MANGROVE ECOSYSTEMS FOR CLIMATE CHANGE ADAPTATION AND LIVELIHOOD (MESCAL) SAMOA PROJECT

LE ASAGA BAY MANGROVES BIODIVERSITY REPORT

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GOVERNMENT OF SAMOA
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EXECUTIVE SUMMARY

There is so much known yet not all documented about the various interesting aspects of mangroves in Le Asaga Bay let alone the entire Safata district mangrove area. The MESCAL Samoa Project believes that the successful accomplishment of its desired purpose of "improved mangrove conservation and co-management for climate change adaptation and livelihood" in the country at least at the site level is largely through the availability of sound baseline information.

FIVE (5) key research activities were conducted for Le Asaga Bay mangroves over the past 14 months of the project. The combination of these activities has provided a baseline description of the Bay's Biodiversity status which is essential for management planning and future monitoring. The scientific surveys have been achieved by means of repeated and lengthy field visits to the various mangrove sites. The major findings are:

(1) Mangrove Verification and GIS Mapping (Site-level)

Proper Mangrove GIS Maps have been produced for the first time for Samoa which includes Le Asaga Bay. Accordingly, the Bay has a Total Mangrove ecosystem Area of 191.82 hectares, this is comprised of a Total Mangrove Cover of 47.82 hectares and Total Estuary Cover of 144 hectares. In terms of mangrove cover alone, it is the third biggest stand in Samoa after Vaiusu-Mulinuu which is 86.41 hectares and Saanapu-Sataoa which is 72.71 hectares. Le Asaga Bay has the biggest mangrove estuary of all sites.

(2) Mangroves Floristics and Biodiversity

Three mangrove species of the five found in Samoa and 32 associated species were recorded in Le Asaga Bay. Mangrove associations are (1) fringing or coastal mainly located along the coast; and (2) riverine or estuarine mainly growing around the mangrove estuary and on the peninsula. Four distinct vegetation types/zones can be distinguished: (1) *Rhizophora* zone; (2) mixed *Bruguiera-Rhizophora* zone; (3) matured *Bruguiera* zone on the back edge; and (4)

Associated species zone connecting to the land. Vegetation and zonation is largely influenced by and/or correspond to the varying physical, climatic and hydrologic features of the bay. The survey proposes that having a Management Plan and raising awareness will help maintain the area and the diversity of life it supports.

(3) Biomass and Carbon evaluation

The Long Plot method was used to determine key biodiversity and biomass characteristics of mangroves at Le Asaga Bay for the calculation of carbon content. The method according to Duke (2013) quantifies biomass of mangrove forests in a way that is scientifically reliable, accurate, low cost, low skilled, simple, pragmatic and relevant. Sampling was done from 11 plots for two dominant vegetation units i.e. *B. gymnorhiza* and *R. samoensis*. Statistical analysis showed that Le Asaga bay mangrove stand heights range from 4-11 m with a total living mangrove biomass of 188-520 t.ha-1. This is the first biomass estimation ever done for Samoa's mangroves so what is inspiring now for the country is that with the total area of mangroves now known from GIS mapping, the related total biomass and stand heights can now be estimated.

(4) Mangrove Fisheries Fauna

Twenty nine (29) fish fauna species and 6 invertebrate species of various life stages occur in the bay. The most common species caught with the four different nets at every sampling time include the *Valamugil sp.* (mullets) and Carangidae (trevallies) of various sizes. This supports the fact that the said two fin fish species are very important in community livelihoods and are the key ones caught from the subsistence and artisanal fisheries in the bay. The two species were also the most commonly occurring of all mobile fish and crustacean species present at every time of sampling. The next common species include the Goatfishes, Emperors, Mojarras, Surgeonfishes and Mangrove crabs.

In terms of relative abundance, goatfish was the most abundant (43.5%) of all the species; followed by the mullet (13.6%) and trevally (10.7%). More variety of fish species were caught

from the upstream and downstream zones and mostly with the Seine and Fyke nets. Failure to catch any big fish (failed nets) does not necessarily mean that the bay's fish fauna has declined or the reproductive individuals are overfished. For now, this can only highlight the need for further sampling of the area.

(5) Mangrove Shoreline Health Monitoring

A mangrove shoreline Video Assessment was the first of this kind to be done for Le Asaga Bay mangroves let alone the mangrove stands of Samoa. Mangrove health was and is fairly good but consistent watching and assessment is essential so to keep track of changes over time. The assessment has provided the baseline for establishing a long-term visual record of mangroves in the bay. The information captured on video will not only contribute to improving site-level understanding of mangrove ecosystem function, values, key threats, and processes but also generate awareness of mangroves in the Safata community and encourage local environmental stewardship.

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1.2. Samoa's mangroves – a brief overview

Mangroves in Samoa are one of the most valuable coastal habitats providing immeasurable benefits (both tangible and non-tangible) to the local communities as well as the ecology and environment surrounding them. These tangible benefits include timber and non-timber products, fishery and other livelihood support systems. The non-tangible benefits include ecological and social functions, such as coastal protection against waves and currents, shelter and habitat for wildlife, and ecotourism.

Mangroves are threatened as a result of increasing coastal population and settlements, unsustainable coastal development and land-based activities. The combination of these with natural forces (e.g. cyclones and tsunamis) has more or less impelled climate change impacts and further eventuating coastal subsidence and erosion. Out of ignorance of their immeasurable values, mangroves are being filled (reclaimed) to make more land, and are also treated as some waste reservoirs; the destructive impacts of which has been the gradual alteration of the rate and nature of their ecological functions. In a continual process of development, some stands in the vicinity of Apia which are privately owned, are the most disturbed hence decreasing in area and are on the verge of disappearance.

Community-based management and conservation programmes for mangroves have been initiated and implemented by government, non-government organizations and local communities. Most of these prioritize education and awareness, and often involves communities in the planning and field implementation of activities. Some villages have developed village rules (and related infringements) for mangrove area management and control. These rules are further translated into bylaws which are recognized nationally at the statutory courts of law.

Mangrove ecosystems are insufficiently addressed in Samoa's environmental legislations specifically in the areas of sustainable development, use and management. Several different government agencies have jurisdiction over the mangroves as either ecosystems or forests.

However, their mandates are unclear hence overlapping and uncoordinated responsibilities over mangrove management. The continuing threatening status of mangroves mainly from people's unregulated activities poses questions relating to the effectiveness of the existing legislation and it's responsiveness in addressing the related issues and the national administration and enforcement.

As with other environmental areas and resources in Samoa, it is widely recognized that adjustments need to be made to existing legislation that address mangrove ecosystems in order to achieve the aims of sustainable development and environmental protection. It is necessary to have the full awareness and recognition of the value of mangroves as both a natural 'mitigating' and 'adaption' measure for climate change and improved livelihood, and not mentioning the opportunities they provide for education, scientific research and eco-tourism.

2. INTRODUCTION

2.1. Regional MESCAL Project

The MESCAL Project is IUCN's multi-country 'flagship mangrove ecosystems project' that is being implemented in Samoa, Tonga, Fiji, Vanuatu and Solomon Islands and funded by the Government of the Federal Republic of Germany under their International Climate Initiative administered by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In responding to address the concerns of these Pacific Island governments on mangrove degradation which is seen to have affected the people's livelihood and natural protective capacities, the project's overarching Goal and purpose is "To increase the resilience to climate change and improve livelihoods through adaptive co-management of mangroves and associated ecosystems". The MESCAL is an action research and development project that pushes for stakeholder collaboration at all levels to address country specific priority issues pertaining to mangrove use and management.

2.2. MESCAL Samoa Project

Deriving from the above regional context, the MESCAL Samoa project's overall goal is to increase resilience of the Samoan people to climate change through adaptive co-management of mangroves and associated ecosystems. It aims to reduce mangrove degradation and loss by restoring these and associated ecosystems through focussing on the following priority areas and outcomes.

(1) improving baseline scientific and traditional knowledge in biological, economic, social and cultural aspects of mangrove resources to assist planning and management;
(2) strengthening environmental governance and co-management that encourages ownership, responsibility and benefits at all levels;
(3) improved conservation and restoration at demonstration site; and
(4) increased awareness, advocacy and capacity development on mangroves including their intrinsic values and surrounding issues.

Siamomua-Momoemausu (2010) outlines the gaps and recommended actions to curb mangrove degradation and assist co-management and governance for improved climate change adaptation and livelihoods in Samoa. The MESCAL Samoa Project has responded well to Samoa's priority but basic needs for mangrove ecosystems as reflected in its respective Outcomes and the resultant national Work Programme. As the first donor-funded mangrove climate change project for Samoa, the project includes both national and site-level activities that have been carefully determined in relation to the project priorities and the resources available.

