Cities and Climate Change Initiative

ABRIDGED REPORT

Apia, Samoa

Climate Change Vulnerability Assessment

UN HABITAT
FOR A BETTER URBAN FUTURE

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UNEP

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Apia, Samoa - Climate Change Vulnerability Assessment

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Introduction

Earth's climate has never been stable. Geological records demonstrate dramatic fluctuations in temperature occurring over millions of years. However, over the last hundred years, the climate has been warming as a result of human activities – a process referred to by scientists as 'anthropogenic' climate change, as it results from the influence of human activity rather than natural cycles.

Samoa is one of the nine countries chosen to undergo a Climate Change Assessment as part of the United Nations Human Settlements Programme (UN-Habitat) Cities and Climate Change Initiative (CCCI), in collaboration with the Commonwealth Local Government Forum (CLGF). The long term goal of the programme is primarily to enhance climate change mitigation and preparedness in cities by assisting local governments to develop climate change adaptation priorities, policies and awareness at all levels. However, in Samoa, there are two distinct tiers of governance. While the national government operates through various centralized structures, it does not have designated local authorities. Instead, communities are managed through a traditional system of village councils who are responsible for a range of public areas, such as education, health and other services.

Samoa, like other Pacific Island States, is prone to natural disasters, most of which are weather and climate related, with floods, storms and wave surges associated with tropical cyclones being the predominant causes. Its tropical location exacerbates vulnerability, with extreme rainfall, temperatures and tropical storms posing significant risks of flooding and storm surges. This vulnerability assessment therefore sets out to measure exposure, sensitivity and adaptive capacity to climate change in the city of Apia. It will identify local vulnerability to potential climate change impacts, drawing on the climate projections and experience of recent natural disasters such as tropical cyclones, storm surges and flooding, as well as all relevant climate related studies conducted to date in Apia. This provides a context for government decision makers to prioritize and design local adaptation and mitigation strategies.

02

Overview of the Country and the Apia Urban Area

2.1 The Country Context

Samoa is a small island state in the southwest Pacific, comprised of four inhabited and six smaller, uninhabited islands located between latitude 13-15^{0}S and 168-173^{0}W longitude. It has a total land area of approximately 2,820 sq km. The two main islands of Upolu and Savaii, comprising over 95% of the land area, are characterized by rugged and mountainous topography. Samoa's exclusive economic zone of 98,500 sq km is the smallest in the Pacific region. Around 46 per cent of Upolu and 70 per cent of Savaii is covered by secondary and indigenous forest.

2.2 Demographics

Samoa's resident population from the 2011 national census was 186,340, with 20 per cent classified as living in the urban area in which the capital city Apia is located. The northwest of Upolu, when combined with Apia's urban area, represents an area of only 311 sq km or 11 per cent of the total land area, but over 50 per cent of the population of Samoa. This has significant social and economic implications, given the growing number of people residing outside traditional village settings and their associated governance structures. Between 70 and 80 per cent of the population live along or within a kilometre of the coast.

Since independence in 1962, significant levels of emigration have slowed the overall rate of population growth. The New Zealand quota scheme, which allows 1,100 Samoans per year to gain permanent residency, is a major factor in the relatively slow increase in population, despite a high annual birth rate.

Internal migration, especially from rural to urban areas, is likely to continue given the greater social and economic opportunities in Apia and the surrounding peri-urban region of North West Upolu. Furthermore, the increased availability of freehold land since the 1990s, previously held as government property, is another driver of recent urban growth. Samoa has a fairly young population. Younger age groups are dominated by males, but over the age of fifty there tends to be more women.

Samoans make up 96 per cent of the ethnic population of the country, with the remaining four per cent made up largely of foreign short term workers. Less than one percent of the national population are non-ethnic Samoans, but this group mostly have some form of connection to Samoa, either by marriage or through a relative. The average household size for the whole country in 2011 was 7.2 persons per household.

2.3 Economic Sector

Samoa has a relatively small but developing economy that has traditionally depended on development aid, overseas family remittances, agriculture, fishing and tourism. Fish and agricultural products are the main exports, with the tourism sector developing in recent years. Agriculture furnishes 90 per cent of exports, mainly coconut cream, coconut oil and copra. Since

Figure 1: Map of Samoa

Source: UN-Habitat

1994, tourism earnings have been the largest source of foreign exchange and have grown significantly from USD 40.6 million in 1999 to USD 107.3 million in 2007. Samoa is one of the highest recipients of remittances in the world as a proportion of Gross Domestic Product (GDP), typically fluctuating between 20 and 25 per cent. Only around 12 per cent of Samoa's total population is engaged in formal paid employment. Two-thirds of Samoa's potential labour force is absorbed by subsistence village agriculture, a dominant sector in the Samoan economy.

In 2014, Samoa graduated from the group of least developed countries and moved into the developing country group. This reflects its relatively large GDP per capita and its higher performance in other economic and human index indicators: over 95 per cent of the country has access to electricity, more than 97 per cent to clean water and 98 per cent to a direct road connection. According to World Bank, in 2013 Samoa had GDP of USD 694.4 million, while its GDP per capita was USD 4,840. The main drivers for Samoa's economy are the primary (ten per cent), secondary (22 per cent) and tertiary sectors (68 per cent).

Samoa depends on imported petroleum for much of its energy needs. It is the government's objective that Samoa switches its reliance on fossil fuels to renewable energy in the near future. The Samoa Energy Policy aims to promote and encourage the use of renewable energy sources including solar, wind, coconut oil and urban waste. Currently, about 95 per cent of Samoa has access to electricity, 32.8 per cent of which is generated from hydro-electric power plants.

2.4 Governance Structure

Samoa has parliamentary democracy style governance modelled under the Westminster system. The Samoan Parliament is a unicameral legislative assembly made up of 49 members of parliament with 47 MPs representing 41 traditional constituents and two MPs representing individual voters. Only matais (traditional

chief titleholders) can stand as candidates for election under universal suffrage. However, Samoa does not have local government systems, meaning all national matters ranging from water supply, electricity, land, planning and infrastructure to village and individual matters are managed by the national agencies.

The 41 traditional constituents are made up of over 300 traditional villages which are controlled by village councils and protected by the constitution. The 1990 Village Fono Act gives village councils (fono) authority over village law and order, health and social issues. This traditional system provides communities with a local governance structure managed by village councils represented by matais with hereditary connections and customary land ownership to the specific area. In the Apia urban area, some lands are under freehold land ownership without the traditional councils. In these areas, with no systematic governance arrangements in place, local churches perform some duties while the national government presides over all statutory matters. The main focus of the churches, however, is social issues and law and order. This puts pressure on the Planning and Urban Management Agency (PUMA), as the central government agency responsible n this area, to ensure environmental protection and sustainable development.
The Ministry of Natural Resources and Environment (MNRE) is the lead agency responsible for developing strategies and policies in relation to climate change and for overall implementation of national adaptation measures. Within MNRE, PUMA is responsible for strategic planning and development in urban areas, as well as facilitating community consultation and issuing development consents. These require and environmental impact assessment and provide a tool to manage building and construction, but currently are not linked to defined activity zones or urban planning priorities. In relation to Apia, PUMA is responsible for conducting the vulnerability and adaption (V&A) assessment and for implementing any plans which result from it.

2.5 Physical and Biological Environment

All the islands of Samoa were formed by volcanic activity. Most soils were derived from basaltic volcanic flows differing largely in age and type of deposit. The young volcanic structure of the island means the soils are, in places, very porous for leaching into the groundwater system.

Approximately 50 per cent of Savaii and 40 per cent of Upolu are comprised of steep slopes derived from volcanic activity. Both islands have central mountain ridges formed from a chain of volcanic peaks and craters. In Upolu, the mountain range runs along the length of the island with some peaks rising to more than 1,000 metres above sea level, surrounded by flat and rolling coastal plains. Savaii contains a central core of volcanic peaks reaching 1,858 metres at the highest point and encompassed by a series of lava-based plateaus, hills and coastal plains. Approximately 80 per cent of the 403 kilometre coastline is 'sensitive' or 'highly sensitive' to erosion, flooding or landslip.

Samoa was once completely covered by indigenous lowland and upland rainforests, with wetlands mostly along the coastal areas and mixed upland swamp forest. Since the mid-1800s, when commercial farming operations were introduced, the native forests on Upolu were cleared for coconut and rubber tree plantations. Agricultural development since independence in the 1960s resulted in further forest clearing to make way for plantations, farms and logging operations across the country. In the early 1990s, major cyclones - Ofa in 1990 and Val in 1991 - decimated the remaining indigenous forest stands to the point that the majority of Samoa's forest is a mixture of secondary growth and disturbed forests. Upland Savaii's montane and cloud forests were able to recover from the cyclones and remain the only undisturbed native forest left in Samoa, while all the forest on Upolu Island has been affected in some way.

Five major common vegetation types are present in Samoa's terrestrial ecosystems: littoral vegetation, swamp and herbaceous marsh, rainforest, volcanic vegetation, and secondary or disturbed forest. For the marine environment, Samoa is surrounded by coral reefs, with sea grass beds, coastal marshlands and mangrove forests bridging the intertidal zones. The marine biodiversity is common for tropical islands, although the biodiversity in Samoa is not as rich or diverse as its neighbouring islands on the Western Pacific. While the smallness and geographical isolation of its islands have led to a high level of species en-

demism, at the same time these factors have led to ecological fragility, with many species having limited defenses against aggressive invasive species.

