Samoa 2013

State of the Environment Report








diversity coral reef
Fa'a-Samoa environment
integrated management
community conservation island nation
climate change livelihood indicators water
sustainable Pacific Ocean forests
development culture

Government of Samoa

Ministry of Natural Resources and Environment (MNRE)
Government of Samoa

SAMOA'S STATE OF THE ENVIRONMENT (SOE) REPORT 2013

Australian Government
AusAID

Government of Samoa

SPREP

MNRE Resource Information Centre

Ministry of Natural Resources & Environment (MNRE)

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1. Community consultation at Uafato Village
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We are indeed grateful to everyone who has contributed towards the SOE review which we hope will greatly assist government officials and all stakeholders in further developing environmental monitoring and reporting as an effective tool for sustainable development. We hope the report proves useful to those who read it and we welcome any suggestions for its improvement in future editions.

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ASP	Agriculture Sector Plan
BioRAP	Biological Rapid Assessment Programme
CBD	Convention on Biological Diversity
CC	Climate Change
CFC	chlorofluorocarbons
CI	Conservation International
CIM Plans	Coastal Infrastructure Management Plans
CPUE	Catch per Unit Effort
DC	Development Consent
DCA	Development Consent Application
DMO	Disaster Management Office
DPSIR	Drivers-Pressures-States-Impacts-Responses
EE	Energy Efficiency
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPC	Electric Power Corporation
FAD	Fish Aggregating Devices
FAO	Food and Agriculture Organization of the United Nations
FPAM	Forest Conservation and Protected Area Management
GEO	Global Environment Outlook
GCRMN	Global Coral Reef Monitoring Network
GHG	Green House Gases
ICCRAHS	Integrated Climate Change Risks into Health & Agriculture Projects
ICCRIFS	Integrated Climate Change Risks into the Forestry Sector
IUCN	International Union for the Conservation of Nature/World Conservation Union
IWRM	Integrated Water Resource Management
JICA	Japanese International Cooperation Agency
FPP	Forest Preservation Programme (JICS)
KBA	Key Biodiversity Areas
LMOs	Living modified organisms
MAF	Ministry of Agriculture and Fisheries
MEAs	Multilateral Environmental Agreements
MESCAL	Mangrove Ecosystem for Climate Change Adapatation and Livelihood
MDGs	Millennium Development Goals
MNRE	Ministry of Natural Resources and Environment
MOF	Ministry of Finance
MPAs	Marine Protected Areas
MSY	Maximum Sustainable Yield
NAPA	National Adaptation Programme Action
NP	National Park
ODS	Ozone Depleting Substance
PACC	Pacific Adaptation to Climate Change
PEAR	Preliminary Environmental Assessment Report
POPs	Persistent organic pollutants
PPCR	Pilot Project for Climate Resilience
PUMA	Planning and Urban Management Agency
RE	Renewable Energy
RED	Renewable Energy Division
SAICM	Strategic Approach to International Chemicals Management
SATFP	Samoa Agro Forestry and Tree Farming Project
SBS	Samoa Bureau of Statistics
SDS	Strategy for the Development of Samoa
SMEC	Snowy Mountains Engineering Corporation
SMSMCL	Strengthening Multi Sector Management of Critical Landscapes
SOE	State of the Environment
SPC	Secretariat for the Pacific Community
SPREP	Secretariat for the Pacific Regional Environment Programme
STMDP	Samoa Tuna Management Development Plan
UNEP	United Nations Environment Programme
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WRI	World Resource Institute
WRD	Water Resources Division, MNRE

FOREWORD

Reviewing and reporting the state of the environment of Samoa is an important part of the government's mandate for achieving environmentally sound and sustainable development. The Ministry of Natural Resources and Environment (MNRE) is entrusted with the responsibility of coordinating the monitoring and review of the state of Samoa's environment with the cooperation and support of its stakeholders in line Ministries, Non-Governmental Organisations and the wider community.

Samoa first completed and published its comprehensive SOE report in 1993 and the second in 2008. The review conducted provides a holistic understanding of the trends in Samoa's natural and human environments under the influence of economic, social and environmental forces over the reviewed period is fundamental to the determinants of future responses to these changes. The findings outlined in the report also indicates the level of effectiveness of policy and educational measures put in place to cope with the consequent impacts of these changes. It is also designed to improve environmental monitoring, education and training amongst decision makers and the general public

Samoa is among nations with the highest level of vulnerabilities to natural and anthropogenic changes, particularly the impacts of climate change. The latter being forecasted (IPCC 4) to become more pronounce this century. These requirements are further urged by both the projected long term global climate change impacts, as well as the increasing short to medium term impacts of variable weather patterns affecting the country, such as extended drought periods and frequent occurrence of severe cyclone.

The need for environmental monitoring is especially critical in Samoa where our people make substantial use of lowland and coastal habitats for farming and developments, nearshore forests and seafood for their day to day living requirements of food, shelter and energy. However, the sustainable development of our environment and resources requires comprehensive public awareness, education, strong partnership and creative management action in order to prevent irreversible decline in water quality, upland and lowland habitats or well as loss of coastal and marine habitats.

In this third SOE Review, the Ministry adopted the 'Integrated Habitat-based approach' and the DPSIR tool as the assessment method for environmental monitoring. It is the hope of Government through the MNRE, that the State of the Environment Report will enhance decision making for environmental protection and sustainable development at all levels of Samoa's economy. It is our hope that this edition of Samoa's SOE will attract attention that is due to the seriousness of environmental issues existing at national and local levels, as well clear doubts that hamper the positive progression of national initiatives in addressing these issues. Moreover, the information herein contained will bring about creative interest from our young generation and the general public to be more involved and take responsibilities for current and future environment management decisions.

Finally producing the SOE Report is not the highlight but making use of the systematic process where all the stakeholders in the country are actively driving and engaging their potentials for reading and acting on their state of the environment realities. Individual and collective actions can make a difference. Ideas, energy, enthusiasm and leadership can enable negative trends to be reversed, turning bad to good. Sustainable management policies and practices should help implement responsive strategies that contribite to stopping and reverse environmental degradation trend, and at the same time reduce the risk of unacceptable future losses. Key findinds from the review and a discussion of **Impacts** and **Responses** provides the substance for the National Environment and Development Sector Plan 2013 - 16 (NESP).

Conserving Samoa's unique environment is our collective responsibility as decision-makers, professionals, teachers, stewards and advocates to ensure that we meet the challenges and bequeath a better future to our children.

Taule'ale'ausumai Tuifuisa'a La'avasa Malua
Chief Executive Officer

EXECUTIVE SUMMARY

Global context

1. Environmental monitoring and reporting at the national level was highlighted by the Rio Agenda for Sustainable Development (Agenda 21) and has since been supported at the global level through the Global Environmental Outlook (GEO) report series that started in 1997. The GEO project itself was also initiated in response to the environmental reporting requirements of the UN Agenda 21 and to a UNEP Governing Council decision of May 1995 which requested the production of a new comprehensive global state of the environment report.

2. As a global report, GEO combines top-down integrated assessment with bottom-up environmental reporting. This approach, which depends on regional assessments from designated regional centres including SPREP, provides the framework for national level inputs into the rolling up of regional impacts and trends. GEO regional reporting preparation also contributed to strengthening national level capacity for the preparation of national SOE.

3. An important addition to environmental monitoring and reporting was the adoption at the Millennium Conference in 2000 of the Millennium Development Goals (MDGs). Samoa has since adopted them as national development goals for its national development strategy. The MDGs helped to promote environmental sustainability as a development goal for Samoa. It also coincided with the growing recognition by policy makers and planners of climate change as a major source of economic vulnerability and an important development issue, and thus contributed to the elevation of environmental sustainability as one of Samoa's four Priority Areas in the 2012-2016 Strategy for the Development of Samoa (SDS).

4. The new status given to the environment in national planning inevitably demand a higher level of transparency and accountability in the way the environment sector is performing. The SOE is the tool for addressing this challenge. The SOE thus offers policy makers, planners, developers, resource managers, school teachers and the general public a holistic assessment of environmental quality, and of the state of health of habitats, species and environmental resources. The SOE also analyses threats faced, causes and where available information allows, future trends emerging from environmental changes.

Approach and Methodology

5. Samoa's State of the Environment (SOE) Report is the result of a comprehensive review and assessment of the changes and trends occurring in Samoa's natural and human environments in response to the impacts of the economic, social and environmental forces. The Report assesses the states, changes and trends in Samoa's environment since last reported in the 1993 and 2006 SOE. The second part of this review is an assessment and updating of Samoa's 1993 National Environmental Management and Development Strategy (NEMS) which provided the broad framework of priority issues and actions for environmental management in the country. The updated document constitutes Samoa's Environment Sector Plan.

6. The approach taken to compiling this SOE report is fundamentally different from that adopted in previous assessments. Whilst the two previous SOE defined the environment by natural resources and human uses (issues based), this SOE organizes and analyses the same based on ecological habitats. It embraces the ecosystems approach and the concept of 'ridge to reef', extending it out to the offshore marine environment as defined by Samoa's EEZ boundaries. The combined assessment of the health of all the defined habitats thus constitutes the overall state of health of Samoa's environment.

7. The approach is generally termed in the environmental assessment literature as the Integrated Environmental Assessment (IEA) methodology or process which revolves around the following five questions:

1. What is happening to the environment and Why?
2. What are the consequences for the environment and humanity?
3. What is being done and how effective is it?
4. Where are we heading?
5. What actions could be taken for a more sustainable future?

8. The IEA assessment process makes use of the DPSIR analytical model (Drivers-Pressures-States-Impacts-Response) to analyse data and information on the states and trends environmental issues and the nature and extend of policy responses. It examines the causes-and-effects relationships between factors that are categorized as Drivers and Pressures of environmental change, and which analysis using measurable indicators provide a basis for describing the State of health of the environment, the Impacts on the health of species, ecosystems and on societies, and Responses for addressing them.

Constraints

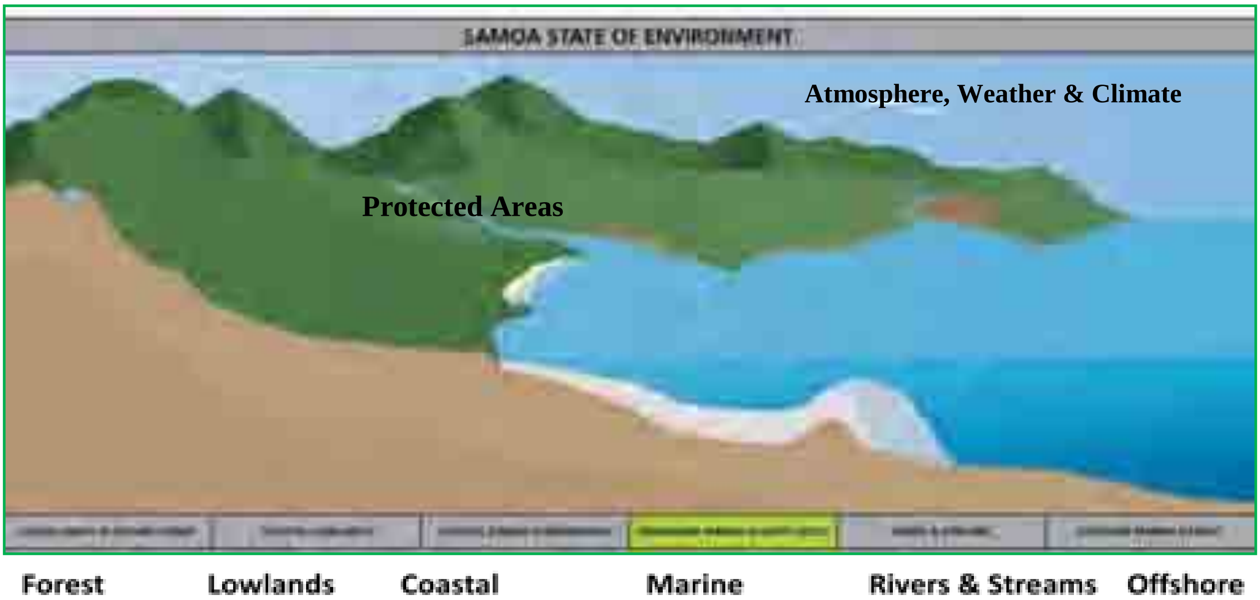
9. A number of constraints hindered the preparation of this report. The main one is the lack of up-to-date quality data and information, and time series data. Data deficiency affected the choice of indicators and how metrics were defined and in some cases, eliminated the possibility of detecting trends or changes over time. Consequently, quantitative assessments of the state of different habitats and species are made where adequate

data is available. For some habitats, e.g. inshore and offshore marine habitats, and tuna stocks assessments, analyses and assessments were recently published by reputable scientific organizations; these assessments are simply used and cited in this report. Where quantitative information is unavailable, assessment is subjective and qualitative, drawing on the experience and knowledge of technical experts within MNRE and its consultants. In other cases, where there is no basis for an assessment, the indicator is simply left unassessed. Doing so highlights the need for its immediate monitoring for future SOEs.

10. The second constraint is inherent in the fact that the use of the DPSIR and habitat based approaches in Samoa's SOE represents the first time these approaches have been applied in the region. As a pilot, there is no existing body of knowledge and regional experience to draw on in dealing with a number of technical issues that emerged. Among these issues is that of defining boundaries between different terrestrial habitats, and deriving discreet states of 'goodness' or 'badness' by which different indicators can be assessed.

11. The mentality adopted in dealing with these constraints is that this is a work in progress with future SOEs to refine and finetune this framework taking into account this experience, and better quality information from monitoring activities which hopefully this SOE will trigger.

Figure 1 - Key habitats based on Samoa's island type



Habitat types

12. Samoa's biophysical environment is examined and assessed based on the following habitat-types –

- Upland habitats and cloud forests
- Lowlands
- Coastal habitats
- Inshore & Offshore Marine habitats
- Rural and Urban Built environment
- Rivers and Streams
- Protected areas
- Atmosphere, Weather and Climate.

The assessment of health of the key habitats are summarized as follows –

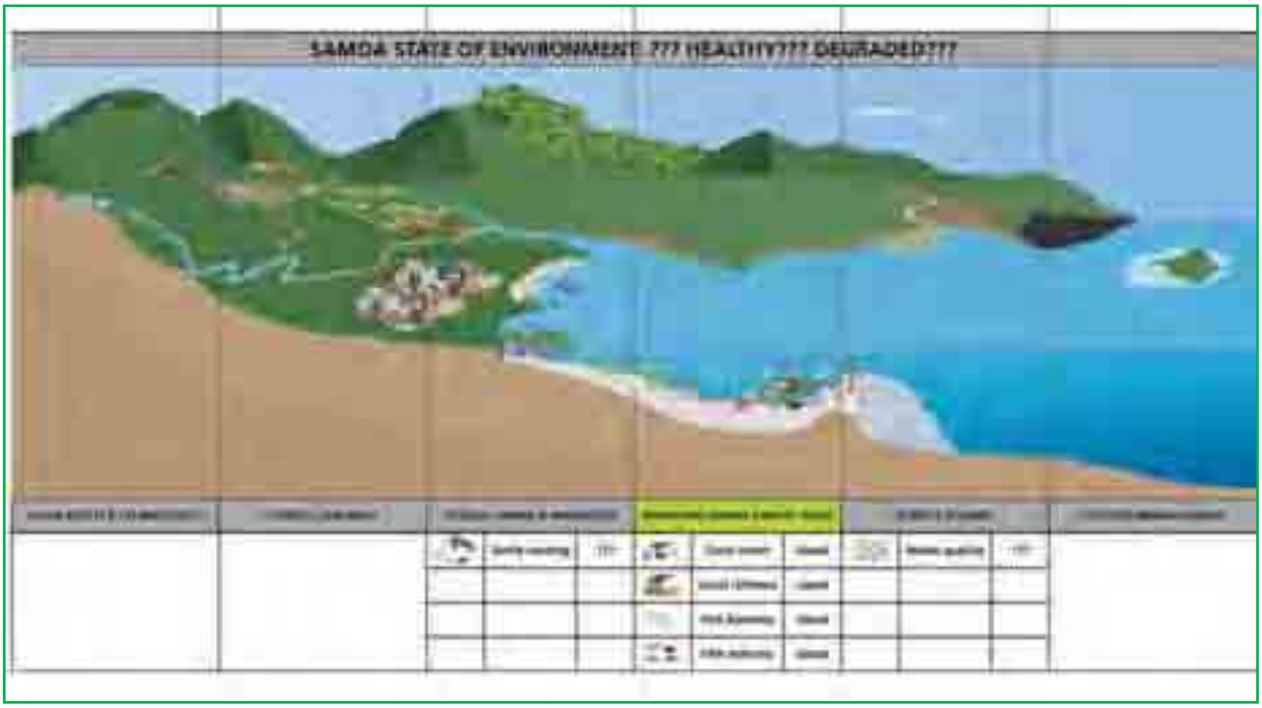


Figure 2

Summary of Assessments of Habitats

Upland Habitats and Cloud Forests

13. Samoa's upland habitats are largely intact and undisturbed by human activities with a high percentage of forest cover (99%) for both Upolu and Savaii. The nature and quality of forests in the uplands of the two islands are now significantly different. For Savaii, 91% of the upland forest area is dominated by native species. For Upolu, non-natives dominate 99% of the upland area. The impact of the invasive vine merremia is the main threat with recent estimates suggesting 24% of all forests affected including upland forests.

14. The data from the BIORAP[1] survey carried out in the upland (above 1,000 m) region of Savaii indicates that the vegetation is very healthy and that it has recovered from damage inflicted by two severe cyclones which hit two decades ago (Val and Ofa), and the forest is returning to its "natural" state. Only 17 alien species were recorded in the area, most of them occurring along a bulldozed track leading up to the upland. Of the 17 alien species, 2 species the *Clidemia hirta* (laau lau mamoe) and *Mikania micrantha* (fue saina) were found to invade native (secondary) forest as weeds, but were not found above 1,370 m elevation. The montane forest is in very good shape, with the worst threat being unauthorized roads being established in the area and related activities that allow the potential for weeds to enter the forest, thereby interrupting future natural succession (BIORAP Report of Upland Savaii, 2012).

15. Also the BIORAP survey found 2 new species of orchids and new to Samoa. Both orchids were recorded during the expedition and (*Calanthe sp. and Bulbophyllum sp*.) are now being studied; one or perhaps both of them representing new unnamed species. Other key findings include:

16. There was no sighting of the Puna'e bird or traces that it still exists, even though there are still significant areas in which searches for this bird have not been undertaken. The survey tends to confirm the view that it is extinct (last confirmed report 1873). Only a single uncorroborated sighting of the endangered Manumea or Tooth-billed Pigeon was made, despite the presence of large numbers of its food trees, raising concern that its situation may now be critical. Reasonable numbers were recorded in a previous upland survey in 1996 but the area no longer seems to be a stronghold for this species. In addition, no Tuaimeo or Friendly Ground-doves were seen. Small numbers of the endangered Ma'oma'o or Mao were found at the second and third sites, re-enforcing a picture that it has particular habitat requirements, which are now hard to find. Other forest birds were found in good numbers including the Matapaepae or Samoan White-eye which is found only in the Savai'i uplands and this may lead to a change in its current IUCN threat status (BioRAP Report 2012).

17. One seabird, a Tahiti petrel, was found at an inland crater, a first record for this species in Samoa. This suggests that the uplands may still be an important area for nesting seabirds and further surveys are needed during the breeding season. The survey found evidence that the uplands contain some of the same threats that have caused Samoa's rarest birds to largely disappear from the lowlands. There was evidence of weeds and rats,

[1] *Atherton. J. and Bruce. J, 2012, Rapid Biodiversity Assessment of Upland Savaii, Samoa.*

while wild cats and feral pigs and cattle encountered in other forest areas around other craters in the interior'. (BioRAP Report 2012)

18. Hunting was obviously occurring at the more accessible areas of the upland mountains. Clear-felling over the past few years of the lowland forests of A'opo-Letui-Sasina, identified in 1992 as one of 5 key sites for biodiversity conservation in Samoa, will also have had devastating consequences for the rarer biodiversity in that part of Savai'i. Although the upland area is remote and infrequently visited, the construction of the Mata o le Afi road shows how threats from invasive species, logging and habitat degradation can escalate very rapidly.
(BioRAP Report 2012).

19. Invasive species, in particular weeds, pest insects (eg, ants), rats, mice, cats and pigs are a major threat to the ecological integrity of the upland forests. Biosecurity is not well understood by the local community and should be the focus for awareness and training opportunities in the future, especially for farmers, foresters and hunters. (BIORAP Report 2012)

20. The interior uplands of Savaii are relatively free of exotic plants, insects and snails. Expert assessment interpreted from the BioRAP survey indicates that forest regeneration was strong and re-establishing composition and structure without competition from exotic plants. (BIORAP Report 2012)

Lowland habitats

21. There are two main lowland habitats – cultivated areas and lowland forests. The total lowland area of Samoa is 218,520 ha, of which cultivated areas comprises 80,589 ha and lowland mixed forests 137,931 ha. Cultivated areas are largely of small sized holdings and with some exceptions, are low tech, use composting and are largely of mixed cropping systems. This typical mixing of trees and crops is ecologically more stable and less vulnerable to outbreaks of pest and diseases. Having said this, invasive species are also widespread including meremia vines, African snails and Taro Leaf Blight.

22. The remaining forests in the lowland areas are predominantly of non-native species with Tamaligi, Pata, Pulu vao, and a host of other light demanding and fast growing species more prominent. These species are the earliest invaders into open spaces created by cyclones, wind throws and abandoned agricultural sites. These forests are less dense, of lower species diversity and don't offer the range of habitats to a diversity of native fauna species as would native forests. Ecologically they are less stable. These forests however will dominate Samoa's lowland, possibly in perpetuity, if the process of natural regeneration is regularly set back before climaxing by cyclones and man-made disturbances. The higher frequency and intensity of cyclones predicted as a result of climate change is thus likely to assist in perpetuating the dominance and continuing spread of non-native species.

23. Other than invasive species, the other main threat to lowland habitats is the indiscriminate clearing for cultivation, particularly of forests within sensitive environments including riparian strips and catchment areas, steep and erosion-prone slopes.

Coastal habitats

24. Of coastal habitats, mangroves are generally in good condition with a high number of viable populations for the two main species *Rhizophora samoensis* and *Bruguiera gymnorrhiza* scattered throughout Samoa's coastline, despite losses in some areas due to harvesting for firewood, land reclamation and waste disposal. The third species – *Xylocarpus moluccensis*[2] is represented by only a small population occupying about 2.5 acres of coast in Siutu Salailua. This species is urgently in need of conservation action. Additional populations need to be established in different locations to avert the possibility of local extinction. Recent studies reported the possibility of three other mangrove species for Samoa but these require scientific confirmation which MNRE plans to do under the current MESCAL project.

25. The health of beaches is indeterminable due to the lack of information on sand budgets, sand migration and replenishment patterns and others. But there is on-going exploitation in the form of sand mining for construction purposes, which MNRE is regulating using a licensing system tied to environmental assessment. Data shows that exploitation is increasing and anecdotal evidence suggests the prevalence of unlicensed commercial sandmining activities. In the absence of data on sand distribution and migration dynamics, it is unclear how sustainability is being monitored.

In-shore Marine and Offshore habitats

26. Within the inshore and offshore marine habitats, the health of corals and coral reefs vary throughout Samoa, but the most healthy reefs and coral assemblages are found in north-western Savaii, with the least healthy of coral reefs along the northern coast of Upolu from the Manono/Apolima strait to the Fagaloa coast. Similarly reef fish is more abundant in the same general areas with northern Savaii having the highest level of abundance, and the northern coast of Upolu the least. There are however more variety of fish species in the northern coast of Upolu, despite lower coral abundance, than north-western Savaii. The knowledge of higher diversity of fish in

[2] *Recent expert assessment (Dr. Norman Duke) of this species under the MESCAL project, suggests that X. moluccensis might be X. grantum.. Scientific confirmation is pending.*

northern Upolu is important for conservation purposes. It suggests the presence of unique coral assemblages not found elsewhere in the country that should be targeted for protection.

27. Tuna stocks are fundamentally healthy especially for Albacore, which is the mainstay of Samoa's tuna import industry. There is some overharvesting of larger and older tuna but the overall biomass is being exploited and harvested within the maximum sustainable yield level. The level of exploitation and fishing prescribed in the Samoa Tuna Management and Development Plan 2011-2015 is sustainable.

28. Many other marine habitats and species such as seagrasses, whales, turtles, are present in small numbers but there is insufficient information to make a determination of their health and population trends.

Rural and Urban Built Environment

29. Samoa's built environment is the highly modified artificial world of human settlements and its supporting physical infrastructure, amenities and services that in itself functions as an organism that consumes resources and generates waste while at the same time, constantly modifying itself in ways that put pressure on its biophysical surroundings. The key indicators for its sustainability examined in this report are population, waste, sanitation, energy, and environmental safeguards. Several other possible indicators were not used due to the lack of data.

Population

30. Samoa's population has been growing at a declining rate in large part due to a high level of outmigration. This trend is predicted to continue and, based on growth rates over the last 20 years, an annual growth rate of between 0.5% and 1.5% is expected. SBS (op cit) considers an annual growth rate of 1.0% to be within sustainable range. The current annual rate of 0.64% per year suggests this predicted growth rate is well within the realms of possibility.

Waste management

31. Waste is an area of concern. Only 11% of the estimated total volume of wastes generated reaches the two semi-aerobic landfills despite a nation-wide public-funded collection system. Green house gas inventories (2006) show a decline in the burning of household wastes compared to previous years, yet the percentage of waste reaching the landfills relative to the total generated is significantly low. There are four possibilities (i) a high percentage of households are not collecting and putting wastes out on the roadside for collection, (ii) waste collecting contractors are not consistently covering the entire 97% of households that should be accessible to collection service; (iii) waste collecting contractors are indeed collecting but are dumping wastes illegally at unapproved sites and (iv) all three possibilities are not mutually exclusive therefore they could all be occurring. It's an important issue for MNRE to look into.

