not sourced or reviewed as part of this Diagnostic Study).

Sea surface temperature

SUMMARY DESCRIPTION

Data from the Nuku'alofa tide gauge indicates a slight increase in sea temperature. It suggests a positive inclination of 0.0057°C/yr (0.057°C/decade). Sea temperatures recorded present a range of temperatures recorded between 1992 to 2010. Sea temperatures appear to have ranged between 23 to 30 degrees Celsius (recorded in 2000).

Coral bleaching is becoming common around the South Pacific and has recently increased partially due to the increase in sea temperature. Coral bleaching has been reported in Tongatapu in Year 2000 as a result of a warming band of oceanic water extending from Fiji to Easter Island. This incidence resulted in coral mortality, destruction of habitats for reef species, reduction is diversity of reef species which in turn affected the fisheries sector and hence the economy of the country (JNAP 2010).

Salinity

SUMMARY DESCRIPTION

Salinity of freshwater provides an approximate guide to the nature and quality of the freshwater lens. When salinity is below the limit for drinking water (2500us/cm), it shows that the freshwater lens is of reasonable thickness and when salinity exceeds the limit, then the freshwater lens is considered thin.

Salinity can be affected by temperature and lack of rainfall. A combination of this would certainly raise the salinity within groundwater. An assessment of several rural villages in Tongatapu, Ha'apai and Vava'u revealed an increase in salinity in these islands during 1997-1998. This increase was related to a drought experience by Tonga and rest of the Pacific islands in 1998. Climate change is therefore depicted to affect salinity in groundwater in future.

At areas near coastline, salinity can be raised by rising sea level due to salt water intrusion to aquifer. The salinity of groundwater near the coastline can vary for weeks after cyclone and storm surges into the coastal zone. As a result, encroaching seawater due to sea level rise reduces the size of water table for small island nation.

KEY SOURCES OF INFORMATION

The Kingdom of Tonga's Initial Communication Report, JNAP 2010.

Turbidity

SUMMARY DESCRIPTION

Coastal waters around Tongatapu are considered to have an average turbidity and in most areas, exhibit low turbidity due to its low lying topography resulting in minimal runoff to sea except during times of heavy rains. However, in enclosed areas (e.g.: Fanga'uta lagoon) turbidity has been reported as high (TEMP 1998). The high turbidity in Fanga'uta due to runoff and lack of water circulation (30 days) has resulted in the die off of many marine organisms..

KEY SOURCES OF INFORMATION

- Lomipeau lagoonal Project, EIA report,
- Damlamian, H. 2008. Hydrodynamic Model of Fanga'uta lagoon: Water Circulation and Applications. EUEDF-SOPAC : Reducing Vulnerbility of Pacific ACP States. Project Report 135.
- TEMPP (1998). In Ellison, J.C: First Report on Development of mangrove Environmental management Plan for Tongatapu,Tonga. WP 5, Hassal and Associates in association with AMSAT.

B8 Climate Variability, Meteorology and Geo-Hazards

Wind

SUMMARY DESCRIPTION

The prevailing winds for Tongatapu consist mainly of consist mainly of the south easterly winds, but cyclones pass through the area, generally from the northeast. Under ambient condition the wind speed is between 2.6/s and 7.5m/s (Figure B9). In extreme wind condition the wind has been recorded to reach 26.3m/s from the northeast direction in previous cyclones. Tropical cyclones are seasonal phenomenon (November to April in

the SW Pacific) with a frequency of 1 cyclone per season for Tonga. The average number of tropical cyclones that affect the south west Pacific per season varies between 8 and 10.

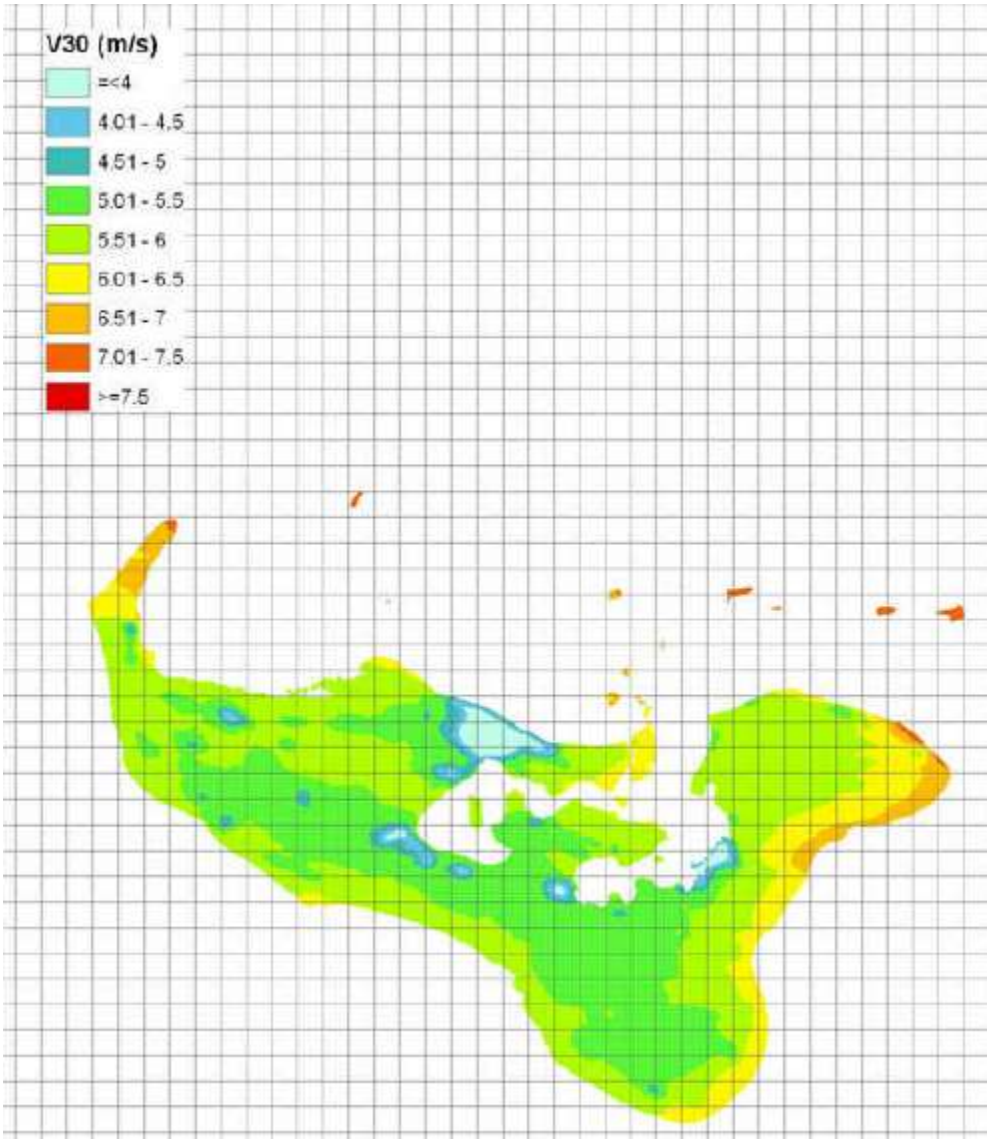


FIGURE B9: WIND SPEEDS AT 30M ELEVATION (SOURCE: WINERGY 2006).

