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Government of Samoa
First National Communication to the UNFCCC

Government of Samoa
Department of Lands, Surveys and Environment

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Foreword

It is difficult to find any place in the world in which the limits to the natural resources are more acutely felt than in the small island states. Samoa is no exception and it is becoming more apparent that it is facing many environmental problems today. The rapidly increasing population, coupled with the fast pace of economic development activities, is stretching the productive capacity of the bio-physical environment to its limits. Besides, the impacts of climate change and sea level rise are also contributing to a further exacerbation of these natural resources.

It is therefore critical to acknowledge the need to utilise what is left of our natural endowment to satisfy our needs for today, to ensure that there is sufficient left to be enjoyed by future generations. Accomplishing this goal is not an easy task. Samoans are all aspiring to achieve an acceptable standard of living, and most derive this from the biophysical environment that is already degraded. Any measure to control the rate of utilisation of, or to access natural resources, needs to be acceptable and practical to all stakeholders.

Besides, there is compelling evidence that Samoa is going through a decade of unparalleled circumstances spurred by a shift in the global weather patterns, dictating anomalous climate change. We only need to recall the 1998 prolonged drought spell that coincided with a very negative southern oscillation index, causing water shortages of up to eight months in several parts of the country. Furthermore, there are several components of the biophysical environment which are still recovering from the devastation caused by Tropical Cyclones Ofa and Val in 1990 and 1991 respectively.

The Government of Samoa, as a result, joined the United Nations Framework Convention on Climate Change (UNFCCC). One of Samoa's first obligations under the UNFCCC is the submission of its National Communication. This action however, will not produce miracle solutions, but it is expected to perform an important role in our fight against adverse impacts of climate change, sea level rise and environmental degradation in general by encouraging the need to:

- identify potential sources and sinks of greenhouse gases (GHG) and to complete a greenhouse gas (GHG) inventory,
- identify vulnerabilities to climate change and sea level rise, and to complete the vulnerability and adaptation statement,
- identify suitable adaptation options,
- provide and to recommend feasible mitigation measures,
- identify areas where the UNFCCC can assist Samoa – whether financially, through the transfer of technology, or sharing of scientifuc and technical expertise,
- identify possible areas where the UNFCCC can be involved to accelerate the reduction of GHG emissions and simultaneously enhance ecologically sustainable development.
- Samoa supports the shift into ecologically sustainable development. With the absence of mineral or fossil fuel deposits, Samoa relies mainly on its degraded biophysical environment to provide sustenance for its fast growing population. This move therefore requires a strong commitment from the government, the business community and the general public. At this point in time, Samoans should understand and appreciate that their natural resources, although degraded and finite, can still be productive if they are given proper care and wisely managed.

Anthropogenic activities are linked to climate change and sea level rise. Samoa's commitment to ecologically sustainable development, therefore, not only helps the damaged environment to recuperate, but it is also a sensible approach to mitigate adversities incurred by changes in climate patterns and sea level rise. Addressing climate change and sea level rise - with a wide range of ramifications - requires a diverse group of experts. As a result, the membership of the National Climate Change Country Team appointed by Cabinet includes key government and non-governmental agencies. The Division of Environment and Conservation is responsible for chairing the team.

This first national communication was only made possible by the strong financial support from the PICCAP, a GEF-funded programme executed by SPREP to enable Pacific Island Countries to meet obligations under the UNFCCC. Technical assistance was provided by the SPREP. The Government of Samoa wishes to acknowledge with gratitude all these organizations.

This report is the initial national communication that Samoa is obligated to submit to the Conference of the Parties to UNFCCC. It is part of Samoa's own efforts as a Convention member State and in its current role as Chairman of the Alliance of Small Island States (AOSIS), to contribute to the development of the Convention and the protection of the global climate system. Further communications will depend to a large extent, on the continuing support from all Samoa's partners in the UNFCCC and other agencies who share the same interest in responding to the impacts of climate change and sea level rise.

Honourable Tuala Sale Tagaloa
Minister of Lands, Surveys and Environment
Government of Samoa.