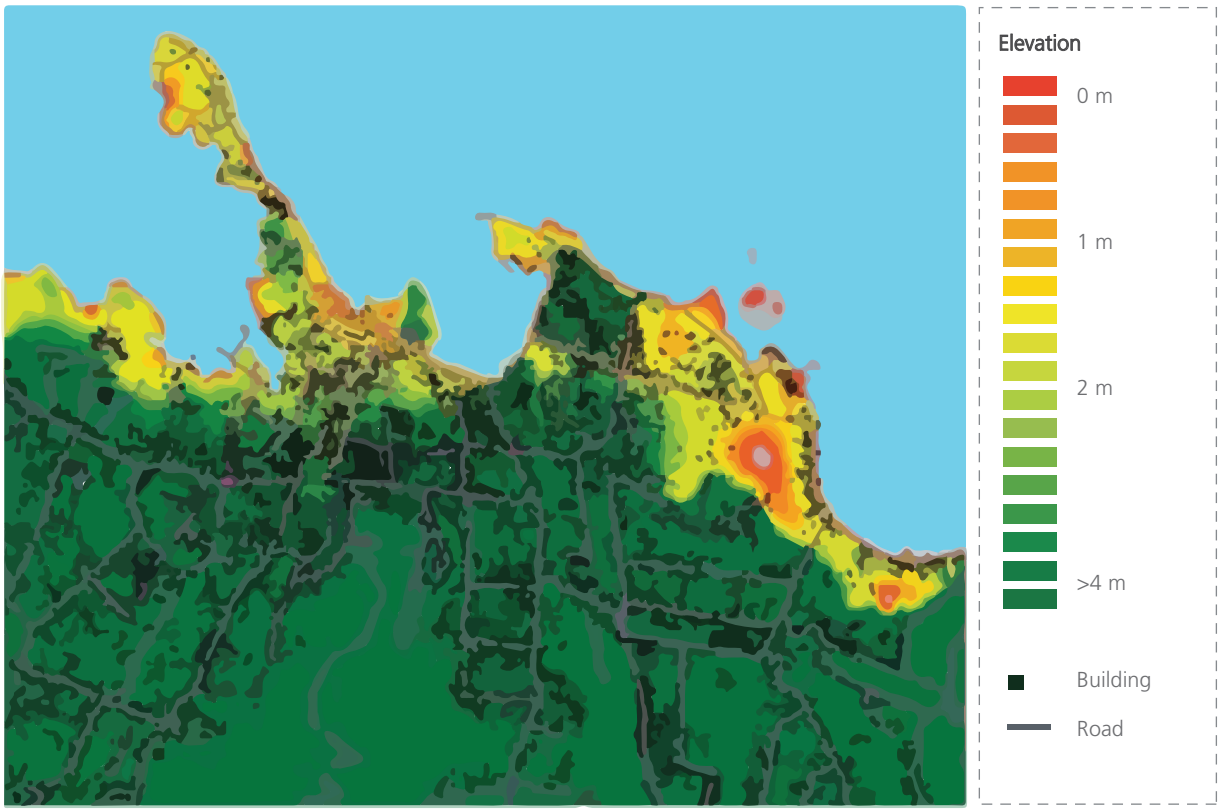
2.6 Geographic Location of Apia Urban Area

Apia is located on the north coast of Upolu Island. The PUMA through its Act reform proposes the Apia urban area (the City) as the four districts Vaimauga East and West, Faleata East and West. The city is home to at least 21 per cent of the total population with a total land area of 61 sq km. It is characterized by a narrow, low lying, coastal plain with Mount Vaea and highlands bordering the city in the south from east to west. The lowland is relatively flat and its elevation is not more than ten metres above the mean sea level.

Across the whole of Apia's urban area lie the catchments of the six streams from Fagalii in the east to Fuluasou in the west. The Fagalii catchment is the smallest, occupying a narrow valley adjacent to the Vaivase catchment. It has a total area of approximately 500 ha. The two largest catchments are the Vaisigano and Fuluasou catchments, each with a total area of 3,200 ha with the Gasegase catchment the third largest at 2,500 ha. The Mulivai and the Vaivase catchments are each approximately 700 ha in area.

There is significant pressure on the lower slopes of the watershed catchment areas as residential development of freehold land pushes into areas previously used for rural activities such as agriculture and forestry. The gently sloping land areas are mostly built up, while intense agricultural activities occur mainly in the highlands.

Figure 2: Elevation Map of Apia



Source: MNRE, Samoa

2.7 Population

The Apia Urban Area (AUA) population has declined from 38,836 in 2001 to 36,853 in 2011. This reverses previous trends and is thought to be caused by the growing population in the urban periphery, both in the north western and the eastern region of Upolu. The total population of AUA now comprises 21 per cent of the total national population. This figure rises to over 30 per cent when the peri-urban region of North West Upolu is taken into account. If the whole of North West Upolu is taken into account, 53 per cent of the entire national population live in this region.

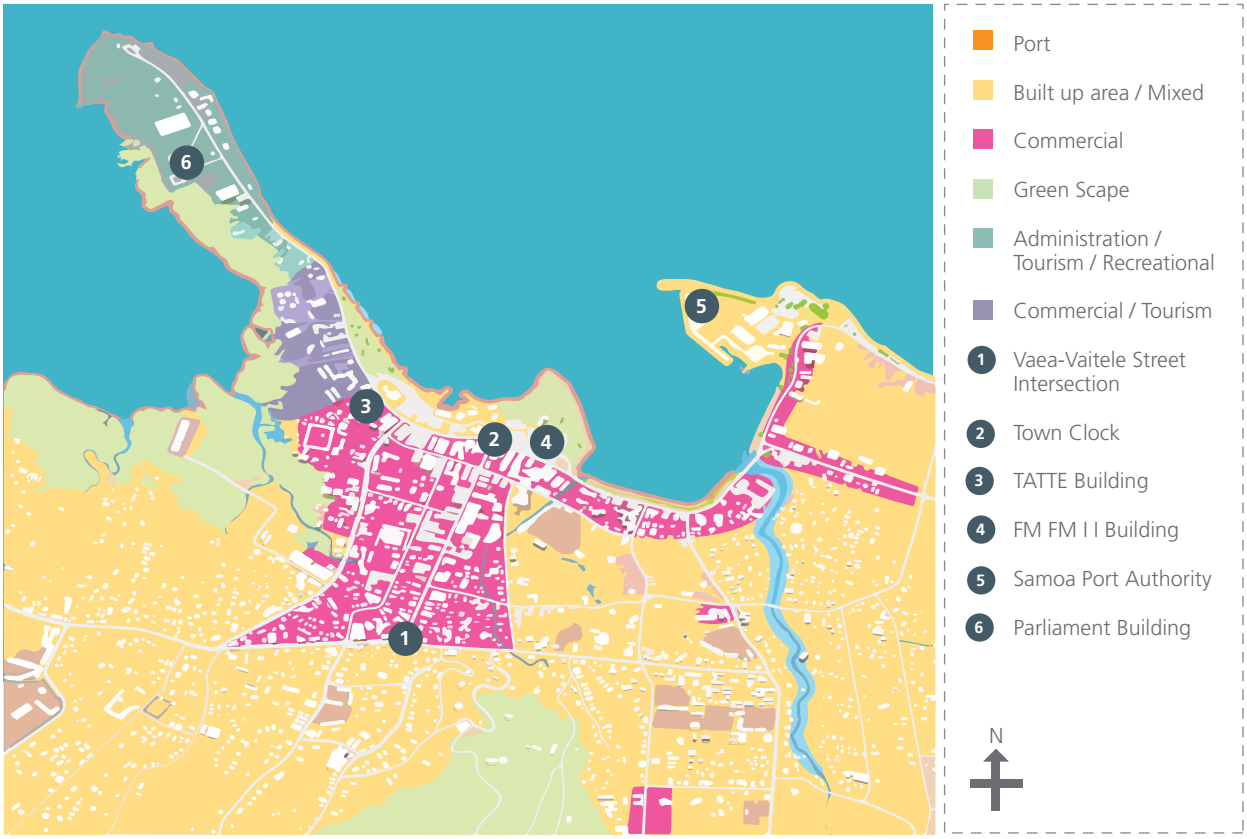
The population density for AUA is 612 persons per sq km, made up of 5,389 households. This is more than ten times the national average population density of 60 persons per sq km. Of the AUA population, around 60 per cent are of working age (15-59) while the other 27 per cent make up the under-14 age group. Of particular significance in this population breakdown is that of the working age group, around 54 per cent are employed while the remainder are either in school or unemployed.

AUA has around 50 schools providing elementary, primary, secondary and tertiary level education. Although there is no specific data for Apia, the national literacy rate for the 15-24 age group is 98 per cent. This is relatively high for a developing country and an important element in public awareness and education programmes.

2.8 Land Use and Land Tenure

The AUA is the only area of Samoa where freehold land ownership is a significant feature. Only 29 percent of AUA households live on customary lands, com-

Figure 3: Apia Land Use



Source: MNRE, Samoa

pared to 69 per cent of households in the country as a whole. However, there is a complete range of urban land uses in each village area as families are granted the right to start businesses on their land. Each area then contains wholesale, service and industrial activities, restaurants, tourism ventures as well as schools. Agriculture and forestry activities are scattered on the highlands.