KEY SOURCES OF INFORMATION

The Department of Meteorology has 6 observation stations in Tonga of which only 2 are fully operational at Vava'u and Tongatapu. Parameters such as rainfall, temperature, humidity measurements are also monitored.

BoM / CSIRO (2014) "Report: Climate Variability, Extremes and Change in the Western Tropical Pacific 2014 - Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports 2014". http://www.pacificclimatechangescience.org/publications/reports/climate-variability-extremes-and-change-in-the-western-tropical-pacific-2014/

Slow onset hazards (SLR etc)

SUMMARY DESCRIPTION

The 2009–2014 National Strategic Planning Framework is the overarching framework that drives Tonga's development path and resource allocation. Over the past three decades the Government of Tonga, being conscious of Tonga's vulnerability to natural disasters, has made a conscious effort to incorporate environmental issues and disaster risk into its national planning and development programmes as evidenced in the National Strategic Development Plan 5, 6 and 7, 8 and the recent National Strategic Planning Framework 2009–2014 (Figure B10). Goal 7 of the 2009–2014 Framework calls for the integration of environmental sustainability, climate change and disaster risks into national planning and execution of programs.

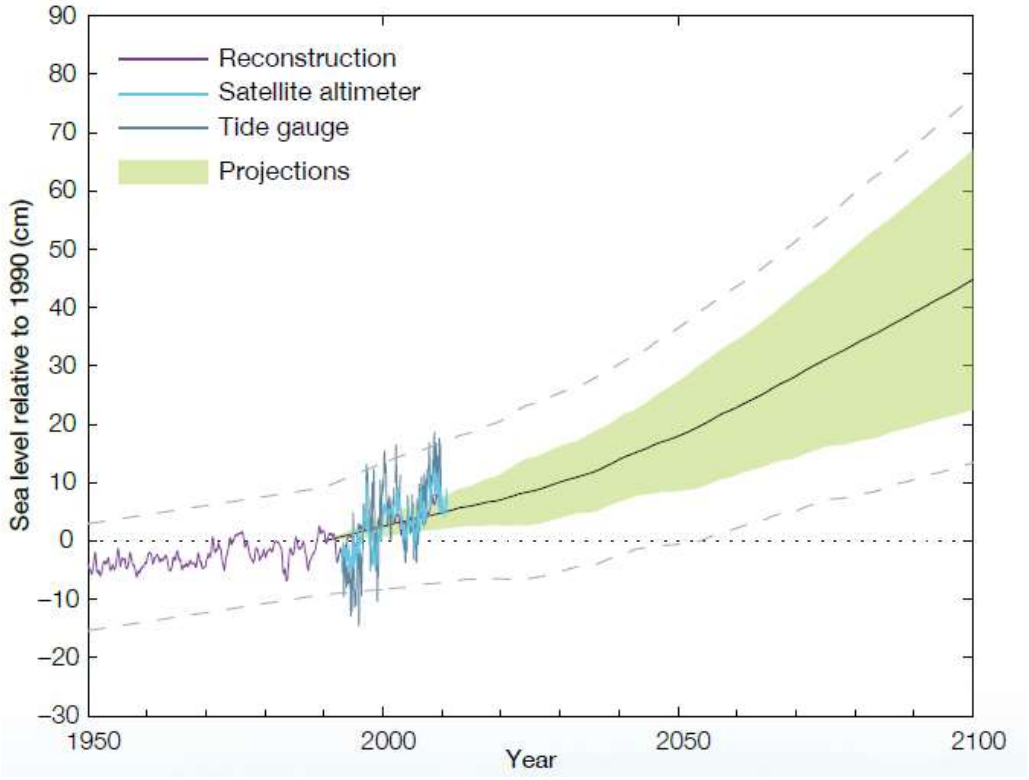


FIGURE B10 (FROM MIMURA AND PELESIKOTO 1997)

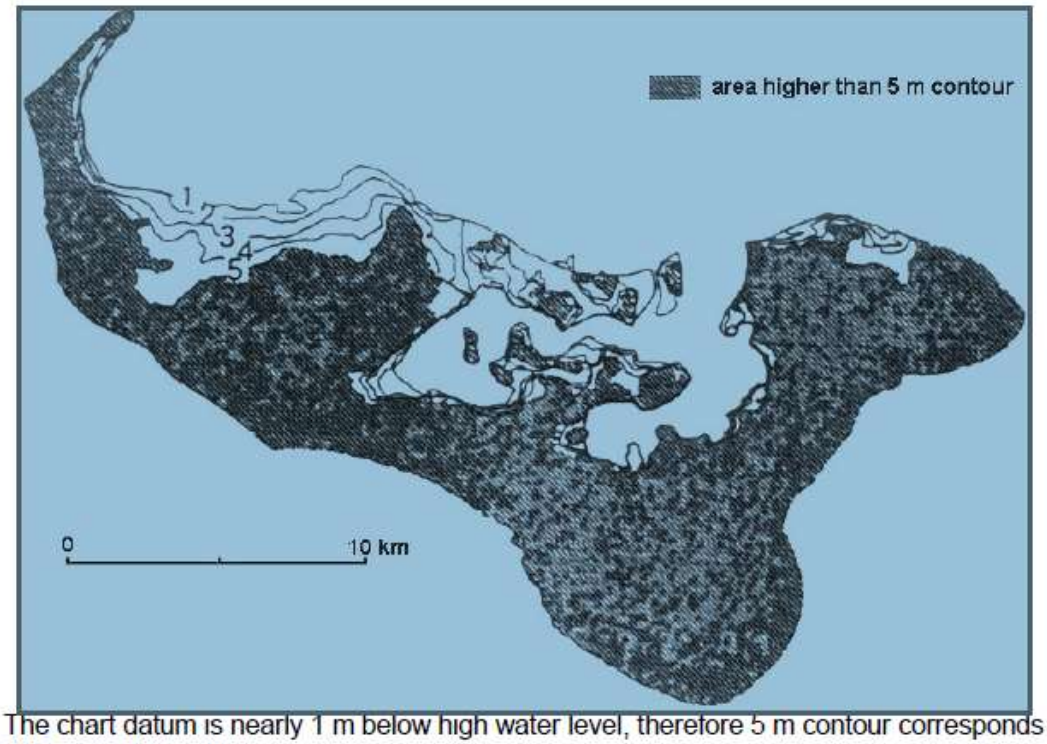
Mimura & Pelesikoti (1997) carried out a vulnerability assessment of Tongatapu to sea level rise. Two scenarios were used for the assessment (0.3 m slr and a 1.0 m slr) combined with the local conditions (sea levels and chart datum) (see Figure B11). The assessment found that Nuku'alofa would break into islands (Refer Fig B12), 58 km2 of coastal area would be inundated, and 10.7 km2 of residential area and 63 % of the population of Tongatapu would be affected (Mimura & Pelesikoti 1997).

[1] 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., & Pelesikoti, N., (1997)

FIGURE B10 (FROM MIMURA AND PELESIKOTO 1997)



(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., & Pelesikoti, N., (1997)

FIGURE B11 – AREAS OF TONGATAPU BELOW 5M THAT WOULD BE IMPACTED UPON BY A SLR INCREASE OF 3.8M

Rapid onset hazards

SUMMARY DESCRIPTION

Historical records indicate an increased trend in tropical cyclone frequency in the South West Pacific since the 1960s. It is also apparent that a corresponding relationship exists between increased cyclone activity in Tonga and the El Nino phenomenon. With the anticipated increase in the occurrence of El Nino events and the potential impacts of climate change, there is a growing need to strengthen specialized warning and advisory services on tropical cyclones and related climatic events.