Executive Summary

National Conditions

General

Samoa has a total land area of 2,934 km^2 and an exclusive economic zone (EEZ) of 12,000 km^2. It forms the western part of the 500km long Samoan Archipelago with American Samoa forming the eastern end. It is a South Pacific Island country located between latitudes 13^0 15' S and 14^0 5' S and longitudes 171^0 23' W and 172^0 48' W, hence, it lies in the tropical cyclone region. As it is closely enveloped on all sides by its adjacent neighbours, Tonga, Wallis and Futuna, Tokelau Islands and American Samoa, thus it has the smallest EEZ in the whole Pacific Region.

The main topographical features of Samoa are rugged mountains of volcanic origin, surrounded by flat and rolling coastal plains. All the islands of Samoa were formed by volcanic activity. Savai'i is regarded as still volcanically active with its most recent eruption producing lava flows between 1905 and 1911. A large percentage of Samoan soils are porous, shallow and clay in texture.

Samoa's climate is typical of small tropical islands, geographically isolated from big landmasses. The rainfall and humidity are usually high. Distinctive wet and dry seasons are experienced only on the leeward (northwestern) sides of the main islands, Savai'i and Upolu. Temperatures are high and generally uniform throughout the year. Samoa experiences southeast trade winds almost throughout the year, however, severe tropical cyclones occur during the summer months, December to February. Samoa is also vulnerable to anomalously long dry spells that coincide with the El Nino Southern Oscillation (ENSO) phenomenon.

Population

Samoa's population, despite the high natural growth rate, has shown a low net increase, which is a direct consequence of the strong emigration process that Samoa has experienced in the last three decades. The last population census in Samoa in 1991 recorded a population of 161298. Population estimates by the Department of Statistics (DOS) for 1994, 1995, 1996, 1997 and 1998 are 163729, 164548, 165371, 166694 and 168027 respectively.

The last population census also indicated, on the one hand, a resurgence of the percentage under the age of 15 years, and on the other, a sharp decline between the age of 20 and 40 years. Despite a slight contribution from a modest fertility decline, the strong age-selective bias of the out-migration process has been identified as the major causal factor.

Samoa's urban population is still growing and it is a serious threat to the biophysical, economic, and social environments. Rural people are still moving into Apia in search of better employment opportunities and to have easy access to better education and health services. The urban population is deriving more from the limited natural resources and simultaneously creating stresses on the social and economic fabric within the community.

The Economy

Samoa's economy depends largely on its natural resources, foreign aid and remittances, although there have been recent contributions from the tourism and manufacturing industries. Traditional exports from Samoa have been mainly agriculture-based with a recent rise in significance of manufacturing and fisheries products. Samoan exports are always vulnerable to constraints generated by external factors such as price instabilities, high transport costs of overseas markets, and harsh weather. Foreign aid and remittances are also prominent features of Samoa's economy. Subsistence living is still regarded as a norm for a large percentage of the population, particularly in the rural communities. This life style will continue to be a salient feature of Samoa's economy in the future.

Need for a National Communication

The Need

The UNFCCC requires that every Party must submit a National Communication as part of its obligations and commitment. Fulfilling the ultimate objective of the UNFCCC which is *to reduce the atmospheric concentrations of GHG to a stable level within a specific timeframe to ensure no adverse human-induced interference with the climate system* will be enhanced by the commitment of all Parties of the UNFCCC in providing National Communications that delineate national circumstances, the status of GHG, emissions, removals, sources and sinks, vulnerability and adaptations to CC and SLR, and possible projects required to acquire adaptation and for proper mitigation measures.

The National Communication also provides a mechanism through which the COP can assist members that cannot meet their obligations and commitments under the Convention. In the case of Samoa, a least developed country, the National Communication enables it:

- to organize and present the CC and SLR related constraints,
- to define Samoa's individual and joint activities specifically designed to combat CC and SLR impacts;
- to impress on external assistance, especially finance and technology, for Samoa in its endeavour to implement the UNFCCC.
- to convince the developed world that Samoa, and all similar countries – geographically and economically - are extremely vulnerable to adverse impacts of CC and SLR despite its insignificant GHG emissions.

The National Communication also provides a yardstick to measure status and standards of implementing obligations and commitments to minimize anthropogenically-induced stress on the biophysical and socio-economic environments. Besides, through the National Communication, Parties can disclose new mechanisms employed at the national level to reduce impacts of CC, and promote participation in the global effort to reduce GHG emissions.