32. Of the waste reaching the landfills, over 50% are compostable and recyclable, meaning the effective lifespan of the landfills are proportionally reduced and not optimised.

Environmental safeguards

33. The Planning and Urban Management Act 2004 and Environmental Impact Assessments Regulation 2007 provide an environmental planning framework that in theory safeguards against poorly designed and environmentally unfriendly development initiatives. Effectively implemented and enforced, it serves an important function of ensuring the built environment's sustainability.

34. There is increasing compliance and public acceptance of PUMA's development consent (DC) process with the number of DC applications received steadily increasing since 2007.

35. Available information is limited but shows that 99% of development proposals screened between 2007 and 2011 were approved and issued with Development Consent. The majority not approved (1%) is due to the lack of information.

36. The PUMA planning framework demonstrates that development is regulated and screened with an environmental filter. Major development proposals that previously would have received the green light based on technical and economic feasibility criteria are now required to satisfy the environmental sustainability criterion. Monitoring and enforcement and monitoring are areas for improvement.

Energy

37. Samoa's energy needs are increasing and Samoa's heavy dependence on imported petroleum products (Samoa Energy Review 2011) will continue in the foreseeable future as demand from a growing transport and infrastructure sector continue to increase. With world energy prices highly fluctuating and generally increasing, Samoa's dependence on imported fossil fuel is a major source of economic vulnerability.

38. The Government's National Energy Policy 2007 goal *'to increase the share of mass production from renewable sources to 20% by year 2030' and 'to Increase the contribution of Renewable Energy for energy services and supply by 20% by 2030*" was reviewed and realized that overall contribution of RE into Samoa total

energy has reduced. The increased demand for energy in the last ten years play a part in reducing renewable energy contribution and the impacts of climate change with prolong drought during EL Nino period and frequent flash flood closed hydro operation during raining season contributes a lot more. The hydrology contribution into generation of electricity reduced from 60% in the early 1990s (when a 4-megawatt hydro station installed at Afulilo) to 32% in 2011. The Energy Review conducted in 2012 recorded that the growth rate of renewable energy since year 2000 was only 0.8%. The result of the Review contributed in the development of the Energy Sector Plan 2012 to 2016, which change the Renewable Energy target to 10% by 2016. Building more hydropower schemes and utilizing of locally available biomass appears to be the main strategy but other resources including solar and wind, biogas digester are promoted and it is seeking funds for rolling out.

39. All renewable energy options impact the biophysical environment in different ways, such as impacts on downstream biodiversity of river diversion schemes for hydropower generation, and unknown risks for native flora and fauna of introduced energy crops. It is important that all introduced RE options are properly assessed for their potential environmental impacts before development.

40. The MNRE Renewable Energy Division (RED) is closely collaborating with SROS in research projects for alternative biofuels. This includes collaboration with other technical organizations to identify affordable and durable conversion technology to utilize waste and unused biomass into useful energy such as electricity, biogas and heat.

Rivers and Streams

41. Regular monitoring of rivers and streams for physical parameters including flow/discharge rates, temperature, turbidity, pH and dissolved oxygen (DO) is on-going under the Water Resources Division of MNRE. Available processed data indicates that river flow/discharge rates are highly dependent on seasonal fluctuations in precipitation making it highly vulnerable to climate change and climate variability. Already, there is an emerging declining trend in river flow rates in the main rivers of Samoa. This has far reaching economic implications particular for agriculture, drinking water, hydropower generation and biodiversity conservation.

42. Rivers and stream water quality is not a major issue based on indicators of turbidity, pH and dissolved oxygen but reported incidences of high *E.coli* counts in several villages water springs is a reminder of the impacts of land use, sanitation and waste management practises on underground water sources. Direct waste disposal into rivers and streams especially for the major rivers in the urban setting has contributed to a lot of pollution to the coastal areas and is now being targeted by the rehabilitation efforts of the Water Resources Division.

43. Increasing levels of demand on water sources for water supply and hydropower generation is also an important issue, with stream flow reduced significantly at developed river systems, and salt water upcoming degrading over developed groundwater sites.

44. Ground Water monitoring to assist in identifying impacts to surface runoffs and salt water intrusion as a result of over-extraction and for better resource use planning instead of adhoc borehole drilling for water supply.

Protected Areas, Sanctuary and KBAs

45. Samoa effectively redefined its protected area network following collaborative work between MNRE, CI and several international conservation organizations that reassessed Samoa's entire biodiversity based on conservation planning criteria of vulnerability and irreplaceability in 2009. The result is a network of 8 terrestrial and 7 marine Key Biodiversity Areas (KBAs) that incorporates the essential components of the existing parks and reserves network. The 8 terrestrial KBAs cover an area of 940km^2 or 33% of Samoa's total land area, capturing within it 12 representations of the 13 native vegetation communities in the country. This terrestrial area also constitutes 33% of Samoa's total land area, more than double Samoa's NBSAP commitment of 15%. The marine KBAs cover approximately 173km^2 or 23% of Samoa's total inshore reef area. Currently, 6 of the 8 terrestrial KBAs and 3 of the 7 marine KBAs have been completely or partially established as conservation areas by the Government of Samoa or by local villages.

46. The Central Savaii Rainforest KBA is singled out as having the highest priority for terrestrial conservation investment. It is the largest contiguous area of rainforest in tropical Polynesia and a site identified internationally[3] as one of the last remaining strongholds for one or more Critically Endangered or Endangered species.

47. The conventional national parks and reserves system which is now encompassed within the KBA network, was recently expanded with the addition of the Lata National Park, bringing the total of officially designated national parks to two in Upolu (Le Pupū Pu'ē NP and Lake Lanoto'o NP) and three in Savaii (Mauga o Salafai NP, Asau-Falelima NP and Lata NP).

48. Prior to the KBA assessment, Samoa's protected area network consisted of 10.794 ha of national parks and reserves, and 12,011,437 ha of marine areas. The marine protected areas include the Aleipata and Safata MPAs,

[3] Alliance of Zero Extinction (AZE), a consortium of over 60 conservation organizations worldwide.

Palolo Deep Reserve and the entire EEZ declared in 2002 as a sanctuary for turtles, dolphins, sharks and whales. This excludes over 60 active community fish reserves.

49. The current status of Samoa's protected area network (existing parks and reserves, MPAs and sanctuaries) is mixed. Only designated parks and reserves have legal status and MNRE is developing management plans under a JICA funded project. The marine sanctuary/EEZ is monitored albeit not regularly mainly for illegal fishing activities. The two MPAs managed by district committees with technical support by MNRE, IUCN and the World Bank. Village based fish reserves are community managed with technical support and regular biological monitoring provided by MAF (Fisheries Division).

50. The challenge for terrestrial biodiversity conservation for the Government now is to acquire legal status and protection for the KBAs and to invest in their management using approaches that integrates the livelihood needs of local villages and resource users that traditionally depend on them.

Atmosphere, Weather and Climate

51. Extreme events related to climate change such as cyclones and flash floods pose the biggest immediate threat to Samoa's biophysical environment as it is to its social and economic aspirations.

52. The changes in climate and climate variability predicted in the previous SOE 2006 are now a reality. These include: increased maximum air temperatures, increased frequency in extreme daily rainfall events, sea level rise of between 2.7 – 8.3 mm a year (PCCSP, 2012). The occurrence of Tropical Cyclone Heta (2004) and Evans (2012) is consistent with predicted climatic changes of increased frequency and intensities of cyclones and other extreme events such as flash floods.

53. But Samoa is also making good progress in reducing vulnerability and in building resilience. This is measured in part in the decreasing size of its carbon footprint based on findings of the 2006 GHG inventory as well as in the level of progress made in the implementation of its priority NAPA activities. Regarding NAPA implementation, a mix of hard (engineering) and soft solutions have been completed and under implementation that includes climate proofing of coastal infrastructure with seawalls, coastline revetments, mangroves replanting, reforestation of steep and erosion prone areas and catchments, capacity building initiatives including information dissemination and awareness raising, coastal infrastructure management (CIM) planning, and in southern Upolu, the relocation of entire vulnerable communities to higher elevations. Similar donor funded climate proofing initiatives are in progress for agriculture, forestry and tourism.

54. These measures flow from adjustments made at the national level of policies and sector plans wherein environmental sustainability and disaster reduction are priority goals in all levels of planning, particularly for vulnerable sectors including water, health, tourism, infrastructure and agriculture.

55. Samoa's Second Greenhouse gas abatement recorded that Samoa's contribution to GHG emission is very insignificant but the frequent occurrence of natural disasters that affects Samoa's economic development in the last two decades encourage the government to promote low carbon development as Samoa contribution to global effort in reducing GHG emission. This efforts starts with Low Carbon Development in the energy sector with promoting of renewable energy that emits no or less Carbon and methane into the atmsosphere. Having said this, projections of future energy needs show significant increases in energy demand in the short term. This will mean continued dependence on imported fossil fuel (petroleum products) and corresponding increases in GHG emissions. The Government is fully aware of this implication hence the emphasis placed on increasing renewable energy output and the use of energy efficient technologies and practises.

56. Samoa has also achieved its zero CFC consumption target and is currently phasing-out HCFC targeting total phase-out by 2040. Samoa is therefore in full compliance in terms of its obligations under the Vienna Convention on Ozone Depleting Substances (ODS) and the Montreal Protocol.

57. Monitoring of local and regional seismic (earthquakes) activities and tsunamis is gaining importance with the recent occurrences of life threatening earthquakes in Indonesia, Japan and New Zealand, and the Samoa earthquake and tsunami of 2009.

Overall Conclusion

58. Overall, Samoa's biophysical environment is continually changing as a result of a complex combination of drivers and pressures from natural and man-made sources. Underlying drivers include wide range of economic development activities (such as development in infrastructure, agriculture, tourism, fisheries), population growth, changing consumption patterns and lifestyles, traditional institutional arrangements governing access to and use of resources, and climate change and climate variability as a result of global warming. These underlying influences give rise to more direct pressure sources such as invasive species, overharvesting of resources, poorly designed development activities, proliferation of non-biodegradable wastes, natural disasters, poor sanitation systems and other factors. They operate singly and collectively, often times synergistically with the impact of one or more triggering others.

59. The biggest immediate threats to Samoa's biophysical environment are extreme events associated with climate change and climate variability, such as cyclones, floods and droughts. These and other climatic and weather pattern changes that were previously predicted are now a reality. Recent experience with Cyclone Evan saw the undoing of years of economic gain in infrastructure development and hard earned livelihood sources, loss of human lives and severe degradation of native habitats and species populations.

60. Other threats exist in the form of waste proliferation, poor sanitation systems, unsustainable harvesting and exploitation of resources, poorly planned development initiatives, and others. But these threats are more manageable with timely and effective interventions, some of which are progressing well to date in all climate change vulnerable sectors.

61. On the other hand, the level of preparedness indicated by the range of NAPA prescribed activities being implemented and planned in all vulnerable sectors, is quite advance. Drivers such as economic development, changing consumption patterns and lifestyles, climate change and climate variability, and others will continue to present challenging situations for environmental sustainability. But there is a heightened level of awareness amongst policy makers and planners of the seriousness of our vulnerability and of the ecological limits of our biophysical environment that are implied in a broad range of policies and strategies currently being pursued. There is also a clear sense of urgency in dealing with our ecological and economic vulnerabilities that is evident in the bold but achievable policies for achieving carbon neutrality and reducing fossil fuel dependence. Collectively, this heightened awareness, the plans now in place, the actions taken and achievements made in all habitats of the environment, constitute a increasing level of preparedness that is the closest indication of Samoa's resilience that can be discerned from the information available to this assessment.

Poster picture by a Saleaumua College student in 2005; Heritage in Young Hands Poster Competition

I. INTRODUCTION

The State of the Environment (SOE) report's primary purpose is to provide a succinct and objective assessment of the state of health of the country's biophysical environment. It should do so in a way that communicates effectively to its targeted audience, which include policy makers and planners as well as gatekeepers of information for stakeholder groups for which this information is relevant - to inform, educate, influence and catalyse positive action and changes in behaviour. Previous SOEs approached this report in different ways and in this new edition, the same search for effective approaches to analysing and reporting the states and trends in environmental health continues, with the adoption of the DPSIR model for analysis and the habitat-based approach as an organizational template for examining Samoa's complex environment.

Samoa's first State of the Environment report was released in 1993, coming in the aftermath of the United Nation's Conference on Environment and Development in Rio de Janeiro in June 1992. The SOE also followed the completion of Samoa's first and only environment sector strategy, the National Environment and Development Management Strategy (NEMS).

The second SOE was compiled thirteen years later in 2006. It followed a series of major initiatives in environmental management in Samoa. Several Multilateral Environmental Agreements (MEAs) were either ratified or acceded to, and Samoa was increasingly engaged in regional and national level initiatives related to obligations under the MEAs. The Planning & Urban Management Act 2004 was enacted, providing the legal foundation for an urban planning agency and the environmental planning framework for screening all development proposals. Major institutional rearrangements also saw the formation of a Ministry of Natural Resources and Environment (MNRE), under whose broad mandate was placed all environmental planning and conservation functions, and which also extended to include the Forestry Division, Meteorology, Water Resources Division, and later other areas such as energy, water sector coordination and disaster management.

A notable feature of the 2006 SOE was its broad scope. It provided an update on the state of the environment, but also prescribed recommendations and priority actions for future implementation. In the context of an outdated 1993 NEMS, it was an opportunity for directing and planning that was too good to miss.

This 2012 SOE follows a significant readjustment in the way the environment is integrated and positioned within the national planning framework. The Strategy for the Development of Samoa (SDS) 2008-2012 SDS was the first to explicitly prioritize environmental sustainability, elevating it alongside the economic and social pillars that previously were the focus of Samoa's national planning framework. This elevated status for environmental sustainability brought it in line with Samoa's MDG goals, and addressed an imbalance in the way sustainable development was conceptualized in earlier SDS.

The basic question of interest is 'what is the state of health of Samoa's biophysical environment?'. The cross-cutting nature of the environment makes answering a challenge on its own, but to achieve it based on reliable and consistent quantitative measurements demands a much greater commitment to environmental and resource monitoring than is presently the case. Due to the inconsistencies in the quality of the information available, the report and the assessments made are similarly inconsistent. But this are temporary teething problems that will be ironed out in future editions, as better designed and targeted information monitoring systems are put in place and data gathering is carried out consistently.

This SOE report is the first output dealing with Drivers, Pressures and States. The updated NEMS – a separate output – will focus on the Impacts and Responses components of the DPSIR model. Thus providing for the compilation of the National Environment & Development Sector Plan (NESP).

2. APPROACH AND METHODOLOGY

2.1 Background

A March/April 2011 workshop by MNRE and SPREP titled National Integrated Environmental Assessment (IEA) Mainstreaming Workshop, examined and subsequently endorsed the process to review Samoa's state of the environment with the application of the Drivers-Pressures-State-Impacts-Responses (DPSIR) framework to analyse data and information on the states and trends of environmental issues and the nature and extent of policy responses. The outcome from this workshop produced the "Plan for Reviewing the state of Samoa's environment". The workshop also resolved to commence preparation for Samoa's 3rd SOE report.

Consultative Process

Consultations for the SOE took four main forms

(i) formal workshops engaging government agencies, SPREP and others

(ii) face-to-face meetings with different agencies and experts to discuss sector specific issues, gather information and in some cases, to clarify data and information previously provided;

(iii) email discussions and communications with key technical experts from government agencies, SPREP and others on specific issues, and

(iv) a series of multi-stakeholder consultations aimed at engaging and soliciting views and comments from other agencies, organizations and civil society at large.

These latter consultations involved five full-day workshops in April and May 2013 with three meetings held in Upolu (Apia) and two in Savaii. Often, issues discussed on email lead to semi-formal face-to-face group meetings to advance discussions or to view technical data (e.g. vegetation type maps) before they can be formalized.

The gist of the consultations undertaken was primarily to engage, solicit and exchange views and in some cases to reach consensus on a broad range of issues starting with the DPSIR model, the SOE report card and its format, indicators and metrics, the habitat-based approach, and the key habitats. Workshops were also used to identify probable sources of data and information, and to arrange further consultation meetings.

The series of public consultations held in Upolu and Savaii provided MNRE an opportunity to present a draft SOE report to the public with the summary of the main issues and findings. Comments from this series of workshops has been taken on board in finalising this report.

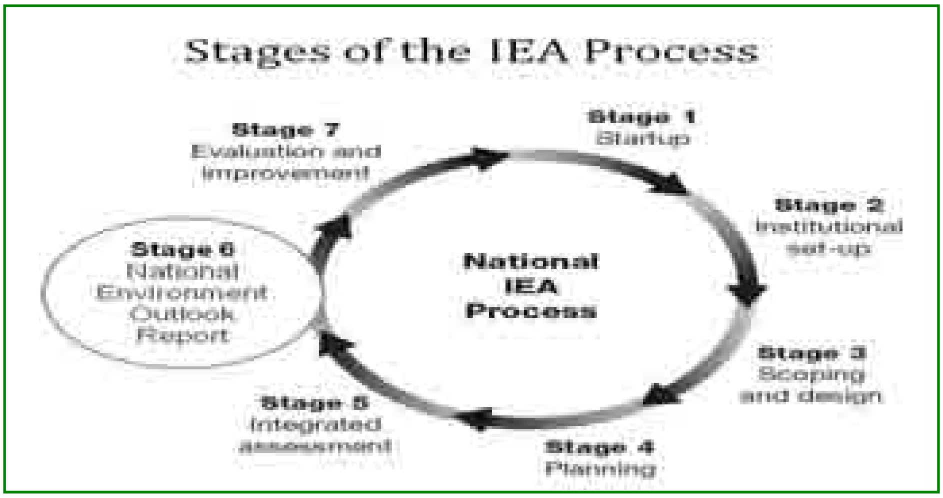
IEA Process and DPSIR

The structure of the IEA process is outlined below. It is aimed at providing relevant answers to the following five fundamental assessment questions on the state of the environment:

1. What is happening to the environment and Why?
2. What are the consequences for the environment and humanity?
3. What is being done and how effective is it?
4. Where are we heading?
5. What actions could be taken for a more sustainable future?

These questions help to clarify the states and trends of environmental change, the causes of those changes and how they impact the biophysical environment and the well being of its dependent human population. It also seeks to clarify the extent and effectiveness of policy responses that were implemented to address impact issues from the NEMS to the various thematic environmental policies (eg., climate changes, biodiversity conservation, SLM and others).

Figure 3: Stages of the IEA Process (UNEP IEA Training, Nairobi, 2010)

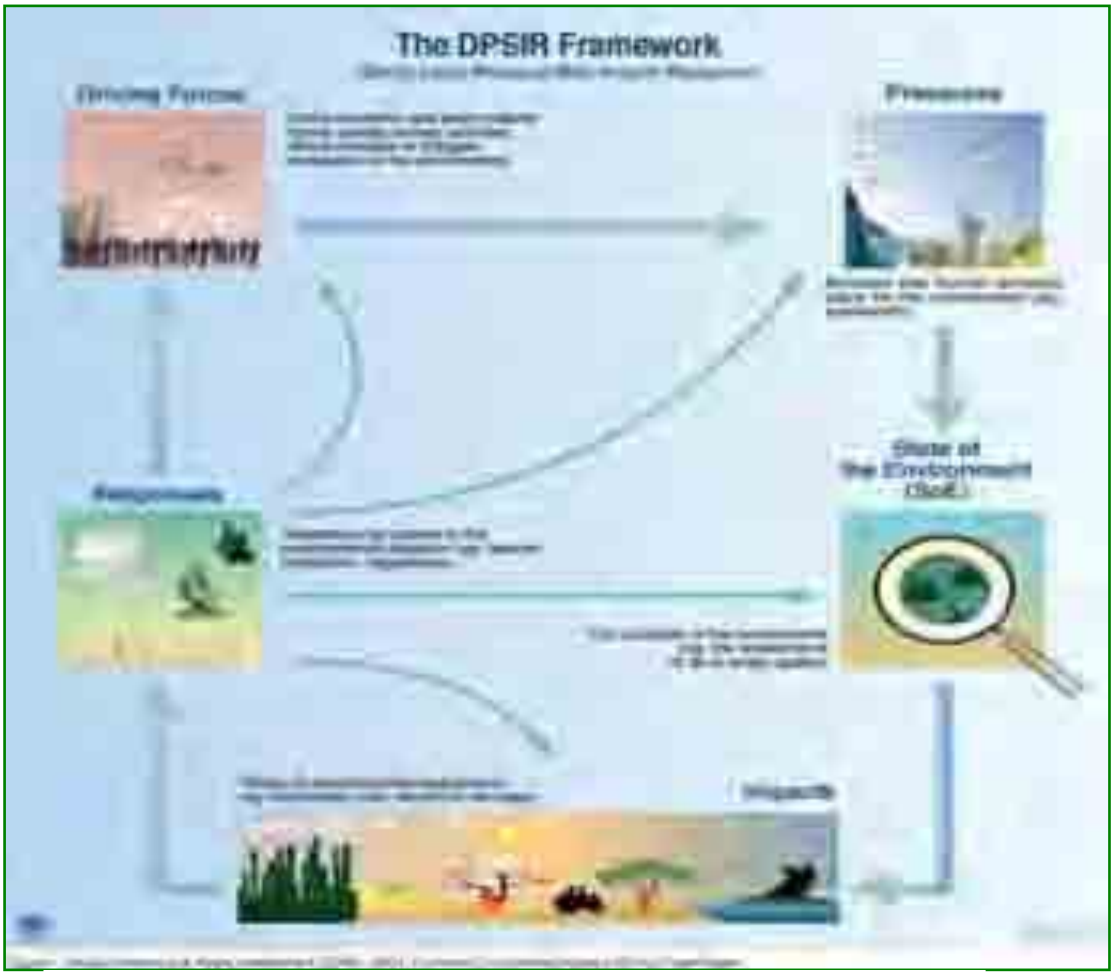


The Drivers, Pressures, State, Response and Impact Analysis of available data and information help provide answers to the first three questions of the assessment:
The Assessment of **State** clarifies what is happening to or the current conditions of the environment;
Drivers and **Pressures** clarify the causes of those conditions;
Impacts clarify the effects of those conditions on wellbeing of human society and the environment;
and **Response** clarifies how much work has been done to improve environmental conditions and how effective were those actions.

The framework assumes cause-effect relationships between interacting components of social, economic, and environmental systems, which are

- **D**riving forces of environmental change (e.g. industrial production)
- **P**ressures on the environment (e.g. discharges of waste water)
- **S**tate of the environment (e.g. water quality in rivers and lakes)
- **I**mpacts on population, economy, ecosystems (e.g. water unsuitable for drinking)
- **R**esponse of the society (e.g. watershed protection)

Figure 4: DPSIR Framework



Source: Delphine Gigout, UNEP/GRID - Arendal

Habitat based approach

In May 2011, a MNRE/SPREP workshop on environmental reporting launched the preparation of the SOE Report Card, and resolved to adopt a habitat-based approach to analysing Samoa's biophysical environment. A habitat based approach signals a significant departure from previous approaches which largely viewed and divided the biophysical environment into discrete chunks of natural resource sectors. As natural resources, environmental assessment became heavily driven by human-centred values that were no different from that of the economic sectors these environmental resources fall under.

A habitat-based approach is seen as providing a balanced, neutral and holistic perspective that recognizes the intrinsic and existence values inherent in ecological processes, habitats and species, while at the same time addressing issues of human use and exploitation that are, in most cases, synonymous with the drivers and pressures.

It divides and organizes Samoa's biophysical environment based on its major habitats, and assesses the state of each habitat separately, with the combined assessment of all habitats providing a composite but complete picture of the whole. The key habitats initially selected were: upland and cloud forests, lowland forests, coastal strands, rivers and streams, near shore marine and offshore marine. These were further refined as the SOE progresses to also take into account (i) habitats of special significance that are spatially cross-cutting e.g. rivers and streams, and protected areas and (ii) the human built rural and urban environment of residential areas, physical infrastructure, artificial landscapes which interactions with the natural environment is the cause of many stresses, and (iii) the atmosphere, weather and climate.

The assessment of environmental health is therefore less of how much of each resource is remaining and available for human consumption but of how well different habitats and species are faring given the impacts of natural, biological and human threats that are in operation.
To the extent possible, within the constraints of the information available, this is what this SOE sets out to produce.

2.2 SOE Format and Organization
Consistent with the DPSIR framework, the SOE is organized under the main headings of Drivers, Pressures and State of Environment assessment. There are overlaps in some drivers and pressures such as climate change and climate variability which can operate at both levels.

The Impacts and Responses components of the DPSIR model are related to but outside the scope of the SOE. These two areas of analysis, in particular the prescriptive 'Responses' component, constitute the main thrust of a separate but companion report to the SOE, which is the updated National Environmental Management and Development Strategy (NEMS).

2.3 Habitat-based approach to assessing the environment
The habitat-based approach to viewing and analysing the bio-physical environment of Samoa is a departure from previous approaches wherein the environment was organized and discussed in terms of its resource values. By assessing the environment within its various habitats, the SOE offers a perspective that is neutral of utilitarian and human centred resource values and provides for a consistent logical framework that is robust and within which all aspects of Samoa's environment can be consistently monitored and analysed over time.