Tropical cyclones are seasonal phenomenon (November to April in the SW Pacific) with a frequency of 1 cyclone per season for Tonga. Historical records indicate an increased trend in tropical cyclone frequency in the South West Pacific since the 1960s (Figure B12). In the 41-year period between 1969 and 2010, 71 tropical cyclones passed within 400 km of Nuku'alofa, an average of one to two cyclones per season. The number of cyclones varies widely from year to year, with none in some seasons but up to five in others. Over the period 1969–2010 cyclones occurred more frequently in El Niño years.

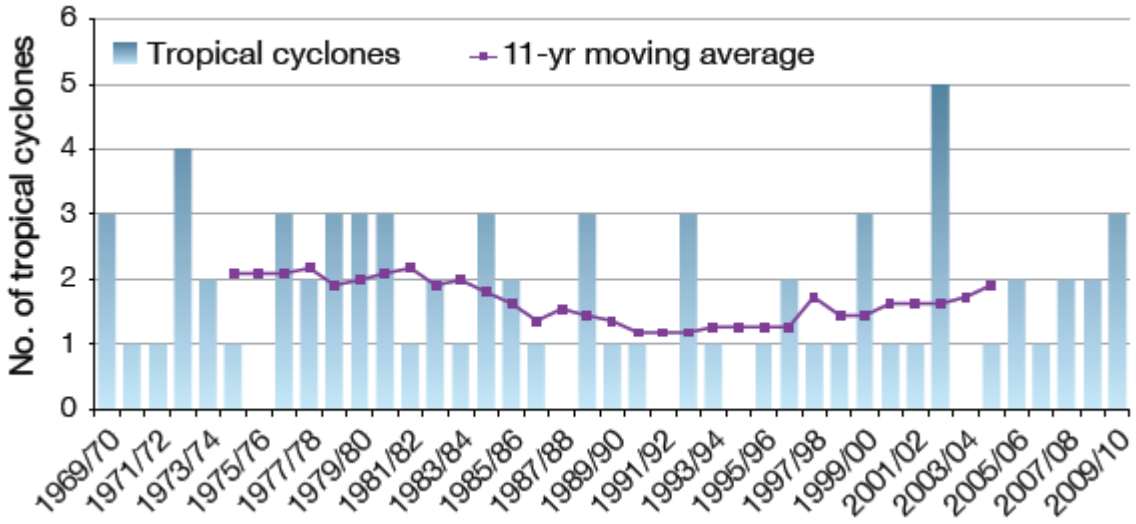


FIGURE B12 NUMBER OF TROPICAL CYCLONES PASSING BY NUKU'ALOFA WITHIN 400KM. ELEVEN YEAR MOVING AVERAGE IN PURPLE (SOURCE: PCSSP 2011).

These areas of vulnerability are confirmed by an analysis of historical records of inundation and storm surges (Figure B13).

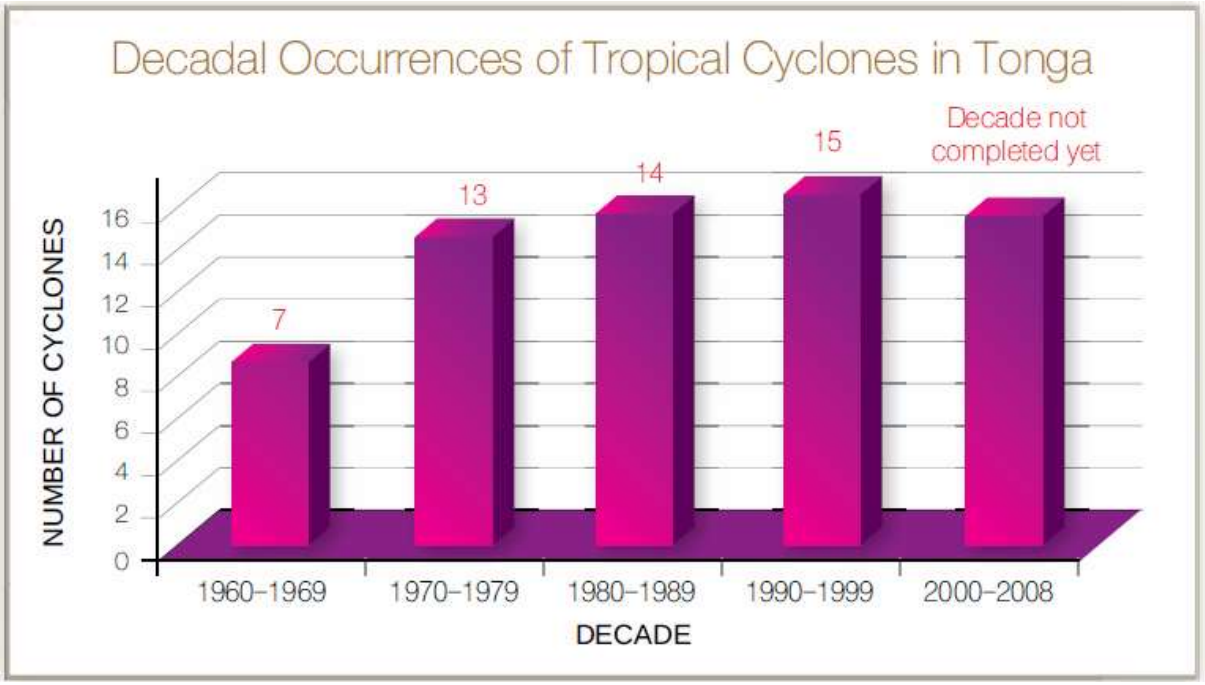


FIGURE B13. CYCLONE OCCURRENCE IN TONGA (TMS 2007).

Hahake District is situated closest to the potential impact of a tsunami arriving from the Tonga Ridge/Trench. Areas at risk from inundation from tsunami waves of different magnitude are reflected in the areas of evacuation zones for Tongatapu (Figure B14), which shows that the study area is a high risk area and furthermore there are no safe routes for escape as the coast road provides the only tarmacked route for fast transport.

The "most vulnerable" evacuation zone classification for Hihifo coastal villages is mainly linked to its topography. For example, virtually all of the Kanokupolu village area (Hihifo District), which extends approximately 300 metres inland from the high-water mark, is less than one metre above high-water mark. To the south, in the area of Ahau and Kolovai villages, the topography is generally higher than at Kanokupolu, above 2 m elevation and rising to approximately 5 m elevation at the southern end of Ahau village. The very flat nature of the topography is immediately evident, as is the distinct break of slope which separates the very low-lying areas and the higher ground to the south in Ahau and Kolovai. At the southern end of the eastern coastline, near Ha'avakatolo and Fo'ui villages, elevations are generally above 5 metres. Ha'atafu, Fo'ui and Ha'avakatolo villages are sufficiently elevated to be protected from coastal processes (SOPAC 1982).