Among other important undertakings, it requires the establishment of a demonstration site to experiment improved mangrove conservation and co-management for climate change adaptation and livelihoods (Outcome 3). To support this purpose, the project sees acquiring and making available site-level baseline information highly conducive in bringing about sound planning and management interventions. Mangroves are perhaps treated as unwanted plants to be removed and/or are smelly habitats to be filled and disposed of. However, good stewards

need to fully realize and recognize the tremendous values of these ecosystems hence a critical need for understanding their biodiversity.

The ensuing section of the Report briefly describes the project demonstration site and further provides justification for the biodiversity assessments that are documented in this Report. Siamomua-Momoemausu (2011) provides a full profile of this site as needed in the earlier stage of the project.

2.3. Le Asaga Bay mangroves - Demonstration Site

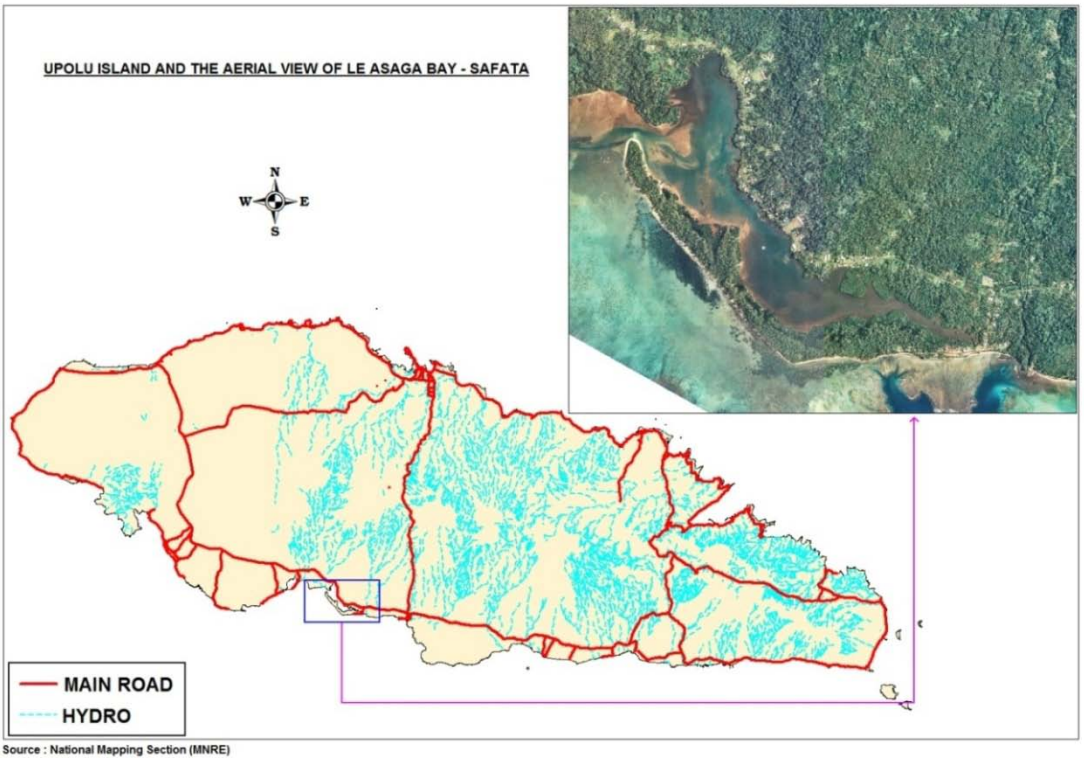

Figure 1: Location of the Le Asaga Bay mangroves

2.3.1. Key features

Le Asaga Bay mangrove system is one of the four major interconnected mangrove systems in the Safata District. It is located on the northern zone of the Safata Bay on the south coast of Upolu (Figure 1). The area is featured by the sheltering Le Muta Peninsula (S 171.8398050 & W

13.99191303) that stretches across the five villages of Nuusuatia, Vaiee, Fusi, Fausaga and Tafitoala (S 171.8130899 & W 14.00674981). It holds a span of mangrove cover with a pre-MESCAL estimate of 26.47 hectares. Like the other three systems, Le Asaga Bay has a major freshwater spring inflow and is surrounded by human settlements even on the opposite Tafitoala Peninsula side.

2.3.2. Livelihood support services

The mangroves of Le Asaga Bay are well established, contributing significantly to the sustenance of livelihood in Safata mainly in terms of seafood and income. They also offer potential income generating opportunities that if conducted sustainably will not affect the natural environment but may lessen pressure on resources. Subsistence and artisanal fisheries for certain key species like mangrove crabs and cockles are a means of livelihood for the district people who respectfully share the mangrove area as a common property and fishing corridor. The extensive area covered by mangroves is important for natural defense of coastline and property.

2.3.3. Site-level threats

Le Asaga Bay is affected by unsustainable fishing of mangrove crabs, poor land practices (e.g. clearing of vegetation), sand mining and erosion. Seawalls have been constructed along the coastal fringe of some villages which have potentially accelerated the erosion of beach sand in these areas. The bay is fairly low lying and therefore already under stress by tidal inundation as the sea level rises and falls more frequently and specifically during extreme high water events.

Through mangrove restoration and strengthened co-management, the project hopes to address these and other issues that will also benefit the other inter-connected ecosystems for improved natural resilience and adaptation against climate change.

2.3.4. Mangrove area Biodiversity

The coastal areas of Safata district is one of the remaining marine biodiversity hotspots in Samoa according to the scientific baselines surveys conducted in the late 1990s which recommended the establishment of the Safata Marine Protected Area as it is today.

Fisk (2002) generally reports in quite some detail the specific features of Safata's coastal biodiversity that includes (i) Mangrove forests and an estuarine environment with abundance and diversity of associated marine life such as fish and mangrove crab; and (ii) Coral reefs/lagoons and associated habitats that provide home for a variety of fish and invertebrate species, extensive seagrass beds, algae/seaweeds and high diversity of coral species. Thollot (1993) listed 20 different fin fish fauna species of the Saana'apu-Sataoa system and further refers to it as greater in diversity than Vaiusu mangroves and forming a quite stable community.

Beichle (1997) recorded 20 land bird species in the Sataoa-Saanapu Mangrove Forest, with the most significant species being the *Anas superciliosa* and the Reef Heron *Egretta sacra*. Park *et al* (1992) later recorded in the same site (i) 12 species of Trees and Shrubs which includes the two common species of mangroves; (ii) 14 species of Ferns (all epiphytes except *Acrostichum);* 11 species of Orchids (all epiphytes); 3 other species (all epiphytes); 1 bat species; and 3 bird species.

Mangrove associated algae exists in 25 taxa (6 Cyanophyta, 10 Rhodopyta and 9 Chlorophyta)[1].

The above and perhaps a few others are probably the only documented biodiversity aspects for certain areas in Safata. It is evident that little (if any) has been specifically documented on Le Asaga Bay.

[1] Skelton et al (2002) sampled at Saanapu and Apia mangrove areas.

2.4. LE ASAGA BAY Mangrove Biodiversity Surveys

Efforts to scientifically research and/or study Samoan mangroves formally are very limited and mostly scattered (Siamomua-Momoemausu, 2010). The important areas that are receiving the least (if any) attention include among others, species distribution and habitats, socio-economic values and livelihoods, traditional knowledge, fauna and fisheries, climate change impacts and adaptation.

As a matter of fact, there is so much known and so little documented about the various interesting aspects of mangroves in Le Asaga Bay let alone the entire Safata Bay. To successfully accomplish improved mangrove conservation and co-management for climate change adaptation and livelihood at least at the site level, the project believes that the collection and making available of related baseline information makes a very essential and tremendous contribution.

This Report documents the FIVE (5) key Research components of Le Asaga Bay mangroves. The combination of these makes up the overall Biodiversity status Report for Le Asaga Bay which also contains the related baseline information that is essential for future monitoring.

(1) Mangrove Verification and GIS Mapping (Site-level);
(2) Mangroves Floristics and Biodiversity;
(3) Biomass and Carbon evaluation;
(4) Mangrove Fisheries Fauna; and
(5) Mangrove Shoreline health Monitoring;

The above have been achieved by means of extensive field surveys and assessments conducted over the last 14 months.