The following habitat-types make up Samoa's biophysical environment –

1. Upland and Cloud Forest habitats
2. Lowland habitats
3. Coastal habitats
4. Inshore and Offshore Marine habitats
5. Rural and Urban Built Environment
6. Rivers and Streams
7. Protected Areas
8. Atmosphere, Weather and Climate

The division between habitats is largely elevation-based but at the same time, tries to approximate the natural divisions between different ecological boundaries and vegetation types. It is a possible area of debate but in the absence of an ideal approach, this solution is deemed defensible and practical. Part of this rationale is to facilitate consistency over time in the spatial coverage for monitoring and data gathering purposes of MNRE going forward. It means even if there are shifts in vegetation types in the future as a result, for example, of climate change, these changes will be monitored within each unchanging spatially defined area, allowing analysts to observe the changes within respective habitat-type.

Some habitat-types identified above also do not comply with the elevation criterion. Rivers and Streams, Protected Areas and Built Environment are cross-cutting in the spatial dimension, extending through a range of elevation bands from uplands to the coast. While theoretically they can be discussed in all terrestrial zones in which they are present, doing so would be repetitive. To avoid this, these are treated as separate habitat-types.

Map 1: Samoa's Coastal, Lowland and Upland Habitats

Source: MNRE, 2012.

Boundaries/Zoning classification
Within each habitat-type, several habitats area discussed and assessed individually with a total assessment for the habitat-type, the sum of these analysis. Species groups of significance are also treated specially. Table 1 below breaks down each habitat-type into its various habitats and key species groups.

Note that this is not exhaustive, and over time with more information, some habitats and species groupings not included in this SOE may be added. The determining factor in the inclusion of the habitats listed below is the availability of information, even though they were still incomplete for many habitats discussed.

Table 1: Habitat-types and Main Species groupings

Habitat types	Habitats & Species Groups
1. Marine/Offshore habitats	Corals and coral reefs Seagrasses Algae communities Seamounts Marine mammals & dolphins Marine reptiles Benthic fishes Pelagic fishes (tuna) Marine molluscs Crustaceans Echinoderms
2. Coastal habitats	Mangroves and wetlands Coastal forests and strand vegetation Coastal marshes Beaches
3. Lowland habitats	Cultivated areas Lowland forests
4. Upland habitats	Upland and cloud forests
5. Freshwater bodies, rivers and streams	Rivers and Streams, lakes, freshwater, springs , groundwater, riparian zones, wetlands

6. Built Environment	Population Housing Sanitation Waste (different types of wastes) Environmental safeguards Energy consumption
7. Protected areas	Protected areas, sanctuary and Key Biodiversity Areas (KBAs)
8. Atmosphere Weather and Climate	GHG emissions Ozone emissions ODS emissions Eco-system based adaptation (NAPA implementation)

2.4 Constraints and Limitations

The habitat-based approach demands a new way of perceiving the biophysical environment and of organizing available data and information. Being new, it gave rise to many challenges some of which will need to be refined and finetuned for future SOEs, using the experience gained in this exercise and the ensuing SOE monitoring activities. These are discussed below -

- Much of the needed information is not available or is otherwise spatially neutral and not disaggregated by habitat-type.
- The key indicator of health for most habitats is area-coverage but the existing satellite images and aerial photographs dates to 1999, with some updating by ground-truthing carried out in 2004. Expert opinion have been sought to estimate and validate the change in area coverage since 2004 and notwithstanding its limitation, this baseline is used extensively in this report in the absence of better information.
- There is a lack of baselines with which to assess changes over time or trends. In most cases, there is considerable anecdotal information of changes over time that clearly point to consistent trends, but there is no quantitative data to support it. In such cases, expert opinion (of the consultants and MNRE technical experts) is used with comments added to qualify any limitations in interpretation.
- As evident in the range of 'habitat-types' Samoa's environment is divided into, some features of the environment such as 'rivers and streams' are cross-cutting in terms of their spatial spread, spreading over two or more of the defined terrestrial habitats. The same applies to 'Rural and Urban Built Environment' which, while largely concentrated in coastal areas, are also found outside these areas. Both are treated as separate 'habitat-types' for this reason.
- Protected areas are discussed as a separate habitat-type. This is more out of expedience because they are important in the context of the assessment, and at the same time, have a spatial spread that extends from the uplands to the sea.
- Assessing the state of health of different habitats and species is made easier with the use of classifications of 'low, medium or high' to indicate the degree of change reported. This is used throughout this report. However, in the absence of adequate and quantifiable data, much of this judgement is based on qualitative expert opinion using on anecdotal evidence and in some cases, together with available but limited data. There are some sources of assessments used here (e.g. Kendall and Poti) wherein these classifications are properly defined, and these are used directly in this report.

Taken together, the limitation in the available data and information means some indicators are either not assessed, or only assessed partially. As well, assessments of trends in most cases are based on qualitative observations and anecdotal information, and expert judgement. Importantly, the inclusion of the selected indicators, despite the absence of assessments for some, is intended to catalyse and encourage the responsible agencies in future monitoring and assessments.

3. DRIVERS OF ENVIRONMENTAL CHANGE IN SAMOA

3.1 Geographical smallness and isolation

Samoa is a small island country in the southwest Pacific, comprising of four main inhabited islands and six smaller, uninhabited islands (refer to Figure 1). Its total land area is 2,900 km2 and its Exclusive Economic Zone (EEZ) is 120,000 km^2.

Like many similar islands in the Pacific Ocean, the physical remoteness and isolation from continental landmasses played a key role in the evolution of its biodiversity. Millions of years of isolation from other genetic influences, and from natural predators and related competitors, allowed the uninterrupted speciation and the gradual evolution of sub-species and species in its fauna, giving rise to the relatively high level of endemism in its biodiversity. The flip side is the high level of vulnerability of these species with less developed natural defensive mechanisms, to alien invasive species, drastic environmental changes and extreme natural events. As a result, the dynamics of species diversity and populations are in a constant state of flux.

Samoa's small geographical area and EEZ is also at the root of many of its environmental challenges. Being of small islands, the coastal zone assumes a disproportionately large role in its biogeography, and the interface between the coastal area and the marine environment a prominent feature. Add to this a high human population and infrastructure concentrated along the coast, the result is a highly active zone where coastal habitats and species are under on-going pressures from land-based pollution, exploitation and other stresses. This is further compounded by the impacts of climate change and climate variability.

The limited size of Samoa's EEZ also plays a role in the population dynamics of the highly migratory tuna resource (Langer, 2006) as well as the dynamics of other migratory species in its biodiversity.

Map 2: Geographical location of Samoa in the Pacific Ocean

Pacific Map downloaded from www.pacifictravelguide.com

3.2 Demographics

Samoa's population as of the 2011 national census stands at 187,820 having grown at an average growth rate of 0.64% since the last census was taken in 2005. Before that, since the 1961 census, Samoa's population growth rate has been declining at around 0.4% per year over the last 48 years. The annual growth rate of 0.64% since 2006 continues a declining trend that, to a large extent, is attributed to the influence of emigration (Malaefono Ta'aloga, pers comm.., MAF and SBS, 2012[4]).

The increase in urbanization of population means the increase in the demand for natural resources and for environmental services. In synergy with increasing incomes, urbanization and changing consumption patterns

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[4] *Ministry of Agriculture and Samoa Bureau of Statistics. 2012. Agriculture Census – Analytical Report 2009. Economics Statistics Division, SBS.*

and lifestyles, an increasing population exacerbates the problem of waste proliferation, putting pressure on landfills, as well as sensitive ecosystems.

The high concentration of population along the coast is directly related to a lot of stresses facing Samoa's environment. Seventy percent (70%) of Samoa's population and infrastructure is located within the coastal area and the combined impact of their land use, sanitation and waste management habits – all contribute to effects that are unsustainable. Some of these include the improper management of solid wastes and wastewater from household sanitation systems, which results in the contamination of underground water bodies, and the degradation of coastal lagoons and coral reefs. Land clearing for settlements and cultivation as well as poor cultivation practices contributes to coastal pollution, increased sedimentation and ultimately the degradation of inshore areas.

3.3 Access to resources and land tenure system

Access to environmental resources is intricately linked to the traditional land tenure system which controls over 80% of Samoa's land resources. The rules governing the allocation of access, use and ownership rights to land and resources under communal ownership are sometimes complicated, and is a subject of several published research and scholarly investigations. In some cases the land tenure system is perceived as a stumbling block to development, because of difficulties of accessing land for development and investment. In the view of others (e.g. O'Meara, 1987)[5], the apparent conservatism that is often perceived as synonymous with an impediment to economic development, is more superficial than fundamental.

Table 2: Land Distribution by Tenure in Samoa

	1989	1999	2009
Customary land	94%	90%	86%
Leased customary land	1%	1%	1%
Leased government land	2%	2%	3%
Own freehold land	3%	6%	9%
Leased freehold	0%	0%	1%
Others/not stated	0%	1%	1%

Source: Samoa Bureau of Statistics Census of Agriculture

In many cases, the communal ownership of resources within villages encourages open access regimes that results in the 'tragedy of the commons', a free-for-all situation wherein self-interested individuals maximize their own benefits until the resource is depleted (Boulding, 1966)[6]. Village inshore marine resources are a classic example where fishing effort is often unregulated. The inevitable result is overfishing leading to resource depletion in the inshore fisheries in many villages (Samuelu-Ah Leong, 2000; Kendall, M and Poti, M.(eds), 2011). But the same laxity in the way access and user rights are allocated is observed in the allocation of use-rights on customary lands - in particular the customary rule where the right of use (and de-facto ownership) of village communal land is acquired and claimed by whoever of the village clears the forest on it. This rule encourages many to clear forested lands merely to stake a claim with little or no long term commitment to its development. Moreover, as reported by O'Meara (op cit), the right of ownership is then inherited directly by those individuals' children.

The environmental consequences of these traditional arrangements are severe and are often manifested in the form of lost habitats, habitat fragmentation, and lost of vegetation cover in sensitive environments including catchments and erosion-prone areas.

Some resources that by law are state-owned, such as rivers and streams, are often disputed by villages with access to them through village-controlled lands needing protracted negotiations. Similarly areas of high conservation value that Government earmarks for protection and located on customary lands are not guaranteed protection with villages support often fickle and prone to reversal, often as a result of internal village politics and disputes. The case of the Uafato Conservation Area Project is an example of where internal village disputes and personality conflicts resulted in a village decision to withdraw its commitment for the conservation of this forest area. Sili village's refusal to allow a Government funded hydropower project on the Vaitai River in 2007 is another example. In 2011, Tafitoala also declined a Government proposal for joint development and ownership of a hydropower scheme using the Tafitoala Stream.

3.4 Economic development

The scope of economic development includes the process and policies by which a nation improves the economic, political, and social well-being of its people (O'Sullivan, A and Sheffrin, S.M.2003)[7]. Its role as a driver of

[5] *O'Meara, J.T. 1987. "Samoa: Customary Individualism." Pp. 74-113 in R.G.Crocombe (ed.). Land Tenure in the Pacific. University of the South Pacific, Suva, Fiji.*

[6] *Boulding, K. 1966. "The economics of the coming spaceship Earth." In: Holden, P and Ehrlich, P.R. (eds.) 1971. Global Ecology: Readings Towards a Rational Strategy for Man. Harcourt Brace Jovanovich, Inc. New York. P. 180-187.*

[7] *O'Sullivan, A and Sheffrin, S.M. 2003. Economics: Principles in action. Pearson Prentice Hall, New Jersey.*

environmental change is all pervasive and often times indirect and discreet. It encompasses the policies, strategies and priorities and the allocation of public funds and human resources as define by the Government and its agencies, the self serving activities of profit-motivated organizations and companies in the private sector, as well as actions of civil society and economically rational individuals.

In Samoa, while the Government promotes and fosters an enabling environment wherein the private sector can realize its potential as the engine of economic development, the Government itself remains the main developer. Its policies dictate and determine the way natural resources are allocated, extracted and use at the level of profit-making corporations, companies and resource-owning entities including villages. The same policies also have profound influence in the behaviour of economically rational individuals at the household level with respect to choices to make on the use of land, forests, marine areas and resources, the choices of technologies to invest in, and in the way people use their disposable incomes. All of these contribute to changes in the biophysical environment in ways that are sometimes sustainable, but more often not.

In the context of these observations, past and current development thinking as set out in Samoa's development strategies including the new SDS 2012-2016 is discussed to highlight the role of economic development as a driver for environmental change in the country. Samoa's economic development in the early sixties to the late nineties was heavily dependent on the exploitation of natural capital. In recent years, however, economic growth has been driven largely by growth in commerce, transport, communications and construction, all linked to and supported by increased numbers of tourists (Rath, 2011).

The diminished contribution of natural capital is partly the result of unsustainable exploitation of forests in the late seventies and eighties, the taro leaf blight in the early 1990's and the devastation wreaked by Cyclones Ofa, Val and Heta in the nineties and early twenties. But there were also inefficiencies and losses caused by more deep-seated institutional constraints such as the traditional land tenure system, lack of institutional capacities in several areas and in some cases, perverted resource policies (Sesega, 2005)[8].

The Government of Samoa's economic goal for the 2012 -2016 planning period maintains a strong emphasis on economic growth, "to rebuild macro-economic resilience and encourage inclusive growth, generate opportunities from global and regional integration as well as build resilience against natural disasters and climate change" (GoS, 2011; p.4)[9]. Predictably, constrained by a narrow resource base, the focus of investment will continue to be on the use of cultivable land, fisheries, forests, water and the natural environment for tourism. In agriculture, the call for scaling up from subsistence to 'semi-commercial' operations, from traditional tools to increased mechanisation, improved access to customary land through leasing, logically means the spatial expansion into existing forests the intensive use of underdeveloped lands, the introduction of new crops and the use of new technologies. The emphasis on renewable energy is likely to see the diversion of rivers for hydropower generation and the possible introduction of alien species – so called energy crops - for biomass gasification and oil production, in addition to a range of biofuel options currently being investigated. Fisheries will be encouraged to ensure its present quota of fishing licenses is fully subscribed. In the case of tourism, its interest in the environment is often related to the use of pristine natural sites, but sustainable tourism standards in promoting resource conservation and recycling and in waste management in tourism facilities are just as important.

Many of these pro-growth policies drive unsustainable impacts. The threat however is well recognized by national planners and both the current SDS 2012-2016 and its predecessor now designates the environment as a priority area with environmental sustainability among the key outcomes. Sector plans are also encouraged to factor in measures for mitigating all foreseeable environmental impacts. The PUMA Act 2004 and the PUMA (EIA) Regulation 2008 also provide the legal framework for screening all development initiatives for environmental sustainability, complementing other environmental frameworks regulating sand mining, coastal reclamation and the importation of living modified organisms (LMOs). This means the remaining question is whether government has the capacity for monitoring and the political will to make difficult pro-environmental decisions where trade-offs with short term economic benefits are inevitable.

For many economically rational individuals at the household level, as farmers or fishers or ecotourism operators with choices to make on the natural resources at their disposal, the pro-growth national and sector policies and strategies will accelerate the continuing shift from a predominantly subsistence existence to a cash based lifestyle. It's a change that has been steadily emerging (Martel, Atherton and Dewulf ,1997)[10] and will accelerate as Samoa willingly participate in an integrated globalized economy.

It is worth noting that noting that most if not all of the economic activities of the informal and semi-subsistence sector operate outside the formal planned sector where environmental filters i.e. PUMA's development consent process, operate. Yet collectively, often in tandem with lax rules governing access and use of resources under

[8] Sesega, S. 2005. "Deforestation and Forest Degradation in Samoa". Working Paper FAO/SAPA SAM DEFOR 01/05.
[9] Government of Samoa. 2011. Strategy for the Development of Samoa 2012 – 2016. Ministry of Finance, Economic Policy and Planning Div, Apia.
[10] Martel, F. J.Atherton and T.Dewulf. 1997. "Pilot Community Deforestation Survey : Western Samoa and Niue – Final Report." SPREP.

customary control, they are significant contributors to the transformation of the biophysical environment that is manifested in habitat fragmentation, the loss of vegetation cover in catchment areas, the sedimentation of coastal inshore areas and the pollution of coastal environments.

3.5 Changing consumption patterns and lifestyles

Samoa's vision for the 2012 – 2016 SDS is 'improved quality of life for all'. The intended outcome is that of a population that is healthier, better educated and prosperous. Inevitably however, the unintended consequence of this outcome is a population that often aspires to lifestyle changes and consumption choices that are environmentally challenging. Samoa has seen its per capita income growing steadily over the last fifteen years[11] (Rath, 2011)[12]. It has also made considerable progress over the years with most of the other MDG indicators. Not surprisingly, there is a direct correlation with changes in public consumption of several key basic needs. For instance, in the case of house construction, there is an obvious shift towards the use of imported construction materials. In energy consumption, biomass is increasingly being replaced by petroleum products and electricity for cooking[13]. Imported labour-saving technologies and household consumer goods comprise a major portion of Samoa's import bill. Increased consumerism and a throw-away mentality add to the proliferation of non-biodegradable wastes, pollution of the atmosphere and increases in greenhouse gas emission[14].

Some consumer choices have direct and indirect environmental benefits. For instance, the reduced dependence on biomass for cooking fuel should lead to lesser deforestation. A growing population of health conscious consumers are demanding organically grown agricultural produce. Recent declines in the use of agricultural chemicals in farming are partly attributed to this (MAF, 2009; p. 41). There is also growing interest in renewable energy and energy efficient technologies e,g, use of biogas digesters, solar panels and energy saving light bulbs, that collectively, will contribute to national efforts to reduce fossil fuel imports.

Changing lifestyles associated with urbanization is a contributing factor. Urban dwellers are less engaged in agricultural activities including backyard cultivation, more integrated into the cash economy and more likely to use electricity and LPG for lighting and cooking.

3.6 Climate change and climate variability

Climate change and climate variability are both a driver and a stressor of environmental change in Samoa. In a nutshell, climate change occurs when short -term weather patterns are altered — for example, through human activity. Global warming is one measure of climate change, and is a rise in the average global temperature.

Climate variability refers to variations in the mean state and other climate statistics (standard deviations, the occurrence of extremes, etc.) on all temporal and spatial scales beyond those of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability). **Climate change** refers to any change in climate over time, whether due to natural variability or anthropogenic forces. Climate variability goes hand in hand with climate change.

The impacts of both on the environment are widely documented. The following section discusses impacts of climate change in the various economic sectors (MNRE, 2006) –

- *Agriculture and Food Production* – Climate induced disasters such as tropical cyclones (its increase in frequency and intensity), flooding in low lying and coastal areas, saline intrusion, coastal erosion and increased rates of coral bleaching mean higher demands and unstable levels of food production affecting income generating activities for communities

- *Water Supply and Quality* – Drought is the most obvious and hard felt impact on water resources especially in relation to quality and quantity. Sea level rise increases the possibilities of seawater intrusion into underground water aquifers as already experienced by many coastal communities;

- *Biodiversity and Ecological Conservation* – The common occurrence of tropical cyclones and drought temperature fluctuation and changes in precipitation patterns lead to changes in the habitats of endangered and endemic species highly affecting Samoa's biodiversity. The intense wave activity of storms overturned much of the coral near shore and severely damaged corals to depth of up to 10 meters (30ft). The changes in sea surface temperature causes bleaching of the corals impacting the habitats of fish species.

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[11] from S$3,650 in 1994 to S$6,969 in 2006 (GoS, 2008)[11] to S$7,138 (~ US$3,121) in 2009 (Rath, 2011)[11], making Samoa a medium human development country with a global Human Development Index (HDI) ranking of 94 out of 182 countries (ibid.).

[12] Rath, Amitav. 2011. Acceleration of Millennium Development Goals in Samoa: Policy Analysis with a Focus on Requirements for Industrial Growth. Final Report Prepared for UNDP – Samoa & UNDP Pacific Centre. UNDP.

[13] Government of Samoa. 2007. Samoa National Energy Policy. Ministry of Finance – Economic Policy and Planning Division. Apia.

[14] Greenhouse gas emission in the road transportation sector increased by 38% between 1994 and 2007 according to the Second National Communication report to the UNFCCC.

- *Health* – There is anecdotal evidence of growth in vector borne and water borne diseases that reconfirm the already changing climate and the impact it has on the health sector. The conditions for the occurrence and spread of these diseases are favoured by the changes in climate;

- *Forestry* – Prolonged periods of drought – usually lasting for three months or more, severely affect forests from high risk of forest fires. Samoa experienced four major forest fires from the drought/dry periods of 1982-83, 1997-98, 2001-02 and 2002-03; and more recently, 2011/12.

- *Infrastructure* – Lowland and coastal flooding and severe coastal erosion impact on the coastal infrastructure as well as the management of the coastal watershed areas especially those, which supply the urban areas.

- *Energy Production* – The droughts in 2002 and 2003 and low rainfall amount in 2008 to 2009 led to rationing of electricity, as the amount of hydro generated electricity dropped. Predicted future increases in the frequency of droughts as a result of climate change will again have severe energy implications until sufficient renewable energy sources are developed. The recent tropical cyclone Evan in 2012 inflicted damaged to hydropower stations.

- *Tourism* – The impacts of climate change on the tourism sector is directly related to the loss or degradation of tourism resources such as beaches, pristine forest habitats, coral reefs, coastal infrastructure and scenic villages. Causes are inundation, flooding, heat related stresses, wind damage, and saline intrusion.

- *Urban Settlement* – The impact of flash floods on Lelata, Vaisigano and other villages in Vaimauga I Sisifo and Apia town area during Cyclone Evan is a stark reminder of the extreme risk associated with settlements in flood prone areas. The extensive damage inflicted on private property and public infrastructure also highlights the shortfalls in urban planning with respect to poor drainage systems, and disaster preparedness. Cyclones and extreme rainfall events are projected to be on the increase both in frequency and intensities and these urban settlement issues will be recurring with the cyclone seasons.

- *Village Communities* – The livelihood of the communities is already seriously threatened by the impacts of climate change. These include physical damage to homes and properties, unstable water quantity; threats to food security as a result of losses in food crops for subsistence and income; coastal erosion and flooding of low-lying areas, and damage and losses to areas of cultural and heritage values (MNREM, 2005).

According to the Samoa's Second National Communication to the UNFCCC, climate change is already a reality with effects already being felt (MNRE, 2010)[15] and recent scientific studies on regional and national climate change scenarios (PCCSP report, 2012). These include – increased maximum air temperature, increased frequency in extreme daily rainfall events, and sea level rise of between 2.7 – 8.3 mm a year (PCCSP, 2012). These include – increased maximum air temperature, increased frequency in extreme daily rainfall events, and sea level rise of between 2.7 – 8.3 mm a year (PCCSP, 2012). Furthermore, best estimates of long-term, systematic changes in the average climate for Samoa indicate that by 2050, sea level is likely to have increased by 36cm, rainfall by 1.25%, extreme wind gusts by 7% and maximum temperatures by 0.7°C (ibid.). Other impacts include a rainfall event of 300mm, which used to be extremely rare, being projected to occur on average of every 7 years by 2050 which is consistent with trends over the past 20 years if significant intensification of rainfall in the country; extreme high sea-surface temperatures, cyclones, as well as more frequent and long lasting droughts (ibid.).

Samoa's National Adaptation Program of Action (MNRE, 2005) calls for the implementation of a series of interventions to strengthen resilience and avoid direct damage to and loss of coastal infrastructure and local communities. The mix of hard and soft solutions proposed involved relocation of infrastructure and coastal population away from hazard prone areas, coastal revegetation, and other low impact options.

[15] Ministry of Natural Resources and Environment (MNRE). 2010. "Samoa's Second National Communication to the United Nations Framework Convention on Climate Change." GEF/UNDP; Government of Samoa.

4. PRESSURES ON SAMOA'S ENVIRONMENT

4.1 Invasive species

Invasive species poses a major threat to Samoa's biodiversity and economy. The impacts are costly and often irreversible. Impacts can range from adversely affecting the productivity and subsequent economic output of primary industry, such as agriculture, forestry and fisheries, to impeding cultural practices and traditions, household food security and sustainable livelihoods, and threatening the integrity and biodiversity of natural ecosystems including vital ecosystem processes, and the existence of rare and vulnerable species.

Samoa has experienced the devastating impact of invasive species on the environment, production systems (crops), and social values of Samoa particularly through invasions of taro leaf blight, the giant African snail (*Achatina fulica*), Myna species (*Acridotheres tristis, A. fuscus*) and Merremia vine (*Merremia peltata*).

The taro leaf blight was extremely costly from an economic perspective, for the impact it had on food security as well as exports. According to Chan (1995)[16], taro production in Samoa dropped by over 95% and the export value fell from $US 3.2 million in 1993 to only $US 53,000 one year later (IPGRI, 2002). From an environmental point of view, it marked the eradication of an exportable species, and ushered in the expansion of the genetic pool for the species in the search for new disease resistant and high yielding varieties of export quality.

The Merremia vine and mile-a-minute (*Mikania micrantha*), are notoriously aggressive species and are listed among the top 30 invasive plants in the Pacific (SPREP, 2000). They are prolific invaders of forest gaps and disturbed sites, with a smothering effect on growing trees, blocking sunlight to sub-canopy and undergrowth vegetation. Although the economic costs have not been quantified, the possible impacts of these vines on agricultural crops and habitats of high conservation value, including Key Biodiversity Areas already approved by the Government as priority for conservation action, is a major concern. The preliminary findings of the 2012 BioRAP surveys (Jeffries et al, op cit)[17] clearly confirm those concerns, with estimates now suggesting that up to 50% of the remaining lowland native forest is dominated by *Merremia* vines (fue lautetele).

Several other invasive forest trees species are also increasingly outcompeting native species in forest gaps regeneration, getting established and moving further and further into old secondary regrowth and primary forests. According to Jefferies et al (op cit), 24% of Samoa's forest is now classified as secondary re-growth- dominated by invasive weedy plant species such as *tamaligi, pulu mamoe, pulu vao and fa'apasī* - especially in Northern Upolu. The dominance of fast growing pioneers in the regeneration of forest gaps and disturbed areas is not an atypical phenomenon. It is the normal cycle of natural regeneration in tropical forests. Slow growing shade tolerant species may or may not regain dominance depending on many factors. But while fast-growing invasive tree species dominate, the quality of forests from a species richness view point will decline. And with it is the ecological stability that is anchored on species and systems diversity.