It is of interest to note the outcome of the 11 March 2011 tsunami off the Japanese coast (recorded as an 8.9 magnitude earthquake which occurred at coordinates Latitude 38.3 North Longitude 142.4 East or about 400km Northeast of Japan's Capital, Tokyo (Near East Coast of Honshu). The earthquake triggered a tsunami which caused severe damage to the east coast of Japan and set in motion a Pacific Wide tsunami wave which saw Pacific wide Tsunami Warnings issued for the entire Pacific Basin which included the Tonga Islands. No major damages were reported in Tonga (Figure B15).

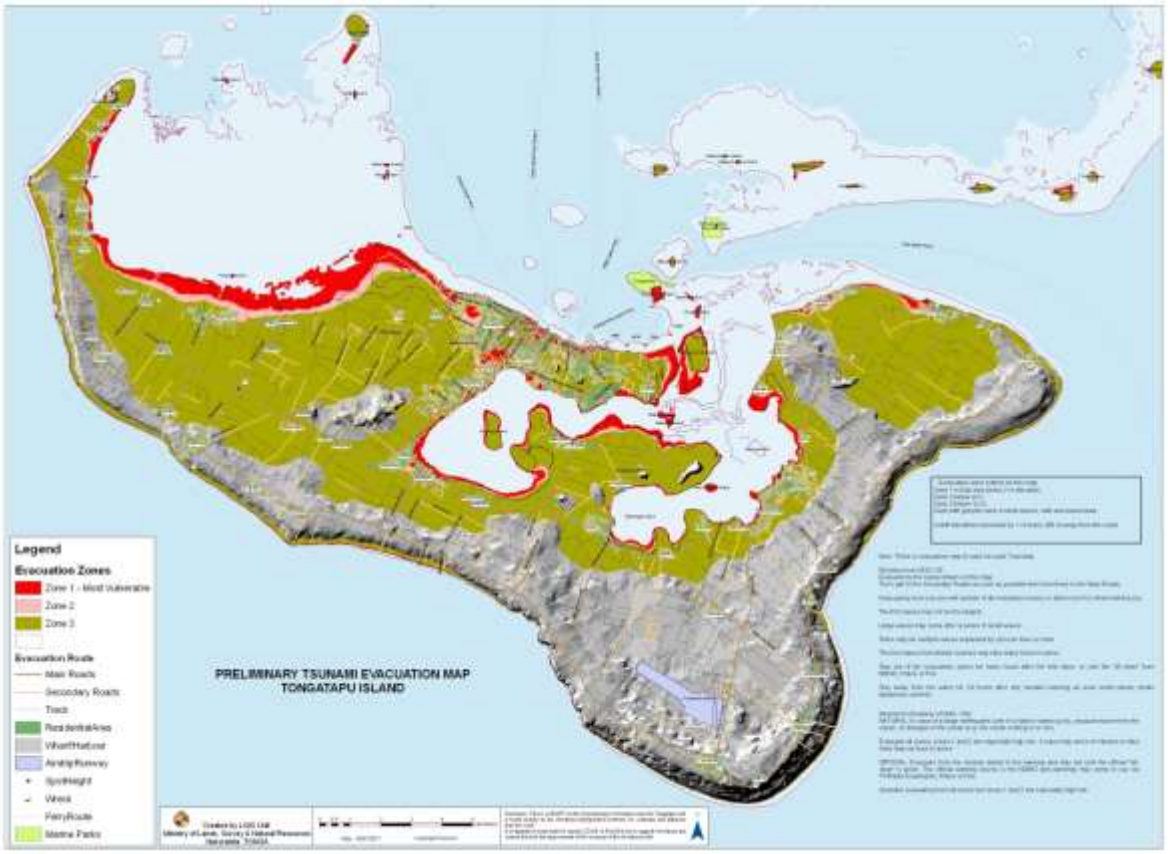


FIGURE B14. EVACUATION MAP FOR TONGATAPU ISLAND SHOWING THE PROJECT AREA COVERS EITHER THE MOST VULNERABLE ZONE 1 OR ZONE 2 CATEGORIES. NBL STUDYAREA VILLAGES MOSTLY CATEGORISED AS "MOST VULNERABLE" ZONE 1.

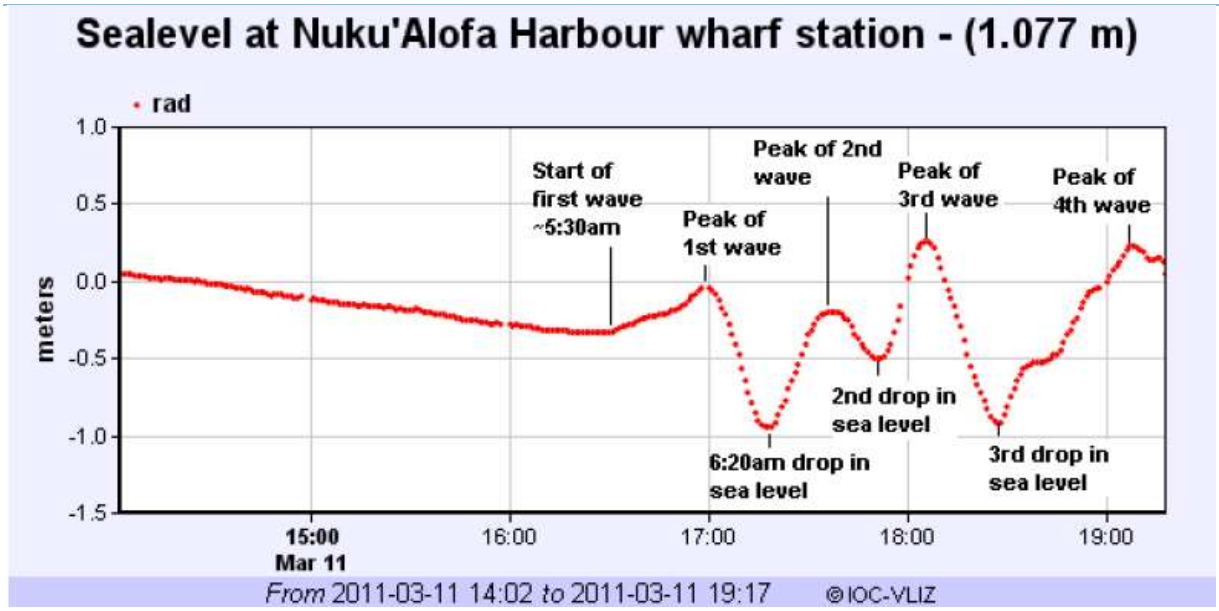


FIGURE B15 SEA LEVEL RECORDINGS AT QUEENS SALOTE WHARF, NUKU'ALOFA, TONGA.

KEY SOURCES OF INFORMATION

Through the use of the recent LiDAR dataset, a series of tsunami inundation maps have been produced for Tongatapu. Datasets are stored in the GIS within MLECCNR.

B9 Sources of Water, Associated Pollution and Water Quality

Sources of Water

SUMMARY DESCRIPTION

The main source of water for Tonga is groundwater which is supplemented by rainwater. Although most Tongan households collect rainwater, the increasing contamination of the groundwater is a source of concern.

With the projected decrease in below average rainfalls due to climate change (BoM/CSIRO 2014), peoples' livelihoods will be affected as potable rainwater for drinking decreases. This will lead to an increase in groundwater extraction resulting in thinning of the fresh water lens and more room for mixing with the underlying saltwater zone. Saltwater intrusion may also take place with the lowering of the water table to below mean sea level.