The GHG Inventory

Changes in the climate and the general weather patterns all over the globe have become very anomalous and increasingly very devastating to human beings and the environment at large. The South Pacific Region and more specifically our own small country, Samoa, is experiencing many changes in climate that present risks to both humans and the environment. The greenhouse effect is identified as one of the factors that may be contributing to these changes.

Samoa's decision to become a Party to the UNFCCC - is both wise and timely, and compiling a GHG inventory is an essential activity for Samoa. An understanding of the GHG sources and sinks is as vital as knowing the magnitude of GHG emissions and removals.

Easy access to an accurate GHG database is a vital factor required for a better understanding of the estimated contribution to enhancing GHG pollutants but more importantly to give guidance in social and economic development planning. It also provides important information to small countries that are extremely vulnerable to CC and SLR to adapt, and to call for global action against the insensitive emissions of GHG into the atmosphere.

In compiling the GHG Inventory, data collection was, in effect, the most difficult phase. However, it provided a useful experience necessary to identify inadequacies that must be improved to ensure better data quality in the future. This improvement process needs to include the GIS which was not available at the time of the inventory.

The inventory indicates that Samoa's GHG emissions in 1994 are: CO_2 = 20.22 Gg, CH_4 = 3.30 Gg, N_2O = 1.26 Gg, NOx = 0.97, CO = 7.42 and NMVOC = 1.58 Gg. By world standards, this is quite insignificant. However, a comparison of the 1994 and 1997 GHG emissions deserves a thorough examination because all the categories have recorded increasing trends during this period. For example, the net carbon dioxide emissions of 34.09 Gg between 1994 and 1997, indicate a yearly increase of about 8.52 Gg. Without accounting for the removal of carbon dioxide due to improvements in land use practices via upgrading forest management and agricultural developments, there is an indication of an increase of 19.45 Gg in carbon dioxide during the inventory period.

Similarly the non-CO_2 GHG also show the same increasing trends. Methane records a net increase of 0.52 Gg between 1994 and 1997. During the same period, all the sources of methane also indicate increased emissions. Based on this net increase, methane in Samoa has been produced at a rate of 0.13 Gg annually. Nitrous oxide records an increased emission of about 0.23 Gg within the inventory period. It means this pollutant is being emitted in Samoa at a rate of 0.06 Gg per year. An even smaller increased emission of 0.075 Gg has been recorded for oxides of nitrogen between 1994 and 1997. This gives an annual rate of emission of about 0.02 Gg for the oxides of nitrogen. Carbon monoxide, on the other hand, recorded a slightly higher emission increase of 0.96 Gg within the same period. The resultant rate of emission of carbon monoxide is therefore 0.24 Gg per annum. The last major GHG investigated is the non-methane volatile organic compound, which also indicated a a very small increase within the inventory period. Between 1994 and 1997, the inventories show that NMVOC emissions increased by 0.199 Gg which gives an annual rate of 0.05 Gg.

In spite of Samoa's relatively small GHG emissions, there is a parallel increasing trend in each of the GHG examined. This increase is likely to continue if it is not addressed properly and promptly. This is not a time to be complacent. To allow this to go unchecked means that Samoa is denying itself one of the tools required in the achievement of its ultimate goal, "to ensure a good and acceptable standard of living for every Samoan".

A problem area, which has been repeatedly encountered when undertaking the GHG Inventory, is the *lack of quality data and poor data management*. Definitely, there is a need to address this problem as soon as possible because it affects not only the GHG inventories but also other research areas. Agencies like the Police Department where the officers are manually recording thousands of vehicles each year are certainly in need of assistance with respect to an upgrade of physical facilities and through training human resources in effective data management procedures.

Vulnerability and Adaptation

About 70% of Samoa's population and infrastructure are located in the coastal area. This is a serious concern because nearly all the coastal settlements in Samoa are located in low-lying areas, hence are, very vulnerable to CC and SLR. This vulnerability is particularly exacerbated during extreme events, as illustrated when Tropical Cyclones Ofa (1990) and Val (1991) devastated Samoa causing damage estimated to be about three times the GNP. The cyclones caused severe damage to agriculture and to bio-diversity. Samoa is also very vulnerable to other extreme climate events, for example, prolonged drought periods associated with the ENSO events and coral bleaching stimulated by extremely low tides.