3. LE ASAGA BAY MANGROVE VERIFICATION AND GIS MAPPING

1. INTRODUCTION

If Samoa has to effectively manage her mangrove ecosystems, defining mangrove boundaries and/or producing maps is an essential requirement. The MESCAL Samoa is the first mangrove-specific project hence the first to produce official mangrove area maps for the country. A few estimations of mangrove areas have been made over recent years, most of which are referred to as 'underestimation' because either they only included mappable stands or misidentified mangrove forests from other wetlands such as marshes. The estimations are shown in the following Table 1.

Table 1: Samoa mangrove areas past estimations

Estimated mangrove area	Reference
1,270 ha.	Zann (1991)
150 - 200 ha.	Liu (1992)
752 ha.	FAO (2005)
209.12 ha.	SAMFRIS, 2005 (only a few bigger stands based on 1999 aerial photographs)

The above estimations have suggested that what is most needed now for Samoa's mangroves is proper mapping[2]. This should include defining and/or re-defining boundaries and updating by ground-truthing the existing layers to reflect the real current situation especially with the continuing shift of coastline. Iakopo (2006) locates 17 mangrove stands for Samoa's two main islands. The project believes that these, and a lot more stands which are known are not properly mapped geographically so that their total areas remain unknown.

1.1. The current mapping work

In the absence of any proper GIS Maps for Samoa's mangroves, this verification and mapping component included all the mangrove stands in the country. However, detailed site-level mapping is needed for Le Asaga Bay mangroves to at least show certain features that are

[2] Also refer Siamomua-Momoemausu (2010).

important for management planning at the site. The key objective was to identify and verify the position, boundaries, area and length of mangrove stands. Part of this was assessing key mangrove and associated species, habitats and interconnected ecosystems.

The specific activities which have been undertaken for this component involved the following:

- ✓ Mapping (GIS) the main mangrove stands and species;
- ✓ Developing GIS Resource Maps of key mangrove and associated species, habitats and interconnected ecosystems;
- ✓ Creating mangrove GIS database including validation and harmonizing of the different existing data sets;
- ✓ Combining all layers of geo-referenced information sets and produce GIS Info System for Demonstration Site (linked to national GIS databases (where relevant);

This report only focuses on the mapping work done for Le Asaga Bay. The national mapping is reported in another separate Report[3].

1.2. Field approach and methodology

The mapping of mangroves was done at the ecosystem-level in the idea to include mangrove trees and the inter-connected and/or surrounding communities which include estuaries as the most important components. These cannot be isolated but altogether they form the entire mangrove ecosystems. The mapping process was two-fold.

(1) **Image interpretation** – interpretation of mangrove stands all around the country used the 1999 existing vegetation maps of Samoa and those downloaded from Google Earth.

(2) **Verification/Ground-truth** – interpreted maps were taken for field verification. The team went around taking the interpreted maps and GPS unit around every mangrove stand to map and/or verify the boundaries. Particular focus was given to verifying certain areas that were not clear enough on the maps. In bigger mangrove areas which also extend inland,

[3] Siamomua-Momoemausu (2013).

transects were laid all the way into the interior and observations were taken accordingly. That way, the cross-section of the stands was observed.

Stem diameter and height of standing mostly matured trees were also measured and recorded along with the observation of events and/or features of the mangroves and shoreline such as impacts type, level and source and natural recruitment. For mapping purposes, specific habitat categories were created to capture the mangroves as ecosystems rather than individual trees. These categories are also used to describe certain mangrove habitats/zones and provide legends to the maps.



2. RESULTS AND DISCUSSION

2.1. Safata Mangroves

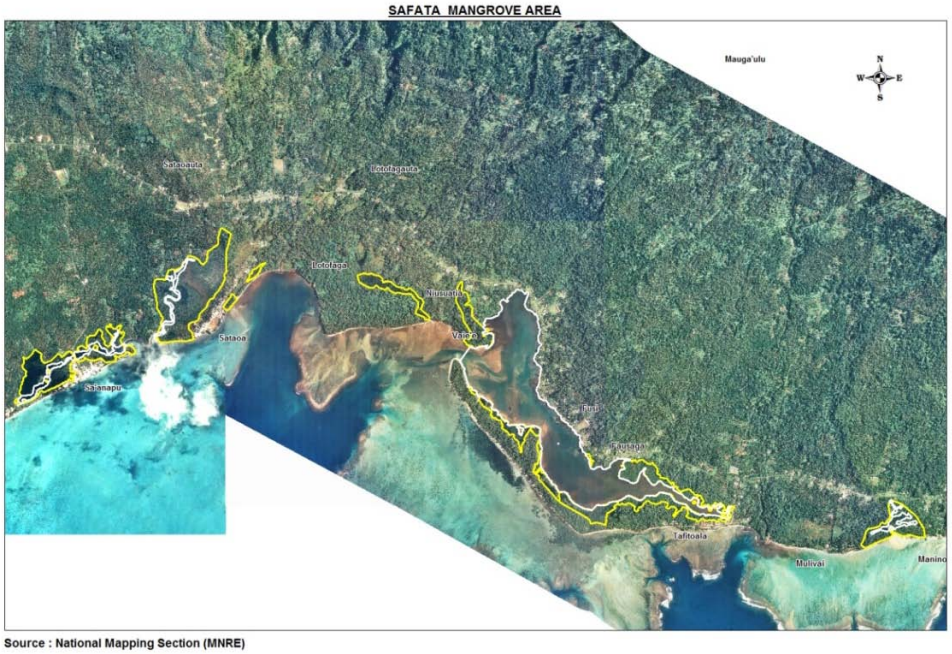

Figure 2: Map of Safata district mangrove ecosystem area

Safata has a total mangrove area of 296.03 hectares, which is comprised of a total Mangrove Cover of 134.75 hectares and an Estuary Cover of 157.28 hectares (Figure 2). Table 2 below provides the details of the size of these areas.

Table 2: Total mangrove areas for Safata

	Mangrove stand/system	Total mangrove cover (ha)	Total estuary cover (ha)	Total mangrove area (ha)	Total mangrove area (%)
1	Saanapu - Sataoa	72.71	9.92	82.63	27.9
2	Lotofaga - Nuusuatia	6.97	0	6.97	2.4
3	Vaiee – Tafitoala (Le Asaga Bay)	47.82	144.00	191.82	64.8
4	Mulivai	11.25	3.36	14.61	4.9
	TOTAL	**138.75**	**157.28**	**296.03**	**100**

2.2. Le Asaga Bay Mangroves

Figure 3 shows the newly produced map for the area. Table 3 shows the detailed information.

Figure 3: Map of Le Asaga Bay mangrove area

Table 3: Le Asaga Bay mangrove area details

Item	Total Area (ha.)	Description
Total mangrove cover - Peninsula - Mainland	 26.14 21.68	Both peninsula and mainland
Peninsula coastline length	4km	From the tip of Le Muta peninsula to end of Tafitoala peninsula.
Width of the mangrove estuary - Widest point (tip) - Narrowest point (mid) - Narrowest point (end)	 920m 260m 80m	Between the peninsula and the mainland
Width of Channel mouth	200m	

Le Asaga Bay is the biggest of the four mangrove systems of Safata with a total mangrove ecosystem area of 191.82 hectares. This estimate comprises of a total mangrove cover of 47.82 hectares and a total estuary cover of 144 hectares. In terms of mangrove cover alone, Le Asaga Bay is the third largest stand in Samoa after Vaiusu-Mulinuu which is 86.41 hectares and Saanapu Sataoa which is 82.63 hectares. Le Asaga Bay also holds the biggest estuary of all estuarine mangrove stands in the country.

2.3. Mangrove plants species and general distribution

Figure 4 shows the general distribution of mangrove species within the bay.

Figure 4: Le Asaga Bay mangrove species distribution

Three of the five species of mangroves found in Samoa occur in Le Asaga Bay. These are the (1) Red (or female) mangrove – togo fafine (*Rhizophora samoensis); (*2) Oriental (or male) mangrove – togo tane (*Bruguiera gymnorhiza)* and the newly added (3) Swamp fern – saato (*Acrostichum speciosum).*

The water edges on both sides of the estuary are mostly lined by the dominating main saltwater tolerant mangrove species *R. samoensis.* It is relatively dense in some places, but partly or fully cleared where settlements exist. *B. gymnorhiza* mostly occupy the back edges or landward areas of the bay also on both sides. In the upper reaches near Tafitoala, *R. samoensis* is mixed with *B. gymnorhiza* at the water edge and then there's a *B. gymnorhiza* community further inland amongst the usual associated tree species. The swamp fern – Saato (*Acrostichum speciosum)* is mostly found behind the *B. gymnorhiza* zone where the substrate is more stable and salinity deficient.