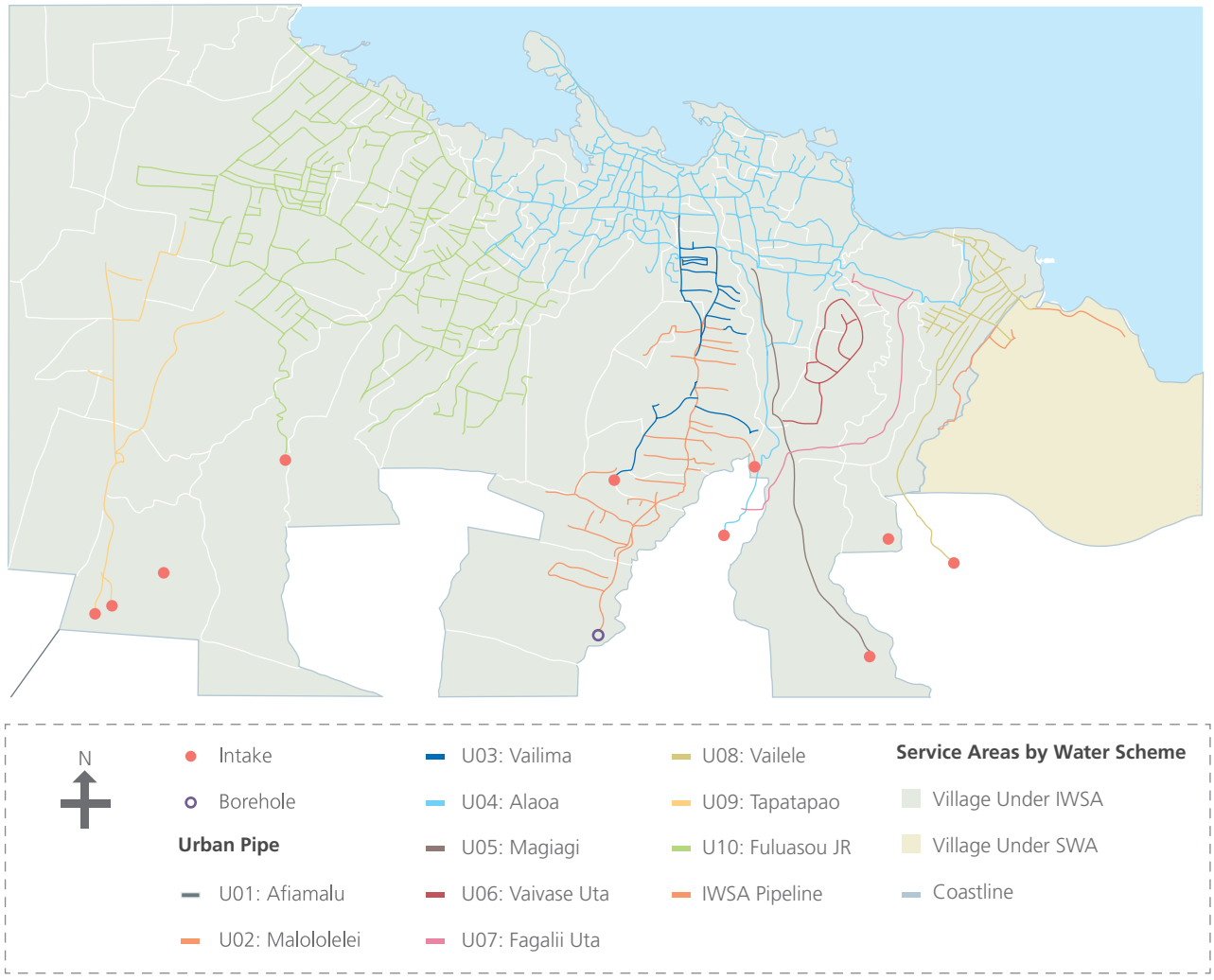
To date, no proper land use plan has been developed for Apia. PUMA, with the support of UN-Habitat, is at the preparatory phase of its design. Since the arrival of Europeans in the nineteenth century, Apia has developed as the main port and administrative centre, with some land converted from village ownership and land use to government and freehold land uses. These changes occurred on an opportunistic basis rather than through planning.

2.9 Key Infrastructure

2.9.1. Water Supply and Sanitation

Water in Apia is supplied from the main urban catchments, with 65 per cent sourced from surface water and 35 per cent from ground water. In addition to the water supply network, which serves the majority of the AUA, many family homes and buildings also collect rainwater through guttering around buildings

Figure 4: Apia Water Supply



Source: Samoa Water Authority, 2012

which is stored in rainwater tanks for use when the network is down during dry periods or after heavy rainfall. Furthermore, more than ten spring pools are found throughout the AUA, used by families and businesses on a daily basis for drinking water, bathing and laundry. These spring pools are also the main source of water for the area after cyclones when the water supply network may be down for two days to a month, as was evident after Cyclones Ofa, Val and Evan.

The final source of water for the communities around AUA is the four main river systems that flow through it. When the river flow is clean, it is used by some of the families for washing and bathing when the water network is down. Apia is served with a wastewater treatment plant used mainly by the commercial sector and multipurpose buildings. Septic tanks are used by almost all households throughout AUA, while a very small percentage use pit latrines.

2.9.2. Transportation

Land

The city is connected with an improved road network at critical locations. The key routes to Apia City are the West Coast road, East Coast road and the Cross-Island road. All major urban road networks are sealed, but several key infrastructure elements such as footpaths and drainage systems need to be installed in areas such as the central business area and roads close to the coastline.

Air

The Fagalii commuter airport is located on the eastern side of Apia, below the hill top of Fagalii village. The airport is paved and used for both domestic and international services, mainly American Samoa. The airport is a short drive from the Central Business Area and has limited area for expansion because of the topography.

Sea

The main port for Samoa is located in Apia Bay. It is the main exit of passengers to American Samoa and the Tokelau islands by ferry. It also serves the main cargo movement into and out of Samoa. Apia Port recently completed extension works and statistics indicate that more than 20,000 containers landed at the Port, with around 20 cruise ships expected to berth during 2013.

2.9.3. Telecommunications

Landline and cellular/mobile telephone services are available throughout Samoa and broadband internet is currently being rolled out nationally. The headquarters of the telecommunications companies are located within the AUA, as well as the main television, cell phone and radio poles. These and other infrastructure are vulnerable to strong cyclone winds, while the main radio communication pole and meteorology equipment on the Mulinuu Peninsular are also located on sea level rise and storm surge risk areas.

2.9.4. Electricity

Over 95 per cent of Samoa's population have access to electricity, while within the AUA every household and business has access. Electricity in Apia is sourced from a combination of diesel and hydro-electric power generation systems. The hydro-electric dams in Afulilo, Lalomauga, and Alaoa generate around 36.8 million kWh annually, amounting to approximately 32.6 per cent of national electricity needs. A supplementary 396 kwh of solar power was also recently installed, with the development of an additional 4 mwh approved in Apia and Faleolo Airport to increase the renewable energy share. The majority of solar generated electricity will be located in the AUA, making it vulnerable to cyclones. Electric Power Corporation, the country's supplier and distributor of electricity, recently moved the main diesel generators inland as part of its upgrading and climate proofing activities.

2.9.5. Drainage System

Apia has an extensive drainage system that is regularly upgraded as new roads and properties are built. Most of the drainage systems follow the river systems of Gasegase, Mulivai, Vaisigano, and Fagalii. Due to the continuous build up of new roads, properties, residences and office buildings, the drainage system has suffered in that now most of the flooding is the result of either blocked drains or natural waterways being reclaimed. A recently completed Apia Spatial Plan is now being used by the Land Transport Authority to upgrade and improve the drainage system, which will hopefully reduce major flooding around Apia during heavy rainfall.

03

City-Wide Vulnerability - Assessment of Key Climate Drivers in Apia

3.1 Assessment Framework

A general climate change vulnerability and adaptation assessment has been chosen as the framework for this study, where vulnerability is a function of exposure, sensitivity and adaptive capacity to climate change.

As defined by the IPCC, adaptive capacity describes the ability of a system to adjust to actual or expected climate stresses, while sensitivity refers to the degree to which a system is affected, either adversely or beneficially, by climate–related stimuli. Exposure relates to the degree of climate stress upon a particular unit of analysis. It may be represented as either long term change in climate conditions or changes in climate variability, including the magnitude and frequency of extreme events.

The main steps for completing Apia's Vulnerability and Adaptation Assessment were as follows:

- **Determining the scope:** identifying the geographic and sectoral focus of the assessment and the systems - natural, social, economic, institutional and built - which will be impacted. This assessment, in line with PUMA's definition of Apia's urban area, includes four districts (Faleata Sisifo, Faleata Sasae, Vaimauga Sisifo and Vaimauga Sasae) due to their population composition and urban service infrastructure.

- **Conducting a baseline assessment:** describing the past and current context, including trends and drivers across each of the identified systems. This involves gathering secondary data from key government departments and other relevant agencies, as

Figure 5: Assessment framework

Source: UN-Habitat

well as documenting individual accounts from cer tain communities.

- **Conducting an impact and vulnerability assessment:** developing an analysis of the projected climatic threats to the target systems. The impact assessment combines the level of exposure and sensitivity of Apia city while identifying the city's climate change hotspots.

- **Validating adaptation modalities and responses:** integrating the assessment with initial consultation results and the outcomes of previous studies to design integrated adaptation options and priorities.

3.2 General Climate

Samoa's seasonal climate varies depending on the wet and dry seasons. On average, about 75 per cent of Samoa's yearly rainfall occurs in the wet season, between October and April, and this is accompanied with warmer air temperatures. By contrast, in the dry season (May - September) Samoa experiences low rainfall (only about 25 per cent of the annual volume) and cooler air temperatures.

Temperatures range from 24 to 32˚C and are generally uniform throughout the year, with little seasonal variation due to Samoa's near-equatorial location. Average annual rainfall is about 3,000 mm, with about 75 per cent occurring during the wet season, and varying from 2,500 mm in the northwest parts of the main islands to over 6,000 mm in the highlands of Savaii. Samoa's topography, particularly its mountains, also influences rainfall distribution. Wet areas are generally located in the southeast and the relatively drier areas – such as the Apia Urban Area - are located in the northwest. Humidity is usually high at about 80 per cent.

Samoa experiences southeast trade winds for most of the year. Severe tropical cyclones occur from December to February. Samoa is also subject to anomalously long dry spells that coincide with the El Nino Southern Oscillation (ENSO) phenomenon. Several of these dry periods have occurred over the last decade, together with several damaging tropical cyclones – which is consistent with expected increase in variability due to climate change.

Samoa's climate profile and climate change projections have been adapted from *Climate Change in the Pacific: Scientific Assessment and New Research, Volume 2: Country Reports*.

Infrastructure in Apia
Photo © Bernhard Barth

3.3 Main Drivers of Apia's Climate

Samoa's climate is normally driven by the South Pacific Convergence Zone (SPCZ) and El Nino Southern Oscillation (ENSO). The SPCZ adds to the intensification of rainfall, especially during the wet season when it becomes active. It is almost non-existent during the dry season, however, resulting in very dry rainfall conditions. It is a zone of wind convergence, cloudiness and rainfall that lies over Samoa in the wet season and retreats towards the equator in the dry season. As a result, Samoa receives more than three times the amount of rainfall in the wet season that it does in the dry season.

ENSO is a natural phenomenon that occurs on a global scale but mainly affects countries in the Pacific Ocean. ENSO has two phases - La Nina and El Nino - but also a neutral phase between the two. During a La Nina year, Samoa experiences flooding in downtown Apia as a result of extreme rainfall. The opposite occurs in an El Nino year. Drought and forest fires are most prevalent during the dry season in the northwest division of Savaii, due to the coinciding effects of El Nino such as low rainfall and a prolonged dry season.

The Climate Risk Profile (CRP) developed for Samoa in 2007, supported by more recent studies in Samoa by the Pacific Climate Change Science Program (PCCSP, 2011) and others, indicate that the major climate risks facing Samoa by 2050 are:

- a sea level rise of 36 cm;
- an expected increase in average rainfall of 1.2 per cent per annum;
- a 7 per cent increase in the velocity of extreme wind gusts; and
- an increase in maximum temperatures of 0.7˚C.