The known list of invasive species in Samoa is appended, including several birds and marine species. Several others are identified as potentially invasive, including a few that were introduced to control existing invasive species.

4.2 Waste and environmental pollution

Pollution and the growing volumes of solid and hazardous wastes are serious threats to Samoa's environment and to its sustainable development. Waste proliferation continues to accelerate with population growth, improved living standards, urbanization and increasing participation in international trade. These factors combine to push households towards consumer economies where imported, ready-to-consume and disposable products are often preferred for their convenience and labour-saving advantages. At the same time, a lot of these products are non-biodegradable, have short shelf lives, and non essential. The result is pressure on existing landfill facilities, increased threat of pollution and contamination of underground water sources, and degradation of coastal and marine environments.

Samoa however has made significant progress in the management of solid wastes. The following situation exists:

- Samoa generates 175kg of waste per capita per annum in the Apia urban area, and 130kg per capita in rural areas; (MNRE, 2010). Statistics show (ibid) that the rate has been declining over the last 10 years since data was collected.
- Most household waste are of organic refuse but plastics and other inert materials constitute a significant and growing share of waste output;
- A Government funded waste collection system is accessible to 97% of Samoa's households.
- Commercial operators especially in the urban area transport their own solid wastes to the landfill for disposal.

[16] Cited by MNRE.2008. National Invasive Species Action Plan 2008-2011. Division of Environment and Conservation, MNRE.
[17] Jeffries, B., Atherton, J. and Foliga, S.T. 2012. "Enhancing Knowledge and understanding of the Biodiversity of Upland Central Savaii". BioRAP Survey Debriefing to MNRE, October, 2012.

- Waste surveys conducted for Upolu indicates that 110.7 tonnes of waste is disposed of at the landfill annually; out of a total waste generated of 970.9 tonnes per year (Setoa, pers comm.). This means only 11.4% reaches the landfill; the remaining 88.6% is either burned in backyard incineration, used as green waste for mulching, buried or is disposed of somewhere. It is also possible that part of the waste collected by contractors is dumped illegally in unapproved sites.
- GHG emission data points to a decrease in backyard incineration of waste with total GHG emissions reduced from 33.09 GgCO_2-e in 2000 to 32.81 in 2007 (ibid), meaning backyard burning of waste has declined.
- Currently, there is no formal collection for recyclable materials.
- Waste water including raw sewage is relatively well managed in the central business district with the recently installed sewage pipeline conveying waste from about 300 commercial operations to the treatment facility in Sogi
- The two semi-aerobic landfills (Tafaigata and Vaiaata) that receive the collected waste are well managed. Both were extended in 2010 with the addition of sludge facilities for treating septage from household and commercial septic tanks.
- Biogas digesters technology is gaining acceptance and working well in specific contexts (e.g. YWAM campus in Falelauniu), recycling household organic, as well as animal and human wastes to produce electricity and cooking gas (methane), and in the process, improving the quality of the waste water released into the environment.

The management of hazardous wastes is less advanced. But there are key areas wherein significant progress has been made. Persistent organic pollutants (POPs) were inventoried in 2004 and the National Implementation Plan for POPs have in part been implemented. This included the enforcement of bans on importation of POPs as stipulated under the Vienna Convention, and identified in the 2004 inventory, the cleaning up of four priority contaminated sites or hotspots identified in that inventory and the re-importation of used electrical transformers and other hazardous wastes to Australia for disposal under a SPREP coordinated initiative in 2005 – 2006. The continued reduction of threats from POPs and its improved management is the focus of a new regional initiative implemented by UNEP[18]. Medical or hospital wastes are also well monitored, regularly collected and properly disposed by incineration using a dedicated incinerator facility at Tafaigata, with a proposal for an incinerator for Savaii in the pipeline.

Beyond these, the management of hazardous chemicals has generally been an area of low priority. MNRE data shows petroleum chemicals as constituting 82% of all chemicals imported with pesticides, pharmaceuticals, and others comprising the rest. There has not been any systematic monitoring or assessment of pollution due to the use and storage of these chemicals, or their effects on humans and the biophysical environment.

The current emphasis on reinvigorating the agricultural sector is likely to result in the greater use of agricultural chemicals notwithstanding the declining trend in the use of agricultural chemicals in recent years[19] (SBS, 2009). Data on sanitation also points to a high level of inferior household sanitation facilities (~80% of all reported septic tanks are not 'true' septic tanks, according to the 2012 National Infrastructure Strategic Plan) that means the level of contaminants entering the soil is higher than previously thought, increasing the risk of contamination and pollution of underground water sources and coastal marine habitats.

The low priority given to waste recycling has implications other than resource sustainability and conservation. It also means that landfills' potential life spans are not optimized. The reported 57% of wastes received that are recyclable or compostable constitutes a significant volume that, recycled or composted, would save space and extend landfill's useful life spans significantly.

4.3 Atmospheric pollution and greenhouse gases

High levels of emission of greenhouse gases (GHG) is polluting our atmosphere and affecting both the quality of the air we breathe, and contributing to climate change and climate variability. Another atmospheric pollutant – collectively referred to as ozone depleting substances or ODS, is largely limited in Samoa to CFCs hydro-chlorofluorocarbons (for refrigeration and air-conditioning) and methyl bromide (a fumigant in quarantine and pre-shipment applications). However data published by the World Resources Institute (WRI) shows not only a decreasing trend for Oceania, but for Samoa, the level of consumption of HCFCs is effectively reduced to zero (WRI, http:/wri.org)[20].

[18] PAS Pacific POPs Release Reduction Through Improved Management of Solid and Hazardous Wastes.

[19] the percentage of farming holdings using agricultural chemicals fell from around 59% in 1989 to 50% in 2009 acording to the 2009 Agriculture Census.

[20] Cited by UNEP and SPREP. 2009. Pacific Environment and Climate Change Outlook. UNEP & SPREP.

Table 3: Consumption of ODS in Oceania and Samoa 2000 – 2007

Region/Country	2000	2001	2002	2003	2004	2005	2006	2007
Oceania	635*	486	490	346	254	238	124	144
Samoa	1	2	3	0	0	0	0	0

Source: World Resources Institute Cited by UNEP & SPREP, 2008). * = metric tons

Of GHGs, total emission increased by 113 percent from 1994 to 2007 with 27% and 25% from transport and livestock farming constituting 27% and 25% respectively, and electricity in fourth place with 12%[21]. The shift from Left hand to Right hand driving is reported to have increased the number of vehicles imported since 2007. There are also plans in the pipeline for recycling oil and other recyclables from used car tyres that will also add to the GHG emission equation.

4.4 Natural disasters

Samoa is prone to natural disasters and in particular cyclones, earthquakes and fires. Climate change and climate variability has exacerbated this vulnerability with future cyclones and other extreme weather events predicted to be more frequent and more intense.

Samoa's vulnerability is partly due to its geographic location (south of the equator) which is an area known for the frequent occurrence of tropical cyclones with damaging winds, rains and storm surge between the months of October and May (SPC-SOPAC, 2011)[22]. Cyclones within living memory include Cyclones, Ofa and Val (1990 and 1991), Heta (2004) and, recently, Evan (2012). All caused extensive damage to important terrestrial and marine habitats and species populations, as well as infrastructure, settlements and crops. In 2009, a devastating tsunami caused significant damage to public infrastructure and private property, and claimed 147 lives in villages along the southern coast of Upolu. Similar impacts were witnessed in Vaimauga I Sisifo and Safata as a result of floods that accompanied Cyclone Evan in 2012.

Samoa is also vulnerable to seismic events because of its proximity to the Pacific "ring of fire" which aligns with the boundaries of the tectonic plates. It's a seismically active region capable of generating large earthquakes and, in some cases, major tsunamis that can travel great distances (ibid.).

Following the 29th September 2009 tsunami, there has been an increased demand to improve understanding of the medium to long-term risks posed by tsunamis to better mitigate their impacts. The historical tsunami database for Samoa, which extends back to 1837, indicates that these islands have been impacted from all the major source regions of the Pacific Ring of Fire, some of them thousands of kilometres away (e.g. Chile/Peru and Alaska). Unfortunately, the historical database only extends back as far as 1837 (Pararas-Carayannis and Dong, 1980; Williams and Leavasa, 2006), and as such is extremely limited for our long-term understanding of these events in terms of distribution, frequency, and magnitude. (Williams, Goff, Sale, Ah Kau, Davies, Wilson, 2008[23]).

Box 1: Country Risk Profile: Samoa

- Samoa is expected to incur, on average, 10 million USD per year in losses due to earthquakes and tropical cyclones.
- In the next 50 years, Samoa has a 50% chance of experiencing a loss exceeding 130 million USD and casualties larger than 325 people, and a 10% chance of experiencing a loss exceeding 350 million USD and casualties larger than 560 people.

Source: SPC-SOPAC. Sept 2011.

Local efforts to better understand seismic events, as well as in their early detection and monitoring inevitably rely on technical expertise and capacities in regional organizations and in more developed countries. These include studies (William et al, ibid.) that will inform the development of a platform for identifying tsunamis within Samoa's recent geological past, and will enable the existing historical tsunami database to be extended beyond 1830 AD.

This will improve our understanding of the long-term recurrence and impact of tsunamis at different coastlines, and of coastal vulnerability and distribution of tsunami risk. Ultimately, the information yielded may be used to strengthen mitigation efforts and help reduce tsunami risk

[21] *Samoa 2nd Greenhouse Gas Inventory Report 2010*

[22] *SPC-SOPAC. September 2011. Country Risk Profile – Samoa. Pacific Catastrophe Risk Assessment and Financial Initiative.* SPC, Noumea.

[23] Williams, S.P., J. Goff, J. Ah Kau, F. Sale (2010). Samoa Palaeotsunami Investigation: Interim Report of Field Survey, 31 July – 20 August 2010; Prepared for the Ministry of Natural Resources and Environment, Government of Samoa. Miscellaneous Report, September 2010.

through mainstreaming into local hazard and disaster management plans. (Williams, Goff, Sale, Ah Kau, Davies, Wilson, 2008). Others include SPC-SOPAC's (op cit) country risk profile for Samoa which gave the following sombre predictions of likely events with estimates of losses (refer to Box 1).

As in previous cyclones, the impact on the biophysical environment will be severe degradation of terrestrial and marine habitats of high conservation value, loss of vegetation cover for critical catchment areas, loss of fauna populations including species that are already threatened, and the overall fragmentation to ecosystems that in and by itself, will diminish their ability to function optimally as ecological services providers.

The degradation caused by natural disasters also often creates conditions favourable to the spread of invasive species of vines and trees, and the irreversible loss of habitats and local species extinctions.

Table 4: Natural Disaster Record of Samoa 2004 - 2009

Date	Location	Type	Disaster Name	Killed	Affected	Estimated Damage US$
December 13, 2012		Tropical Cyclone	Evan	4 (not including 10 missing)	2088 households, in 164 villages , approx. 14,777 people (based on 2011 Census)	$480 million SAT ($210.7 million USD)
29 September 2009	Eastern and South Eastern Coast of Samoa	Tsunami	Tsunami	143 (excluding including 5 missing)	Approx. 5274 people, approx 685 households	Damage – SAT$211.96 (USD$84m) and losses – SAT98.16m (USD$39m)
8 – 16 September 2008	Asau and Aopo, Savaii	Bush fire	Asau and Aopo Bush fire	0	0	SAT$163,995.07
January 25, 2008	Apia	Flash flood	Apia flood	0	0	0
6 February 2006	Apia	Flash flood	Apia Flood	0	Approx. 20 – 30% of 38,836 population of Apia (2001 Census)	Approx. SAT$300,000.00
February 16, 2005	Savai'i and Upolu Islands	Tropical Cyclone	Olaf	0	0	0
January 05, 2004		Tropical Cyclone	Heta	1	30,000	500,000

Source: Based on information from Filomena Nelson, DSMO, MNRE, February 2013.

4.5 Unsustainable exploitation of resources

Unsustainable exploitation of resources will continue to add stress to Samoa's biophysical environment. It has already significantly altered the distribution and composition of Samoa's forests. It is also reported in fisheries and water resources.

The unsustainable exploitation of native forest resources for sawmilling and agriculture is well documented (Sesega, S. 2005). It is the result of a combination of factors including food production, cash income generation, expansion in settlements and land profiteering (ibid.). At present, the low volumes extracted in the few remaining logging activities[24] are indicative of the largely depleted nature of Samoa's native merchantable forests. Existing logging is small scale and centres around the salvaging of remnant trees in previously logged areas and in agricultural lands. In the foreseeable future, the low level of logging is not expected to be an important

[24] *Estimated at around 3,000 – 5000m3 per year*

environmental issue except where it may affect water catchment areas, areas prone to soil erosion, and habitats earmarked for conservation within approved Key Biodiversity Areas. There are also recurring reports of harvesting of mangroves in some communities for fuel.

In the fisheries sector, overfishing in the inshore area is a major issue that will continue to threaten the integrity and sustainability of coastal resources and coral reefs. The underlying drivers are the combined effect of population, the open access nature of coastal fisheries resources, and the increasing demands of an increasingly cash based lifestyle in rural communities. Recent statistics (MAF, 2011)[25] showed that 24.8% of households were engaged in fishing. Ah Leong et al (2009)[26] noted that 86% of all fishing is carried out in the reef area, with 42% of the average household containing at least one fisherman. The catch per unit effort has steadily increased, from 1.8kg/hr in 1990, to 2.1kg/hr in 1997 to 2.24kg/hr in 2007 (Valencia et al. 2007)[27] which Ah Leong et al (op cit.) noted as indicating overfishing.

Of Samoa's tuna resource, the total annual tuna catch is within sustainable levels (i.e. within the Maximum Sustainable Yield), but there is overfishing of larger and older albacore stock. Langer (op cit) attributes this to the combined effect of a high level of fishing effort from Samoa's domestic long lining fleet and a small and restricted EEZ. The result of both is a dwindling stock of large and older albacore as the natural process of stock diffusion and replenishment from neighbouring seas lags behind the rate of exploitation.

MAF (op cit) also observes that the growing practice of sending consignment of seafood as gifts to relatives' overseas ('fa'aoso') is a contributing factor.

With respect to water resources, SOPAC et al (2007) noted that there has been no national assessment on the stress put upon the individual catchments and aquifers but the available qualitative information, particularly for Vaisigano and Fuluasou Rivers, indicates that there is significant over-abstraction with between 65-80% of the surface water flow from these catchments used in water supply (ibid.).

4.6 Land based Pollution

The impact of land based activities on coastal resources is closely associated with the high population densities along coastal areas. Land reclamation, sand and scoria mining and road construction have also been known to destroy fish nursery areas. Similarly, poor land management has led to erosion and consequent siltation of lagoons (Tuivalalagi & Morrison, 2004[28]; Ah Leong et al, 2009; Mulipola, et al.).

A SMEC (2011)[29] study of Afulilo dam's impact on the Fagaloa Bay best demonstrates the impact of coastal pollution from land-based sources. The reservoir is an old peat swamp with rotting logs and biomass that were not removed during dam construction. The result is the high level of tannin in the water that passes through the powerhouse into the Fagaloa Bay, discolouring the bay and limiting the amount of sunlight received by corals, algae and seaweeds for photosynthesis. But SMEC (ibid) also found significant levels of orthophosphate (PO4)[30] and nitrates which exceed thresholds[31] internationally considered unacceptable for tropical coastal waters supporting a healthy coral ecosystem. Following an intensive 11 month monitoring program of the Bay, SMEC (ibid) concluded that the three most likely causes of the water quality degradation are:

- Enrichment with orthophosphate and nitrate from faulty sewage systems of the residences of the hundreds of families living within 100m of the shore;
- The unrestricted livestock foraging (1000s of pigs and many cattle) along the shore leaving tons of manure and highly disturbed ground behind;
- The switch to kava production on steep slopes (due to the loss of coconuts, as a result of Heta 2004), leaving tracts of very loose soils on the slopes at each harvest time—leading to large scale increases in sediment levels and turbidity.

The use of agricultural pesticides and chemical fertilizers is relatively widespread but the level of usage (volume) has fluctuated over the years since 1989, possibly corresponding to the relative state of agriculture between the pre-Taro Blight and post-Taro Blight years. This is depicted in Graph 1.

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[25] Ministry of Agriculture and Fisheries. 2011. Agriculture Sector Plan 2011-2015.Vol 1. MAF Apia.

[26] Samuelu-Ah Leong, Joyce and Sapatu, Maria. 2008. Status of Reefs in Samoa 2007. In: Whippy-Morris (ed.). 2009. South-West Pacific Status of Coral Reefs Report 2007. Coral Reefs Initiative for the Pacific. SPREP, USP, GCRMN and ReefBase Pacific. SPREP, Apia.

[27] Cited by Ah Leong et al (2008).

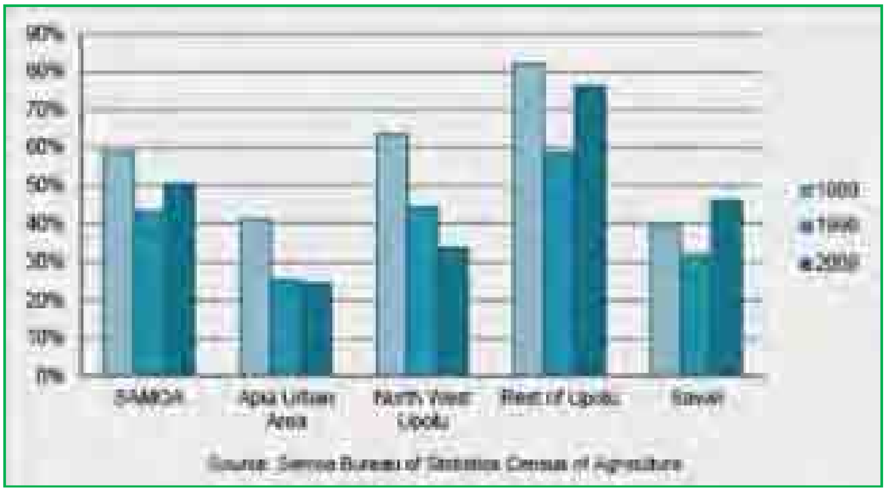
[28] Tuivavalagi, N.S. & Morrison, J. 2004. Land based activities and impacts on coral reefs and the marine environment of Pacific Islands. In H.Yukishira (eds.), Towards the Desirable Future of Coral Reefs and the Western Pacific, 23-26 July 2003 (pp. 69-88). Palau PICRC.

[29] SMEC. April 2011. Preparing the Afulilo Environmental Enhancement Project. ADB TA: 7121 SAM. Phase 1 Final Report. SMEC International Pty Ltd..

[30] PO_4 combines with nitrogen stimulates algae growth and zooplanktons.

[31] The 0.03 mg/L standard used in Australia, New Zealand and in Carribean Islands

Graph 1: Proportional of Holdings Using Agricultural Chemicals



Statistics of chemicals imported show that the overall amount imported, and assumed used is relatively low. Concerns however are in usage within catchment areas and near surface water sources. Looking forward, the emphasis given in the SDS 2012-2016 and the Agriculture Sector Plan to re-invigorating the agriculture sector is likely to see an escalation in the use of a range of agricultural chemicals as the sector seeks to boost production with scaled-up semi-commercial and larger scale farming units.

4.7 Poor Sanitation

Poor sanitation resulting from the use of inferior household sanitation systems and practises contaminates underground water sources, pollutes and degrade coastal environments and poses a health threat to human populations from water borne diseases.

In Samoa, a high percentage of faulty septic tanks is highlighted in several reports suggesting that a high level of pathogens and nutrients end up in underground water bodies. Two recent independent studies confirmed this. Latu et al, (2012) tested water from village springs in three Upolu villages and found unacceptably high level of E.coli. SMEC's study of Fagaloa Bay (2010) also found similar correlations between the high number of unimproved and inferior sanitation systems and water quality, as well as the high level of pollutants and degradation of the inshore marine environment. Moreover, SMEC also postulates that wastes from free-ranging domestic animals especially pigs and cattle is a major contributor to the high level of pollution found in the Fagaloa Bay.

4.8 Poorly planned development activities

Despite efforts on the part of the Government to provide a framework within which all development activities are properly screened and vetted for environmental sustainability, many local initiatives and activities are occurring without proper vetting. Many are coastal in nature involving sand mining, coastal reclamations and constructions within hazardous zones. Many mangrove areas are destroyed to make way for construction, by waste dumping and for firewood. Water is abstracted without proper licenses and formal assessments. Cultivation in sensitive habitats including catchments, forests of high conservation value and on steep erosion-prone slopes is widely observed.

The larger issue is the lack of integrated land and resource use planning but it's a complicated issue with drivers including the land tenure system coming into play. However some positive developments and progress can be seen with the host of planning frameworks and guidelines now in place for regulating developmental initiatives. Prominent among these are PUMA's regulatory mechanisms as set out in the PUMA Act 2004, PUMA (EIA) Regulation 2006 and the Environment Code of Practice (2006). The PUMA legislation's requirement for the development of Sustainable Management Plans (SMPs) was recently tested using the Vaitele peri-urban area. District Coastal Infrastructure Management (CIM) Plans is a useful guide with specific recommendations to Government, private developers and communities for improving the resilience of coastal communities and developments.

PUMA's regulatory framework for Development Consent Applications (DCAs) framework is complimented and supported by similar permitting systems for regulating sand mining and coastal reclamation activities administered by the Land Management Division of MNRE, for underground water exploration and abstraction administered by the Water Resources Division. In agriculture, the pesticides registry lists approved agricultural chemicals that are safe and environmentally friendly for importation. MAF has also developed the technical capacity for matching crops to land use productivity to optimize land use and productivity and this advisory service is available to farmers to guide crop selection. Risk assessment procedures are in place for screening potential biosecurity threats posed by any imported living modified organisms.

Photo from the Vaisigano Flood of Dec 2012, Cyclone Evan: Report by MNRE & GHD Ltd

Tafitoala Bridge

5. INDICATORS FOR ASSESSMENT

Environmental indicators measure the state of and pressures on the environment. Properly used, they inform planners and managers of the state of health of specific aspects of the environment at specific points in time, enabling the tracking of changes and trends in environmental health. Good indicators are widely understood to have the following characteristics –

- Scientifically sound
- Easily understood
- Show trends over time
- Sensitive to the change that they are intended to measure
- Measurable and capable of being updated regularly
- The data and information are readily available.

Indicators for this SOE were developed and debated in a consultative workshop on the (date), May 2012. MNRE staff and technical staff from other agencies were grouped largely according to areas of expertise to identify and recommend indicators and metrics for different habitats. The full range of indicators discussed is appended. The use of specific indicators not only allows for better measurement of key aspects of the environment, but it also assisted in identifying the relevant information to target in information gathering.

In this SOE exercise, many indicators initially identified were not supported by the available data. Consequently, some indicators were culled with those supported by the available data used. In most cases, there are no baselines against which to measure 'change' and to assess trends, except those defined for the SDS 2012-2015 indicators. These have been used where appropriate.

As a result, assessment of condition and trends were made based on expert judgement where there is sufficient anecdotal evidence to make an informed assessment. Otherwise, the condition is described but no assessment is made using the selected indicator, or the trend is simply noted as 'Not known'. In the case of biodiversity, IUCN's assessments of conservation statuses and population trends for redlisted species are heavily relied on to validate findings from available information. In most cases, the IUCN's redlist classification and trend assessment is used.

One of the major challenges is to capture the degree of change that has taken place. In this report, categories of 'low', 'medium' and 'high' are used in a matrix to indicate how much of a positive change has taken place. Determining the break-point between 'low', 'medium' and 'high' is done subjectively in most cases where the quality of the data is poor. Most commonly, where triangulation is possible, the general consensus view is taken. Otherwise, it's a judgement call by the author or of relevant experts in the specific area being assessed.

In some reports, for instance, the coral and fish assessment by Kendall and Poti (2011), assessment of several datasets of Samoan corals, reefs and reef fish were combined and analysed together. To define the break-points between low, medium and high, a computer generated algorithm was used to make this determination.

The final list of indicators used in this report is given in the table below. Indicators for environmental sustainability reported in SDS 2012 – 2016 are also provided for comparisons.