2.4. Habitats and Resources within Le Asaga Bay estuary

The various habitats found in the bay include:

(i) Shallow sandy areas outside the estuary, at the interface of the estuary and the coastal zone (river mouth sand flat).

(ii) The lower part of the mangrove-lined estuary (downstream mangrove) downstream from tidal mixing. This part of the estuary is most influenced by in-flushing of ocean waters. Downstream mangrove habitats are most favorable for invertebrates like cockles and macro algae (e.g. *Halimeda*) growth.

(iii) The upper part of the current extent of mangrove forest (upstream mangrove) upstream from tidal mixing. This area receives the constant influence of freshwater than the downstream mangrove.

(iv) This is the mainland edge opposite the peninsula which has eroding banks but has been reinforced with rock walls. There are scattered but young mangrove seedlings along the

rock walls with clear signs of clearing in some areas. This particular habitat is threatened by extensive human impacts.

Of the other mangrove systems in Safata, Le Asaga Bay holds the two main and important resource habitats (Figure 5) of:

(i) *Venus Shells* (*Gafrarium tumidum*) habitat – This occupies an area of about 10.9 hectares and is located in the downstream mangrove zone where is most influenced by in-flushing of ocean waters.

(ii) *Halimeda* macro algae habitat- This is about 19.03 hectares and is also located in the downstream mangrove zone.

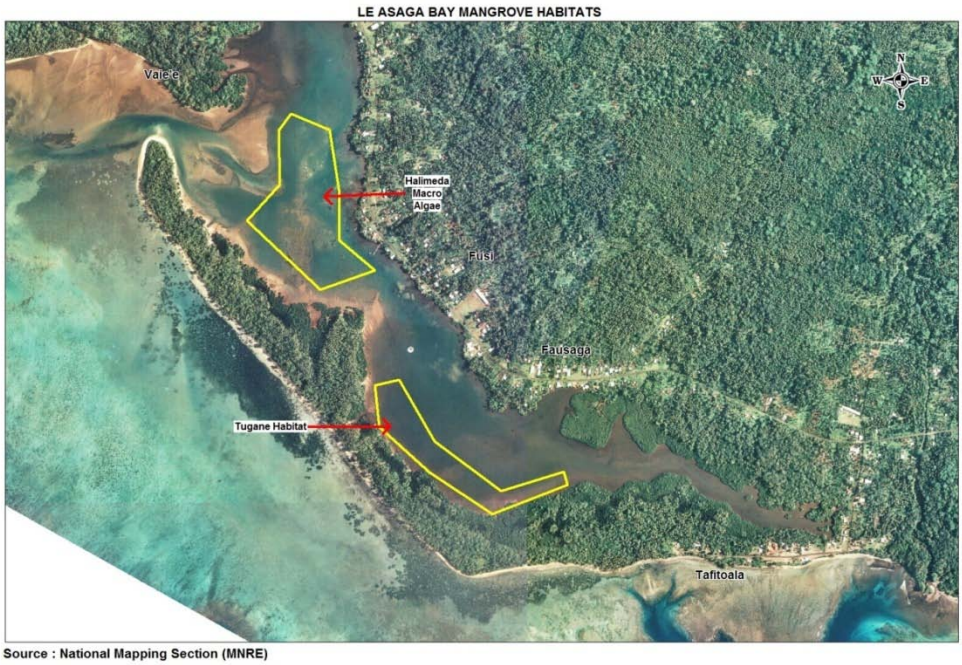

Figure 5: Le Asaga Bay habitats and associated resources

2.5. General assessment of the areas

Excellent natural recruitment has been observed overall indicative of healthy seedlings and shoots. Further expansion was observed of the *R. samoensis* towards the western end of the

bay. Small young aggregates forming small stands are common in very sheltered areas. There is extensive erosion at the seaward edge of the peninsula. There are no mangroves in this particular area but only associated plants with very high canopies.

Significant erosion is also attributed to the bordering of the water edge by mostly individual but matured *B. gymnorhiza* in some areas. A few *R. samoensis* are suffering from prolonged tidal inundations as shown by dying branches and leaves. Overall mangroves on Le Asaga peninsula as observed contribute significantly in countering the erosional impacts of waves and currents as well as the prolonged tidal inundation.



3. CONCLUSION & RECOMMENDATIONS

Le Asaga Bay has the third biggest mangrove cover and the biggest mangrove estuary of all mangrove stands in Samoa. It also affords the most essential ecosystem goods and services which highly contribute to upholding the environment and sustaining people's livelihoods. Such a significant area in a fairly healthy condition deserves effective management which includes sustainable utilization of resources. Even that need is urgent with the impacts of climate change that can be attributed to prolonged spring tides submerging and stressing the mangroves, eroding the coast and gradually reducing mangrove cover[4].

[4] Patolo, personal communication.

For the first time, this component has produced geographic mangrove maps for the Safata district mangroves and Le Asaga Bay. These maps will be very useful instruments to aid the effective management of mangrove ecosystems in Samoa.

Some of the key areas to be considered for future work to sustain this component may include the following:

1. It is essential that the mangrove areas that have been mapped and verified be monitored regularly to detect any changes in cover.

2. Conduct detailed mapping for other bigger mangrove stands in Samoa, similar to how mapping was done for Le Asaga Bay mangroves.

3. Conduct training for the relevant MNRE staff on mangrove GIS mapping and field verification techniques.

4. MANGROVES FLORISTICS AND BIODIVERSITY

1. INTRODUCTION

Le Asaga Bay is fortunate to have a sizeable mangrove forest which supports livelihoods in the area. However their overall extent has not been accurately measured and so there is a scarcity of information and knowledge regarding its existing flora and the variety of life it holds and supports. To provide the basis for planning and management of the mangroves of Le Asaga Bay, it is essential to at least assess their biodiversity to understand their status of wellbeing.

1.1. The current Mangroves Floristics and Biodiversity Survey

Mangroves in Le Asaga Bay were surveyed in May 2013. The survey investigated the selected mangrove stands of Tafitoala, Fausaga-Fusi and Vaiee-Nuusuatia on the peninsula side, basically to determine and record flora species composition and zonation types.

1.2. Field Methodology

Surveyors walked from sea to land (low to high tide mark) through the mangrove forest at a set bearing. All species of mangroves located along each transect were examined and features such as height, diameter at breast height (DBH), phenology and substrate types were recorded. For each site selected, transect lines were established from the seaward margin at a right angle into the mangrove interior and towards the back edge. Along the transect line, DBH measurements were taken for some selected healthy matured trees and were further tagged for future monitoring. The survey also examined and recorded species present in isolated patches of mangrove stands on the water edge as well as in the immediate beach areas.

2. RESULTS AND DISCUSSION

Le Asaga Bay mangroves fall into two of the four major associations of mangroves, the classification of which correspond mainly to physical, climatic and hydrologic features of the bay. These associations are (1) fringe or coastal mangroves mainly located along the mainland coast; and (2) riverine or estuarine mangroves growing around the mangrove estuary and on

the peninsula. Four distinct vegetation types/zones can be distinguished. That is from the seaward edge: (1) *Rhizophora* zone; (2) mixed *Bruguiera-Rhizophora* zone; (3) matured *Bruguiera* zone on the back edge; and (4) Associated species zone connecting to the land.

2.1. Tafitoala mangroves

The four zonation types are very distinct at Tafitoala mangroves. This area does not have much freshwater influence which partly explains the situation. Of the entire bay, Tafitoala holds the *healthiest Bruguiera* mangrove forest and a patch of almost undisturbed associated plants. Trees are fairly matured as indicative of their stem girths, stand heights and canopies. A very interesting feature is that most of the *B. gymnorhiza* mangroves have well established and already flowering epiphytes growing on them.

The canopy cover is generally uniform; understory seedling density is generally low, except where gaps occur, prolific growth of *R. samoensis* and *B. gymnorhiza* was noted. The two were also the dominant canopy species observed. *R. samoensis* tends to occupy the outermost seaward fringes while the landward stand is occupied by *Inocarpus fagifer* (Polynesian chestnut – Ifi), *Barringtonia asiática* (Fish poison tree – Futu), *Hibiscus tiliaceus* (Beach hibiscus – Fau) and many others. The *R. samoensis* in this particular area are generally taller than those observed in the other parts of the bay. The girth width of the biggest *B. gymnorhiza* that was measured was 26cm with an estimated height of 13m: this being much bigger than the associated species that were also measured. Human disturbance is very minimal so the area overall is very healthy.

The substrate is not too muddy in the *Rhizophora* and mixed *Bruguiera-Rhizophora* zones, only about a few centimeters in depth at low tide. It is fairly clayish and dry at the *Bruguiera* zone. Mangroves in fringe areas are normally inundated by practically all high tides, while those at the higher topographic boundaries may be flooded only during the highest of tides (spring tides) or during storm surges.