3.3.1. Rainfall

The 2011 study by the PCCSP indicates that the annual and seasonal rainfall trends for Apia for the period 1950 – 2005 are not statistically significant.

However, the daily rainfall of 400 mm or more had a return period of 41 years. It is anticipated that it will become a 38 year event by 2050. Six-hourly rainfall of 200 mm was a 30 year event in 2007 and is likely to become a 20 year event by 2050. However, the CRP noted in 2007 that daily rainfall of more than 300 mm was becoming more common, with a then current return period of 10 years.

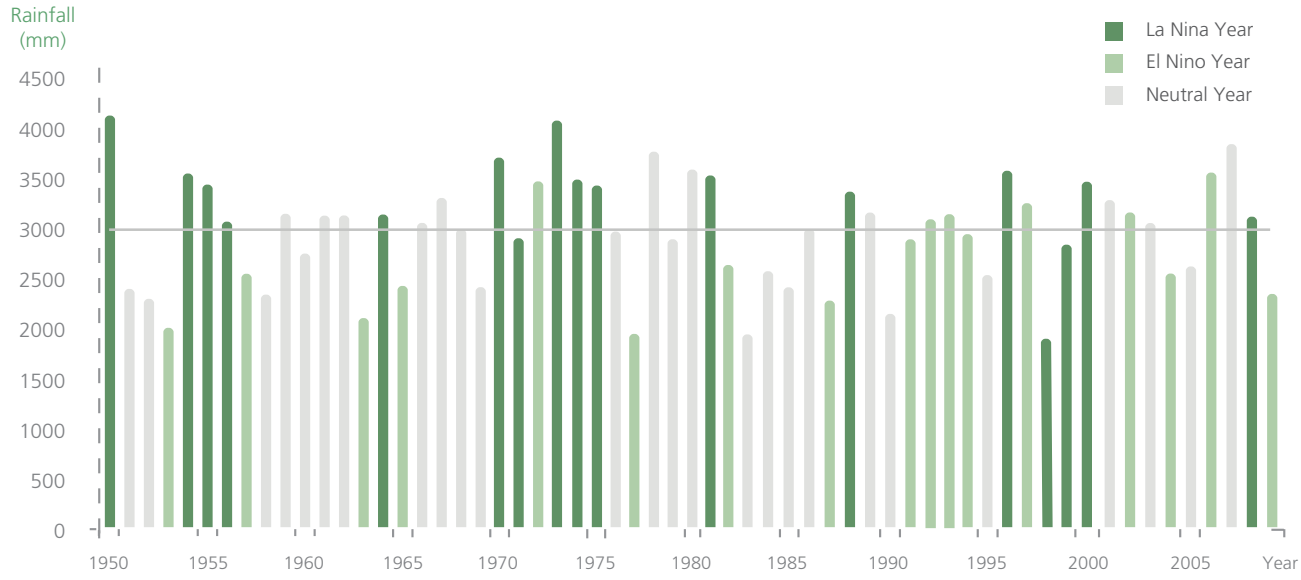
3.3.2. Drought

There is considerable inter-annual and inter-decadal variability in the patterns of drought for Apia. However, there is a clear correlation between drought and El Niño events. Little change is projected over the course of the twenty-first century. Based on the CMIP 3 models project data, the majority estimate that mild drought will occur approximately seven to eight times every 20 years in 2030 under all emissions scenarios, decreasing to seven times by 2090, while severe drought is projected to remain approximately stable, at once to twice every 20 years.

3.3.3. Wind

The CRP 2007 report indicated a 75 year return period for extreme gusts of 70 knots, but this will likely reduce to about 40 years by 2050. Tropical cyclones have historically occurred about once every 1.8 years, with between zero and four occurring in any one year. While the intensity of tropical cyclones is expected to increase as a consequence of rising water temperatures, the impact of climate change on their frequency is unknown. Cyclone frequency has increased between 1831 and 2000 and this trend may continue and possibly accelerate under climate change scenarios. Current maximum wave heights associated with

Figure 6: Annual Rainfall in Apia



Source: Pacific Climate Change Science Programme, 2011

cyclones are estimated at 9 and 10 metres for 50 and 100-year events respectively. The frequency of an event with the intensity of Cyclones Ofa (Class 4) may increase from once every 50 years in 2008 to once every 20 years in 2030. According to World Bank estimates, this scenario could result in an annual expected loss from coastal flooding of USD 80 million, amounting to 9 percent of GDP.

3.3.4. Air Temperatures

Positive trends are evident in both annual and seasonal mean air temperatures at Apia for the 1950 – 2009 period. Maximum air temperature trends are considerably greater than minimum air temperature trends.

Air temperature is projected to continue to increase over the course of the twenty-first century. There is very high confidence in this direction of change because:

- Warming is physically consistent with rising greenhouse gas concentrations.

- All CMIP3 models agree on this direction of change. CMIP3 model simulate a slight increase (<10C) in annual and seasonal mean temperature by 2030.

3.3.5. Sea Temperatures

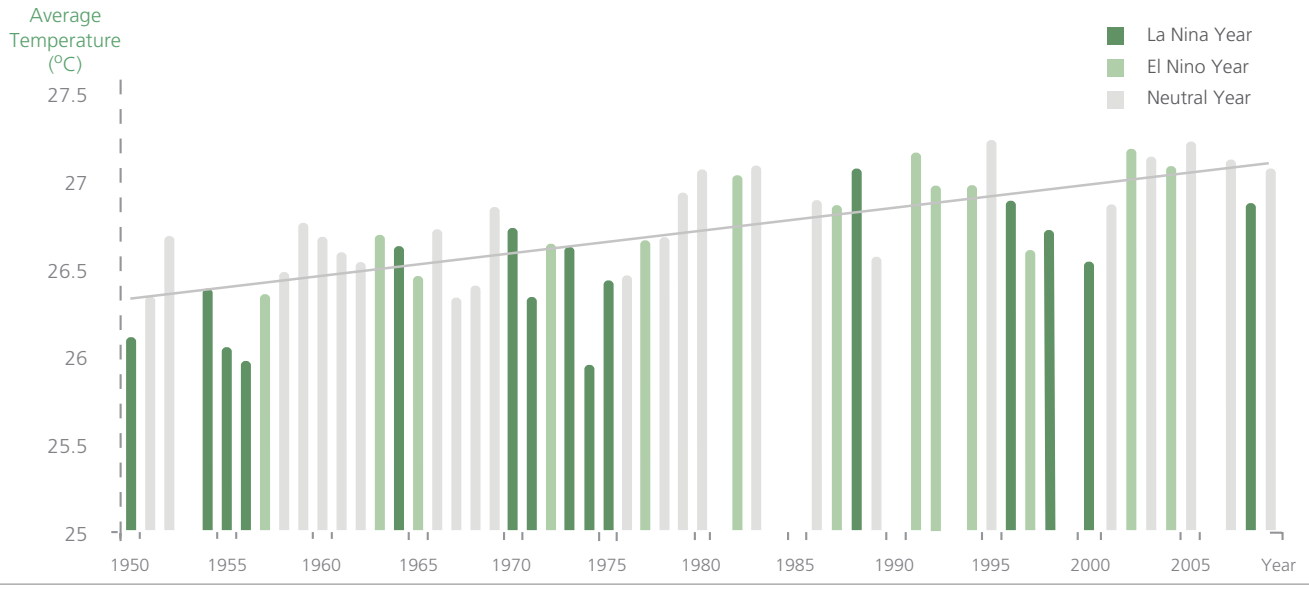
There is significant variability in the maximum annual sea temperature for Apia, although there is evidence of a rising trend between 1993 and 2006. Sea temperature increases are a primary driver of atmospheric instability, leading to effects such as higher intensity storm events and prolonged periods of drought. In addition, ocean warming and acidification are leading to coral bleaching in tropical areas worldwide, with potential for irreversible damage to protective coral reef environments.

3.3.6. Sea Level Rise

Monthly averages of the historical gauge, satellite (since 1993) and gridded sea level (since 1950) data are in close agreement after 1993 and indicate inter-annual variability in sea levels of 20 cm (estimated 5 – 95 per cent range) after removal of the seasonal cycle.

The annual climatology of the highest daily sea levels has been evaluated from hourly measurements by the tide gauge at Apia. High tides show a small variation throughout the year with an April-May minimum and a July-August maximum. There is no seasonal cycle in

Figure 7: Annual Mean Temperature in Apia



Source: Pacific Climate Change Science Programme, 2011

the long term variations in sea level, although during La Nina years sea levels tend to be higher from January to June and during El Nino tend to be lower from February to September.

The observed long-term trend in relative sea level in Apia is 5.2 mm per year, but maximum hourly sea level is increasing by approximately 8 mm per year - a significantly greater rate of increase than observed in global and local trends. For Apia, an hourly sea level of 1.8 metres above mean sea level was a 1:100 year event in 2007, but is likely to become a 1:4 year event by 2025.

The scientific understanding of sea level rise and, in particular, the contribution of ice sheet melt has improved somewhat since the Climate Risk Profile was produced, but there are still significant uncertainties around the role of major ice sheets and deep ocean warming. Since the CRP was produced, a number of papers have been published suggesting that sea level rise by 2100 could be 1.5 or even two metres. However, most of the research in the literature points to rises of less than one metre by the end of the century. Larger rises cannot be ruled out, and it is recognised that future sea level rise may well be underestimated by current models. This suggests that the 2007 CRP projection of 36 cm increase in sea level for Apia by 2050 may need to be revised upwards slightly.

A precautionary approach would suggest that a figure in the region of 0.4 – 0.5 metres of sea level rise by 2050 at Apia should be used for this vulnerability assessment and the planning which follows. A further factor, reflected in the absolute and relative values of sea level rise is that Samoa is undergoing subsidence at a rate of between 0.1 and 1.7 mm per year due to long-term volcanic cooling effects.

Even with a relatively modest scenario of 26.2 cm sea level rise by 2030, damage caused to low-lying communities by storm surge events represents a serious threat to Samoa. In addition, sea level rise may cause salt water to encroach into the fresh groundwater aquifer, an effect known as salination – which may lead to significant issues for both health and agriculture. A sea level rise of 26.2 cm is estimated to increase the level or risk across all asset classes by more than 200 percent compared to today.