Table 5: Indicators Used by Habitat Type

Habitat-type	Habitat	Indicators and metrics
Marine/Offshore habitats	Corals and reefs	Area coverage - % change in area coverage relative to baseline Abundance/biomass - % change in biomass relative to baseline Species richness – - no. of incidences of occurrences of species in sample population Coral community structure – - subjective assessment based on expert observation
	Fish	Abundance/Biomass - % change in biomass relative to baseline (MSY) Species richness - no. of incidences of occurrences of species in sample population

Coastal habitats	Mangroves	Area coverage – - Total area coverage - # of viable mangrove communities Species richness – - % of native species with viable populations
	Beaches	- volume (m^3) of sand approved for mining/year; - # of sand mining licences granted/year; - # of new beaches mined / year
Lowland habitats	Lowland forests	- % of lowland areas under forest cover - % of lowland forests dominated by non-native species - % of lowland forest areas affected by Merremia peltata vine - % of native bird/mammal species present
	Cultivated areas	- % of cultivated areas using inorganic fertilizers and agricultural chemicals - % of cultivated areas using organic fertilizers only - % of cultivated areas under multiple cropping systems
Upland habitats	Upland & Cloud forests	- % of upland areas under forest cover - % of upland forests dominated by non-native species - % of upland forest areas affected by Merremia peltata vine - % of native bird/mammals species present - % of native bird/mammal spp with increasing or stable populations
Built environment	Population	- annual growth rate less than 1.0% - population density in urban/ rural areas
	Waste	- % change in waste generation rate per capita per day relative to an established baseline; - % of hh waste reaching landfill relative to total waste generated - % total hh population accessible to public-funded waste collection system; - % increase in vol of solid waste recycled relative to baseline
	Sanitation	- % of hh with improved sanitation systems - % increase in households etc. using biogas digesters - % change in confirmed cases of diarrhea
	Environmental safeguards	- % of development consents issued over total application received - % of proposals modified on environmental grounds relative to annual total - % of proposals for DC declined on environmental grounds
	Energy	- % petroleum products imported - 10 - 20% in RE generation for consumption relative to total energy used. - % of improved energy efficiency and conservation implemented
Rivers and Streams	Water Quantity	- % change in average flow/discharge rates of rivers and streams - change in groundwater level - No. of perennial streams with minimum environmental flow requirements defined
	Water Quality	- % of village springs with *E.coli* count exceeding national standards - Turbidity - DO - pH - Trends in freshwater abundance/biomass

	Watershed health	- % of catchment areas with forest cover exceeding 70% of total catchment area - % increase in area (ha) of watersheds rehabilitated (fenced, planted and with human activities effectively controlled) - No. of watershed management plans approved and under implementation
Protected Areas	KBAs, parks and reserves	Area coverage - % of area designated as protected area with legal status - % of total KBAs with legal status - % of total KBAs with management plans.
	Species of high conservation value	- As per IUCN RedList categorization and assessment
Atmosphere Weather and Climate	GHGs	- Net GHG emitted (emission minus removals)
	Ecosystem based adaptation (NAPA etc implementation)	- # of climate adaptation and mitigation projects completed and under implementation
	ODS	- # compliance companies and technicians - 10% by 2015 (HCFC)

Table 6: Environmental Sustainability and Disaster Reduction Indicators from SDS 2012-2016

Goal 7: Environmental sustainability and Disaster Risk Reduction

Indicator/Target	Baseline Figure 2007/2008 (or earlier dated)	2008/09	2009/10	2010/11	Source
Percentage of land area covered by forest increases	90,444 ha (13%)	121,000 ha	171,000 ha	154,987 ha	MNRE
No. of trees provided under the community forestry programme increases	136,884	158,184	170,784	175,200	MNRE
Number and area of protected areas rises	120,840 ha (42%)	120,840 ha (42%)	120,840 ha (42%)	136,853 ha	MNRE
Percentage of power from renewable energy sources	42.1	36.2	43.0		EPC
Percentage of urban population with access to improved sanitation increases	91% in Apia urban area with flush septic (2006 Census) 834 households (10%)			1,457 households (82%)	MNRE
Percentage of population with access to treated water supply increases	22.4% (July 2004) 65% of SWA customers have access to treated water supply	65% of SWA customers have access to treated water supply	75% of SWA customers have access to treated water supply	80% of SWA customers have access to treated water supply	SWA
Percentage of development consents issued over total applications received	83%	97%	82%	98%	MNRE

6. STATES AND TRENDS

Figure 3: Samoa's conceptual diagram of its unique habitats and culture

Source: Tracey Saxby (Univ of Maryland) 2012 & MNRE SOE Working Group 2012.

Photo of Upland Savaii from the BIORAP Report 2012

6.1. UPLAND HABITATS

6.1.1. Upland and Cloud Forests

The upland and cloud forests of Samoa that lies above elevation of 600m asl, and covers a total area of 65,380 ha with 49,038 ha (17%) in Savaii and 16,342 ha (6%) in Upolu. The Upland and Cloud forests were last assessed by Schuster et al 1999. There have not been any further studies since, until the 2012 BioRAP survey.

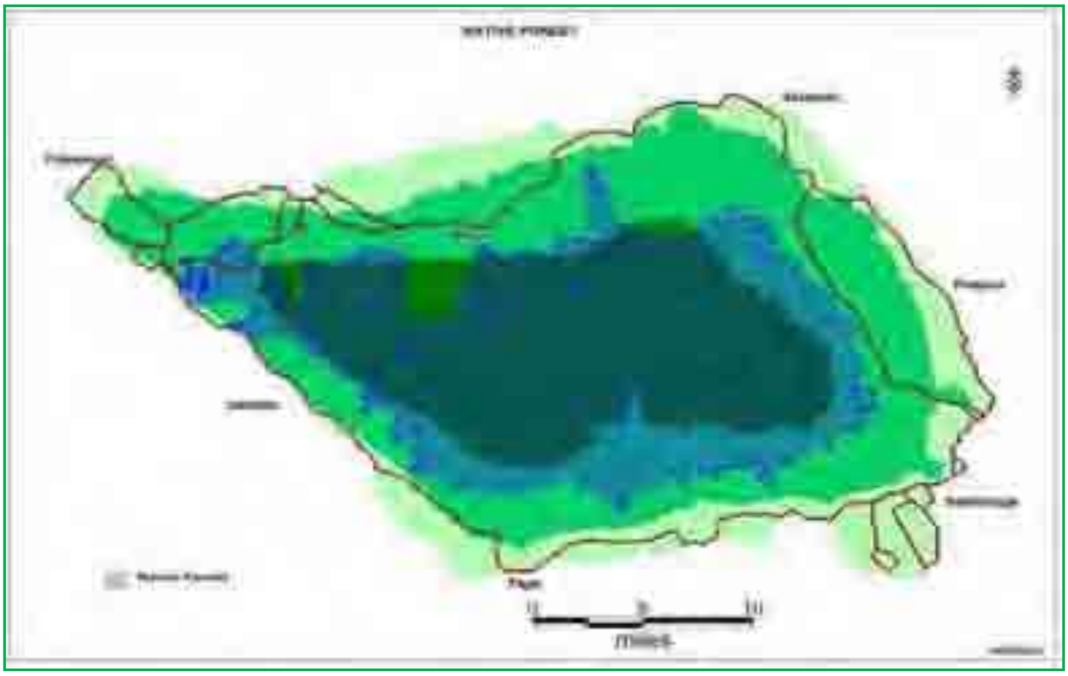
MNRE's forest cover analysis based on 2004 data provided the following breakdown between native and non-native forests on both Upolu and Savaii. It is understood that this area is largely unchanged to date.

Table 7: Upland and Cloud forests in Upolu and Savaii (elevation of 600 m and above)

	Native Forests		Non-native forests		Total forested area		Non-forested areas	TOTAL AREA
	% (a)	ha	% (a)	ha	% (a)	ha	ha	ha
Savaii	91.2	49,038	8.8	4,732	100	53,770	0	53,770
Upolu	0	0	99.0	11,489	99.0	11,489	121	11,610
Samoa	75	49,038	0.23%	16,221	99.8%	65,259	121	65,380

Source: MNRE 2012. Note: (a) = as a percentage of each island's total area

Map 3: Distribution of native forests in Savaii



Source: MNRE (2012)

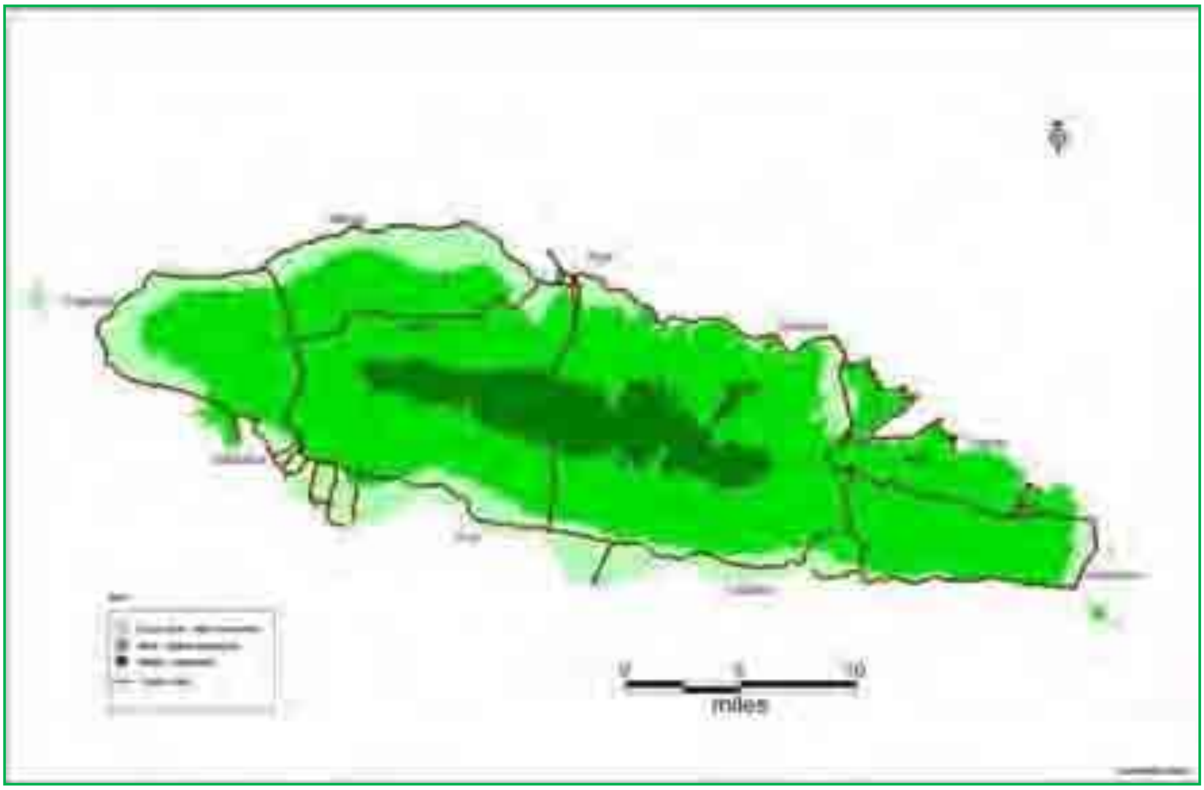
The upland and cloud forests conditions was last described by Schuster et al (op cit), coming not long after Cyclones Ofa and Valerie in the early 1990's, as follows -

"The whole country was heavily damaged by the two recent cyclones, with northern Savaii and Upolu suffering the most damage. At the higher elevations of Savaii, where there is no additional human interference, the forests are recovering. At the lower elevations, such as the foothills and montane forests at Salega, Safune and Gagaifomauga, and Asau, where there has been additional damage due to forest cutting, they are recovering more slowly.

The BIORAP (Biological Rapid Assessment Program) survey conducted by SPREP, Conservation International Pacific Islands Program (CI), MNRE and with technical assistance from its development partners (Critical Ecosystem Partnership Fund/CEPF; Birdlife Pacific partnership, New Zealand Department of Conservation/ DOC;

United States Geological Survey/USGS) in May 2012 provided some key data and observations in particular to the forests and biodiversity of upland Savaii.

Map 4: Distribution of native forests on Upolu



Source: MNRE (2012)

On Upolu, the damage to the montane forests is much more extensive. No montane sites (those above 600m) were found that either have good forests or are clearly on their way to recovery (although Solosolo and Sauniatu had fairly intact lowland forests). This is largely because of direct and indirect human interference. The area of central Upolu between Tafuaupolu and Lepue has been extensively cut in recent years. The vegetation is now largely dominated by several aggressive introduced species that thrive in this disturbed habitat. The worst three of these introduced species are the African rubber tree, Koster's curse, and night-blooming cestrum. The latter species is particularly damaging to the Lepue area" (ibid. p: 9).

Current Status -
Available information from MNRE shows that the upland and cloud forests in Savaii are largely free of human activities including cultivation. There is limited access to the top of Mt Silisili in Savaii and mainly used by visiting tourists and scientists and possibly bird hunters.

The BIORAP survey analysis assessment (2012) was not available at the time for the review, however, the MNRE forest cover analysis in Table 7, is used based on 2004 data. Expert assessment (J.Atherton, 2012) and anecdotal observations, however, suggest that not much has changed in area coverage with losses due to limited logging and clearing compensated for by previously cleared areas reverting back to forests as agricultural activities decreased during the last 20 years. On this basis, the following observations can be made –

1. The combined upland areas of Upolu and Savaii are well vegetated with 99% forest cover assessed; with Savaii fully covered (100% and Upolu having 75% coverage.
2. Most of the upland forests of Savaii (91%) are of native species while the upland forests of Upolu are now virtually all non-native (99%).
3. The Upolu upland forest is, as a result, less diverse in terms of flora and fauna species. This also means it is less ecologically stable.

Like the lowland forests, while there is good area coverage to maintain ecological functions of water storage, soil stability, microclimate variations etc., forest quality in terms of native species richness has degraded, particularly in Upolu. The lack of forest biomass (density) data limits the assessment in terms of forest quality but it is likely that density has decreased in Upolu where non-native species are dominant.

There is no specific information on whether *Merremia* has extended its spread to upland forests but this is highly likely in the non-native Upland forests of Upolu.

6.1.2 Overall Assessment -

Upland and Cloud Forests Health indicators	Low	Medium	High	Very High	Trend	Comment
% of forest area coverage is high			✓		➔	.
forest density/biomass is high					Not known	No information.
% of area under non-native species is low			✓		🡩	High due to 100% coverage of Upolu.
% of area affected by *Merremia* and other vine species is low.		✓			🡩	*Merremia spp* affects about 24% of all forests in Samoa.

The BIORAP survey which was carried out by a team of experts (locals and internationals) provided the following status as noted in the Rapid Assessment of Upland Savaii Report;

Due to the rare ecosystems, the threatened terrestrial species in the upland and its natural values, the upland area above 800 m elevation should be given some form of official protection and for the forests to be managed sustainably in a way that puts conservation as a priority. In addition to conserving the upland forests, emphasis should also be placed on the conservation of adjacent lowland forests, especially for birds and flying foxes which make daily and seasonal movements between the two areas following the flowering and fruiting of different trees. Although the upland area is remote and infrequently visited, the construction of the Mata o le Afi road shows how threats from invasive species, logging and habitat degradation can escalate very rapidly.

The report confirmed five plant communities to exist in the area: montane forest, cloud forest, volcanic scrub, and Carex bog, and perhaps Pandanus swamp forest. Most of the area above 1,000 m elevation is montane forest, followed in total area by cloud forest. From the data and observations, it appears that the vegetation is very healthy and that it has recovered from damage inflicted by two severe cyclones that hit two decades ago (Val and Ofa), and the forest is returning to its "natural" state. Only 17 alien species were recorded in the area, most of them occurring along the bulldozed track. Of these, only Clidemia hirta and Mikania micrantha (fue saina) invade native (secondary) forest as weeds, but were not found above 1,300 m elevation. The montane forest is in very good shape, with the worst threat being unauthorized roads being established in the area.

Montane forest blends into cloud forest, with the main difference being perhaps the dominance of Reynoldsia pleiosperma (vī vao) in the latter. Montane forest probably has the most diverse flora of any community of Samoa. It is home to more species of trees, lianas, ferns, and orchids than any other vegetation type in Samoa.

The cloud forest community is found at the highest elevation on Savai'i. It imperceptibly blends into montane forest at its lower boundary, which, based upon the data and delineation of the vegetation communities during the present study, can be placed at about 1,500 m elevation. During the daytime, the upper slopes of the island are usually cloaked in clouds. The warm, moist trade winds ascend the mountains and cool down, causing the condensation of water into clouds and rain, making the climate of the cloud forest decidedly cool and damp.

The cloud forest is virtually untouched by man because it is too remote, too wet, and too cool to be used by the villagers. The only visitors are the occasional pig hunters.

Key biological findings:

- The geological diversity caused by many episodes of volcanic activity has promoted a rich pattern of biodiversity in the landscape.
- Many plants, birds, insects and snails have an ancient association with the Samoan islands and have their stronghold in Savai'i's montane and cloud forests.
- Many moths and snails documented in this survey are examples that are unique and new to science.
- Invasive plants and insects typically impacting islands elsewhere in the Pacific are mostly not found in the upland forests and measures to limit their spread are possible.
- Wild cats, rats and pigs have penetrated some remote higher altitude areas with impacts on birdlife and native vegetation but natural values still persist and active management could conserve these values.

Based upon the BIORAP field study, several recommendations were noted from the report.

a. Extend the montane Savai'i botanical survey - More botanical surveys and more plots are needed to give a more complete picture of Upland Savai'i.

b. Enforce existing laws - Laws are in place to regulate timber cutting in Samoa. However, logging still occurs on Savai'i despite the absence of logging permits. It is sometimes difficult to reconcile differences of opinion between local land owners and the government, making protection of the native forests problematic. Although laws are on the books, they are often not enforced. The bulldozer road up to Mata o le Afi is illegal and potentially devastating to the area, as it opens up an avenue for the introduction of new weeds to the area. The road is the biggest threat to the integrity of Upland Savai'i.

c. Protection of the whole area - The whole upland area above 800 m elevation or lower should be given official protection. This is a very difficult goal, because the villagers around the island are unaware of how important the area is as a watershed and for its biodiversity. The island of Savai'i has been rated as the 23rd most important island in the South Pacific in terms of its conservation value. The area is remote and infrequently visited, so the biggest threat is the currently existing (but deteriorating) road and future plantation roads. With new roads comes logging and the establishment of temporary plantations, leading to irreparable harm to the environment.

d. Education - The importance of Upland Savai'i for its biodiversity and watershed value should be the focus of an education program in schools and to the public. The MNRE should embark on a programme that highlights the great importance of the upland area of the island.

e. Flora of Samoa - The flora should go along with a biodiversity survey of Samoa's forests because just knowing what plants occur in Samoa is not enough. Their range in Samoa and possibly rarity should also be known.

6.1.3 General Recommendations

1. MNRE should invest in a new aerial photography exercise to update its outdated data sets on forest coverage.

2. Ecological studies and surveys recommended by the recent BioRAP report should be supported.
   - ✓ Conserve the upland and adjacent lowland forests
   - ✓ Raise awareness on and enforce environmental laws
   - ✓ Manage the threat to the upland forests from invasive species
   - ✓ Manage ecotourism to the upland forests sustainably
   - ✓ Improve knowledge of the ecology and biodiversity of the upland forest
   - ✓ Implement management regimes for highly threatened species

3. Avoid and discourage at all cost the construction of access track to the Savaii Upland Forest.

Track road along the Mata o le Afi @ 1520 meters above sea level, Photo from BIORAP Survey

6.2. LOWLAND HABITATS

The lowland habitat includes all terrestrial areas between elevation 60m and 600m, It includes 48% of Savaii (80,930 ha) and 69% of Upolu (73,460 ha) (MNRE, 2012). Combined, the lowland area includes 154,390 ha or 56% of Samoa's total land area.

The state of health of Samoa's lowland zone is examined within the two dominant habitat types namely,
(i) cultivated areas and (ii) lowland forests.

6.2.1. Cultivated areas

The impact of cultivation on the environment varies widely based on the types of agricultural practices used. Agriculture in Samoa continues to evolve from purely subsistence to semi subsistence and commercialization, due to the demands on a growing population, the continuing shift to a cash-based economy, and technologies. The current Strategy for the Development of Samoa (SDS) 2012-2016 and the Agriculture Sector Plan (ASP) 2012-2016 clearly sets out goals and strategies for the re-invigoration of the agricultural sector both for local food security and for exports. Scaling up from subsistence to semi-commercial and larger scale production, with increased mechanisation and use of modern technologies clearly envisions the transformation of all cultivable lands to crops. Efforts to promote mechanisation are already underway with MAFF hiring out excavators to assist farmers clear rocks and other debris that hinder the use of machines.

The risk of adverse impacts of agriculture on the environment is well recognized and both the SDS and ASP call for appropriate mitigation measures to ensure environmental sustainability.

The main environmental impacts from cultivation are (i) the threats to sensitive environments including habitats of high conservation value and catchment areas; (ii) excessive use of inorganic fertilizers and chemicals, (iii) the loss of ecological stability as a result of large scale mono cropping. There are implications for climate change and greenhouse gas emissions of increases in land conversion and increase in livestock populations. Similarly there are adverse impacts on coastal environments and underground water sources of the free-roaming approach to the management of domestic pigs.

Current Status -

The Agriculture Census 2009 reported a total area under cultivation of 92,310 acres representing 13% of Samoa's total land area of 2,841 km^2 (MAF, 2012). FAO (2004) provided this distribution (Refer to Table 8) by various cropping types and land uses.

Table 8: Land Use Distribution

	%	ha	Comments
Plantation crops (sole)	18.6	53,000	
Mixed cropping	3.6	10,000	
Grasslands	6.2	17,500	
Forests	68.0	192,000	
Others	3.2	10,800	Includes urban areas

Source: FAO cited by MAF 2012[32]

There is however no disaggregated data by habitat types used in this SOE. As a result, it is not possible to determine the impacts of cultivation activities on different habitats.

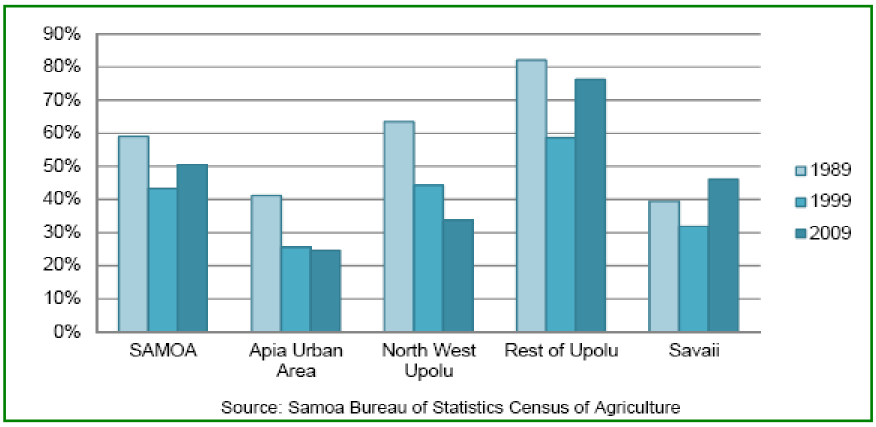
Are current cultivation practises environmentally sustainable? The lack of data limits the scope of investigation possible, but a partial answer to this question may be discerned by examining the following indicators –

a. the extent to which cultivation uses inorganic fertilizers and agricultural chemicals
b. the relative area coverage between more ecologically stable mixed cropping systems and mono-cropping arrangements, and
c. the amount of cultivation on erosion prone lands including steep slopes and catchment areas;
d. the types of cultivation and farming methods used.

According to MAF & SBS (2012), the use of organic fertilizers consistently increased throughout all regions of Samoa between 1999 and 2009, increasing from 15% of all holdings to 29%. Prior to that, there was little change between 1989 and 1999 for Savaii, but Upolu showed some fluctuations dropping to 13% in 1989 before increasing to 24% of holdings.

[32] *Ministry of Agriculture (MAF) and Samoa Bureau of Statistics. 2012. Agricultural Census Analytical Report 2009. Economic Statistics Division, SBS.*

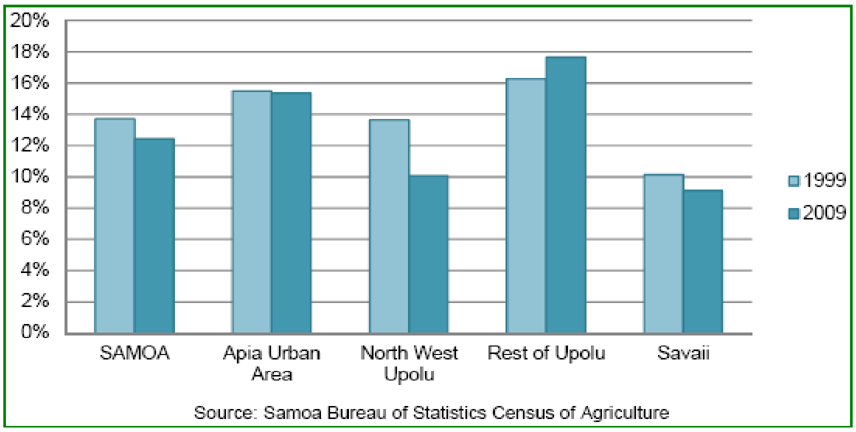
Graph 2: Use of Organic fertilizers (compost)



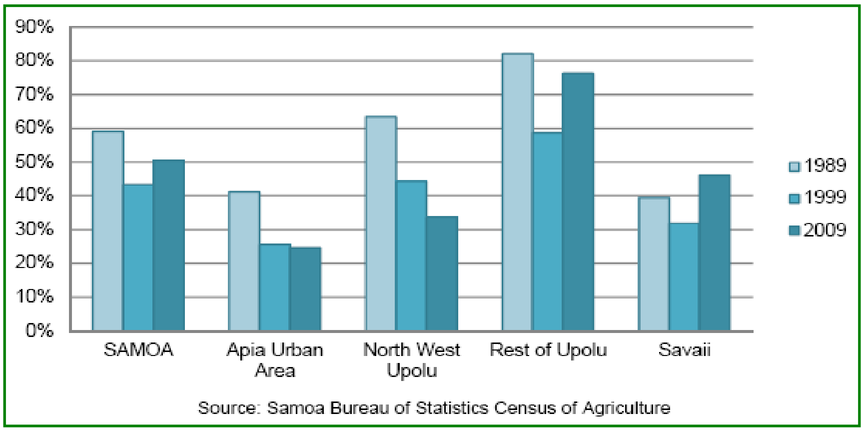
The overall level of organic fertilizer use in Samoan agriculture in 2009 is around 50% of all farm holdings, having decreased from around 59% in 1989 to around 42% in 1999. Northeast and Southern Upolu (Rest of Upolu) appears to have the highest use of organic fertilizer use with over 75% of all holdings using compost, slightly down from over 80% in 1989.