KEY SOURCES OF INFORMATION

Tonga Water can be approached for water resource and use information. MLECCNR (Geological Department) can be approached for groundwater or hydrogeological information.

Land Based Pollution Sources

SUMMARY DESCRIPTION

Most households in Nuku'alofa rely on individual septic tank systems for wastewater disposal. Many septic tanks are undersized, improperly constructed, and maintained only when full or overflowing. Septic tanks are the main source of contaminants in aquifers within the Nuku'alofa area. Contaminated groundwater

discharging to the coastal fringe and lagoon areas causes excessive algal growth, and there are concerns about impacts on the aquatic ecosystems. Monitoring wells to assess groundwater quality have been constructed, and a water quality monitoring program commenced in June 2010.

Contamination mostly occur from pesticides and fertilizers used in agriculture, and from Persistent Organic Pollutants (POPs) used in power supply and construction. Improper disposal of these pollutants not only contaminates the ocean, but also causes seepage into groundwater.

In 2007, a new landfill was commissioned at Tapuhia; a household solid waste collection system was implemented on Tongatapu; and the Waste Authority Limited (WAL) was established to take control of solid waste collection and disposal. This includes responsibility for disposal of sewage at the Tapuhia facility.

B10 Biodiversity and Habitats

Coastal and Marine

SUMMARY DESCRIPTION

The coastal and marine environment varies depending upon the specific region. The marine habitat diversity of Tongatapu basically consists of mangroves; rock terraces; sand beaches; saline and brackish wetlands, mudflats, reef flats and coral reef (barrier, fringing and submerged) (4th Review Biodiversity Strategy and Action Plan). In turn, these systems support a high diversity of fauna (Figure B16).

Off Hihifo District (Coastal Unit 2), the nearshore submerged habitat is dominated by coral reefs (on the west coast) and an ecosystem structure and function that is closely tied to, and dependent upon, mangroves and patch reef areas on the eastern coast. The reef systems impacting on the ecological environment of the east coast of Hihifo are up to 3km offshore from the 6 villages being reviewed.

Fauna	Species number
Scleractinian corals	192
Other types of corals	16
Fish	>300
Molluscs	150
Echinoderms (star fish, urchins etc.)	33
Crustaceans (crabs, shrimp etc.)	26

FIGURE B16. ESTIMATED NUMBERS OF DIFFERENT FAUNA TYPES OF TONGA (AFTER 2006 TONGA BIODIVERSITY ACTION PLAN).

Terrestrial

SUMMARY DESCRIPTION

The coastal flora of Tongatapu is characterised by moist forests along the coastal fringes with species of *Hibiscus, Calophyllum, Pometia, Casurina, Barringtonia* and *Scaevola* the most common. Mangroves are

dominated by *Rhizophora*, (3 species), *Xylocarpus* (2 species), *Bruguiera gymnorrhiza* and *Lumnitzera littorea (see detailed mangrove assessment below)*. Although examples of all these flora types can be found within the project area the coastal (landward) habitats have all been significantly altered by humans either through conversion to agriculture/plantation use and urban development of the villages that border the coastline.

A key authoritative publication on Tongan mangroves is the work of Netatua Prescott in 2002. The report states that prevailing winds and associated wave action are the S.E. Trades, hence mangroves occur on the leeward north shore, and in the extremely sheltered semi -enclosed lagoons such as Fanga'uta Lagoon. Degree of exposure to ocean exchange affects sediment budgets in the mangrove system, manifested by sediment quality and influencing mangrove community structure. The tidal range is 1.07 m, semi-diurnal with a slight inequality.

In Hihifo, for example, the artificial wetland in the Kanukopolu area is an important habitat for at least part of the life cycles of the two species of mullet (*Mugil cephalus* and *Valamugil seheli*) fished in Tongatapu, for snappers (*Lutjanus.kasmira*), trevallies (*Caranx spp.*), groupers (*Epigephelis spp.*), breeding grounds for three types of emperors (*Lethrinusspp.*), and several species of penaeid prawn. Crabs (*Sesarnia* sp.) and molluscs (*Littorina* sp.) are common in the mangroves. The mangroves are also habitat for birds, which can include rare or endangered species. In Tonga, birds that utilise the mangroves include the Wattled Honeyeater *(Foulehaio carunculata*), Pacific Reef Heron *(Egretta sacra*), Pacific Black Duck *(Anas superciliosa)* and the Great Crested Tern *(Stema bergii)*. Migrants include the Pacific Golden Plover *(Pluvialisfulva)*, Wandering Tattler *(Heterosceles incanus)* and Bar-tailed Godwit *(Limosa lapponica)* (Scott, 1993).

It is stated that mangrove species tend to occur in zones according to micro-elevation and frequency of inundation. Therefore, it is best to replant with the species that used to grow in the zone, i.e. Rhizophora on the seaward margin, and *Bruguieral Excoecaria* on the landward margin. The mangrove species *Bruguiera gymnorrhiza* (Tongo ta'ane) has become particularly over-exploited in Tongatapu (especially in Hihifo), so that it is presently rare. This is because its bark is used for the manufacture of the red dye in decoration of tapa, which has high ceremonial and cultural significance in Tonga. The growing rarity of this species and pressure on the remaining trees demands particular attention.

A key issue regarding mangrove establishment nurseries is the impact that pigs have on seedling growth. Pigs commonly walk and dig in the mangrove mud looking for shellfish. This disturbs mangrove muds and natural regeneration is often prevented. As mangrove mud is naturally low in oxygen, oxygenation naturally occurs at through structures such as crab holes and root fibres. Disturbed mangrove mud has poor structure, and tends to therefore be very low in oxygen. This will cause reduced rates of tree growth and seedling success, and reduced numbers of fauna such as crabs and fish.

Marine Living Resources

SUMMARY DESCRIPTION

The reefs and lagoons are the prime fishery for subsistence. In addition to fishing, a wide range of shellfish and other marine life is harvested from the tidal flats at low tide for consumption or for production of shell handicrafts for sale to tourists. Offshore commercial pelagic fishing comprises of large tuna species of albacore, yellowfin, bigeye, and skipjack.

Marlin and sailfish are also common. Albacore tuna is the most highly valued and most abundant species of the zone (ESCAP & GOT, 1990; Thistlethwaite et al. 1993). Very little information and data, however, is available on 'offshore' resources, thus the state of coastal and marine resource refers to coastal area resources.

KEY SOURCES OF INFORMATION

Department of Fisheries (within MAFFF) hold all available information on fish stocks in Tongatapu.

Marine Non-living Resources

SUMMARY DESCRIPTION

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 a rapidly increasing demand for sand (EPACS & GOT, 1990). Sand is surfaced-mined by bulldozers or shovels from beaches. On Tongatapu and Vava'u, sand is mined by the MLSNR and then sold to the public. In 1987, 21,909 tonnes was sold from the Tongatapu stockpile while in 1999, 29,000 tonnes was sold from the Tongatapu stockpile (MLSNR 1988, 1999).

The environmental impact of present beach-mining activities is obvious in Tonga, as many of the more popular beach areas have already been stripped of sand and are now little more than beach rock (*pers.obs*). In many locations on the west coast of Hihifo (Coastal Unit 2 as an example) beach rock is exposed and in some areas beach erosion occurs when sand mining has been carried on above the high water level. The replacement by longshore sediment transport is temporary as the beaches are all limited in extent and many are small pocket beaches with no input from adjacent areas (SOPAC, 1982).