3.3.7. Salination

One third of Samoa's water supply is sourced from groundwater, making it vulnerable to increased salinity. The salinity of coastal groundwater is determined by the rate of pumping and average annual rainfall, as well as sea level rise. Looking at only sea level rise, it is estimated that the "freshwater lens" could move inland by about 160 metres in Upolu by 2100, with potential for significant contamination of freshwater sources.

3.3.8. Flooding

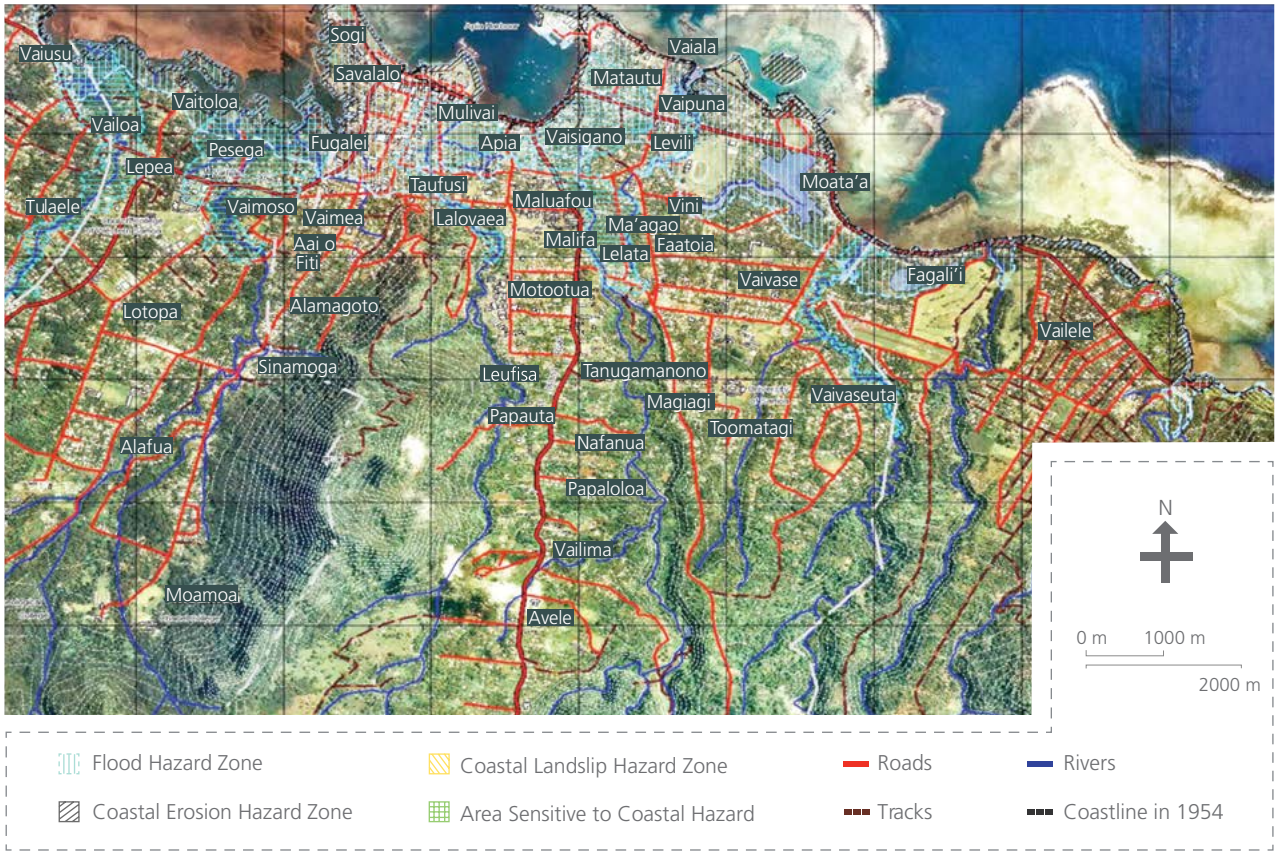
The Integrated Flood Management report did not discover any specific information on the effects of climate change on Apia's rainfall or tidal levels, although it is generally accepted that the frequency and intensity of rainfall events will increase and that sea levels will rise as a consequence of climate change. A key element of preparedness of infrastructure in the AUA for the effects of climate change on rainfall and tides is the review of the quality of existing infrastructure. There is little to be gained from expending funds on raising the capacity of existing infrastructure to cater for climate change effects on rainfall and tides if that infrastructure is not well engineered in the first place.

04

Apia: Exposure and Sensitivity to Climate Change

Apia is located on a floodplain vulnerable to a range of impacts as a result of climate change. Apia's key hazard zones are mapped out in Figure 8.

Figure 8: Apia Hazard Map



Source: MNRE, Samoa

4.1 Extreme Rainfall and Increased Precipitation

Flooding in Apia as a result of intense rainfall and increased precipitation is not unusual. The 2012 flooding associated with tropical Cyclone Evan inundated much of central Apia, causing disruption to traffic, business operations as well as property damage. The Vaisigano River overflow recorded inundation levels of greater than one metre from the ground, reaching a maximum of two metres at site specific locations in under an hour. Communities along the river floodplain were flooded, leaving a layer of mud after the water abated. Residents were forced to evacuate to designated safe haven grounds.

An increase in precipitation and extreme rainfall in Apia would also mean increased soil erosion, landslides, and surface flooding for communities on the coastal plain, in low-lying areas and along the four river catchments in the city. Roads and underground infrastructure, including electrical and communication lines, water, septic tanks and sewer systems are highly prone to flooding. Fisheries' economic activity is also disrupted. Communities in the low-lying areas and also along the river streams are particularly at risk. There are a total of 7,253 peoples in 19 communities vulnerable to flooding.

4.2 Exposure to Sea Level Rise

Based on sea level trends and coastal hazard studies conducted to date, 15 coastal villages would likely be at risk from rising sea waters with a total population of 14,050. Community consultations in Saina, one of the villages vulnerable to flooding, revealed that there had been an observed increase in sea water level. Coastal inundation is estimated to have ranged from eight to 15 metres along the shore, and there are signs of erosion in the village cemetery by the coast, despite the community's efforts to replant the coastal front to prevent erosion. This is consistent with observations from villages on the eastern side of Apia, such as Fagalii, Moataa and Vaiala, where coastal erosion is evident.

4.3 Exposure to Tropical Cyclone and Storm Surge

The entire area of Apia is vulnerable to tropical cyclones as it is exposed to the sea. The damage across Samoa from Cyclone Val alone in 1991 amounted to some 36 percent of national GDP. In late 2012, Cyclone Evan also caused significant destruction of durable physical assets, amounting to Samoan tālā (SAT) 251.6 million (equivalent to USD 110 million) and caused production losses (and higher production costs) of SAT 228.9 million. These figures are very significant for the relatively small size of the Samoa economy. The impact on the housing sector is estimated to have come to SAT 38.4 million.

Table 1: Economic Damage Caused by Previous Natural Disasters in Samoa

Event	Return Period (Years)	Asset Damage (USD million, 2005 prices)	Loss of GDP (USD million, 2005 prices)	Total GDP (USD million)	Loss as % of GDP	Notes
Cyclone Ofa, 1990	25	166	15	161	113	Buildings and infrastructure
Cyclone Val 1991	100	388	36	163	260	30% agricultural assets
Cyclone Heta 2004	10	1	4	236	2	Limited damage
Tsunami 2009	50	54	50	277	38	Buildings, infrastructure and tourism
Cyclone Evan 2012	100	103	100.6	632	29	Productive Sector

Source: World Bank 2010, and Government of Samoa 2013 (Samoa Post-disaster Needs Assessment Cyclone Evan 2012)

4.4 Exposure to Flooding

With four major rivers flowing through it and into the sea, the AUA is potentially exposed to major flooding. Further flooding is experienced every year as a result of heavy rainfall. The most exposed and regularly impacted area is the Central Business District (CBD), due mainly to the poor drainage system. But as seen in previous incidents of flash flooding, those living along flood plains and river banks are also exposed when the rivers overflow.

Apia is the location of the CBD and also a central location for government departments, commerce and social services such as hospitals, schools, and churches. The CBD is situated in a high risk area for flood, sea level rise, storm surge and cyclone, so is constantly under threat. The schools located in the respective high risk areas have at some point in the recent past already suffered damage related to the climate related events. The National Hospital at Motootua's only exposure is to cyclones, but the designs have been incorporated to the newly built hospital to withstand up to category 5 cyclones.

The parks and recreational areas along the coast, including beaches and the Palolo Deep Marine Reserve, are under threat from climate events such as storm surges, cyclones, and coral bleaching for marine areas. Although the Fugalei Mangrove Forest has not been declared a specific conservation area, it is a very important ecosystem for its ecological functions as a nursery, filtration area and biodiversity rich food source. The area is constantly exposed to flooding, especially from the Gasegase and Fuluasou rivers.

4.5 Sensitivity of Key Sectors and Livelihoods

4.5.1. Tourism

Tourism is the backbone of the Samoan economy. Prior to Cyclone Evan, statistics documented that foreign exchange earnings from the tourism sector recovered SAT 330 million in 2012, continuing the growing trend from SAT 308.1 million in 2010 and SAT 310.5 million in 2011.The sector employed approximately 1,800 employees. More than half of the available hotel rooms in Samoa are found within Apia and the broader AUA. Many are located in areas along the wa-

terfront and are vulnerable to cyclones, storm surges and flooding. The total value of destroyed sector assets after Cyclone Evan amounted to SAT 43.6 million: SAT 39.6 million from the destruction to hotel rooms and their contents, with another SAT 4.0 million for auxiliary services.

4.5.2. Agriculture

Agriculture contributes about 10 per cent of Samoan GDP, but employs around two-thirds of the national labour force. The numerous effects of climate change and variability - cyclones, flash floods, high rainfall, high temperature and long dry periods - have made agricultural production increasingly challenging. Climatic changes have meant a greater incidence of pests and pestilence, leading to a loss of quality and quantity in production.

Unstable and inconsistent food production caused by climate change has affected farmers' capacity for self-sufficiency, not to mention their ability to generate income from their crops. Perhaps the most devastating effect of natural disasters in Samoa is the damage wrought on agricultural production, and consequently the sector's capacity to supply domestic demand. Samoa's geographic location presents difficulties in terms of reducing the vulnerability of the agriculture sector, particularly as cyclones, droughts and floods become increasingly common.