Of inorganic fertilizers, their use has generally declined in the last 10 years. This is depicted in Graph 3 below.

Graph 3: Percentage of farm holdings using inorganic fertilizers



Graph 4: Proportion of farm holdings using agricultural chemicals



The fluctuations in the use of agricultural chemicals over the last thirty years appear to correlate to the ups and downs in commercial taro production, before and after the Taro Leaf Blight. It is possible that the increase in 2009 will continue with the present sector emphasis on reviving agriculture.

It is difficult to assess the environmental impacts of agro-chemical use except for specific locations and uses. On a general scale, the total volume of agro-chemicals imported is relatively limited. (refer to Table 9 below).

Sector plans now being mobilized to reinvigorate the agricultural sector is likely to also lead to a significant increase in the use of agro-chemicals. This concern is well recognized in the Agriculture Sector Plan 2011-2015 which calls for the use of environmentally friendly production and farming systems especially within watershed areas from affecting water supplies. The larger issue here is the need for an integrated land use plan wherein all legitimate land uses are taken into consideration, to ensure the legitimate needs for agriculture, water resources management, biodiversity conservation and many others are properly coordinated and integrated.

Table 9: Chemical Categories by Use, 2009

Chemical Category	Production	Volume (kilolitres*/tonnes)	Estimated value (ST)	% of total cost
Petroleum	None	88,580 k/litres	117M	82%
Consumer	None	1,640 tonnes	10M	6%
Pharmaceuticals	None	Unknown	7M	5%
Industrial	None	800 tonnes	7M	5%
Pesticides	None	50 tonnes	2M	2%
Fertilizers	None	50 tonnes	100,000	<0.1%
Other Chemicals	None	Unknown	60,000	<0.1%

Table 10: Types of agricultural chemicals used

	Herbicides			Insecticides	Fungicides
	Total	Sting	Gramoxone/ Paraquat	Total	Total
SAMOA	50%	13%	30%	0.9%	0.4%
Upolu	52%	13%	31%	1.1%	0.4%
Apia Urban Area	22%	11%	9%	2.8%	1.8%
North West Upolu	33%	12%	18%	1.3%	0.1%
Rest of Upolu	76%	14%	48%	0.6%	0.4%
Savaii	46%	12%	29%	0.4%	0.3%

Source: Samoa Bureau of Statistics Census of Agriculture

Assessment of Cultivated Areas

Cultivated Areas Health indicators	Low	Medium	High	Trend	Comment
% of agricultural holdings using organic fertilizers		✓		↑	
% of agricultural holdings inorganic fertilizers		✓		No information	Trend likely to increase with expected expansion of cultivated area
% of holdings of mixed cropping		✓		No information	
% increase in volume of pesticides and fertilizers used	✓			→	Trend likely to increase with current efforts to re-invigorate the agricultural sector.
% increase in cultivations on catchment areas				?	No information available.
% increase in cultivation in sensitive ecosystems and protected areas				?	No information available.

6.2.2. Lowland forests

Available data for Samoa's forests is dated to 2004. No recent data has been generated since. However expert opinion (J. Atherton, 2012) is that very little has changed in terms of the total forest area coverage. This observation is consistent with trends in three main factors that were influential in shaping the remaining forests of Samoa, (i) the decrease in the total area of land under cultivation since 1989[33]; (ii) the end of large scale commercial forest logging and (iii) the absence of any cyclones since Cyclone Heta in 2004.

Logging, agricultural clearing residential clearing, relocation due to tsunami, rising sea level and cyclones caused extensive damage and fragmentation to the once dense native forests, opening up the undergrowth to sunlight and creating conditions that favour, and were taken advantage of, by wind dispersed, light demanding and fast growing pioneer species, most of them non-native and invasive. Most prolific and common among these invaders are tamaligi spp (*Albizzia falcataria and Albizia chinensis*), Pulu vao (*Funtumia elastica*), Pulu mamoe (*Castilla elastica*), fa'apasi (*Spathodea campanulate*), and a host of others. The same open conditions are also conducive to the spread of highly invasive vines notably fue lautetele (*Merremia peltata*) and fue saina (*Mikania micrantha*). These species quickly outnumber remnant native trees, dominating the canopy layer and the undergrowth. And while the process of ecological succession will eventually result in the replacement of short term pioneers by long term shade tolerant species, mostly natives, this is not guaranteed if more cyclones breaks this cycle before it has climaxed, returning it to the open spaces and in the process, perpetuating the dominance of light demanding pioneers.

This phenomenon is presently being played out in Samoa's remaining forests in all areas including lowlands. So much so, latest analyses now categorize the entire lowland forests as 'non-native'. This categorisation means while there are native species present, it is now largely dominated by non-native species. MNRE[34] analysed forests by forest types and came up with the following results -

Table 11: Lowland forest cover in Upolu and Savaii (60 – 600m elevation)

Lowland forest cover in Upolu and Savaii (60 – 600m elevation)

	Native Forests		Non-native forests		Total forested area		Non-forested areas	TOTAL AREA
	% (a)	ha	% (a)	ha	% (a)	ha	ha	ha
Savaii	0.08	146	48	80,784	48.08	80,930	0	80,930
Upolu	0	0	69	73,460	69.0	73,460	200	73,660
Samoa		146		154,190		154,190	200	154,390

The main change therefore in the character of Samoa's remaining lowland forests is its composition. From a biodiversity conservation perspective, the new non-native dominated forests are of low quality. The old stands of secondary forests were relatively stable because of its multilayered structure hosting complex interdependent and

[33] *From 166,485 acres in 1989 to 92,310 acres in 2009 (SBS, cited by MAFs Agricultural Census Report 2009.*
[34] *New maps of forest cover based on 2004 data.*

symbiotic interrelationships between flora and fauna species, which diversity ensured ecological stability. Such include native birds that depend on specific fruit trees for food and epiphytes that live off large dominant canopy species, fruit trees that depend on specific bird species for seed processing and dispersal, sometimes ferns that found niches in the shady but cool understorey and many others.

The lowlands of both Savaii and Upolu now comprise of only 0.08% and 0% of native forests respectively. In terms of the whole country, 54% of Samoa's lowlands are forested albeit with non-native trees. Compounding the degradation of lowland forests, the recent BioRAP survey estimates that "…perhaps 50% of the remaining lowland native forest is dominated by *Merremia* vines (fue lautetele)." The prolific nature of *Merremia* suggests that this is a worsening problem, with expansion into more forests to be expected.

There is no data relating to biomass but in general, young secondary forests of non-native species now dominating lowland areas are less diverse and less dense, therefore of lesser biomass than the old secondary forests they replaced.

Assessment Lowland Forests Health indicators	Low	Medium	High	Trend	Comment
% of lowland habitats under forest cover			✓	→	54% total for Samoa; 48% Savaii; 69% Upolu.
% of lowland forests dominated by non-native species				↑	About 100% of both Upolu and Savaii lowland areas are of non-natives.
% of area affected by Merremia and other vine species.		✓		↑	*Merremia spp* affectes about 24% of all forests in Samoa.
% of native bird species present				No information	

6.2.3. Overall assessment of Lowland Habitats

The two main habitats assessed in the lowland region namely cultivated areas and lowland forests can only be assessed qualitatively given the lack of scientific data.

Current cultivation practices are relatively sustainable. They are irrigation-free, have a relatively high usage of organic fertilizers and are generally low impact due to their small scale holdings and the use of traditional and simple tools including machetes and chainsaw for land clearing. Being irrigation-free, there is no dependent on underground or surface water sources that normally put stress on underground aquifers and rivers. The traditional cropping system wherein trees and crops are mixed in a traditional form of permaculture or agroforestry design is ecologically more stable.

The volume and types of imported agricultural chemicals are properly regulated. This is not likely to pose issues except where they are used excessively in sensitive ecosystems or near rivers and streams. These concerns are recognized and taken on board in the current Agriculture Sector Plan.

The spread of cultivation areas is a concern, particularly where it threatens sensitive environments including catchment areas, erosion-prone areas and areas earmarked by KBAs for conservation. It calls for proper coordination between sectors but it's a complex issue where customary land tenure interests are involved.

Lowland forests are widespread. There is high area coverage but the quality of non-native dominated forests is low in biodiversity conservation terms. Species richness and diversity will decline as non-native species become more dominant. Biomass is likely to be lower in these non-native dominated forests although there is no quantitative data to support that observation. The spread of *Merremia spp* and other invasive vines is a serious concern from an ecosystem health and biodiversity conservation perspective. They are difficult and costly to contain, and will therefore most likely to continue to expand in the foreseeable future.

6.2.4. General Recommendations

1. Close coordination and collaboration with MAF is needed to ensure planned expansion in agriculture does not impact negatively on sensitive habitats including catchment areas, riparian strips, steep slopes prone to erosion and slips and areas earmarked for biodiversity conservation.

2. Mixed cropping systems should be encouraged in the place of large scale monocultures as agriculture seeks to expand into larger holdings and mechanised agriculture for increased production.

3. Data gathering is needed including mapping data to enable future assessment of the environmental impacts of agriculture on the environment.

4. Replanting of native species of trees should be encourage nation-wide to stem the increasing spread and dominance of non-native trees in Samoa's forests.

5. Effort should be made to contain the spread of invasive vines especially Merremia peltata. These measures should also be incorporated into management plans for national parks, KBAs and catchment areas.

National replanting events at the Togitogiga National Park with schools, 2009/ Photo by MNRE

Widespread of the Merremia vine in the lowlands

6.3. COASTAL HABITATS

Samoa's coastal environment is defined in this SOE are "all areas from the high water mark to 60 meters in elevation including mangroves, marshes and coastal strand vegetation." It encompasses the coastal and nearshore ecosystems that are significant in terms of resources that Samoa depends on for their livelihood, recreation and for tourism development. These ecosystems are the most heavily impacted and are the most susceptible to changes by natural and human activities (McLean 1991 cited by SPREP 1994)[35].

The following ecosystems and habitats are examined and assessed –

- Mangroves and wetlands
- Coastal Strand Vegetation
- Coastal marshes
- Beaches
- Cultivated areas and
- Forests

6.3.1. Mangroves

Mangroves are unique ecosystems that live halfway between the land and the sea. There are over 80 known species worldwide, of which three are found in Samoa. These are *Rhizophora samoensis* (Red mangrove), *Bruguiera gymnorrhiza* (Oriental mangrove) and *Xylocarpus moluccensis (grantum).* The latter is extremely rare and is found in only one location (2 acres in size) in Siutu Salailua in Savaii.

The total area of mangroves has been variously estimated – Zann (1991)[36] estimated 1,250 ha and Bell (1985)[37] 1,000 ha. Its distribution is confined mainly to Upolu and Savaii, often along sheltered coastlines where sediments deposit, such as river estuaries.

Despite the relatively small area covered by mangroves, the Vaiusu Mangal near Apia is considered the largest mangrove area in Eastern Polynesia. The Vaiusu Bay and Saanapu-Sataoa mangrove stands are the two main mangrove stands in Samoa, with a number of other stands scattered throughout the two main Islands.

Mangroves form a very productive ecosystem playing an important ecological role as nursery grounds and as a physical habitat for a wide variety of vertebrates and invertebrates. In addition, they recycle nutrients, and maintain the nutrient mass balance of estuarine ecosystems. Mangrove leaves, wood, roots, and detritus material provide essential food chain resources and habitat to a wide variety of wildlife. They also serve as storm buffers, and their roots stabilize shorelines and filter sediments from rivers, enhancing water clarity.

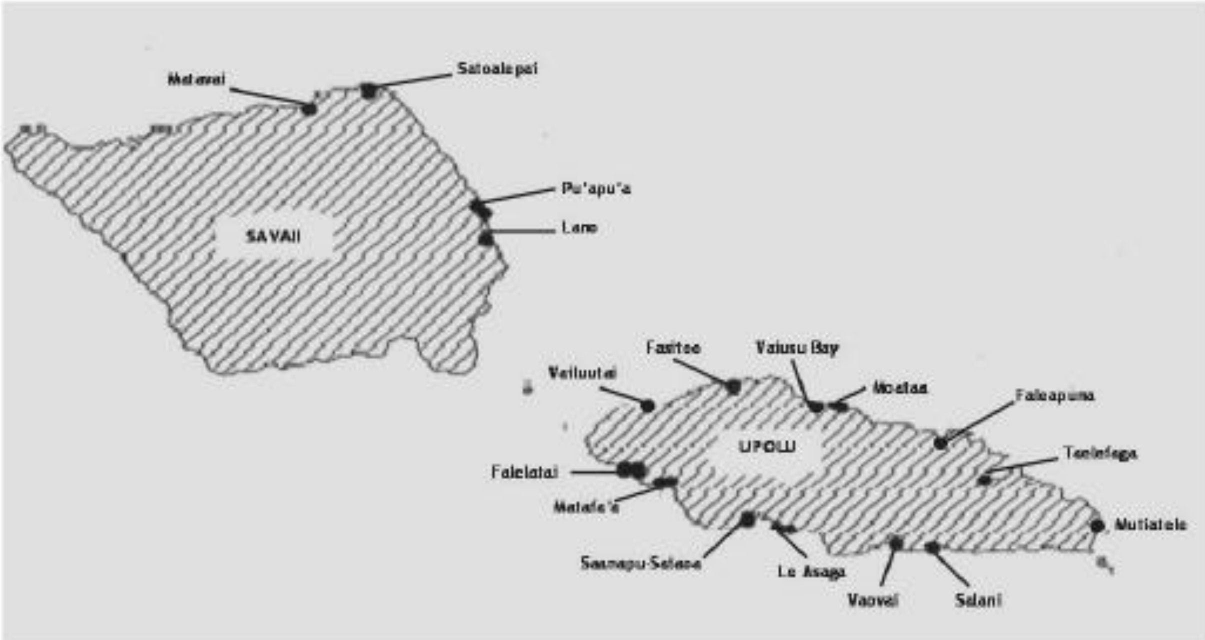
Significantly, mangrove areas provide shelter for many marine fauna species including a diversity of fish species, crabs, shellfish, seabirds and others, and nursery grounds for important fish species such as eels, mullets and trevallies. These species breed and spend most of their juvenile life stages in the safety of the mangrove root systems. Here they are provided with food and protected from the big predators, moving back into the seas only when they mature. Other animals include shrimps, prawns, mangrove crabs and certain bivalve species which live in the muddy areas, while oysters grow up the mangrove roots. Several bird species known to utilise mangrove habitats include the Pacific Reef Heron, and Golden Plover.

Photo 1: The tallest remaining Bruguiera trees in the Matafa'a mangrove forest. Source: Mataese & Saifaleupolu (2011). Photo by © Fiu Mata'ese Elisara, OLSSI.

[35] *SPREP. 1994. Assessment of coastal vulnerability and resilience to sea-level rise and climate change: case study-Yasawa Islands, Phase II. South Pacific Regional Environment Programme, Apia.*

[36] *Cited by Lopeti, E and T.Foliga. undated. Samoa Country Report. MNRE/MAF-Fisheries. Unpublished report.*
[37] *Iakopo. M. 2006. Mangroves of Samoa: Status and Conservation. Ministry of Natural Resources, Environment and Meteorology, Samoa. 40pp.*

Map 5: Distribution of mangrove forests in Samoa



Source: M. Iakopo. 2006.

Current State

Assessments of Samoa's mangrove forests are in progress under the MESCAL project. Under this project, a number of new mangrove areas previously unreported have been found (M. Momoemausu, pers com, 2012) and in some areas, existing stands have expanded with young seedlings colonizing surrounding areas including seawalls (ibid.). As a result, the existing mangrove areas is estimated to be larger than previously estimated by Zann (10,250ha; op it) and Bell's (10,000; op cit), even taking into account losses due to anthropogenic activities.

Elisara and Saifaleupolu (2011[38]) conducted a biodiversity audit of five mangrove areas[39] and reported some areas in better condition (e.g. Faleseela-Matafa'a) than others (Taelefaga and Tiavea). The main threats identified in this report are summarized in Table 12 below.

Table 12: Mangrove Crabs and Threats

Main Threats	Mangrove areas assessed			
	Matafa'a-Faleseela	Taelefaga	Tiavea-tai	Siutu-Salailua
Wood harvesting	✓	✓		
Invasive species				
Agriculture	✓	✓		
Grazing		✓		
Dwellings		✓		
Infrastructure		✓		
Natural disasters		✓	✓	
Coastal surges/ Climate Change	✓			✓

Source: Based on Saifaleupolu and Elisara (2011) op cit.

The only known stand of *Xylocarpus moluccensis* (Schuster, 1993) - located in Siutu Salailua - remains in a healthy state with no sign of threats from human activities (Elisara et al, 2011). But there are natural changes to its habitat with areas previously described to be dried swamp now observed to be inundated and under seawater (Elisara and Saifaleupolu, op cit). Whether or not these changes are seasonal, or detrimental to the health of

[38] *Saifaleupolu, T.S. and Elisara, FM. 2011. Biodiversity Audits for the Mangrove Stands in Matafaa-Faleseela, Tiavea-tai and Taelefaga Villages. Unpubl. OLSSInc.*
[39] *Tiavea-tai, Matafa'a, Faleseela, Taelefaga and Siutu-Salailua.*

X.moluccensis remain to be seen. An area of 2.0 acres remains, which is slightly less than the 2.5 acres reported in 1993 by Schuster (op cit).

The likely increase in the total area under mangrove (Momoemausu, pers com) is good news, however, the fact remains that mangrove forests are continually lost (MNRE, 2006), as a result of number of factors including land reclamation, waste disposal and harvesting for firewood and building materials.

Overall, from a species conservation perspective, *Rhyzophora* and *Bruguiera spp* have healthy viable populations based on existing reports of biomass and coverage. Their greater value however is the critical role they plays in the lifecycles of many marine and estuarine species, and the protection function it provides for fragile coastal ecosystems against wave surges, winds and erosive currents.

The severely limited biomass and population of *X.moluccensis* is a matter of serious conservation concern.

Assessment of habitat health

Habitat health indicators	Low	Medium	High	Trend	Comment
% of area coverage remaining			✓	↓	
No. of viable populations of native species remaining		✓		→	*Rhysophora* and *Bruguiera* are well represented but *X. moluccensis* is critically threatened.
Species health indicators	Low	Medium	High	Trend	Comment
Species abundance - % of area coverage remaining					
Rhizophorasamoensis		✓		↓	Probably declining in total area coverage but no immediate threat of depletion and extinction.
Bruguiera gymnorrhiza –		✓		↓	Probably declining in total area coverage but no immediate threat of depletion and extinction.
Xylocarpus molluccensis -	✓			↓	Critically threatened and in need of urgent conservation action.
Species richness – no. of viable populations remaining					
Rhizophora samoensis		✓		↓	
Bruguiera gymnorrhiza –		✓		↓	
Xylocarpus molluccensis -	✓			↓	Only one small community surviving in Savaii. Critically threatened.

6.3.2 Coastal forests and strand vegetation

Samoa has 403 km of coastline (Goven, 2009). The ecology of this coastline consists of a range of coastal plant communities including herbaceous strands, littoral shrubland, pandanus strand, mangrove forests and littoral forests (Whistler, 1992)[40]. Plant communities within this area are low in species diversity because not many can tolerate the harsh conditions of high winds, battering salt spray, and extreme high temperatures in the summer. Plants must also be adapted to sandy saline soils, with extremely low nutrient loads, and low water holding

[40] *Whistler, A. 1992. Flowers of the Pacific Islands Seashore: A guide to the littoral plants of Hawaii, Tahiti, Samoa, Tonga, Cook Islands, Fiji and Micronesia. Univ of Hawaii Press. Hawaii, USA.*

capacity[41]. The full range of species of plants in Samoa's coastal area is described and listed by Whistler (1992), with the diversity of species of various types of vegetation given in Appendix 9.

Table13: Diversity of Coral Species in Samoa

	Type of vegetation	No. of species in Polynesia[42] & Micronesian	No. of species in Samoa
1	Trees	29	24
2	Shrubs	28	15
3	Herbs	37	14
4	Vines	16	12
5	Grasses & sedges	10	7

Source: A.Whistler (1992)

Whistler (ibid) noted that much of these types of communities have been lost or degraded, with the best remaining examples being at Aleipata Islands, O le Pupū Puē and sites on the south (central) coast of Savaii[43].

In general, over 80% of Samoa's coastline is highly impacted and modified by human population and settlements. Most remaining vegetation are either domestic trees and crops of some social or economic value, (e.g. coconut, breadfruits, bananas, coconuts etc), or trees that are spared for coastal protection purposes including pulu (*Ficus spp*), talie (*Terminalia spp*), fau (*Hibiscus spp)* or littoral species adapted to coastal salt water sprays that have naturally regenerated and got established in open unused areas.

Forest cover analysis by MNRE (2012) show the following percentages of vegetation cover in the coastal zone by native and non-native species.

Table 14: Coastal habitats forest cover in Upolu and Savaii (0-60m elevation)

	Native Forests		Non-native forests		Total forested area		Non-forested areas	Total Area (ha)
Savaii	0.0 %	0 ha	20%	34,596 ha	20 %	34,596 ha	1,804 ha	36,400
Upolu	0%	0 ha	20%	22,086 ha	20%	22,086 ha	5,644 ha	27,730
Samoa	0%	0 ha	20%	56,682 ha	20%	56,682 ha	7,448 ha	64,130

Source: MNRE, 2012

An important addition to the coastal zone vegetation is the Government's One Million Tree initiative for climate change mitigation. Maps show that over 60% of tree planting under this program were within the coastal zone. (Refer to maps in Appendices 3 and 4).

Current Status

There is no recent update of the status of unique littoral plant communities identified by Whistler (op cit) including those communities within the Le Pupu Puē National Park and the Aleipata MPA. The new plantings under the One Million Tree Program are a mix of natives and non-native species, and predominantly of timber quality. These are planted mostly in association with existing infrastructure including seawalls, and coastal roads.

Assessment

Coastal forests/strand health indicators	Low	Medium	High	Trend	Comment
% of area under forest cover	✓			?	Currently under protection and conservation management.
% of area under protection				?	No information.
% of known native coastal species					No information.

[41] *En.wikipedia.org/wiki/Coastal_Strand*

[42] *The Polynesian countries this referred to are Hawaii, French Polynesia, Cook Islands, Samoa, Tonga and Fiji*

[43] *Whistler, A. 1992. National Biodiversity Review of Western Samoa. Unpublished Report for SPREP Apia, Western Samoa. 1992.*

6.3.3. Coastal Marshes

Samoa's documented coastal marshes consists of the following –

Table 15: Coastal Marshes in Samoa

	Name and Location	Description
1	Falealili Marsh, Upolu	A series of small herbaceous marshes on the south coast of Upolu, degraded by human impact. The small marsh at Malaemalu was identified as a priority site for conservation by Pearsall and Whistler (1991), but this site is now very degraded and is no longer considered to be a priority.
2	Apolimafou Marsh, Upolu	A small herbaceous marsh at the west end of Upolu, the least disturbed of any coastal marsh in Western Samoa.
3	Pu'apu'a Marsh, Savai'i	A small marsh near the east end of Savai'i, degraded by human settlement and not considered to be a priority area for protection.
4	Faga Marsh, Savai'i	A small marsh near the east end of Savai'i, degraded by human settlement and not considered to be a priority area for protection.
5	Falealupo Marshes (Cape Mulinu'u), Savai'i	Two areas of coastal marsh at the extreme western end of Savai'i, degraded by past exploitation and human settlement, and severely damaged by Hurricane Ofa in 1990. The preservation of the village forest under a covenant agreement has in the last few years increased awareness of the conservation importance of this area. The southern marsh (Tofutafoe) was recommended for designation as a Nature Reserve by Holloway and Floyd (1975), and identified as a priority site for conservation by Pearsall and Whistler (1991).
6	Sato'alepai Marsh, Savai'i	A large degraded marsh near Matautu Bay at the northern tip of Savai'i. The cyclones of 1990 and 1991 opened up an outlet to the sea, and sea water now flows freely into the marsh.

Source: MNRE 2012

Current Status

There is no recent data for updating the respective status of the listed marshes.

Assessment of habitat health

Monitoring is urgently needed to update the conservation status of Samoa's marshes. Anecdotal reports indicate that the Apolima-fou marsh is critically threatened by coastal reclamation and other local community activities.

Coastal marshes health indicators	Poor	Medium	Good	Very Good	Trend	Comment
% of area under protection					Unknown	

6.3.4. Beaches

Most of the beaches in Samoa are formed by coral particles broken up by storms or passed through the guts of coral-eating fish, such as parrotfish, and washed ashore by waves and currents. Some beaches are also formed by particles carried from inland by rivers. Beaches prevent waves eroding and washing away the shore and are homes for some eatable bivalve species as well as other species the shells of which are used to make traditional necklaces and other handicrafts.

Beaches are also a major attraction for tourists. Consequently activities such as sand mining can also be quite ruinous to beach aesthetics and therefore tourism. Conversely, tourism developments on or in close proximity to beaches including fale constructions and land reclamation, are putting stress not only on beaches but also the coastal environment that receives wastewater discharges and other pollutants.

Current status

There is no information on beaches as habitats other than the few that are nesting sites for hawksbill turtles within the Aleipata MPA. Information on sand resources is also limited.

The main interest in beaches is as a source of sand for construction purposes, and for tourism and recreational purposes. MNRE regulates the mining of sand through a licensing system that is supported by environmental/resource assessment. But the limited information makes sustainable management impossible.
The enforcement of permit conditions by the Ministry is difficult due to limited capacity and resources but also due to the customary ownership nature of land, which in the view of communities, extend to beaches even if they are below the high water mark. Not surprisingly, anecdotal information suggests that exploitation is higher than the level of extraction formally approved and reported.