Besides human life and health, the areas regarded to have the highest vulnerabilities are the coastal zone, water, agriculture and bio-diversity. All these are vital components of the bio-physical environment from which the Samoans derive their livelihoods. A 'no-regrets' approach to adaptation is necessary, despite high initial costs, to provide effective measures to mitigate adverse impacts caused by CC and SLR. Undesirable last resort adaptation measures, for example population relocation or total displacement, usually arise from a failure to acknowledge the need to adapt quickly and appropriately. Although, Samoa's vulnerability will increase with future global CC, it is imperative to develop a national policy framework to raise awareness about the need for adaptation and mitigation actions.

Outcomes of the V&A Assessment of Samoa show that:

- the increasingly frequent intense cyclones affecting Samoa are a major threat to its sustainability in the modern world and global economy;
- the 'best guess' scenario indicates that by the year 2100 temperature will have increased 2° C, with SLR of 49cm, and rainfall increase of 4.1%. This is the basis for environmental sensitivities described with regard to CC and SLR;
- further detailed information is needed in order to make better predictions of V&A needs of Samoa;
- 70% of the population and infrastructure is situated in the coastal zone, thus there is a need for adaptation measures to be focused on those areas;
- increased heat stress on organisms and altered water requirements for various species are also associated with CC and SLR. This would severely stress Samoa's uniquely adapted bio-diversity and thus necessitate further adaptation for alien and potentially invasive species;
- enhanced stress due to environmental and socio-economic changes coupled with CC and SLR;
- implementation of adaptation measures and strategies in Samoa should take a 'no-regrets' approach. The least cost adaptation options are consistent with this approach; and
- there is compelling evidence that by global standards Samoa is one of the most vulnerable nations to CC and SLR.

Responses to Climate Change and Sea Level-Rise

Samoa has already taken positive actions to implement the UNFCCC objectives and aims. The NEMS Report for Samoa (1993) identified 12 priority areas requiring urgent attention. Samoa as a result, complied accordingly by developing draft policies for Population, Water, Land-use and Waste while, in the meantime, undertaking measures to address Bio-diversity and CC. Developing the above draft policies was no easy task, but the unrestrained support from all the stakeholders plus the initiative taken by the various committees and the leadership role of the DEC provided the necessary momentum to have them completed.

In addressing the CC and SLR issue, Samoa's NCCCT, in close collaboration with the DEC, MAFFM, MFA, MOT, TD, SWA, NGOs, private businesses and the communities, has completed the GHG Inventory and the V&A Assessment. Projections and recommendations in this National Communication are all based on the outcomes of these two studies.

The completion of the GHG Inventory and the V&A Statement marks a significant step taken by Samoa to implement the UNFCCC. These two studies provide the foundation for developing suitable and practical mitigation and adaptation strategies. In addition to the impacts caused by CC and SLR, data-related constraints were also identified in both studies. Adaptation and mitigation measures, therefore, should also address these problems because finding proper solutions is instrumental to generating effective responses to impacts from CC and SLR.

Environmental awareness has pervaded through many sectors of Samoa's economy and, as a result, both Government agencies and the public at large have started to design and to construct suitable residential accommodation, buildings, seawalls, roads, etc., to accommodate adverse impacts. The most obvious step taken by the Government in this respect is the construction of the Apia seawall. The other tools that Samoa uses in its adaptation and mitigation campaign against CC and SLR are legislation, projects/surveys, and education. Within these areas, there are specific needs to be addressed, either through national measures or jointly with external assistance offered under the UNFCCC and the Kyoto Protocol.

Samoa is committed to the objectives of the UNFCCC and the Kyoto Protocol. It therefore, welcomes the continuing assistance from, and the opportunity to work collaboratively with, the global community to raise awareness about the vulnerabilities to CC and SLR and to adapt accordingly, and to promote cost-effective and culturally acceptable adaptation and mitigation procedures.