2.2. Fausaga-Fusi mangroves

The Fausaga-Fusi area is identifiable of having a relatively thick *Rhizophora* zone and several isolated pockets of stunted *R. samoensis* trees bordering the water edge. The *B. gymnorhiza* exist in the immediate interior, relatively thin and quite distinct in terms of heights and canopies. This area has very tall coconut trees, some of which have no tops, dead but still standing amongst the other usual associated flora. The topless palm trees were a result of some lightning events a few years back.

The substrate in this area is muddy but clayish sandy towards the Fusi area. Vegetation zonation differs in some areas particularly where the substrate is quite sandy. Mixed vegetation of scattered young *B. gymnorhiza* and coastal shrubs follows immediately behind the *Rhizophora* zone. Vegetation is mostly scattered and/or unevenly distributed at the interior. Zonation and vegetation types may be more or less determined by freshwater mixing as the area is well exposed to freshwater sources on the adjacent mainland side.

The *R. samoensis* look healthy and greenish and natural regrowth is excellent. However, the Fausaga-Fusi area overall is noted as quite disturbed. The cutting of mostly associated trees and shrubs was evident. Dead logs and other debris were seen in some areas. Erosion is also

significant and sign of receding coastline is shown in the occurrence of *Bruguiera* trees at the water edge. It is worth noting in this Report that the Fausaga-Fusi mangrove area holds the very rich Venus shell (*Gafrarium tumidum*) habitats which serve as an important livelihood source for the local people of Safata.

2.3. Vaiee-Nuusuatia

The Vaiee-Nuusuatia area is the more coastal part of the mangrove bay that ends at the tip of the Le Muta peninsula at the channel opening to the ocean. This is the transitional zone between the shoreline and the mangrove bay which is sandy all around and is significantly and directly influenced by the ocean. Salinity is very high compared to the other areas in the bay.

The *Rhizophora* only border the Nuusuatia seaward edge and it breaks sharply and disappears along the Vaiee stretch. In the immediate interior, matured and healthy *Bruguiera* trees exist among other associated trees. Mixed and beach-associated vegetation dominates the area around the tip of the peninsula. These trees are also very matured and healthy. Vines and shrubs are also present at the water edge.

Overall, three mangrove species and 32 associated species were recorded in the three areas surveyed. These are recorded in Table 4 below.

Table 4: Flora species (mangroves and associated) observed in Le Asaga Bay.

Species Common Name	Species Scientific Name	Species Samoan Name
Oriental mangrove	*Bruguiera gymnorhiza*	Togo tane
Red mangrove	*Rhizophora samoensis*	Togo fafine
Swamp fern	*Acrostichum aureum*	Saato
Fish/ Sea poison tree	*Baringtonia asiatica*	Futu
Beach hibiscus	*Hibiscus tiliaceous*	Fau
Screw pine	*Barringtonia samoensis*	falaga
Indian mulberry	*Morinda citrifolia*	Nonu
Polynesian chestnut	*Inocarpus fagifer*	Ifi
Hibiscus	*Thespesia populnea*	Milo
Tree fern	*Cyathea spp*	Olioli
Coconut	*Cocos nucifera*	Niu
Alexandrian laurel	*Calophyllum inophyllum*	Fetau
	Glochidion ramiflorum	Masame
Screw pine	*Pandanus tectorius*	Fasa
No common name	*Clerodendrum inerme*	Aloalo tai
No common name	*Dendrolobium umbellatum*	lala
Coral tree	*Erythrina fusca*	lalapa, gatae palagi
	Fagraea berteroana	Pualulu
	Lycopodium phlegmaria	Laaufaipale
Half-flower	*Scaevola taccada*	To'ito'i
Bird's nest fern	*Asplenium nidus*	Laugapapa
Ribbon fern	*Ophioglossum pendulum*	Laugapapa
Giant hare's foot fern	*Davallia solida*	Laugasese
Wart fern	*Phymatosurus scolopendria*	Lauauta
T-grass	*Paspalum conjugatum*	Vaolima
One leaf fern	*Pyrrosia lanceolata*	Lautasi
Beach morning-glory	*Ipomoea pes-caprae*	Fuemoa
Beach pea	*Vigna marina*	Fuesina
Wax plant	*Hoya australis*	Laumafiafia
Sickle spleenwort	*Asplenium polyodon*	
Rabbit foot fern	*Davallia epiphylla*	
Flat fork fern	*Psilotum complanatum*	
Leafless orchid	*Taeniophyllum fasciola*	
Oak leaf fern	*Drynaria rigidula*	
Easter orchid	*Earina sp.*	

3. CONCLUSION AND RECOMMENDATION

The mangroves at Le Asaga Bay are an important component of the coastal ecosystem, essentially maintaining the productivity of marine species in the area. Deforestation of the mangroves and the accumulation of waste materials in the area, if allowed to continue will result in severe loss of trees, inadequate re-growth and overall reduction of the mangrove cover. The new baseline information collected from this survey makes a valuable contribution to the very small yet almost non-existence pool of information specific to Le Asaga Bay mangroves. Most importantly, these are most needed for effective management planning and protection of the bay and its resources.

To help bring about effective management of Le Asaga Bay mangroves, and to ensure long term sustainability of the related resource base, the following actions should be considered as priority.

1. Conduct inventory and monitoring surveys for all mangrove stands in Samoa to collect and document various floristics and biodiversity information. These surveys must be made consistent so to be able to keep track of the changes or determine trends in mangrove biodiversity over time.

2. Intensive awareness and education should be provided to all sections of the community on the vulnerability of the mangrove ecosystems including the inter-connected habitat and ecosystems, and the need to utilize them in a responsible manner.

3. Develop in consultation with all stakeholders a Mangrove Management Plan for the area that can be enforced and implemented by the local community and all others concerned.

4. As part of the Mangrove Management Plan, local people particularly fishermen should be trained to carry out periodic monitoring of the mangroves that includes follow up surveys.

5. MANGROVE BIOMASS AND CARBON EVALUATION

1. INTRODUCTION

Of the various ecosystem services afforded by mangroves, carbon storage is perhaps the least investigated, yet critically important. Mangroves are a natural mitigation measure for climate change. They are potentially valuable in carbon mitigation programmes, such as Reducing Emissions from Deforestation and Forest Degradation, and Enhancing Forest Carbon (REDD+)[5]. Nellemann *et al*. (2009) reports that mangrove forests are among the major carbon sinks of the tropics and according to Kauffman et al (2012), they are among the highest productivity of any forest type. Furthermore, because of the values of, and threats to, mangroves, surveys to describe forest composition, structure and ecosystem carbon pools are needed to monitor status and trends (Kauffman *et al*, 2012).

In the absence of any evaluation on carbon sequestration for Samoa's mangrove or for any other forest ecosystems, the current evaluation made possible by the MESCAL Project, has provided new scientific information for climate change mitigation purposes.

1.1. The current Mangrove Biomass and Carbon Evaluation

Assessing Carbon Sequestration potential of key mangrove ecosystems in Samoa has been one of the desired activities for the MESCAL Samoa Project because of the priority need through research to document related baseline information.

The surveys were implemented in early May 2012 through 2013 respectively, the primary objective of which was "To rapidly and accurately determine key biodiversity and biomass characteristics of mangrove stands at Le Asaga Bay for the calculation of carbon content". The characteristics include species, stem density, canopy height and stem diameter.

[5] mechanism to reduce global GHG by compensating countries for avoiding deforestation or forest degradation.

1.2. Field Methodology and sampling areas

The surveys used the **Long Plot Method**, which according to Duke (2010) is a preferred method for rapid, relevant and accurate sampling of forest biomass. The basic field assessment unit is a plot of sampled trees. The intention is to sample mangrove vegetation present in each plot or area. Sampling areas were the *Bruguiera* and *Rhizophora* mangrove forests of Tafitoala and Fausaga (Figure 6). Sampling was done at two different times; the *Bruguiera* forest in May 2012 and the *Rhizophora* forest in May 2013.

Figure 6: Mangrove Biomass Sampling Areas

The sampled plots were selected according to the three mangrove zones (species assemblage types) within the survey areas. These zones, characterized by different species and structural elements, include:

(i) Sea fringing – dense, gnarled trees with a tangle of above ground roots – like *Rhizophora species* with *Sonneratia alba*.

(ii) Interior mangrove (mid) – tall erect trees, tall canopy – dominated by *B. gymnorhiza* along with *R. samoensis* .