A rapid assessment revealed that roughly 45 per cent of agricultural area in Upolu was severely impacted by Cyclone Evan, with another 30 per cent moderately impacted. Damage to fisheries was in the artisanal sector, with about 27 per cent of canoes owned by artisanal fishers reported as damaged. The main cash crops damaged include coconuts, breadfruit, bananas, cocoa and other fruit trees. Regardless of Cyclone Evan's impact, agricultural performance had been poor, given the decline in share of GDP from 19 per cent in 1995 to 10 per cent in 2011. Climate change and associated disasters such as droughts and flash floods continue to impose serious constraints to development, to the extent that farmers seem to be in a constant state of recovery.

4.5.3. Sensitivity of Natural Ecosystems

At the ecosystem level, climate change is expected not only to affect the diversity of native fauna and flora, but also the ecosystems that provide goods and services for human welfare and development. These are already experiencing environmental stress: bleaching of coral reefs and sedimentation from inland flooding and pollution; reduction in mangrove areas and waste contamination, degrading fish stocks; and in watershed areas sedimentation and the spread of invasive trees, increasing the likelihood of landslides.

Extreme climatic conditions relevant for the marine biodiversity sector include: sea-level rise; higher ocean surface temperatures; increasingly frequent and intense tropical storms; frequent flooding; extreme high and low tides; and increasing ocean acidification.

These climatic changes will have potentially disastrous consequences for marine biodiversity and ecosystems, including:

- habitat mortality: coral bleaching, erosion, and sedimentation;
- accelerated coastal erosion that will remove beaches and mangroves important to certain marine species;
- coastal inundation and higher levels of sea flooding;
- waves and storm surges into coastal land areas, causing salinity in coastal wetlands and coastal springs;
- mangroves and wetlands pushed further in land by frequent king tides and sea-level rise;
- eutrophication, sedimentation and siltation of water resources, leading to invasive species proliferation;
- increased habitat and nursery areas destruction, ensuing in species decline;
- decline in inshore fisheries; and
- loss of natural reefs protecting coastal communities.

A post-Cyclone Evan assessment revealed that reefs adjacent to rivers experienced additional damage with excessive amount of sediment, mud and debris such

as logs and trees washed down from the four main catchments.

4.5.4. Infrastructure

Public infrastructure in Apia and linkage systems will be susceptible to the projected increase in climate stresses in the coming decades, including cyclones, extreme flooding and storm surges. During Cyclone Evan in 2012, a number of roads became inaccessible as a result of surface flooding and surges. One of the lifeline bridges, situated in Leone, linking the route designated for vehicles over 10,000 tonnes to Matautu wharf was damaged. The bridge has not been rebuilt and a new route is now being assigned for heavy duty vehicle movement. Subsequently, road users in the vicinity have been diverted to the Lelata Bridge, increasing congestion and raising travel times to the CBA by an average of 10 minutes.

Lifeline bridge damaged at Leone.
Photo © UN-Habitat / Bernhard Barth

4.5.5. Water

The main water resources and water supply systems in Apia are extremely vulnerable to current climatic patterns. In 1997–1998 and 2001, periodic droughts associated with El Niño events led to rationed water supply and depleted water reservoirs. In 2006, low flows resulting from a 57 per cent below average rainfall (associated with a weak-moderate El Niño) resulted in water shortages despite rains for August and September being 32 per cent and 41 per cent above average, respectively. As a result, electricity was also rationed at certain parts of Apia as rain water stock was inadequate to feed the hydroelectric dams for power generation.

Heavy rainfall, cyclones and flooding adversely affected water quality and quantity, due in part to erosion and sedimentation. These have been exacerbated by extensive forest clearance within the uplands of the watersheds to the south of Apia. Extreme heavy rainfall causes immediate flooding, which in turn leads to extensive erosion, loss of terrestrial habitats, damage to agro-forestry and destruction to vital infrastructure.

4.5.6. Electricity

Electricity is amongst the most vulnerable utilities to climate events, especially within the AUA, where the majority of the electricity uses pole lines. These either get blown over from the strong winds or get swept away by the floods, as was demonstrated during recent events. Within the AUA, the Alaoa hydro station is also highly vulnerable to flooding and strong winds. During droughts, the Alaoa hydro power station does not have enough water to operate regularly so reverts back to the Tanugamanono Diesel power station to provide for the electricity needs of the Upolu. Now that the Fiaga diesel operated power station is working, the Tanugamanono station has closed down but remains as a standby.

The Power Sector Expansion Plan includes the relocation of Tanugamanono Diesel Power Station to Fiaga, not only to distance it from the growing population but also as an adaptation measure for climate events such as flooding or cyclones. Furthermore, EPC is now working on undergrounding all the power lines around the Apia area and at a later stage around the country.

4.5.7. Housing

Most housing in Samoa is made of cement or treated walls and flooring with iron roofing. While the data on building permits was not available during the development of the report to confirm dwelling conditions, observations during field visits identified that in certain pockets of Apia substandard community dwellings exist. UN-Habitat's definition of 'informal settlement'

may not be fully applicable to the context of Apia. Besides being situated on customary village lands and/or freehold property, these communities also have access to treated water supply, reliable electricity and proper sealed access roads maintained by the government. Nevertheless, the assessment suggests that many of these houses do not fall within the standards of the National Building Code. In addition, there is no proper land use plan produced to date for Apia, meaning developments are managed by the Planning and Urban Management Agency on a case by case basis.

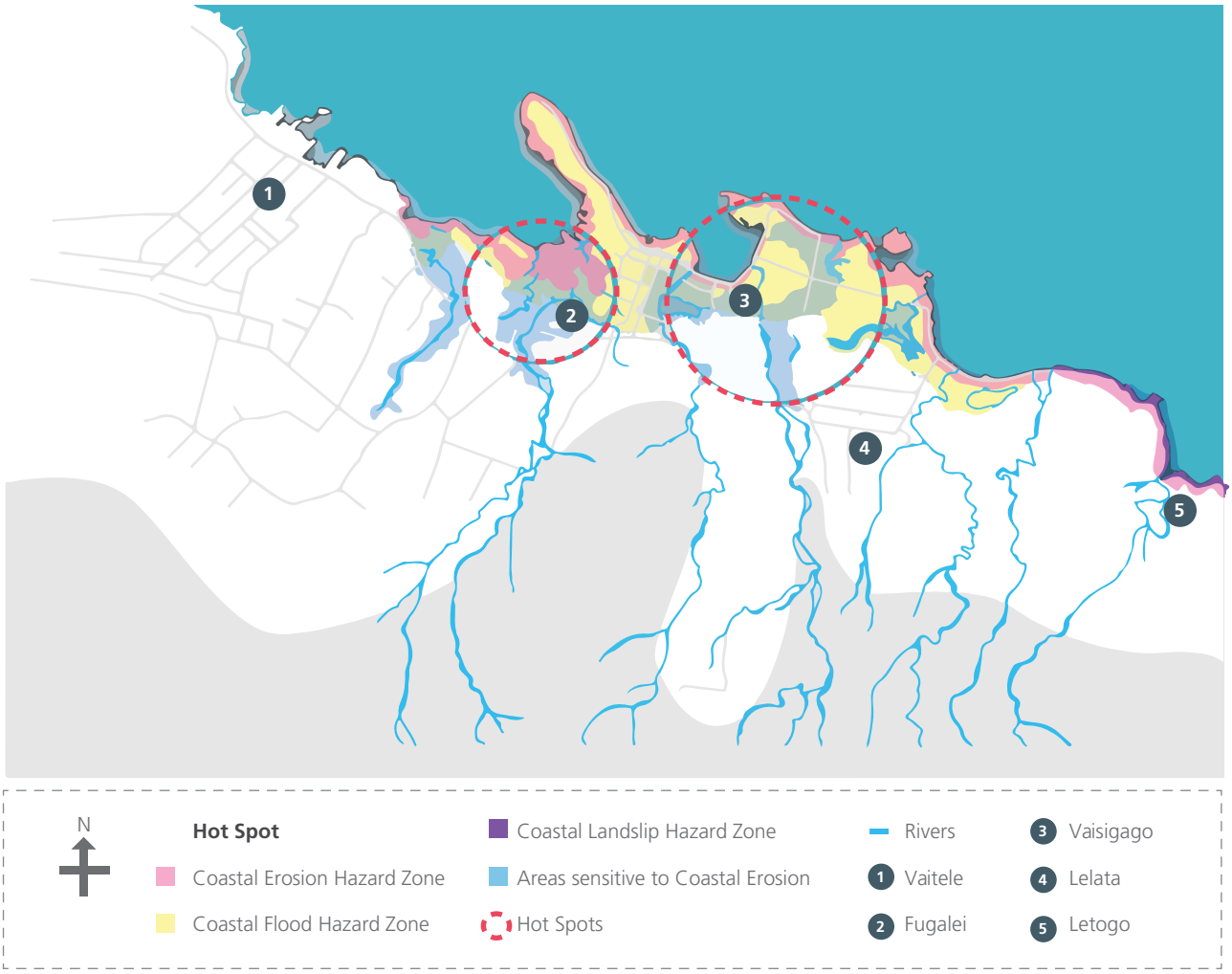
Damaged housing in Apia, post- Cyclone Evan, 2012
Photo © UN-Habitat / Bernhard Barth

05

Climate Change Hotspots

Figure 9 below show the areas most exposed and sensitive to the impacts of climate change and climatic variability. These areas are considered hotspots, as they are exposed to multiple risks from tropical cyclone, storm surge, sea level rise and intense rainfall, and have been classified as priority areas.

Figure 9: Climate Change Hotspot Areas in Apia



Source: Puma, MNRE, Samoa

5.1 Hotspot Region 1: Gasegase River Floodplain

The area comprises ten coastal villages with a total population of over 4,000 people and on average 6.8 persons per household. Around 50 per cent of houses and businesses are located within the coastal flooding hazard zone. All families in this region are permanent residents of the villages, who have cultural ties to land, but there are also commercial buildings such as supermarkets, hardware stores and other businesses on freehold lands within the region. The main sources of income are paid jobs and livelihoods such as carpentry, handicrafts, bartending and security, with less than 20 per cent involved in fishing and seafood gleaning.