Acronyms

amsl	Above mean sea level
CC	Climate change
CD	Customs Department
CDM	Clean Development Mechanism
DEC	Division of Environment and Conservation
DLSE	Department of Lands, Surveys and Environment
DOS	Department of Statistics
DTCI	Department of Trade, Commerce and Industry
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Nino Southern Oscillation
FAD	Fish aggregating device
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
Gg	Gigagram
GS	Government of Samoa
GWS	Government of Western Samoa
MAFFM	Ministry of Agriculture, Forests, Fisheries and Meteorology
MFA	Ministry of Foreign Affairs
MOT	Ministry of Transport
NCCCT	National Climate Change Country Team
NEMS	National Environmental Management Strategies
NGOs	Non-governmental organisations
NMVOC	Non-methane volatile organic compound
ODS	Ozone depleting substances
PICCAP	Pacific Islands Climate Change Assistance Programme
PWD	Public Works Department
SLR	Sea level rise
SPCZ	South Pacific Convergent Zone
SPREP	South Pacific Regional Environment Programme
SWA	Samoa Water Authority
TD	Treasury Department
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
WWF	World Wildlife Fund

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National Circumstances and the UNFCCC

"*Global Warming is not a distant, future threat. In fact, there is compelling evidence that a shift in our planet's weather patterns and changes in climate are already underway. A huge array of data from all over the world clearly signals that change is occurring. From droughts to melting glaciers and ice caps, from dramatic flips in ocean currents to regional increases in extreme and violent storms, the indications are that climate change is happening now*". **(WWF 1998)**

Table 1.1 National Circumstances

Criteria	1994
Population	163729[a] (Source: DOS)
Relevant areas (square kilometre)	
Total Land	2,934
EEZ	120,000
GDP (1994 US$)	18,755,868 (Source: Treasury)
GDP per capita (1994 US$)	114.55 (Source: Treasury)
Estimated share of the informal sector in the economy in GDP (%)	Not applicable
Share of industry in GDP (%)	20.90
Share of services in GDP (%)	27.96
Share of Agriculture in GDP (%)	14.0
Land area used in agricultural purposes (sq. km)	1,195.47
Urban population as per cent of total population	45,000
Livestock population:	
Cattle	11,066
Pigs	150,000
Horses	315
Poultry	300,000
Forest area (square kilometre)	999[b]
Population in absolute poverty	Not applicable in Samoa
Life expectancy (years)	
Male	65.4
Female	71.9
Literacy rate (% of adult literacy)	98[c]

[a] – Department of Statistics Estimates, [b] – estimated from Forest Area Statement (GWS 1992b),
[c] – Fairbairn & Vaai (1994)

1.1 Geography and Geology

Samoa is a group of small islands in the tropical South Pacific Ocean located between latitudes 13^0 15' S and 14^0 5' S and longitudes 171^0 23' W and 172^0 48' W in a west north-west to east south-east orientation (Gilson 1970; Salale 1978; Saifaleupolu 1985). The inhabited islands are Savai'i, Upolu, Manono and Apolima. The most populous and also the more developed island is Upolu, where the national capital Apia is located (Fairbairn & Va'ai 1994, GS 1999b).

Samoa lies approximately 3000 km north north-east of Auckland, New Zealand, 4500 km east north-east of Sydney, and 4300km south of Honolulu (GWS 1990a; 1991a). Samoa's contiguous neighbours are Tonga to the south, Wallis and Futuna to the west, Tokelau Islands to the north and American Samoa to the east. It has a total land area of 2,934 km^2 and an exclusive economic zone of 12,000 km^2. Samoa forms the western part of the 500 km long Samoan Archipelago with American Samoa forming the eastern end (Saifaleupolu 1985; GWS 1991).

A rugged and mountainous topography characterizes the main islands (Taule'alo 1993a). Approximately 50% of Savai'i and 40% of Upolu are composed of steep slopes derived from volcanic activity (Curry 1955). Both islands have central mountain ridges formed from a chain of volcanic peaks and craters. In Upolu, the central mountain range runs along the length of the island with some peaks rising more than 1000 metres above mean sea level (amsl), surrounded by flat and rolling coastal plains (Curry 1955; Saifaleupolu 1985). Savai'i, on the other hand, contains a central core of volcanic peaks reaching the highest point of 1858m encompassed by a series of lava-based plateau, hills and coastal plains (Curry 1955; SPREP 1993d; Taule'alo 1993a).