(ii) Landward (high) – tall erect trees – various species with notable buttresses – like *Inocarpus fagifer* (Polynesian chestnut – Ifi), *Barringtonia asiática* (Fish poison tree – Futu), *Hibiscus tiliaceus* (Beach hibiscus – Fau).

A total of 11 x 50m plots were established for sampling the various mangrove forest characteristics. *Bruguiera* trees below 5 cm, low lying, ground cover of seedlings or other species were excluded.

1.3. Long Plot field setup

Duke (2010) provides the details for measuring a mangrove plot using the Long Plot method however for these particular surveys, at least two replicate plots were done for each of the zones.

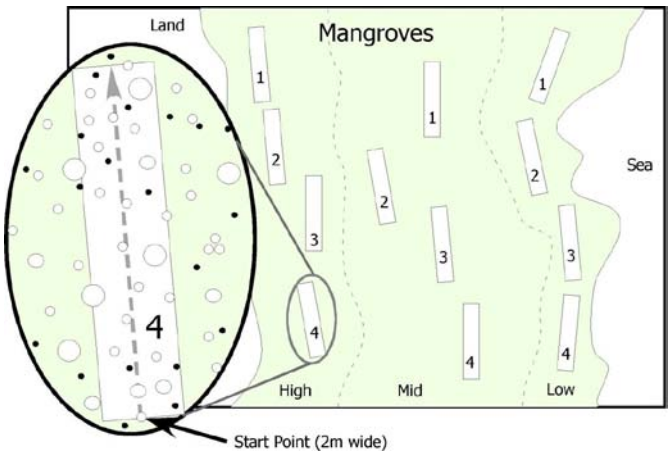

Figure 7: Layout of long plots for a replicated sampling design

The plots were two meter wide and orientated along tidal contours or parallel to the shoreline or sea (Figure 7) as to minimise variability of species and structural assemblages dependent largely on inundation frequency and elevation.

Field Measurements were taken for:

(i) **Tree girth and stem diameter:** The stem diameter of trees and shrubs were measured as proxies of their standing biomass. This was done using a small tape measure. The measurements were afterwards converted to diameter using simple circle trigonometry.

(ii) **Tree height:** Tree heights for both vertical (standing) and leaning tress were also visually estimated.

Individual trees were measured at their respective positions along the transect length. The *Bruguiera* trees are more accessible and were easy to measure. The *Rhizophora* trees were very difficult to measure because of their tangles of above ground roots and their multi-stemmed structure.

GPS readings were recorded at both start and end points of every plot.

1.4. Data entry and analysis

The data collected were entered into a pre-formatted Excel spreadsheet with fields and columns matching the field Datasheet. These were then sent to Dr. Duke of James Cook University, Australia for statistical analysis and synthesis of results.

2. RESULTS AND DISCUSSION

Duke (2013) provides a comprehensive analytical Report on the evaluation however the following is only a brief account of the findings.

2.1. Vegetation units

Le Asaga Bay mangrove biomass data were collected from 11 plots for 2 dominant mangrove vegetation assemblages, *Bruguiera gymnorhiza* (9), and *Rhizophora samoensis* (2). The two species form a dominant component of the Samoan mangrove ecosystems.

2.2. Biomass and Structure

The following are the summary results (Table 5) for Le Asaga Bay mangrove biomass and carbon content as synthesized. Please refer Duke (2013) for the explanation of the results.

Table 5: Results analysis summary

The data shows derived estimates of carbon (t.ha-1) in living above ground biomass (AGB) and below ground biomass (BGB). Estimates were made from the allometric common equations by Komiyama (2005) and Chave (2005) based on stem diameter. 'AGB/H' refers to Chave's equation that includes total average tree height (Hgt). 'CanWHgt' refers to the weighted canopy height, termed Lorey's height. 'BA' refers to stand basal area. SEX1 stands for 'Standard Error x 1'.

Species	Biomass & Structure	Samoa average (t.ha-1)	SEX1
Bruguiera gymnorhiza	AGB Komiyama	350.1	29.0
	AGB/H Chave	134.9	12.9
	AGB Chave	242.6	20.2
	BGB Komiyama	124.8	9.7
	Hgt(m)	7.2	0.3
	CanWHgt(m)	9.0	0.5
	BA(m2/ha)	58.8	4.4
Rhizophora samoensis	AGB Komiyama	106.8	
	AGB/H Chave	39.5	
	AGB Chave	72.8	
	BGB Komiyama	54.5	
	Hgt(m)	4.2	
	CanWHgt(m)	4.3	
	BA(m2/ha)	32.7	

Overall, the estimations have generated a conclusion that Le Asaga Bay's (representing Samoa) mangrove stand heights (both two dominant mangrove vegetation units i.e. *Bruguiera* and *Rhizophora*) range from 4-11 m with a total living mangrove biomass of 188-520 t.ha-1.

Although there may be a few that are slightly taller in other sites, this is generally the canopy height range observed around the country. This can further imply that the mangrove vegetation units sampled are truly representative of the Samoan mangroves. Biomass estimates generally reflects that the amount of biomass corresponds to canopy height. In other words, plots with taller canopy heights have higher amounts of biomass.

In comparison with the other four MESCAL countries (Table 6), it is very interesting yet encouraging to see that Samoa has the least Plots and dominant vegetation unit, but is ranked third in terms of Total living mangrove biomass. Samoa has the only plots definitely dominated by only *Rhizophora samoensis* rather than other mangrove species.

Table 6: Mangrove Biomass estimations for the 5 MESCAL countries

Country	No. of Plot	Dominant mangrove vegetation unit	Stand heights	Total living mangrove biomass
Solomon Islands	12	3 *Bruguiera* species *Rhizophora* species *Ceriops tagal*	12-25 m	478-1059 t.ha-1
Fiji	43	3 *Bruguiera gymnorhiza* *Rhizophora* species *Xylocarpus granatum*	4-17 m	327-950 t.ha-1
Samoa	11	2 *Bruguiera* species *Rhizophora* species	4-11 m	188-520 t.ha-1
Vanuatu	26	5 *Bruguiera gymnorhiza* *Rhizophora* species *Ceriops tagal* *Xylocarpus granatum* *Avicennia marina*	4-19 m	155-747 t.ha-1
Tonga	25	4 *Bruguiera gymnorhiza* *Rhizophora* species *Excoecaria agallocha* *Lumnitzera littorea*	3-9 m	94-326 t.ha-1

3. CONCLUSION AND RECOMMENDATIONS

These baseline biomass estimates are the first ones ever done for Samoa's mangroves. With the total area of mangroves now known from GIS mapping, the related total biomass and stand heights for the entire country can now be estimated.

These baselines which never existed before in Samoa, have initiated the pool of related information that will be in great use for national mangrove management and protection. More importantly, they will contribute significantly to our knowledge specifically on ecosystems services and climate change mitigation. The findings of this survey also bring to mind how changes and damage to mangroves in Samoa have affected their biomass. Clearly, if mangroves trees are cut down or cleared from the stands, it results in the reduction of their woody biomass and eventually their carbon content.

Overall, it is inspiring to know how much carbon Samoa's mangroves contain and the potential opportunities for future investment in this area if these important ecosystems are well protected and managed. The successful completion of this particular component is a milestone for the MESCAL Samoa Project especially in terms of the generation and making available of related baseline information, as well as the opportunities that have developed the technical capacity of the local officials on mangrove biomass evaluation.

This respective component Report recommends for:

1. The continuation of Long Plot biomass data collection for the same dominant vegetation types from the same and other mangrove areas in Samoa.

2. Exploring the possible ways of estimating the biomass content of all mangroves in Samoa using the baseline estimates generated from this project component.

3. Assessment of C-sequestration potential of key mangrove ecosystems in Samoa as part of baseline information collection.

4. Follow up or refresher Training of the local government officials on Biomass Survey methodology and Data analysis.

6. MANGROVE FISHERIES FAUNA

1. INTRODUCTION

The mangrove system of Le Asaga Bay is home to a diverse array of fish and invertebrates. Certain species are resident while others which include the commercially valuable fish species only spend part of their lifecycle (spawning and nursing) in mangroves then move to the sea where they spend most of the time.

Le Asaga bay estuary supports three main fisheries: (1) Mangrove crab fishery; (2) Mullet fishery; and (3) Venus shell (*tugane*) fishery. These fisheries sustain many households in and around the area so level of dependency on these resources is quite high which may have led to overfishing if continued without some form of control. While 35 species of fish have been recorded from the only reported survey of estuarine fish in the Safata District, those exploited by the various fisheries undertaken in Le Asaga bay are not documented at all. As an essential element of biodiversity, it is important to describe these fish fauna to understand the functioning of the related communities for better management and future monitoring.