Dwellings in the hotspot area of Sogi village, Apia.
Photo © PUMA, MNRE, Samoa

Though communities have access to treated water and reliable electricity supply, with sanitation mainly through individual septic systems, the housing quality is vulnerable to intense storm events and flooding. The Sogi community have been allocated land by the government to purchase so they can relocate to higher ground on the south western part of Apia. This was to secure resilience of the community from climate risks and to allow space for government project extensions. The dwellings do not generally satisfy the Samoa National Building Code. According to community respondents, financial constraints are the main obstacle as they cannot afford the cost of building materials and are unable to obtain loans due to not having enough collateral from their existing land.

While the community is bordered by a mangrove swamp area on the coast, it is a favourable area for vector organisms such as different species of mosquitoes and pathogens, resulting in new viruses. Not only would new vectors extend their range in the area, but new pathogens would be carried by vectors that already inhabit the area. According to consulted village leaders, despite these conditions there were no serious health problem such as malaria or typhoid arising in the area. However, the post-Cyclone Evan assessment revealed an increase in diarrhoea from poor quality water and septic or sewerage overflows caused by flooding. This, coupled with the spread of Influenza, made it difficult for the community to care for vulnerable populations such as the elderly and family members with special needs.

Sanitation systems in a vulnerable village in Apia.
Photo © PUMA, MNRE, Samoa

The Gasegase River that runs through the region directly affects families living adjacent to the river. According to residents of the area, during floods large trees coming down from the watershed areas usually block the waterways and drainage, re-diverting the flow towards the town and causing heavy floods.

5.2 Hotspot Region 2: Vaisigano River Floodplain

Region 2 comprises a mixture of businesses and nine village communities with a total population of around 6,000 people. These are located on the floodplain including Matautu, Apia, Vaiala, Vaipuna and Moataa, while Lelata, Maluafou, Faatoia, Vini Fou and Levili are situated on a natural non-active river channel.

The area is prone to flooding whenever there is an overflow in Vaisigano River as a result of intense rainfall. Additionally, the coastal parts of the area were originally wetland and coastal marshlands that have been reclaimed. Approximately 80 per cent of the region is residential, but it also comprises a small hydro-electric dam, hotels, schools and businesses. The main source of income for this region is paid employment.

Unlike Hotspot region 1, the 2012 flooding associated with Cyclone Evan recorded inundation levels exceeding a metre at most sites. This was also the case in Lelata, Faatoia Maluafou and Matautu, where flooding led to the deaths of three people. Initial measurements at Lelata, for instance, recorded a maximum flood height of 2.35 metres.

As a result of a major investment in awareness raising by the government through various channels, communities have a good understanding of climate change and its impacts. The biggest challenge is the availability of resources to facilitate adaptation measures. Many

Table 2: Community Perception of Vulnerability by Climate Risk

Climate risk	Possible impact on urban areas	Level of sensitivity		
		Current	2025	2050
Sea Level Rise	Coastal Erosion	High	High	High
	Natural Ecosystem	Moderate	High	High
	Damage to near shore infrastructure	Moderate	Moderate	High
	Damage to homes	Moderate	Moderate	High
Storms	Damage to homes	High	High	High
	Damage to infrastructure	Moderate	Moderate	Moderate
Flooding	Damage to infrastructure	High	Moderate	Moderate
	Vector borne diseases	High	High	High
	Damage to homes & businesses	High	High	High
	Damage to Natural Ecosystem	Moderate	Moderate	Moderate
Drought	Decline Water Supply	Moderate	Moderate	Moderate
	Decline agriculture produce	Moderate	Moderate	Moderate
	Fire	Low	Low	Low

Source: Community workshop validation exercise, 31 October 2013

respondents indicated that financial support would enable them to relocate or undertake upgrading measures such as raised floors in their homes.

Interestingly, despite recognizing the impacts of sea level rise on their land and property, a significant number of community members insisted that they would continue to live in the area. Such a view is understandable, given its convenience to public services and the costs associated with relocation. This shows that communities value their lands and are therefore unwilling to move from their current communal setting.

06

Adaptive Capacity in Apia

Adaptive capacity refers to the ability of a city and its actors to cope and respond to potential climate change impacts. It is a function of wealth, technology, institutions, information, infrastructure, and social capital. Apia, as the capital and only urban centre in Samoa, benefits from having more resources allocated to plan and finance improvements to its adaptive capacity, especially for state controlled infrastructure and utilities such as roads, water supply, electricity, communications and buildings.

There have been numerous studies and projects undertaken by the government at both a national and local level to identify climate risks, vulnerabilities, mitigation and priority actions to improve AUA's resilience and adaptive capacity. These initiatives, together with the support of donor partners and organizations such as the European Union, Australian Aid, New Zealand Aid, CLGF, the United Nations Development Programme (UNDP), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and other donor partners have contributed to a large number of projects and studies in recent years to assess the city's services, infrastructure and other areas of potential vulnerability. In addition, different government departments have also produced or are in the process of producing national plans incorporating elements of climate proofing and adaptation into health, education, water and other sectors.

Drawing on the outcome of these studies, a number of priority actions have been identified and developed. It is important to note that the studies undertaken involved intense public and community based consultations. Some of the actions and recommendations in the studies and projects have already been implemented, mainly by the government. These include a sewerage treatment plant, urban drainage improvements, upgraded water supply and treatment as well as coastal replanting and rehabilitation projects. Power lines have been buried underground, with renovated hydro power and diesel generation facilities relocated outside the urban area. Road construction and maintenance has also been climate proofed.

Furthermore, the National Disaster Management Plan has coordinated among government agencies, the private sector and civil society organizations to establish early warning systems, immediate response and long term recovery in the event of a disaster. This was put into action during Cyclone Evan to ensure impacted businesses and families were taken care off.

Non-Government Organizations (NGOs), the private sector and individuals play important roles. NGOs have continued to be involved in the implementation of government-led climate change activities. Their major role is in advocacy for environmental management and highlighting local environmental issues. There are three NGOs taking part in Samoa's Climate Change programme, who are all members of the NCCCT: Matua-i-le-oo Environment Trust Inc. (METI), O le Siosiomaga Society Inc (OLSSI) and Samoa Red Cross Society Inc.

Other inter-governmental agencies involved in assisting Samoa with its climate change response include UN programmes such as UNDP, UN-Habitat and the United Nations Framework Convention on Climate Change Global Environment Facility (UNFCCC-GEF), as well other programmes and partnerships, including the German Academy for International Cooperation (GIZ), the Samoa-Australia Partnership for Development, and development banks (for example, the World Bank and Asian Development Bank). The World Bank's Pacific Risk Assessment and Financing Initiative has supplied detailed geospatial information to mitigate and manage disaster

risks, while its Pilot Programme for Climate Resilience (PPCR) supports the building of climate resilience. Samoa is also working with the government of Japan on risk pooling and insurance mechanisms, and is one of five Pacific Island countries involved in a pilot insurance scheme.

Pacific programmes with climate change components are also critical, such as those of the South Pacific Regional Environment Programme (SPREP) and the Secretariat of the Pacific Community (SPC). Academic institutions also play a role in raising public awareness on climate change. Environmental courses and climate change related subjects are available for students interested in these fields. The two main institutions are the National University of Samoa and the University of the South Pacific.

6.1 Adaptation Plans

The following national plans and strategies directly address climate change:

6.1.1. Coastal Infrastructure Management Strategies and Plans

MNRE developed Coastal Infrastructure Management (CIM) Strategies and Plans to manage coastal community assets and infrastructure in the event of coastal erosion, flooding and landslide induced by extreme events. These initiatives are now to be extended under the Pilot Program for Climate Resilience and Adaptation Fund to accommodate inland flooding and watershed management, particularly in light of their effect on coastal infrastructure.

6.1.2. National Adaptation Program of Action

The government of Samoa has undertaken extensive consultations to identify community priorities for adaptation to climate change under the National Adaptation Programme of Action (NAPA). The agreed national priorities under NAPA include:

- upgrading and protection of community water supply (urban and rural);
- support and protection of agriculture and forestry sector;
- implementation of CIM plans; and
- integrated catchment management.

The government of Samoa, with external assistance, is implementing measures through these projects to reduce the risks associated with climate change by identifying community priorities for adaptation, particularly activities with a large overlap between development and adaptation benefits. In addition the government, through its line ministries, aims to strengthen capacity to improve early warning systems, update the National Building Code and develop design standards to respond to severe storms. The result is the revised National Building Code of the Ministry of Works, Transport and Infrastructure.

In addition to the CIM Strategy and Plans, as well as the National Adaptation Program of Action, there are many other policies and frameworks that should contribute to climate change adaptation and mitigation. However, the lack of integration between these different instruments does not make it possible to do so in a comprehensive and systematic manner, while the specific urban dimensions of the problem do not come under any particular focus. These shortfalls must be addressed urgently.

6.2 Adaptive Capacity at the City Level

City-wide adaptive capacity was initially identified and analyzed using several dimensions: infrastructure, utilities, housing, environment, stakeholders, culture, economy and information.

6.2.1. Infrastructure

Sea walls already exist at the most built up coastal area of Apia city. These provide a level of protection to inland property and infrastructure from storm events, serving as temporary measures while other strategies are implemented inland. It is now recognized that Sa-

moa's many sea walls will not be an adequate long term solution to defending the island against tsunami, sea level rise, intense tropical storms, and associated impacts. As part of the Pilot Program for Climate Resilience, funded by the World Bank and the Adaptation Project by UNDP, Samoa will upgrade the economic corridor, the west coast road that links Apia city and the main Faleolo International Airport, as well as associated drainage improvement and coastline protection work.

6.2.2. Utilities

In 2007, the Samoa Power Sector Expansion Plan developed climate proofing actions for the production and delivery of electricity to the public, both for the AUA and throughout the country. These include the relocation of the Tanugamanono Power Station further inland to Fiaga, the undergrounding of electricity lines, the establishment of substations for better connectivity during power failures, and the upgrading of hydro power stations such as Alaoa within the AUA.
The Land Transport Authority is using the Apia Master Plan to upgrade the drainage systems and river protection for the Apia CBD and AUA, to reduce flooding and overflow during heavy rainfall.

The Samoa Water Authority and the MNRE, as part of the Samoa Water Sector Plan, are collaborating in improving the adaptive capacity of the AUA to climate change. Priority actions include securing the watershed area for protection, widening and deepening waterways, and extending protected areas around river banks. For the water supply, the SWA is prioritizing the reduction of leakages from the current levels of 60 to 70 per cent of production, and upgrading its water treatment plants to improve resilience. It is important to note that all families living in Apia have access to water.