KEY SOURCES OF INFORMATION

Maps and reports on all aspects of offshore geology and surficial marine deposits off Tongatapu can be found at the Geological Services Unit of MLECCNR, Tonga. Appendix A and Table 3.1 provides an overview of data on this issue outlines key geological references of relevance to Tongatapu.

APPENDIX C: KEY STAKEHOLDERS VISITED

NAME	MINISTRY/ORGANISATION	EMAIL ADDRESS
Mr. 'Asipeli Palaki	Ministry of Lands, Environment and Climate Change and Natural Resources (MLECCNR)	a_palaki@yahoo.com
Mr. Vailala Matoto	Ministry of Agriculture, Food, Forestry & Fisheries (MAFFF)	vailala@kalianet.to
Mr.'Ofa Fa'anunu	Tonga Meteorological Service (TMS), Ministry of Transport	ofaf@met.gov.to
Taniela Hoponoa	MAFFF	taniela_hoponoa@yahoo.com
Mr. Richard Atelea Kautoke	GIS, Ministry of Lands, Survey & Natural Resources (MLSNR)	rakautoke@lands.gov.to
.Mr.Apai Moala	Geology, MLSNR	apaimoala@yahoo.com
Mr Taaniela Kula	Planning and Urban Management Unit (PUMA)	tkula@puma.gov.to
Mr.Sione Faka'osi	Tonga Community Development Trust	s.fakaosi@tcdt.to
Ofa Kaisamy	MLECCNR	Kaisamy_ofa@yahoo.com
Mr.Niu Fakakovikaetau	Public Health, Ministry of Health	niu.fakakovikaetau@gmail.com
Pesalili Tuiano	Ministry of Works	Hakautupu1@yahoo.com
Mrs. Siale Ilolahia	Civil Society Forum of Tonga	csft@kalianet.to
Mosese Lavemai	Port Authority Tonga General Manager	mlavemai@portsauthority.tbu.to
Ms Seini Fotu	MLECCNR	sfotu09@gmail
Ms Mafile'o Masi	MLECCNR	mafileo_masi@gmail.com
Mr.Fuka Kitei'aho	Geocare Company (EIA Consultant for Output 3)	fooksie1@gmail.com
Quddus Fielea	Tonga Water Board	qfielea@gmail.com
Ms Luisa Tuiafitu Malolo	MLECCNR	ltvtuiafitu@yahoo.com

Poasi Fale Ngaluafe	MAFFF (Head of Aquaculture Research)	poasif@tongafish.gov.to
Renee Vaiomonga	Geological Division Director, Ministry of Lands and Survey	geology@kalianet.to
Sione Tukia	MESCAL - Team Coordinator for Tonga	sionelepa@yahoo.com
Tukua Tonga	PUMA – Director (Ministry of Finance and Planning)	tukuatonga@gmail.com
Leveni ‘aho	Deputy Director of Works (Ministry of Works)	levenih5@gmail.com

APPENDIX D – WORKSHOP 1 "COASTAL ISSUES"

Handouts

Preparation of a Diagnostic Study to inform an Integrated Coastal Management Plan for Tongatapu, Tonga.

Meeting 1 (May 2014) Coastal Issues Meeting

Questionnaire Handout

Overview to Integrated Coastal Management Strategy Planning (ICMSP)

Integrated Coastal Management Strategy Planning (ICMSP) is a way of improving decision making and delivering a sustainable approach to managing human activities in the marine and coastal environment. It is a planning process that enables integrated, forward looking, and consistent decision making on the human uses of the sea and coasts.

Human uses can include amongst others: commercial fishing; recreational fishing; aquaculture; shipping; oil & gas exploration and production, port management and associated activities, renewable energy production, e.g., wind, waves; sand extraction and dredging; dredged material disposal; coastal recreation and tourism; offshore housing development, airport extensions offshore; pipelines, offshore cables, telecommunication transmission lines; bio-prospecting; desalinization; military activities; scientific research; marine protected areas; cultural and historic conservation, e.g., ship wrecks.

To this end, ICMSP is an approach and process that should assist existing institutions, organisations and agencies to work together in a cooperative and coordinated fashion.

To better understand the challenges and opportunities that face the implementation of ICMSP in Tongatapu, **we need to understand from you what are the current barriers and impediments to developing an approach and process for ICMSP in Tongatapu**. To help us do this, please answer the following questions overleaf:

EXERCISE 1: What are the critical ICM issues to consider?

Using marker pens, indicate your "top 5" issues of relevance to Tongatapu's coastal zone on the table below:

Issue Description	
Coastal Development and Climate Change	
Demand for limited coastal land (housing, industrial, commercial, private development, speculative development)	
Construction of new land (reclamation)	
Reclamation from the existing mainland	
Construction and maintenance of coastal structures (e.g. corniche, retaining walls, bridges, ports)	
Beach maintenance / replenishment	
Port construction, development, management	
Growth in subdivisions of agricultural land	
Future demand of sediment supply for construction	
Unrestricted access to / along the coast	
Coastal land / seabed ownership (land rights)	
Threats to cultural, archaeological, heritage sites	
Increased water use / discharges to coastal waters	
Impacts to navigation (navigation routes, channels, buoys, etc.)	
Climate change, sea level rise and flood risk	
Changes to coastal morphology, coastal processes, hydrology	
Regulation, monitoring and enforcement (incl. statistics)	
Disaster and climate related adaptation, resilience and mitigation	
Poorly drained areas and poor implementation of building codes	
Impact of forestry policy development on coastal areas	
Marine (offshore) Development	
Offshore mineral exploration / development	
Need for sub-sea cables, pipelines	
Demand for marine sediment (dredging)	
Impacts to navigation (navigation routes, channels, buoys, etc.)	
Regulation, monitoring and enforcement (incl. statistics)	
Disposal of waste from ships	
Coastal Awareness and Education	
Cross Ministerial awareness of coastal management issues	
Public awareness of coastal management issues	
User conflict resolution	
Co-operation and co-ordination between Ministries, Directorates, Municipalities	
Regulation, monitoring and enforcement (incl. statistics)	
Coastal Ecology and Conservation	
Loss of habitats due to reclamation, dredging, etc.	
Commercial fishing / fisheries impacts	
Establishment of Protected Areas	
Regulation, monitoring and enforcement (incl. statistics)	
Water quality / pollution impacts from pesticides/fertilisers	
Loss of important / protected / key species	
Climate change impacts (salinity, temperature rise, sea level rise)	
Water, Land and Air Quality	
Waste water and sewage impacts (domestic)	
Commercial / industrial outfalls	
Saline intrusion to groundwater resources	
Dredging and reclamation pollution / water quality impacts	
Dumping of solid wastes (coast and sea) and number of designated dump sites	
Pollution events (spills, accidents, deliberate pollution) resulting in water borne diseases	
Regulation, monitoring and enforcement (incl. statistics)	
Indiscriminate dumping of solid waste and its impact on local community health (vermin, vector borne diseases)	
Burning of trash and garden waste, combustion of fossil fuel	
Tourism and Recreation	
Regulation of watercraft	
Coastal access and facilities (beaches, provision of shade, parking, litter, safety, beach management)	
Development and management of port facilities, harbours etc	
Scuba diving and associated facilities	

Issue Description	
Recreational fishing	
Eco-tourism	
Regulation, monitoring and enforcement (incl. statistics)	
Heritage tourism	
Fishing / aquaculture	
Loss of important areas (nursery, spawning, fishing)	
Overfishing	
Regulation, monitoring and enforcement (incl. statistics)	
Aquaculture development (Govt., private, re-stocking)	
On-shore facilities (landing sites, storage, refrigeration)	
New / emerging fisheries	
List below any further "issues" of direct relevance for incorporation into an ICM Plan for Tongatapu.	