1.1. The current Mangrove Fish Fauna Survey

Le Asaga Bay mangroves fisheries fauna was surveyed between 14 June and 26 September 2012. It is the first assessment of this kind done for the Bay and supposedly the third[6] specifically for Samoan mangroves. Undertaking the survey was an initial step to understanding the Bay's baseline mangrove faunal biodiversity and fisheries resources through providing a strong basis in both faunal representation and methodological approaches to:

- provide a good spatial representation of the most common species (those making up more than 20% of occurrences) present at the time of sampling,
- detect the occurrence of at least the most common mobile fish and crustacean species present at the time of baseline sampling,
- begin to define the occurrence of key life-history stages in the bay,

[6] The first two surveys are reported by Fisk (2002) and Thollot (1993).

- provide a strong starting point for developing a fisheries fauna guide as a standard allowing comparisons between this and future studies,
- provide a base-line for:
    - future sampling at different times of year to allow the base-line data to be extended with temporal understanding,
    - on-going monitoring, and more detailed habitat-specific studies.

1.2. Field Methodology and sampling areas

The survey sampled 4 zones (Figure 8 & Table 6), each comprising a number of habitats. The intention is to produce a broad understanding of the fauna of each zone by sampling its related dominant habitat, and concentrating sampling along edges where most species occur in highest abundances. Multiple examples of each zone were sampled from prioritized sampling locations to ensure that a core of key data is collected if sampling was limited due to logistic constraints.

Figure 8: Le Asaga Bay sampling zones

The characteristics of the sampling zones are provided in Table 7.

Table 7: Zone Characteristics

Zone	Characteristics
1. River mouth sand flat	Shallow sandy areas outside of mangrove estuaries, at the interface of the estuary and the coastal zone.
2. Downstream mangrove	The lower part (downstream from tidal mixing zone) of the mangrove-lined estuary. This is the part of the estuary most influenced by marine waters.
3. Upstream mangrove	The upper part of the current extent of mangrove forest (upstream from tidal mixing zone). This area has more constant freshwater influence than the downstream mangrove zone.
4. Rock wall	This zone has eroding banks reinforced with rock facing. There are scattered mangroves along the rock walls but forests have apparently been cleared for habitation or these banks may have historically lacked mangrove forests. This zone has extensive human impacts along its banks.

1.3. Sampling Gears/Nets

Each zone was sampled with a suite of gears most suitable for that area. Because of conditions and the physical structure of the different zones different gears were employed in specific habitat types. The Cast net was employed across all zones to provide standardisation however it was only possible to sample rock walls with the gill net.

Although the cast net data can be comparable across zones, the full data set for each of the zones cannot be directly comparable on a quantitative basis because of the variety of gears used. Consequently, the primary comparisons will be based on species occurrences rather than comparative estimates of abundance. Table 8 shows these different gears and Table 9 shows the zones and sampling gears suitable and was used for each zone.

Table 8: Sampling gears

Cast net 	**Fyke net** 
Gill net 	**Seine net** 

Table 9: Sampling gears suitable for each zone

Zone	Habitat	Gear
River mouth sand flat	All habitats	Seine nets, cast nets, gill nets
	Drains	Fyke nets
Downstream mangrove	Deep edges	Gill nets, cast nets
	Shallow banks	Seine nets, cast nets
	Mangrove drains	Fyke nets
Upstream mangrove	Deep edges	Gill nets, cast nets
	Shallow banks	Seine nets, cast nets
	Mangrove drains	Fyke nets
Rock wall	Deep edges	Gill nets, cast nets
	Shallow banks	Seine nets, cast nets

1.4. Data entry and analysis

The key dataset that was collected from the survey included fish names and species, length and number, zone and habitat types, deployment time and number. Other physical data also recorded included salinity, water temperature and pH and GPS readings for every sampling. The raw data collected were entered in a prescribed Excel Spreadsheet and was sent for analysis by the regional experts (Prof. Marcus & Ross) in Australia.

2. RESULTS AND DISCUSSION

A full analytical Report from the experts will be available soon however, preliminary findings have revealed that about 29 fish fauna species and 6 invertebrate species of various life stages occur in the bay either temporarily or permanently. Interesting to have discovered in the estuary was the presence of certain coral reef-associated fish species such as surgeonfish, snapper, goatfish, Crescent perch, etc. which tells that these fish more or less make the mangroves part of their life.

The most common species caught with the four different nets at every sampling time include the *Valamugil sp.* (mullets) and Carangidae (trevallies) of various sizes. This supports the fact that the said two fin fish species are very important in community livelihoods and are the key ones caught from the subsistence and artisanal fisheries in the bay. The two species were also the most commonly occurring of all mobile fish and crustacean species present at every time of sampling. The next common species include the Goatfishes, Emperors, Mojarras, Surgeonfishes and Mangrove crabs. In terms of relative abundance, goatfish was the most abundant (43.5%) of all the species; followed by the mullet (13.6%) and trevally (10.7%). More variety of fish species were caught from the upstream and downstream zones and mostly with the Seine and Fyke nets.

Surgeonfish	Snapper	Blood spot squirrelfish
		

It was obvious from the survey that different fish species and invertebrates of different sizes move into the mangroves during high tide and move out during low tide through the drains. Some of these fish species include the trevally, goatfish, mullet, snapper, crescent perch, mojarras, sea bream and mud crab. The inedible fish species that were also common at and around the drains were the goby, eel catfish, puffer fish and the cardinal fish. Having sampled some same fish species with different length ranges (from 3cm) is a possible indication of the occurrence of key life-history stages in the Le Asaga Bay.

There were several failed nets i.e. nets that were deployed but did not catch any fish. The biggest fish caught were a couple of mullets of 27.75cm from the downstream mangrove zone and with the cast net sampling gear. That is, most of the fish were small and undersize. Among the fin fish species captured were a few mangrove crabs *(Scylla serrata*), a *Casseopea* (up-side-down jellyfish) and a mangrove lobster. These were entangled in the nets. The Venus shells that were also observed were in varying sizes but mostly 3cm or a little bit more. The Table 10 below lists all the fauna captured in Le Asaga Bay during the survey.

Mangrove crab	Up-side-down jellyfish	Mangrove lobster
		
Pufferfish	Eel catfish	Halfbeak
		

Table 10: Fisheries Fauna of Le Asaga Bay

Species Common Name	Species Scientific Name	Samoan Name
Bartail Goatfish	*Upeneus vittatus*	Ulaoa
Dot-tail Goatfish	*Parupeneus indicus*	Tauleia
Goldline Goatfish	*Mulloidichthys samoensis*	Afulu
Cresent perch	*Terapon jarbua*	Avaava
Emperor	*Lethrinus harak*	Filoa-vai
Sea bream (redtail emperor)	*Lutjanus argentimaculatus*	Filoa patuamumu
Fringelip or warty-lipped mullet	*Crenimugil crenilabis*	Anae (>20cm)
Blue-spot mullet	*Valamugü seheli*	Popoto (15 – 20cm)
Engel's mullet	*Valamugil engeli*	Aua (8-12cm)
Mullet	*Liza melinoptera*	Poipoi (5-8cm)
Mullet		Matapona (12-20cm)
Trevally	*Carangidae*	Lupota (8-20cm)
Trevally	*Carangidae*	Lupo (<8cm)
Mojarras	*Gerres macrosoma*	Matu
Mojarras	*Gerres oblongus*	Matu-loa
Herring	*Sardinella articauda/melanura*	Poi/Nefu
Herring	*Sardinella albella*	Pelupelu
Surgeonfish	*Acanthurus xanthopterus*	Palagi
Snapper	*Lutjanus fulvus*	Tamala
Goby (mudskipper)	*Acentrogobius nebulosus*	Manoo
Pufferf1sh	*Arothron manilensis*	Sue
Milkfish	*Chanos chanos*	Ava, Avali'i
Longjawed Barracuda	*Sphyraena flavicauda*	Saosao
Blood spot squirrelfish	*Flammeo sammara*	Malau tui
Mountain bass	*Kuhilia rupestris*	Inato
Yellowtail	*Mugil sp.*	Afa/utualii
Cardinalfish	*Apogon lateralis*	Fo
Halfbeak	*Zenarchopterus dispar*	Ise
Eel catfish	*Plotosus anguillaris*	Apoa
Up-side-down Jellyfish	*Casseopea*	Alualu
Mangrove crab	*Scylla serrata*	Paalimago
Mangrove lobster		Ula togatogo
Red claw mangrove crab	*Sesarma erythrodactyla*	U'a
Venus shell/cockle	*Gafrarium tumidum*	Tugane
Sand cockle	*Asaphis deflorata*	Pipi

3. CONCLUSION AND RECOMMENDATIONS

The various species caught is a good representation of the faunal biodiversity of Le Asaga Bay however there may be still a lot more that were not sampled but utilize the mangroves in one way or another. A local source confirmed the regular abundance of big mullets and trevallies in the bay especially during high tide; also that the various fish species sampled are the key ones fished in the bay by the people of Safata (Patolo, personal conversation).