6.2.3. Housing

Housing development may be possible in some coastal areas, but would be generally considered to be a transition option with raised floor levels to allow for more frequent and higher flood levels. This is permitted in the CIM Plans, which include planning regulation and enforcement. There will be unintended consequences – for example, if floor levels are raised for some buildings, this may increase the impact of flooding on neighboring buildings due to the reduction in flooding capacity. The CIM plans have noted that buildings with floor levels less than two metres above sea level will on average be flooded every year under future climate change projections.

Community adaptation measures in the wake of Cyclone Evan
Photo © PUMA, MNRE, Samoa

Concrete fences and elevated floor levels for flood protection.
Photo © PUMA, MNRE, Samoa

Raised land and floor levels next to water.
Photo © PUMA, MNRE, Samoa

Coastal residents in the villages of Sogi, Fugalei, Vaimoso and Vaitoloa have built homes with elevated floor levels to cater for variable sea level.

Moving to higher ground inland generally provides the most effective means of protection from the consequences of rising sea levels over the long term. However, it requires a detailed and robust strategic and urban planning framework. The Planning and Urban Management Act (2004) is undergoing a review with the aim of improving the consenting process and giving communities more say in the planning process. In the longer term this should identify appropriate zones for regulating and limiting various activities related to housing. Suitable zoning would prohibit or restrict certain uses in areas of higher risk – for example, limiting the number of structures or floor area in coastal zones, and preventing existing structures from being expanded or replaced.

Stilted housing in Sogi village.
Photo © PUMA, MNRE, Samoa

6.2.4. Environment

Coral Reefs

The coral reefs continue to be impacted by coral bleaching, for which at this stage no effective solution has been found, and sedimentation. Based on the assessments, the coral reefs closer to land and less than two metres below sea level seem to be most vulnerable, while corals in deeper areas such as the Five Mile Reef and along the reef edge, where less pollution reaches, are less susceptible to its impacts.

Inter-Tidal Flats and Mangrove Forests

The coastal area of AUA is covered mostly by mangrove forests along the Apia Peninsula on the west and the Moataa mangroves on the east. Over time, these have been reclaimed and are now less than half of the original size. The mangroves have been an important natural filter for sedimentation and land based pollution flowing into the marine area, but over the years the waste has increased beyond their carrying capacity. The adaptive capacity of the mangrove and the inter-tidal flats are therefore also determined by the volume of excess waste dumped in the area from the growing population and the sedimentation deposited from flooding.

Watershed Areas

The four main rivers flowing into the AUA cover a total catchment area of close to 10,000 ha. These are subject to pollution from sedimentation following heavy rainfall and the growth of alien invasive trees that can easily break off and cause slides along the steep slopes of the catchment areas. The fallen trees also create more problems downstream with blockages and flash floods as well as debris along the coast. Rehabilitation of the watershed areas is a major programme for the Water Resources Division of MNRE, involving the use of native trees while also encouraging families to move plantations and homes away from the river banks and along the watershed slopes.

6.2.5. Civil Society

Adaptive capacity reflects a community's ability to take concrete actions to reduce its vulnerability. This is why resilience strengthening efforts should focus their resources on the most vulnerable groups and territories. Building adaptive capacity and resilience at a grassroots level offers a valuable alternative to top-down implementation approaches and centralized planning.

As part of the Climate Change Vulnerability Assessment, a stakeholder analysis was carried out. This highlighted the need to broaden participation in order to enhance the adaptive capacity of Samoa, including not only central and city officials but also academic institutions and the private sector. Civil society organizations also have a vital role to play. Through their long-standing ties with local communities, they have made significant contributions in terms of working with residents to build capacity and awareness about climate change, in particular with regard to its impacts on livelihoods, disaster risk management and post-disaster recovery. Despite this, the initiatives have been small scale, and more needs to be done to enhance local knowledge and resources. At the same time, communities need to be encouraged and assisted to take ownership of these problems, as well as the practical solutions.

Support to civil society and community-led initiatives addressing climate change has been provided through a number of mechanisms. Using the Samoa UNDP-GEF Small Grants Programme as well as its Community Centred Sustainable Development programme, UNDP funds community-based adaptation projects that use existing village-level delivery mechanisms and strengthen national-local institutional linkages.

Between 2004 and 2008, through the World Bank-financed Samoa Infrastructure Asset Management Project, MNRE ran the Risk Adaptation Measures Grant Scheme to build community resilience. A new scheme through the Pilot Program for Climate Resilience will be established to finance low cost and small scale community initiatives designed to help local coastal communities withstand the impacts of natural hazards. More recently, the Government established the Civil Society Support Programme (CSSP) in order to harmonize support to civil society. The CSSP pools donor funds and makes it easier for civil society groups to access resources under a common application process and reporting requirements. The CSSP will provide both funding and capacity building support to NGOs and Community Based Organizations (CBOs) for a

range of development activities to benefit communities and vulnerable groups. The Samoa Umbrella for Non-Government Organizations (SUNGO), as a focal point for civil society, will be the key provider of capacity building support to NGOs and CBOs.

6.2.6. Culture

Samoa's adaptive capacity is strengthened by its cultural tradition of close-knit family connections and social obligations. This is the most important safety net in terms of adapting to climate change. Collective support systems are still alive and strong in Samoa. During the tsunami in 2009, and the flash floods in 2012, although there were shelters provided by the government, the majority of families sought shelter with their relatives.

6.2.7. Tourism

The major hotels, tourist attractions, and facilities located in Apia will continue to be vulnerable to climate change impacts. Hotels have already taken steps to improve their adaptive capacity. In addition to insurance, many have taken steps to strengthen building structures to withhold winds and surges, as well as developing resilience through measures such as rainwater tanks, energy efficient products, renewable energy sources and even relocation to safer sites when possible.

6.2.8. Agriculture

The agricultural sector within the AUA is mostly geared towards domestic consumption, meaning the impact from climate change will be minimal compared to other parts of the country. As most of the crops and livestock owned by families in the AUA are for domestic consumption rather than commercial use, any damage can be offset in the short term through disaster relief work.

6.2.9. Information

Early warning systems are a major element of disaster risk reduction. The Samoa Meteorology Division of MNRE is mandated to monitor and forecast natural disasters including meteorological, hydrological and seismic hazards. Advisories and warnings during disasters are disseminated via mobile SMS, radio, TV, church bells and school sirens to trigger public evacuation during natural disasters.

6.3. A Risk Management Approach

A risk management approach is necessary, combined with the use of scenarios to examine potential impacts from climate change, for both risk likelihood and risk consequence. For example, the likelihood for the timing of increases in sea level rise is subject to a high degree of uncertainty. However, the risk magnitude is more certain - it is possible to say with some certainty that a sea level rise of more than a metre is highly likely to occur at some point, given the continued emission of greenhouse gases into the atmosphere, and that sea level rise is likely to continue to accelerate beyond this level.

Looking then at the consequences of sea level rise, it is often possible to provide a wealth of information, such as mapping the flooded area in different scenarios and assessing economic, environmental, cultural and social impacts. Response options can also be evaluated in terms of a long-term strategic response which looks at the feasibility of defence, accommodation and retreat. Without such a framework, there is a high risk of 'mal-adaptation' - that is, the implementation of a response which is either harmful, restrictive or more costly in the long term.

In the short and medium term, more extreme events are likely to lead to more severe impacts from cyclones and flooding – thus increasing the need for a joint focus on both disaster preparedness and climate change resilience. There has been a range of work carried out to develop tsunami zones, including storm surge impacts, and to enhance emergency response. This could be supplemented by further work to strengthen a shared approach.

07

Recommendations and Conclusion

The study concludes that Apia's exposure to climate change varies with respect to climatic hazards. The projected climate change scenarios currently predict a moderate exposure of Apia to intense and more frequent hazard risks in the future with respect to rainfall, storms and sea level rise. Despite low drought projections, it remains a concern because of its potential effect on electricity, water and livelihoods, leading to knock on impacts for the city population.

The climate projections, exposure and sensitivities outlined in this report should be considered when planning major infrastructure developments to ensure that buildings and other assets are designed and located in suitable areas to withstand future changes and to develop adaptation responses for the urban communities, particularly critical at risk hotspots.

It is recommended that the following key actions be undertaken as part of a comprehensive risk management and response strategy, reinforcing priority adaptation options proposed under previous studies:

- Prioritize the development of land use controls and regulations, acknowledging the importance of managed retreat from high risk coastal areas and identifying low risk areas where development can be encouraged. The Economics of Adaptation to Climate Change (EACC) report for Samoa notes that "relocation must be seen as the most sustainable longer term option…and key infrastructure relocation should be seriously considered as part of the implementation phase of the CIM plans".
- Develop appropriate rules and regulations within these geographic hazard zones.
- When assessing coastal defence options, explore the merits of soft defences such as dunes, beach nourishment or mangroves alongside hard infrastructure such as sea wall, including lifetime cost and longevity.
- Improve flood forecasting and early warning systems to effectively communicate risk and implement a necessary response at all hours.
- Develop an Apia climate change resilience plan, policy or strategy to address the urban area's vulnerabilities.
- Ensure the capacity development of all actors involved in climate change in Samoa is ongoing and a cross-cutting priority.
- Engage urban communities in consultations and action planning to increase their ownership of the issues brought about by climate change and variability, while also educating them about the secondary risks that may be caused by specific climate impacts.

UN-Habitat's Cities and Climate Change Initiative promotes enhanced climate change mitigation and adaptation in developing country cities. This document is an initial output of the Cities and Climate Change Initiative activities in Apia, Samoa. This abridged report is based on the report titled: "Apia, Samoa – Climate Change Vulnerability Assessment" funded by the United Nations Development Account, and Cities and Climate Change Initiative.

Starting with a brief background of the city, this report addresses Apia's climate change situation from a climate risk perspective that focuses on hazards, vulnerabilities, and the adaptive capacities of the city. Following the insights gained from clarifying the climate change challenges, the report proposes the key sectors for climate change adaptation and mitigation measures in Apia. It finally recommends key actions to be undertaken as part of a comprehensive Apia response strategy, reinforcing priority adaptation options.

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