EXERCISE 2: INSTITUTIONAL ARRANGEMENTS FOR ICMSP

1. Do you currently consult with other Ministries/Departments on;

   a. Implementation of current coastal /marine activities? ☐

   b. Design of future coastal or marine related planning/strategies? ☐

Please provide a comment whether consultation is useful if you have ticked either box or if a box is not ticked – does this present a problem?

2. Do the boundaries of operation/jurisdiction of other Ministries/Departments compete/conflict with your own?

Yes ☐ No ☐ Don't know ☐

If yes, please provide details.

3. To what extent does the opinion of others influence your day to day coastal planning;

   a. from Research/scientific communities? ☐

   b. from the other government departments ☐

   c. from other non government organisations (e.g. NGOs)? ☐

4. What do you consider the principle barriers to you implementing your responsibilities on coastal matters?

Please provide details

5. What information or data gaps do you believe need to be filled to help deliver ICMSP in the future for Tongatapu (e.g.: offshore sand surveys/improved data on coastal habitat extent or training on ICMSP etc)?

Please provide details

6 What training /advice do you feel your Ministry/Department may need on the following "themes" areas?

- Coastal setback policy guidance (linked to development control measures along the shoreline);

  Yes ☐ No ☐ Don't know ☐

- How to regulate new environmental policy guidance notes (e.g.: for reclamation etc);

  Yes ☐ No ☐ Don't know ☐

- Institutional arrangements – how to become an effective ICM planner and training/work experience needs.

  Yes ☐ No ☐ Don't know ☐

- How to enforce new or existing and coastal consents?

  Yes ☐ No ☐ Don't know ☐

- Financing ICMSP – how to involve the finance /private sector and how to establish private /public partnerships to deliver ICMSP;

  Yes ☐ No ☐ Don't know ☐

- Stakeholder engagement and education strategies – how to raise interest in coastal risk matters within Tonga?

- Yes ☐ No ☐ Don't know ☐

EXERCISE 3: The Coastal Management Area for Tongatapu – where should this be drawn?

The Coastal Management Area (CMA) shall need to be defined by an inland boundary and an offshore boundary. The offshore boundary maybe defined by (for example):

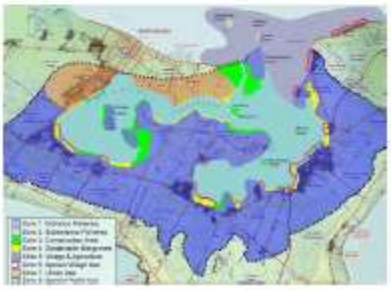
- -5mCD bathymetry contour;
- Critical nearshore natural habitat extents;
- A 500m buffer around development sites that are beyond -5mCD.

The inland limit maybe defined (for example) by:

- the maximum extent of worst case tsunami inundation limits (or flood extent areas), or
- An appropriate dominant inland feature (e.g. a road).

In groups of 2, define the characteristics/features that need to be considered to help define the CMA for the following areas:

a) Area 1: North coast (Puke to Popua including Nuku'alofa)
b) Area 2: Fanga'uta Lagoon
c) Area 3: North East coast (Hahake District - Makuanga to Niu'toua)
d) Area 4: East and South coast (Niu'toua to Hihifo District)
e) Area 5: Hihifo Peninsula



Additional questions to consider helping future ICM Plan production in Tongatapu (to be collated during May / June 2014).

Issue 1: Monitoring Progress of ICMSP Implementation

Implementation of an ICMSP requires inter-organisational working but also a mechanism to document and demonstrate that the process is working. This requires a monitoring and evaluation programme that provides:

- A **monitoring system** designed to measure indicators of the performance of ICMSP management measures;
- **Information on the performance of ICMSP measures** that will be used for evaluation; and
- **Periodic reports** to decision makers, stakeholders, and the public about the performance of the marine spatial management plan.

Questions for the JNAP Secretariat
a) Can existing systems be adapted to achieve a workable reporting and monitoring framework for ICMSP in Tonga and who would should have responsibility for delivery and sign-off on specific ICMSP performance indicators?
Comment

Issue 2: Lead Agency for ICMSP

Two key issues concerning identifying lead agencies to drive an ICMSP framework is that all parties should be able to embed any new framework within the Governments administrative system, and be able to facilitate bringing together different sectors of government to focus their activities in an integrated manner. In deciding a "lead authority" it is important to recognise that there is a separation between the authority to **plan** for ICMSP and authority to **implement** ICMSP and these two roles do not necessarily have to reside within the same organisation. What is important is that a lead authority has the capacity to undertake the following:

1. construct and facilitate the necessary networks necessary to bring together the expertise and knowledge essential for ICMSP, and
2. enact either existing legislation in a coordinated manner and/or construct new legislation specific for ICMSP.

Questions for the JNAP Secretariat
b) What new authorities would need to be established to achieve ICMSP in Tonga and who should lead this process?

c) To what extent would current practices need to be revised to ensure a continuous process of integration, cooperation and coordination between all involved organisations in ICMSP?	
Comment	
d) In terms of populating an organisational structure for ICMSP, who should be the ;	
• lead authority?	?
• other primary (or key) management organisations from within GoT?	?
• other organisations from GoT that would need to be kept in a communication/ feedback loop?	?

Issue 3: Capacity Building for ICMSP in Tonga

Capacity building is a term used to describe initiatives which aim to increase the capability of those charged with managing the coast, or contributing to its management, to make sound planning and management decisions. Capacity building can occur at the level of the institution, where it aims to improve the arrangements for management, or individuals, where it centres on training and professional development. With both there is an emphasis on the application and use of knowledge rather than simply acquiring more knowledge.

Within a finalised coordination framework it is important that the appropriate balance of expertise is brought together to provide the information and knowledge base to deliver ICMSP. This will involve a broad range of disciplines covering at least fisheries and marine biology, geography, economics, engineering and planning to name a few. They will not only need to have expertise within their own discipline but also be able to apply their expertise within an ICMSP context.

Questions for the JNAP Secretariat
a) To what extent do institutions and individuals, charged with aspects of managing the coastal space and resources, have the capacity to engage with ICMSP in Tonga?
Comment


Issue 4: Communicating Best Environmental Practice

Land reclamation and other development activity have already altered the environmental status of the marine and coastal environment of Tongatapu. To mitigate against this, it is often important to establish and implement an integrated ecosystem protection and restoration strategy that is science-based and aligns conservation and restoration goals at all levels of government in Tonga.