Table 16: Sand mining permits and volumes 2008 - 2011

	2008 - 2009		2009 - 2010		2010 - 2011	
	# of permits	Vol (m3)	# of permits	Vol (m3)	# of permits	Vol (m3)
Commercial	19	7,630	13	2,055	16	1,665
Individuals	51	n.a.	53	732	49	517
TOTAL	70	7,630	66	2,787	65	2,183

Source: Based on data from MNRE (2012)[44]

The information collected on the number of permits and volumes approved (Table 16) for mining have little value for sustainable management in the absence of data on total available sand budgets and information on sand migration patterns for different locations.

Of seawalls, 27.0 km of seawalls were constructed during the period 2008 – 2010, with approval from MNRE. A further 3.0 km is planned for Upolu, while about 67 requests for seawall/riverwall are being reviewed by the Ministry. There are reports of coastal erosion and scouring of coastlines that are threatening seawalls themselves. This indicates poor designing of seawalls and or that seawalls may not have been the best option for coastal protection for some locations.

The impact of mining and seawall construction on beaches is important from a coastal protection point of view. Excessive mining of sand especially in already vulnerable beaches compound erosion and scouring and can lead to the loss of protection of coastal assets and infrastructure from wave surges and tsunamis. According to MNRE[45], this is already observed in villages that have unsustainable sand mining activities on their beaches. Worse still, adverse transboundary impacts are reported triggered by or compounded by sand mining in neighbouring villages (ibid.). A coastal study to determine and confirm the speculated effects of seawall structures on the natural beach sand movement and sedimentation process, is in the pipeline (ibid.).

Assessment of habitat health

Beach habitat health indicators	Low	Medium	High	Trend	Comment
Vol. of mined sand		✓		↑	Mining is likely to be higher than reported.
No. of mined beaches				No information	No. of beaches not known.

6.3.5. Overall Assessment of the Coastal Habitats

The coastal habitats assessed consist of mangroves, marshes, coastal strands and beaches. Except mangroves, there are significant gaps in our knowledge of the state of marshes, coastal strands and beaches. This is an important area for information gathering for future assessment.

Based on what is known, mangrove habitats are relatively healthy with the two main species (*Rhizophora mangle* and *Bruguiera gymnorrhiza*) well represented by intact and viable communities throughout Samoa. Work currently carried out by MESCAL point to new mangrove areas being identified that were not previously documented. A number of replanting initiatives by local communities and MNRE is adding to the total mangrove biomass. Having said this, Saifaleupolu and Elisara (2012)[46] observed continuing harvesting by locals for firewood and for local house constructions in some mangrove areas, which is consistent with anecdotal and informal reports.

The only stand of *Xylocarpus molluccensis* still found in Samoa is an urgent priority for protection. MNRE is strongly urged to take direct restoration measures including the option of establishing a second population elsewhere.

Coastal marshes need reassessment to ascertain their conservation status and to inform conservation planning.

Beaches are generally valued for the sand resource it provides but are also important as habitat for some high priority conservation species i.e. hawksbill turtles. The level of extraction is under Government management through MNRE's licensing system but, in the absence of data on sand budgets and in-house expertise in coastal processes, sustainable management is ineffective. Consequently the overall status of our beaches is unknown.

[44] *Faainoino Laulala, MNRE, pers comm.. 2012.*
[45] *Moira, MNRE, pers comm.. 2013.*
[46] *Op cit*

6.3.6 General Recommendations

1. Sand mining from coastal beaches need to be more stringently monitored for their wider impacts on nearby coastlines and neighbouring beaches.

2. Research on sand migration and sand budget and accompanying coastal processes is needed to assist MNRE is managing its sand licensing and coastal reclamation activities.

3. An assessment of Samoa's coastal marshes is long overdue with several that are of high conservation value and of regional significance to be given priority.

4. The only stand of *Xylocarpus molluccensis* found in Siutu Salailua should be an urgent priority for protection. MNRE should implement restoration measures for the existing stand and should also at establishing other *X.molluccensis* populations in other sites.

5. Soft solutions such as coastal replanting using appropriate tree species should be encouraged in the place of seawalls for some coastal locations.

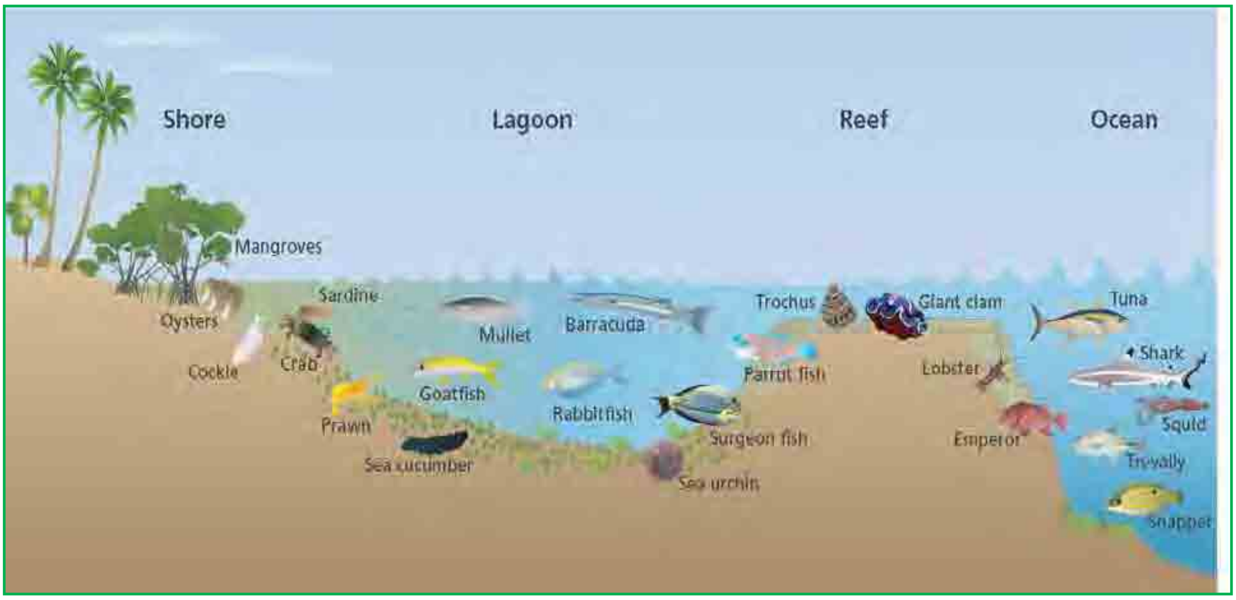
Sand minig at Solosolo/ photo by MNRE, March 2013

Tafitoala coast, Post-cyclone Evan Jan 2013

6.4 INSHORE and OFFSHORE MARINE HABITATS

Samoa's marine environment extends from the high water mark to the boundary of its EEZ and including the inshore area, coral reefs, seagrass beds, lagoons and other deep sea habitats such as sea mounts, etc.. Exception to this definition is mangroves and beaches which are zoned under 'coastal environment' in this SoE. Off shore environment extends from the reef outwards.

Figure 6: A typical profile of Samoa's marine/offshore habitats showing distribution of fish and other marine species



Source: Graphics by Tracey Saxby (Univ Maryland, 2012) based on King and King, 1995

6.4.1. Corals and Coral Reefs

Coral reefs are the most complex, diverse, species-rich as well as highly productive biological systems in the world. They provide habitats to one-third of all marine fish species and tens of thousands of other species. Although Samoa is not as well endowed with coral reefs compared to other Pacific Islands (MNRE, 2006), they provide ecological services that are extremely important to Samoa's marine biodiversity, economy, food security and coastal protection.

A total reef area of 10,000km^2 to a depth of 50metres (Samuelu-Ah Leong et al, 2008[47]) is estimated for Samoa. The general distribution of Samoa's coral reefs are illustrated in Map 6.

According to Zann (1991) [48] , the reefs have shown all stages of reef evolution: recent lava flows with only a veneer of corals, young, incipient fringing reefs growing on older lava flows; mature, wide and well-developed fringing reefs; young barrier reefs with relatively deep lagoons; mature barrier reefs with infilled lagoons; offshore ancient drowned barrier reefs; and platform or patch reefs. Zann (ibid.) also estimated reef age to range from a few centuries old to over 10,000 years.

The largest reef in Samoa is on the north-west Upolu from Apia to Manono Island. Savaii has a relatively small area (about 52 km^2) of coral reefs, surrounding the island. Off the lava coasts, there is an additional 10-15 km^2 of rocky shelf, which supports some coral growth. Reefs are best developed from Salelologa to Puapua in the east; Saleaula to Manase in the north; Asau to Sataua in the west and Satupaitea in the south east. Savaii's reefs are mainly fringing reefs with reef flats or shallow lagoons.

[47] *Samuelu-Ah Leong, Joyce and Sapatu, Maria. 2008. Status of Reefs in Samoa 2007. In: Whippy-Morris (ed.). 2009. South-West Pacific Status of Coral Reefs Report 2007. Coral Reefs Initiative for the Pacific. SPREP, USP, GCRMN and ReefBase Pacific. SPREP, Apia.*

[48] *Zann, L. P. (1991). The inshore resources of Upolu, Western Samoa: coastal inventory and fisheries database. Report prepared for the Government of Western Samoa. FAO/UNDP SAM/89/002 Field Report. Unpubl.*

Map 6: Distribution of coral reefs in Samoa

Source: MNRE Mapping Section, 2012

During the early 1990s, the status of the coral reefs ranged from highly degraded to very good (Norseman and Mulipola, 1995) [49] . However, population of fish and invertebrates on reef surveyed had been reduced by heavy fishing and collecting, indicating that no area had been unaffected by human activities. The two consecutive cyclones, Ofa and Valerie had impacted considerably on Savaii's coral reefs (Zann and Bell, 1991). Massive damages and destruction occurred to all reefs as rubble sediments were piled on the reef forming cyclone banks. Moreover, outbreaks of crown-of-thorn starfish (alamea) have seriously affected reefs on Savaii during 1978-1983 and 1993 (Zann and Su'a, 1991). Zann and Mulipola (1997) also reported extensive areas of dead coral off Salelologa in the early 2000s. In additional to naturally induced damages on coral reefs, dynamite fishing has also attributed significantly on the destruction of inshore reefs.

Current status

The assessment presented in this report on coral reefs and coral fish is based on two reports (a) the Kendall and Matthews et al (2011) report and the 2009 IUCN Red List of Threatened Species (cited by CI, et al. 2010). Kendall and Matthews et al (op cit) combines data from many pre-existing studies and datasets (including those of the MAF Fisheries and GCRMN) into a more robust characterization of the reef communities in Samoa that none of the studies could have achieved alone. It does not eliminate certain challenges inherent in normalizing and combining results from many studies, but it maximizes the use of available information, provides the broadest possible geographic scope and reduces sensitivity of the findings to the biases associated with any one dataset. The 2012 IUCN Red List provides information on species coral species and their conservation statuses. (Appendix 2).

Using datasets from 61 sites (Savaii 23, and Upolu 38), the current state of health of Samoa's coral reef is assessed based on three indicators – coral cover, coral richness and coral community structure.

Coral cover

The assessment of coral cover by Kendall and Poti (eds., 2011)[50] drew on data from 61 sites (Savaii 23 and Upolu 38), using a standardized approach to classify values of each variable at each site as 'high', 'medium' or 'low' relative to other sites surveyed with the same study methods. It was not possible to simply pool site values for each variable from all datasets into a single analysis for a number of reasons, including differences in the method of data collection, differences in site characteristics and because different studies quantified different aspects of the coral and reef community that were not directly comparable (ibid.).

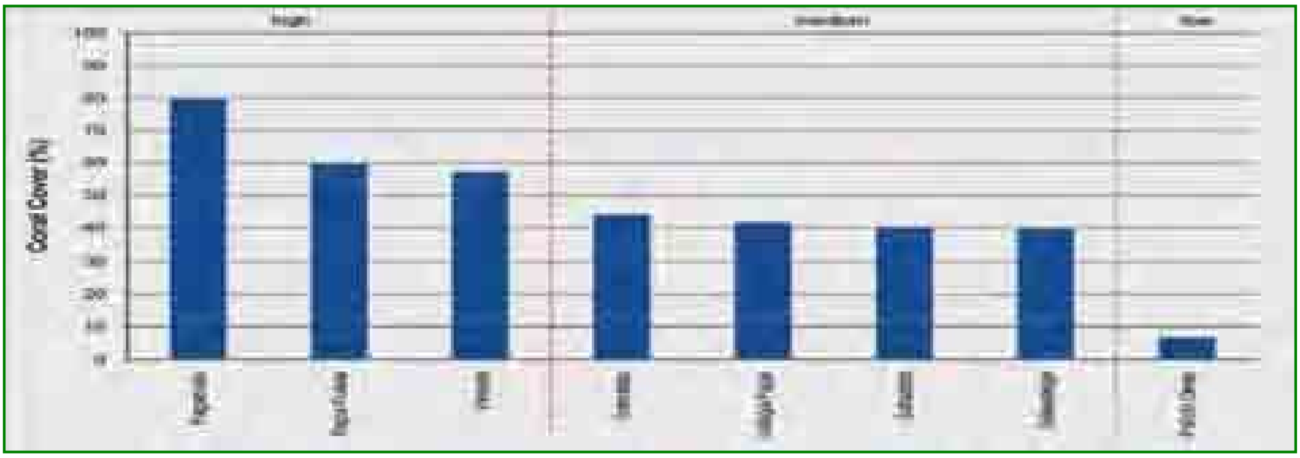
[49] Horseman, N and Mulipola, A. (1995). Catch data and collection from market surveys in Western Samoa, (BP. 65). In: Dazell, P and T. Adams (Eds). South Pacific Commission and Forum Agency Workshop on the Management of South Pacific Inshore Fisheries. Manuscript collection of country statements and background papers Volume 1. Integrated Coastal Fisheries Management Project Technical Document No. 12. SPC, Noumea, New Caledonia.

[50] Matthew Kendall and Matthew Poti (eds.). 2011. A biogeographic assessment of the Samoan Archipelago. NOAA Technical Memorandum NOS NCCCOS 132. NOAA, USA.

Assigning breakpoints between 'high', 'medium' and 'low' required the application of a algorithm (the Natural Breaks Algorithm) that identified natural break points in the data that maximizes similarity of values within classes and maximizes differences. The result of this analysis is as follows -

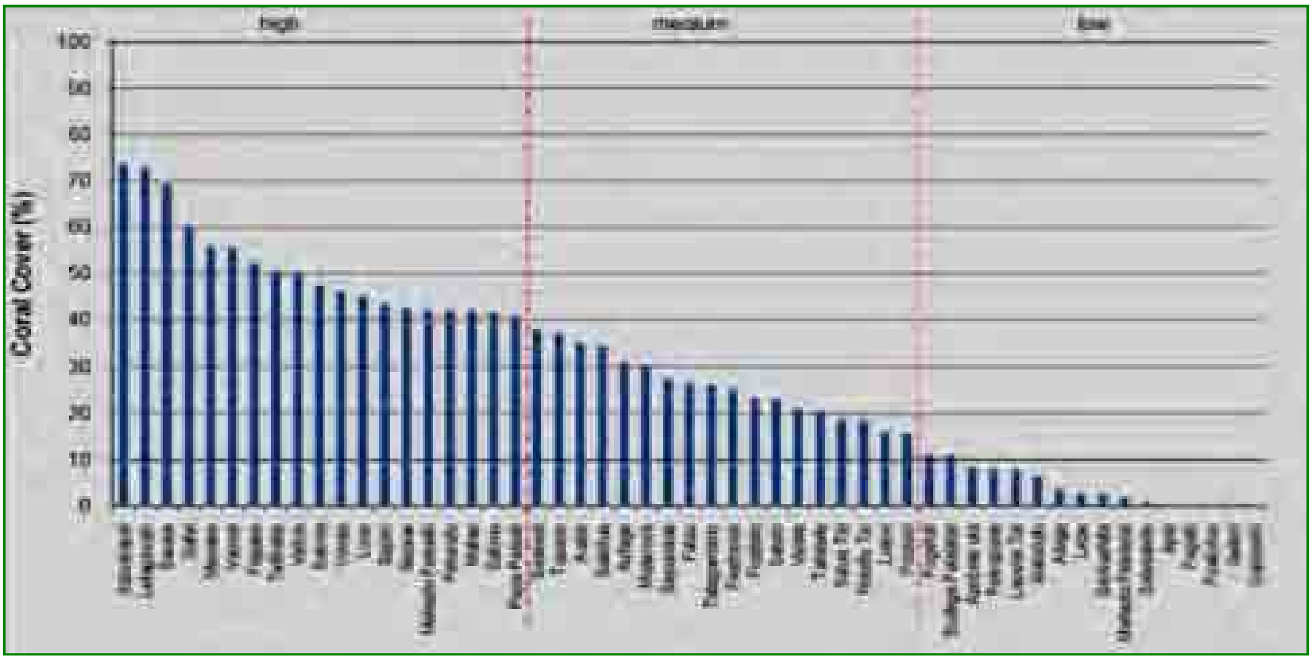
- Overall, over 40% of Samoa's coral reefs have 'high' percent of coral cover ('high' = 50% or better based on GCRMN assessment and 40% or better based on MAF's Village Fisheries Reserves analysis).
- By island, a much larger proportion of Savaii (~60% of coastline) was rated as having 'high' coral cover compared to Upolu (~30%).
- The north and northeast facing coasts of Savaii possess a large proportion of sites with high coral cover (Map 7). In contrast, Upolu has more moderate and variable values with areas of low coral cover along the north and west coasts, especially for Manono Is/Apolima Strait and between Apia and Fagaloa Bay.

Graph 5: Coral cover assessment based on GCRMN[51] data



Source: Kendall & Poti (eds.). 2011. *A Biogeographic Assessment of the Samoan Archipelago*. NOAA, USA.

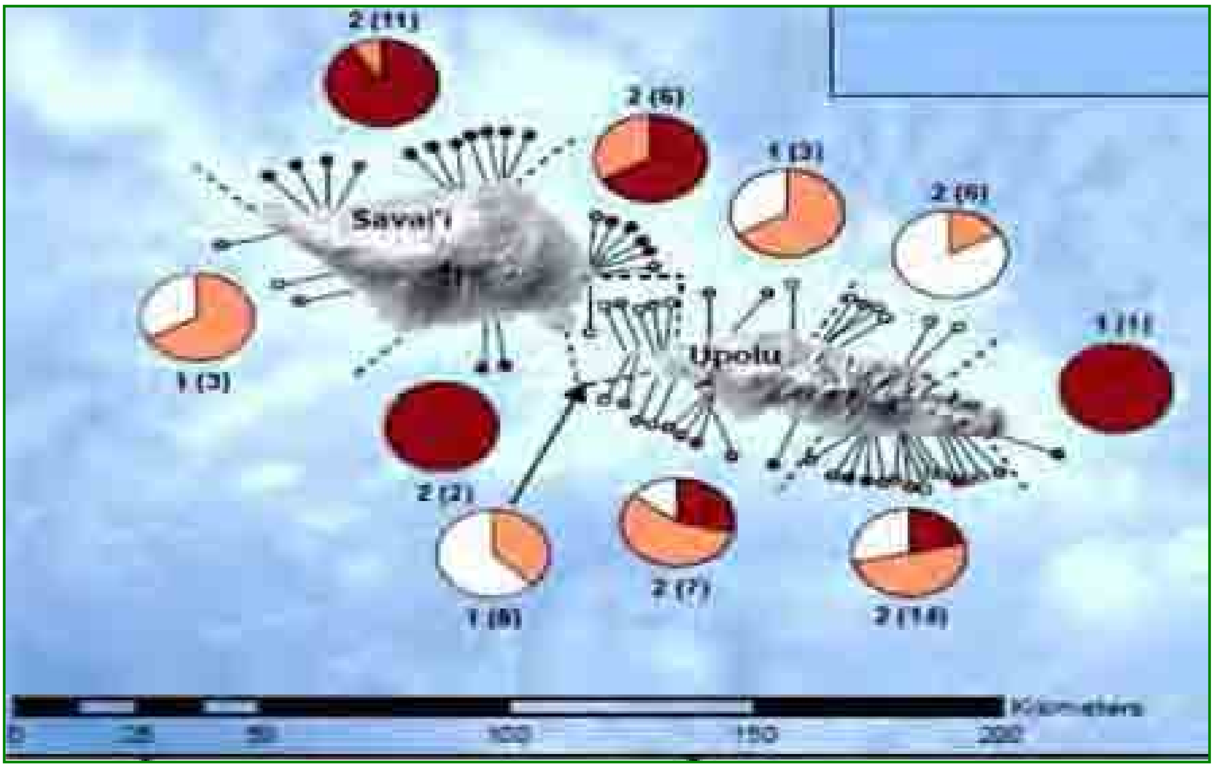
Graph 6: Coral cover assessment based on MAF's Village Fisheries Reserves data



Source: Kendall & Poti (eds.). 2011. *A Biogeographic Assessment of the Samoan Archipelago*. NOAA, USA.

[51] *Global Coral Reef Monitoring Network*

Map 7: Coral cover survey sites across Samoa.



Sites and pie charts are coded high, medium and low coral cover values.

Legend

Compared to the 2006 SoE which reported a 'reasonably high' coral cover throughout Samoa based on 2004 reports, Kendall and Poti et al (ibid)'s assessment shows a continuing trend of improvement in coral reef cover.

Coral Richness (or diversity)

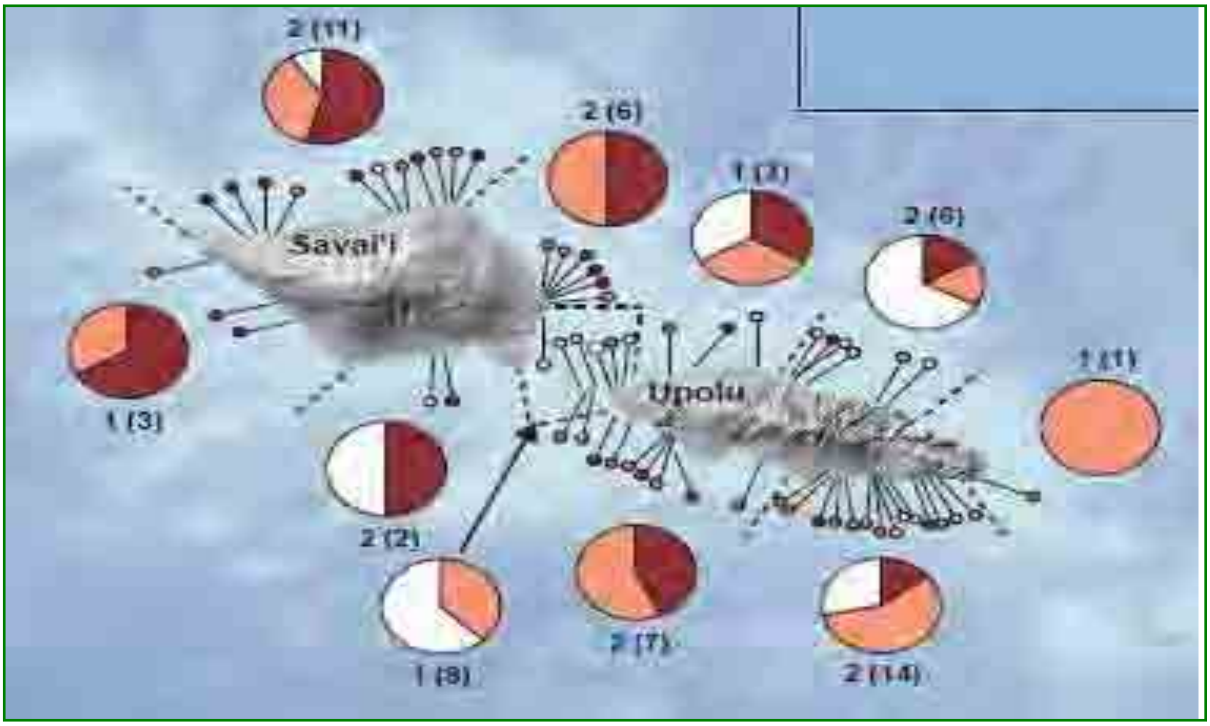
MAF-Fisheries estimates a coral reef fauna comprising of approximately 50 species of hard coral and around 900 fish species and numerous other reef-dependent organisms (MAF-Fisheries 2003). IUCN (2012) included 52 species of corals in its Red List of Threatened Species, with the Staghorn Coral (*Acropora rudis*) the only species considered 'endangered'[52]. Appendix 2 lists coral species redlisted by IUCN.

Overall coral richness for Samoa is rated 'high' for about 35% of the country's coastline (Kendall and Poti (op cit). By island, about 50% of Savaii's coastline and 25% of Upolu's coastline is rated as having high coral richness.

There are some distinct biogeographical patterns of coral richness within each island or within the island group as a whole. For instance, Savaii has a small proportion of sites with low coral richness relative to Upolu. Also the proportion of sites with high coral richness generally declines eastward in Samoa. Compared to Savaii, Upolu has somewhat more moderate and variable values with concentrated areas of low coral richness in the Manono Island/Apolima Strait area and between Apia and Fagaloa Bay.