All the islands of Samoa were formed by volcanic activity (Curry 1955; Wright 1962). The island of Savai'i is regarded as still volcanically active with its most recent eruption producing lava flows between 1905 and 1911 (Curry 1955; Kear & Wood 1959; 1963; Wright 1962; 1963; Pearsall & Whistler 1991; SOPAC 1999). Kear, Camber and Brands (1979) have indicated that the volcanic rocks are mainly olivine basalt, pictrite basalt and olivine dolerite. Most soils were derived from basaltic volcanic flows differing largely in age and type of deposit. The aa and pahoehoe lava types and scoria and volcanic ash are the most common soil types in Samoa (Kear & Wood 1959; 1963; ANZDEC 1990). A large portion of Samoa's soils are porous, shallow and clay in texture (Wright 1963; ANZDEC 1990).

1.2 Climate

The climate of Samoa is characteristic of small tropical islands that are geographically isolated from big landmasses (GWS 1991; Saifaleupolu 1998). The main features of the Samoan climate are as follows:

- high rainfall and high relative humidity,
- a generally uniform temperature all year round,
- winds dominated by the south-easterly trades winds,
- the occurrence of tropical cyclones during the southern-hemisphere summer,
- long dry periods, particularly in the northwestern coastal areas, which coincide with ENSO phenomenon.

The average annual rainfall in Samoa is high with a distinctive variation in spatial distribution. The leeward sides of the main islands receive an average of about 2200-mm of rainfall per year. In contrast, an average rainfall of about 5000 mm per year has been recorded in the windward sides, with the highlands of Savai'i and Upolu receiving more than 6000 mm annually (Camber 1978). The major factors that influence the rainfall distribution are the island topography, the meridional migration of the South Pacific Convergent Zone (SPCZ) and the persistent south-east trade winds (Saifaleupolu 1985).

Samoa is usually hot all year round because it is close to the equator and its landmass is too small to cause any significant seasonal temperature variation (Saifaleupolu 1985). Likewise, the diurnal temperature variation is relatively small. Observations at the Meteorological Office at Mulinu'u, have shown that the highest mean temperature of 27.1 ^{o}C occurs between December and March. The lowest mean temperature of 26.0 ^{o}C on the other hand, occurs between July and September. The highest temperature officially recorded in Samoa was 35.3 ^{o}C, at Asau Station 3m amsl, at the northwestern tip of Savai'i, while the Afiamalu Station, 750 amsl, in Upolu recorded the lowest of 11.1 ^{o}C.

The most striking feature of Samoa's surface winds is the dominance of the south-easterlies. These winds are directly associated with the meridional migration of the SPCZ (Saifaleupolu 1985). The SPCZ is generally located further north of the Samoan Group in winter but moves southward to Samoa's latitudes during the summer. Therefore, the south-easterlies prevail in winter months while the wind direction becomes more variable during summer. The close proximity of the SPCZ to the Samoan islands during summer results in the winds being generally stronger than in winter. Heavy rainfall throughout the country and strong winds characterize these periods. For instance the Samoan Islands were severely damaged by tropical cyclones 'Ofa 1990, Val 1991 and Lyn 1993 (Fairbairn 1993; GWS 1992a; Taule'alo 1993a). These natural disasters were very destructive to both the natural cultural environment and had severe implications for the economy of the country (Fairbairn 1993; Fairbairn & Va'ai 1994).

1.3 Population

1.3.1 Growth and Trends

Table 1.3 portrays the growth pattern of the Samoan population in the last 80 years. The population during this period, with the exception of 1917 and 1921, has always exhibited an increasing trend. The population declines in 1917 and 1921 were a direct consequence of epidemics (UN Report 1948). For example, in 1918 an epidemic of influenza killed more than 8000 people which was about 20% of the total population of Samoa at the time (Connell 1983; Lockwood 1971; UN Report 1948).

Samoa's population expanded rapidly after the Second World War and it acquired the highest growth rate of 4.08% between 1945-1951 (Connell 1983). The improved quality of facilities and efficiency in the health and medical services are the main factors underlying the rapidly expanding population that has increased more than fourfold within the last eighty years (GWS 1993b; UN Report 1948).