Questions for the JNAP Secretariat
How can environmental protection be included into current land use planning strategies in Tonga (development guidance/codes of practice/financial incentives etc), and can appropriate planning "tools" be used (or put in place) to mitigate unforeseen changes arising from previous coastal developments?
Comment

Issue 5: Linking Land Use Policy with Coastal Policy

Tonga is drafting a new Land Use Policy (2014) to take forward best practice and to include climate resilience into planning design. Although there is a tendency to "look seaward" within the context of ICMSP, much of the issues and pressures facing coastal and marine areas arise from land-based sources in Tongatapu.

Questions for the JNAP Secretariat
Is it possible to enhance water quality along the coasts and marine areas of Tonga by promoting and implementing sustainable practices on land?
Comment

Issue 6: Data Management for ICMSP

A key requirement of ICMSP is data and information exchange. Compiling and mapping data is expensive and can take large amounts of time and resources. Not all the data collected will be useful for ICMSP and so careful selection will be needed. A general rule is that data should be up-to-date, objective, reliable, relevant and comparable.

Questions for the JNAP Secretariat
a) Is all the necessary data available? Is there an inventory of information on the current status of the coastal and marine environment including social and economic aspects?
b) What processes need to be put in place to strengthen and integrate national coastal monitoring systems, sensors, data collection platforms, data management, and mapping capabilities into a national system and integrate that system into international observation efforts?

Comment

Issue 7: Public and stakeholder engagement

There is a need for a strong element of community engagement and participation to ensure success in implementing ICMSP. Involving key stakeholders in the development of ICMSP is essential for a number of reasons. Of these, the most important is because ICMSP aims to achieve multiple objectives (social, economic and ecological) and should therefore reflect as many expectations, opportunities or conflicts occurring in the ICMSP area.

Questions for the JNAP Secretariat
Are mechanisms in place, across all involved organisations, for meaningful public engagement to help formulate and ICM Plan for Tongatapu in the future?
Comment

Preparation of a Diagnostic Study to inform an Integrated Coastal Management Plan for Tongatapu, Tonga. Meeting 1 (May 2014) Coastal Issues Meeting

Outstanding Data - requests for knowledge and information

JNAP Technical members and key Tongan stakeholders need to be aware that the contract with SPC **DOES NOT INCLUDE FOR ANY NEW BASELINE DATA COLLECTION**. It is reliant on existing information relating to the coastal and marine area. Sustainable Seas Ltd have been compiling as much available data as possible, and we would welcome your view and assistance on "where we are" regarding the availability of data and information on various topics of relevance.

Table 1 identifies the six proposed ICMSP "theme headings" that maybe taken forward for the future ICM project. The Themes are established to reflect the future demands on coastal and marine space in Tongatapu and represent the management issues relevant to the entire coastal and marine plan area.

The column entitled "topics of relevance" refers to the detailed topics that need to be considered within each specific Theme and of potential key relevance to Tongatapu.

ICM THEME	TOPICS AND ISSUES OF RELEVANCE
THEME 1 - Accessing and Using the Coastal Management Area	• Coastal hydrodynamics; • Residential development and land ownership; • Maintenance and construction of coastal structures; • Beach/waterfront management and recreation (public space); • Water based recreation (and facilities); • Tourism facilities; • Development guidance in the CMA • Land use zonation; • Piers and docks.
THEME 2 - Transportation in the Coastal Management Area	• Commercial ports; • Fishing harbours;; • Shipping routes; • Coastal navigation and waterways (incl: aids to navigation); • Leisure boating (permits/services etc)

For more information, contact the Consultant Team Leader, Jonathan McCue (email: jonathan.mccue@sustainableseas.co.uk

	• Water taxis etc. • Coastal roads.
THEME 3 – Protecting and conserving habitats in the Coastal Management Area	• Coastal hydrodynamics; • Water pollution (storm water and effluent disposal); • Marine ecology / habitat; • Natural shoreline / nearshore features; • Marine protected areas; • Open space preservation; • Sensitive Marine Areas • Fishery exclusion zones.
THEME 4 - Resource management in the Coastal Management Area	LIVING RESOURCES • Pelagic fisheries; • Shellfisheries; • Aquaculture/mariculture. NON LIVING RESOURCES • Deep sea minerals fields; • Sand resources; • Water resources (groundwater aquifers); • Offshore water aquifers.
THEME 5 - Safety and security in the Coastal Management Area	• Disaster risk reduction (natural hazards); • Oil spill contingency planning; • National "Homeland" security (offshore boundaries) • Search and rescue (SAR); • Submerged communication cables; • Critical infrastructure and "sensitive areas"; • Commercial and light industry development; • Military use areas;

For more information, contact the Consultant Team Leader, Jonathan McCue (email: jonathan.mccue@sustainableseas.co.uk

	• Coastguard.
THEME 6 - Cultural heritage in the Coastal Management Area and offshore	• Heritage tourism issues; • Offshore cultural issues - • "Noble" owned areas and Customary lands

Table 1 – ICM Theme Headings, Topics of Relevance.

Table 2 is produced in partnership with all JNAP members regarding the availability of any knowledge, information or data relating to each specific topic. This shall be developed during the next two weeks, and shall be completed by the end of May 2014.

(NB: not having data available on a subject does NOT mean that a successful ICM Plans cannot be produced. This is in fact quite normal on an international level. Lacking data is not ideal, but it highlights the challenge and future need to ensure ALL stakeholders (Ministries and Departments) work together to collectively agree on what new data collection exercises are required into 2014).

TOPICS OF RELEVANCE	DATA AVAILABILITY AND STATUS (FORMAT ETC)
THEME 1 – ACCESSING THE COASTAL MANAGEMENT AREA	
Coastal hydrodynamics;	Separate consultancy reports and EIAs. PASAP project completed coastal modelling for Ha'apai but not Tongatapu. No central repository for coastal process related information.
Residential development;	
Coastal structures;	
Beach/waterfront management and recreation (public space);	
Water based recreation (and facilities);	
Tourism facilities;	
Development Guidance (Building Controls in the CMA)	
Foreshore ownership and land use zonation;	
Piers and docks.	
THEME 2 - Transportation in the Coastal Management Area	

For more information, contact the Consultant Team Leader, Jonathan McCue (email: jonathan.mccue@sustainableseas.co.uk

APPENDIX E: METADATA GIS FILES PRESENT IN TONGA

GIS Information (taken from MLECCNR Geographical Information Section).

1. **Topographic Mapping**
    a. Topographic Layers
        i. Authority Table (available on request)
2. **Imageries**
    a. Satellite Imageries
        i. QuickBird 2004 – 2006: all islands of Kingdom
        ii. LiDAR Data – Dec 2012
        iii. Geoeye (Ttpu)– March 2009

    b. Aerial Photos
        i. 1990
        ii. 1991

3. **LIDAR**
    a. Full dataset for – i. Tongatapu,
        ii. Pangai - Haápai

4. **Land Parcels**
    a. Tax Lots for Tongatapu
    b. Villages - HP

5. **Etc.**

Data Title	Data Content/Extent
Aerial Photography	May 1990
Google Earth imagery	2002 and 2005, 2009 and 2011
Topographic Information	Interpolated data received from PUMA (original date of spot heights uncertain).
Tide gauge data (Nukua'lofa port station)	Raw data received from tide gauge for 1991 to 2011.
Building Codes for Tonga (2007)	Sections A, B, C, D to NH
Admiralty Charts	Admiralty Chart - "Approaches to Tongatapu including Eua"