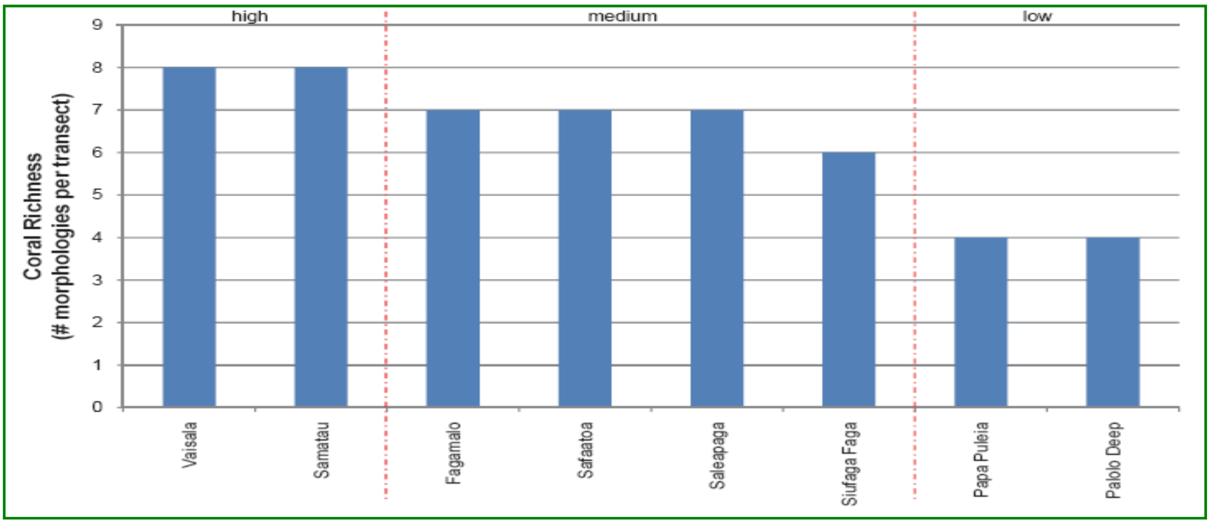
[52] *An **endangered species** is a population of organisms which is facing a high risk of becoming extinct because it is either few in numbers, or threatened by changing environmental or predation parameters.*

Map 8 – Coral richness at survey sites across Samoa.



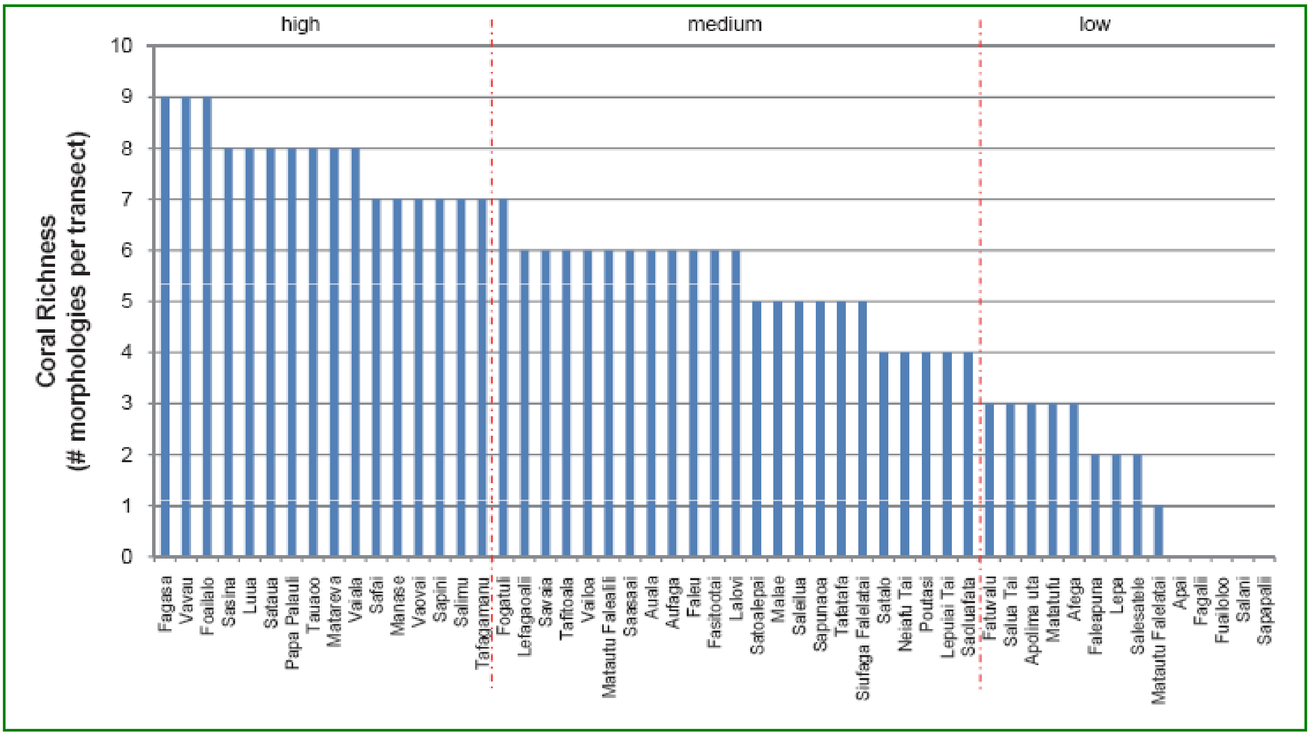
Sites and pie charts are coded as high, medium or low coral richness values.
Source: Kendall & Poti. (eds.) 2011.

Graph 7: Coral Richness Assessment based on GCRMN sites



Source: Kendall & Poti (eds.). 2011.

Graph 8: Coral Richness Assessment in Villages Fisheries reserves



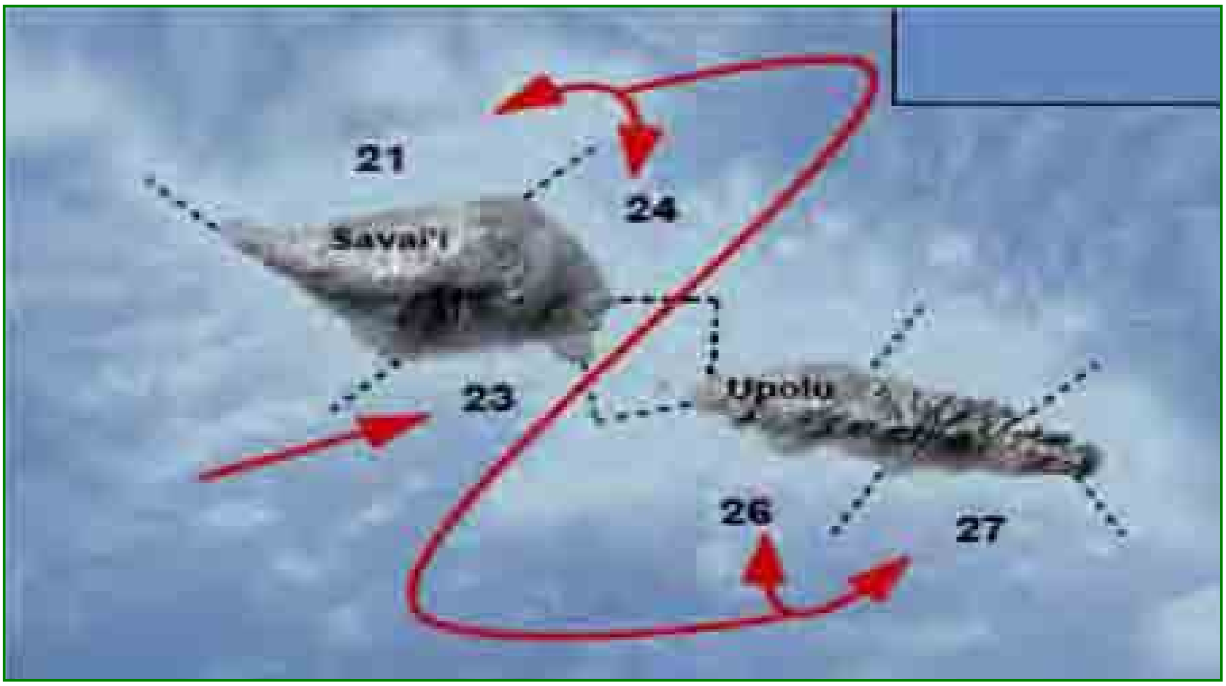
Source: Kendall & Poti (eds.). 2011.

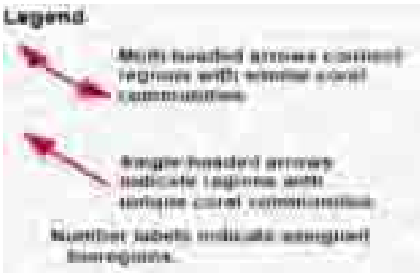
Coral community structure

Data for assessing coral community structure are both sparse and inconsistent (Kendall and Poti et al, 2011). However the available GCRMN and SFR datasets revealed consistent patterns of overlap among sites around southern Upolu and northern Savaii as well as a separate and unique coral community in sites on southern Savaii.

As indicated in Map 9, coral patterns observed in bioregion 21 and 24 in northern Savaii are also found in bioregions 26 and 27 in Southern Upolu. The coral community structure in Southern Savaii (bioregion 23) is not found anywhere else in Samoa. Notably the northern coast of Upolu from Manono/Apolima Strait to Fagaloa in the east has very poor community structure, which is consistent with its assessed low rating in coral cover.

Map 9 – Bioregions of Samoa that share similar coral communities and those with unique coral communities.





Source: Kendall & Poti (eds). 2011.

Assessment

The above assessment based on coral cover, coral richness and coral community structure show a variable state of health between different bioregions of Samoa. In a 2008 assessment, Ah Leong-Samuelu et al observed that Samoa's coral reefs are recovering well since after Cyclone Heta relative to an earlier assessment by Zann (1991) who observed following Cyclone Valerie that coral reefs throughout the country were 'seriously degraded'. Taken in the context of these qualitative observations, the Kendall and Poti et al's assessment confirms improvements in some bioregions, while others are in much poorer state. A 'high' assessment for coral cover and coral richness indicates higher quality reefs that may be more resilient to some stressors including human impacts (Edinger et al. 1998, Houk and Musberger 2008)[53]. The reverse is true for a 'low' assessment for coral cover.

[53] *Edinger et al. 1998, Houk and Musberger 2008 cited by Kendall and Poti (ibid).*

Overall Coral Reef Health Assessment

Habitat condition	Low	Medium	High	Trend	Comments
Coral cover/abundance					Trend assessment is mainly based on IUCN (2012) assessed trends for 31 coral species as 'decreasing', 1 as 'stable' and 20 species are 'unknown'.
- N W Savaii			✓	↓	
- Northern Upolu	✓			↓	
- Southern Upolu		✓		↓	
- Southern Savaii				?	Unknown. No information.
Coral richness					One coral species, *Acropora rudis* (Staghorn coral) is categorized as Endangered by IUCN.
- N W Savaii		✓		→	
- Northern Upolu			✓	→	
- Southern Upolu		✓		→	
- Southern Savaii					Unknown. No information.
Coral community structure					The increasing trend assessment is based on qualitative and anecdotal observations including comments by Kendall & Poti (op cit).
- N W Savaii			✓	↑	
- Northern Upolu	✓			↑	
- Southern Upolu		✓		↑	
- Southern Savaii	✓			↑	

General Recommendations

1. Supporting on-going monitoring and regular assessment of areas where coral diversity is high to inform resource management and conservation planning. Ensure consistent use of methodologies and indicators to maximize data comparability and utility.

2. Target areas of Northern Upolu where coral diversity is high for marine conservation purposes.

3. Encourage, provide technical support and where possible, facilitate access to funding of communities for marine conservation projects.

4. Encourage coral replanting interventions in marine areas that are degraded but with high coral diversity i.e Northern Upolu.

5. Maintain collaboration with GCRMN and other similar organizations for marine monitoring activities.

6.4.2. Seagrasses

Sea-grasses are found in shallow soft muddy sand areas and are similar to flowering plants on land. They provide shelter and food for many marine animals and stabilize foreshores. Typically, seagrasses are found in water depths of 2-12 metres where light can penetrate and allow them to photosynthesise. They are an important food source for many herbivorous fish species, marine turtles and invertebrates. Seagrass leaves provide shelter to many small animals, sheltering them from predators, the weather and strong water currents. Other than providing shelter for marine animals, they also play an important role by acting as sediment traps and nurseries for many species. They are special habitat areas because they are important to the livelihood of many marine organisms such as fish, crabs, prawns, octopus and turtles. Big sea animals like turtles forage on these seagrass beds while small animals live amongst them. Seagrasses are not directly used by humans, and because of this their importance is often overlooked.

Map 10: Seagrass distribution in Savaii

Source: Juney Ward, MNRE. 2012.

Map 11: Seagrass distribution in Upolu

Source: Juney Ward, MNRE. 2012.

Current Status

Seagrass bed distribution in Samoa is limited with the best patches found around Manono Island and the Northern coasts of Upolu[54]. Only two species of seagrasses have been reported to occur in Samoa, *Halophila ovalis* and *Syringodium isoetifolium* (Hartog 1970, cited in Skelton et al. 2000). Some researchers (Skelton et al, op cit). are of the opinion that *H. ovalis* reported in Samoa is probably endemic or belongs to another species, *H. minor. Halophila spp.* specimen collected from the Palolo Deep Marine Reserve recently showed it to resemble *H. minor* morphologically.

There has not been any detailed survey of the status of seagrasses in Samoa since 1992.
Not enough information is available to assess seagrasses using indicators of area coverage, biomass and richness. The main threats are sedimentation from land based sources, and activities such as sand-dredging.

Assessment

Not enough is known about Samoa's seagrass ecosystems to make an informed assessment. It is an information gap that needs to be addressed for future assessment.

[54] *MAF-Fisheries(b). 1 June 2002. Marine Environments – Educational materials. Fisheries Division.*

Overall Health Assessment

Habitat condition	Low	Medium	High	Trend	Comment
Area coverage	✓			Unknown	Limited distribution to a small no. of sites.
Abundance (biomass)	✓			Unknown	No information.
Richness (species diversity)				Unknown	Two confirmed species only both present in small but viable population.

General recommendations

1. Encourage village based conservation of representative populations of seagrasses ecosystems using existing community based conservation tools.

2. Monitor seagrass ecosystems on a regular basis and gather other relevant information to inform future assessment and conservation planning.

6.4.3. Algae/Seaweed

Marine algae or seaweed consist of a large and diverse group of primarily plantlike organisms. They use photosynthesis to obtain their food. They vary in form from small, single to complex multicellular forms such as the giant kelps of the eastern Pacific that grow to more than 60 meters in length and form dense marine forests. Marine algae play very important roles in the marine environment in that they are primary producers thus forming the base of the food chain that contribute to economic well-being in the form of food, medicine and other products.

Algae diversity consists of 198 taxa, comprising comprising 15 Cyanophyceae, 89 Rhodophyceae, 33 Phaeophyceae and 61 Chlorophyceae. This represents about 50-60 percent of the potential algal flora from Samoa (Skelton & South 1999). Results of a floristic survey of Palolo Deep by Skelton (2000) reveal a total of 128 species of which 89 are new records, bringing the total of known marine algae from Samoa to 360 with 205 species present in Palolo Deep alone. Four red alga from Palolo Deep are recognised as new to science, viz *Amansia paloloensis, Ceramium upolense*, *Ceramium kramerii* and *Ceramium rintelsianum* (South & Skelton 1999; 2000). *Ceramium rintelsianum* is found only in the Palolo Deep Reserve; however, extensive research of the flora of neighbouring islands may reveal the presence of this alga (ibid.).

There are three species of algae in Samoa that are consumed by people, the seaweeds *Caulerpa racemosa* [limu fuafua], *Caulerpa sp.*[limu fuafua], and *Halymenia durvillei* [limu aau]. Two species of seaweeds have been introduced into Samoa for aquaculture trials. These are *Kappaphycus alvarezii* and *K. denticulatum.* Another one, *Eucheuma denticulatum*, is reported to have been introduced to the Vaiusu-Faleula area in 1975 but farming was not successful[55]. The status of these introduced seaweeds in our marine environment is unknown[56].

Marine algae in tropical environments are very important as they are considered primary producers which form the complex association with higher species diversity (Dahl 1972). Keat (1996) mentioned that coralline algae are important in cementing and strengthening coral reefs and large algae help provide shading for some benthos.

Current Status

Mulipola (2002)[57] observed that the state of knowledge on the diversity of marine algae in Samoa was nonexistent until Skelton's work on algae up to 2005 (J Ward, pers comm.). Results from this study reclassified the Samoan archipelago to third richest in terms of total species for genera Chlorophyta, Phaeophyceaae and Rhodophyta from 20 places throughout the Pacific. The same report also speculated that the Apia flora includes unique algal species that are not yet recorded from the rest of Samoa (eg, *Gracilaria ephemera, Codium arenicola, Spatoglossum macrodontum and Ceramium rintelsianum*). Of the 360 total species, 57% are represented in the Apia flora. The Apia district hosts more than half of the species found in the rest of Samoa in a 10km stretch of coastline (Skelton, 2005)[58].

A MAF-Fisheries (2010) report noted that algae and seaweeds represented 20% of the substrates within all 16 fish reserves monitored but there is no listing of the 16 reserves wherein this observation was made.

[55] Skelton et al. 2002.
[56] *MAF Fisheries(a). 8 June 2003. Marine Resources I – Educational materials. Fisheries Division.*
[57] *Mulipola, A. 2002. Marine Resources of Samoa – Report prepared for Samoa's National Report for the World Summit on Sustainable Development, Johannesburg, South Africa, July 2002. MAF-Fisheries. Apia.*
[58] *Skelton, P.A. 2005. A survey of the benthic marine algae of the Apia District, Samoa, South Pacific. (Thesis for the Degree of Doctor of Philosophy. University of the South Pacific). 628pp.*

Overall Health Assessment

An informed assessment is not possible in the absence of data on the selected indicators.

Habitat condition	Low	Medium	High	Trend	Comments
Area coverage				?	No information
Abundance/Biomass				?	No information
Species Richness/Diversity			✓	?	No information. High diversity based on Skelton, P A. 2005.[59]

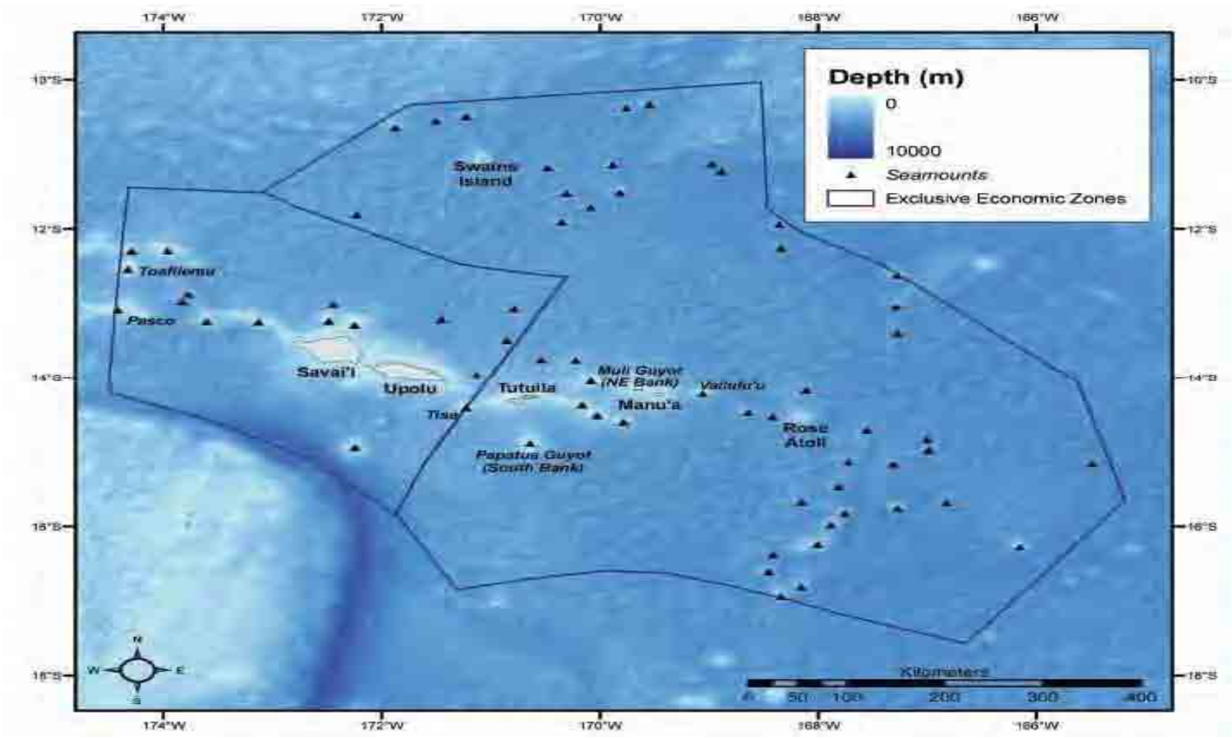
General Recommendations

1. Monitoring of seaweed colonies is important and should be a priority in DEC's monitoring activities.
2. MNRE should explore options for the conservation of representative habitats of seaweeds and algae including the use of village fisheries reserves.

6.4.4. Sea mounts

Seamounts are underwater mountains of volcanic origin. In this report, Bauer et al's (2011) definition is used i.e. seamounts are totally submerged underwater mountains but extending to a minimum of 150m above the seafloor. They are often formed near mid-ocean ridges or subduction zones at the edge of tectonic plates but also occur over upwelling plumes (hotspots) within plate boundaries (Wessel 2001)[60].

Map 12: Seamounts in the EEZ of Samoa and American Samoa



Like all geologic formations, seamounts change in shape and height over millions of years as a result of gradual processes of volcanic growth upward out of the seafloor, growth of coral reefs if emergent or shallow enough, and eventually the processes of erosion and subsidence or sinking of the reshaped structure back into the seafloor. The Samoan Archipelago is part of a hotspot chain that extends from the volcanically active Vailulu'u seamount in the east to west of the island of Savaii (Hart et al. 2006) and includes examples of many stages in the seamount life cycle.

[59] *Ibid.*

[60] *Cited by Bauer, Laurie B and Kendall, M.S. 2011. Seamounts within the Exclusive Economic Zones of Samoa and American Samoa. In: Kendall, M and Poti, Matthew (eds.). A Biogeographic Assessment of the Samoan Archipelago. NOAA. NOAA Technical Memorandum NOS NCCOS 132. NOAA –US Department of Commerce.*

Seamounts are not only interesting features geologically as described above, but also biologically in that they represent oases of biodiversity relative to the comparatively barren ocean floor and seafloor surrounding them. Seamounts offer an array of habitat opportunities, current fields, and depth zones for planktons, fish and coral to occupy, they play a role as "stepping stone" features connecting populations of reef fish and coral between islands, are known gathering sites for many pelagic fish species , and consequently are popular destinations for fishing and scientific study (Rogers, 1994).

Current State

Sixteen (16) seamounts have been identified within Samoa's EEZ and one (called the Tisa Seamount) is situated on the EEZ boundary between Samoa and American Samoa[61]. Their distribution in Samoa's EEZ is given in the map above. Locations and morphological conditions are tabulated in Table 17.

Table 17: Locations and Morhological Characteristics of Samoa's 16 seamounts

Name	EEZ	Source	Longitude	Latitude	Depth of top (m)	Height (m)
Agavale seamount	Samoa	1,2	-168.1543	-15.6757	4,887 (3)	269 (3)
Pasco Seamount	Samoa	1,2	-174.4157	-13.0865	94 (4)	3.051 (3)
Si'usi'u Seamount	Samoa	1,2	-173.6039	-13.2414	1,269 (3)	2,359 (3)
Taumatau Seamount	Samoa	1,2	-172.2503	-13.2894	842(3)	1890 (3)
Toafea'I Seamount	Samoa	1,2	-173.9573	-12.2925	488 (3)	2,976 (3)
Toafilemu Seamount	Samoa	1,2	-174.3238	-12.5384	30(4)	2,737 (3)
Tuapi'o Seamount	Samoa	1,2	-173.1259	-13.2477	425 (3)	2,966 (3)
Uo Mamae Seamount	Samoa	1	-172.2427	-14.9441	645 (3)	3,169 (3)
Unnamed seamount 27	Samoa	1	-170.7861	-13.0671	3,796 (3)	1,004 (3)
Unnamed Seamount 30	Samoa	6	-173,7718	-12.8724	3,032 (3)	601(3)
Unnamed Seamount 38	Samoa	6	-173.8263	-12.9707	2,349 (3)	1,379 (3)
Unnamed Seamount 39	Samoa	6	-174.2913	-12.2940	1,711 (3)	1,250 (3)
Unnamed Seamount 40	Samoa	6	-172.4459	-13.0042	3,098 (3)	698 (3)
Unnamed Seamount 41	Samoa	6	-171.4520	-13.2108	3,451 (3)	1,326 (3)
Unnamed Seamount 42	Samoa	6	-170.8492	-13.4912	3,711 (3)	941 (3)
Unnamed Seamount 43	Samoa	6	-171.1356	-13.9646	2,430 (3)	1,297 (3)

Source: Kendall and Poti (eds). 2011.

There is a general lack of information on the biological communities of Samoa's seamount. The limited information that is known points to two seamounts having a high possibility of hosting mesophotic reefs[62]. These two – Pasco Seamount and To'afilemu Seamount - rise up to less than 150m below sea level. Generally mesophotic reefs range from 30 to 150m.

Assessment of Habitat Health

There is insufficient information to make an informed assessment of the health of Samoa's seamount, particularly of the two noted above to have the potential for supporting mesophotic reefs.

Seamount health indicators	Low	Medium	High	Trend	Comments
- coral biomass of mesophotic reefs				No information	

General Recommendation

1. Encourage research and exploration of seamounts within Samoa's EEZ.

[61] There are 48 seamounts within American Samoa's EEZ for a total of 65 between the EEZs of the two Samoas (ibid.).

[62] Mesophotic Coral Ecosystems (MCEs) extend from 30 m (100 ft) to greater than 100 m (330 ft) and are characterized by the low availability of light for photosynthesis and the presence of corals, sponges and algae as the dominant structural components. Little is known of their distribution, abundance, productivity and susceptibility due to difficulties of working at depths beyond the range of conventional SCUBA diving (http:// ccri.uprm.edu).