The samples have implied that some fish are primarily resident and many of their population reside in the mangrove areas. Others may have visited the estuaries from either the sea or rivers mainly to forage, while others may have passed through as a corridor for breeding migrations either within the area or in adjacent coastal waters. The presence of juveniles indicates both the role of mangroves as nurseries and the certain species which breed and nurture in the bay.

The findings overall has provided some ideas regarding the inter-connectivity of Le Asaga Bay mangroves, the other three mangrove systems in Safata and the adjacent sea. It further portrays that the production of fisheries which are dependent on the mangrove detritus forms an essential component of the mangrove ecosystem productivity.

Factors like unsuitability of sampling time and zone, inappropriate net deployment technique, tidal variation and disturbance in sampling area affected the samples collected. Failure to catch any big fish (failed nets) does not necessarily mean that the bay's fish fauna has declined or the reproductive individuals are overfished. For now, this can only highlight the need for further sampling of the area.

This research component recommends that Samoa needs to:

1. Conduct another survey for Le Asaga Bay as a follow up of the current one so to determine any difference in the fisheries fauna;

2. Replicate this survey approach and methodology in other mangrove areas to collect the related information;

3. Document the various fisheries conducted in Le Asaga Bay mangroves as well as other major stands in and around the country;

4. Assess the status of the mangrove crab and Venus shell (*tugane*) and other resources exploited in Le Asaga Bay for regulation and management.

5. Conduct a follow up training on fisheries fauna survey techniques for the government employees and the local communities.

7. MANGROVE SHORELINE HEALTH MONITORING

1. INTRODUCTION

It is generally known that mangrove ecosystems are indeed rich in biodiversity and biomass yet times are changing and there is a need to watch over them from the increasing impacts of human influences and climate change among other destructive factors.

A Shoreline Video Assessment was conducted for Le Asaga Bay mangroves in March 2013. Similar to the surveys reported above, this is the first assessment of this kind to be done for the Bay let alone the mangrove stands in the country to provide an indication of the health of the mangroves and the estuary as a whole. The key Objectives were and are to:

(i) Establish a long-term visual record of Le Asaga Bay mangroves;
(ii) Improve site-level understanding of mangrove ecosystem function, values, key threats, and processes;
(iii) Generate community awareness of mangroves and encourage local environmental stewardship; and
(iv) Provide a standardized method to assess shoreline mangrove condition and change over time

1.1. Field Methodology

The video assessment took a continuous video recording of the entire estuary bank of Le Asaga Bay. The video enables determination of the state of the mangroves through observations of tree height, density, present species, the number of seedlings and the health of the forest. Other features that influence mangroves were recorded such as: bank type and condition, adjacent land use, built features and other vegetation (Duke et al., 2012).

The assessment involved 5 key assessors each performing specific but coordinated tasks.

1. Handy camera Operator – to control and take footages using the Handy camera.

2. GPS Operator – to take waypoints and tracks of mangrove boundaries with the GPS units.

3. Photographer – to take photos of mangroves as the assessment proceeds.

4. Observer/ Recorder – to observe and record information on data sheets.

5. Boat Driver – to drive the boat



1.2. Video Data storage and analysis

The datasets collected included (i) Video clips; (ii) GPS coordinates; (iii) Still photos; and (iv) Notes of observations which were recorded in a prescribed Data Form. These were altogether sent to the regional expert Dr. Norm Duke in Australia for analysis.

2. RESULTS AND DISCUSSION

A full Report of the assessment will be available from the experts soon however, the preliminary results based on the observations are as below. It is important to note that this assessment was conducted about three months after Cyclone Evans hit Samoa so the impacts of the said cyclones on the mangroves were still distinguishable.

- Mangrove Height: The heights of mangroves are estimated to range from 4m to 11m, the *Rhizophora samoensis* being normally shorter than the *Bruguiera gymnorhiza*.

- Mangrove Health: The mangroves are very lush and healthy however some had broken and dried branches as a result of the cyclone.

- A number of fallen trees mainly the associates were observed. The area has never been so severely affected before unfortunately it appeared that it has been disturbed to some greater extent by the previous cyclone. However the cyclone impacts, there is excellent natural recovery and many trees have grown back.

- Species: The *R. samoensis* and *B. gymnorhiza* are the two mangrove species that were and are distinguishable from the boat. The salinity tolerant *R. samoensis* is the dominant species which occur all along the estuary banks.

- Other Vegetation: The associated plants most identifiable from the boat include the coconut trees (*Cocos nucifera) and* Beach hibiscus (*Hibiscus tiliaceus*). These are fairly tall and healthy looking.

- The bank: The estuary banks are naturally flat rather than slope on the peninsula side hence it is more stable with the accumulation of materials carried to and fro and deposited by the currents. However on the land side of the estuary, the banks are fairly sloped and eroding and so are reinforced with rock facing.

- The substrate is muddy at the upstream parts of the estuary where there is little tidal mixing but sandy downstream due to much tidal mixing.

- Point Features: There is extensive human impact along the estuary banks on the land side. Village houses and a jetty are located right on the banks.

- Another unusual feature that was captured is the occurrence of very tall, topless and dead but standing coconuts in the Fusi-Fausaga area.

- Change: A notable change in the mangrove area is the expansion of young and small stands of *R. samoensis* towards the west of the estuary. There used to be no mangroves in these areas until recently.

3. CONCLUSION AND RECOMMENDATIONS

Despite the impacts of the cyclone that were and are still observable in the area, there was and is a good indication of rapid natural regrowth. With these and other increasing impacts of human influences and climate change which threaten the health of mangroves, consistent watching and assessment is essential so to determine the health of the mangroves and the estuary from time to time.

The assessment is the first one of this kind to be done for the Bay and for the mangroves of Samoa. It has provided the baseline for establishing a long-term visual record of mangroves in the bay, as well as a standardized method to assess shoreline mangrove condition and change over time. The information captured by the video will not only contribute to improving site-level understanding of mangrove ecosystem function, values, key threats, and processes; but

also generate awareness of mangroves in the Safata community and encourage local environmental stewardship.

The urgent recommendations that have derived from this survey are as below.

1. Using the baselines from the current assessment, develop a medium to long-term assessment and monitoring plan for the Le Asaga Bay mangroves so to keep track of the shoreline mangrove condition and change over time. Consistency needs to be an important part of the plan.

2. Where practicable, replicate the assessment in other mangrove areas to collect relevant information and include these sites in the monitoring plan.

3. Raise awareness both community and public on mangrove ecosystem function, values, key threats, and processes using the video and other related knowledge products.

4. Run a follow up Shoreline Video Assessment Methodology training for the relevant government officials so to up-scale skills and knowledge on such assessment techniques including the use of tools and equipment.

8. GENERAL DISCUSSION AND CONCLUSION

It needs a paradigm shift to fully realize and appreciate what mangrove ecosystems really are.

The above surveys are the first ones to have been conducted for the mangroves of Samoa. Thus, the resultant baseline findings have added to the almost non-existence pool of related scientific information in Samoa. These are a tremendous and essential contribution yet the basis for bringing about improved mangrove conservation and co-management for climate change adaptation and livelihood in Le Asaga Bay. In combination, they show the extreme importance of these ecosystems in sustaining the ecological systems and people's livelihoods at Le Asaga Bay.

The findings and implications of the studies regarding mangroves overall suggest that the consideration and adoption by the government of Samoa of these new findings and recommendations will hopefully lead to a better understanding of the importance of the mangrove resources, promote sustainable use and development while at the same time implementing proper measures to control intensive exploitations resulting from people's increasing reliance on the resources.

In conclusion, the successful completion of the FIVE Surveys is both a huge achievement for the MESCAL Samoa Project and a tremendous benefit for the government of Samoa particularly in terms of: (1) Availability of baseline information in country to assist national and site-level mangrove management; and (2) Improved technical capacity of government officials in relation to mangrove surveys methodologies and techniques. The project sees that these and the recommendations of the respective surveys provide a basic sustainability roadmap for the government of Samoa to follow at least from now in her attempt for improved and effective mangrove co-management for climate change adaptation and livelihoods.

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