Despite the increasing trend, the net annual population growth has experienced a sharp decline since the early 1970s (GWS 1983). Table 1.2 shows that the net annual growth rate never exceeded 0.73% since 1971. This has been accredited to the high rate of net out-migration (Connell 1983; Fairbairn 1991; GWS 1987a; 1993b). Although the fertility decline due to birth control may have contributed, this was more than offset by the corresponding decrease in mortality rates (GWS 1987b; 1993b).

One of the major features of Samoa's population before the 1991 census was the large percentage under the age of 15 years (GWS 1993b). A 3% decline has been recorded in this age group between 1981 and 1986 largely due to a fertility decline (GWS 1987b). The outcomes of the 1991 census, however, have shown that the decline has stopped (GWS 1993b). The same census has also indicated a sharp decline in population numbers between the age of 20 and 40 years. Despite a slight contribution from a modest fertility decline, the strong age-selective bias of the out-migration process has been identified as the major causal factor (GWS 1993b).

Table 1.2 Population of Samoa 1911-1991

Year of Census	Samoan Population	Total Population	Net Annual Growth Rate (%)
1911	33554	38084	0.51
1917*	35404	37331	-0.33
1921*	32601	36422	-0.61
1926	36688	40231	2.09
1936	52232	55946	3.91
1945	62422	68197	2.43
1951	80153	84909	4.08
1956	91883	97327	2.93
1961	113101	114427	3.51
1966	130110	131377	2.96
1971	144111	146627	2.31
1976	150089	151983	0.73
1981	153920	156349	0.57
1986	156000	157408	0.14
1991	158121	161298	0.49

Source: DOS (GWS 1993b). * Major epidemics.

A recent survey undertaken by the Department of Statistics (GS 1999b) has identified an urgent need for improving the registration system of births and deaths to ensure the availability of up-to-date population statistics required for planning and policy purposes.

1.3.2 Urbanization and Internal Migration

Samoa's urban population is still growing, although it is not expanding as fast as in other countries of the Pacific Region (Connell 1984, GWS 1987b; 1993b). Spurring this population growth is the urban migration of rural families (GWS 1981; 1990a; UN 1982), who are driven by the search for quality social service, and the need to find wage employment (Connell 1984; Pitt 1970; Saifaleupolu 1998; Taule'alo 1993b; Tuiteleleapaga 1980).

This has become a serious threat to the biophysical, economic, and social environments in the urban areas (SPREP 1993d, Saifaleupolu 1998). In common with many Pacific Island countries today, Samoa's expanding urban population is demanding more from the natural resources which has resulted in unsustainable development (Iakopo & Reti 1990; Taule'alo 1993a). In agricultural land for example, Fairbairn (1991 & 1993) has observed a markedly reduced fallow period in the Apia urban area. The high demand for land has also resulted in the conversion of water catchments for agriculture and settlement (Fairbairn 1991; GWS 1987a; Iakopo & Reti 1990). Consequently, enhanced runoff from cleared areas during heavy rains is contributing to the rapid decline in quality of the urban area water supplies (Reti 1990).

Sewage disposal and the associated health hazards are other serious concerns regarded as closely linked to the growing urban population (GWS 1992c; Taule'alo 1993b; Zann 1991a). In the absence of a public sewage system, the households are served with on-site facilities. This is a critical health hazard as poorly maintained facilities allowed leaching of human wastes that have polluted the ground water and nearby lagoons (GWS 1992c; JICA 1998; Taule'alo 1993a). The urbanization process is also identified to have encouraged land reclamation in the mangrove marshes and sea fronts in the Apia urban area (Zann 1991a). According to the NEMS Report for Samoa (Taule'alo 1993b), the expanding urban population is also associated with the deteriorating quality of several social services.

1.4 The Economy in Brief

As in many developing countries, Samoa depends mainly on its biophysical resources to maintain economic growth and to sustain the livelihood of its people (Bifani 1992; Fairbairn 1993; GWS 1984; 1987a; Myers 1989).

The national economy, however, depends to a very large extent, on two other major sources of income namely, foreign aid and remittances (Fairbairn 1991; GWS 1987a; 1992a; World Bank 1995).

Samoa's traditional exports have been dominated by agriculture-based and forest products but more recently, manufacturing and fisheries products have become significant (Fairbairn 1991; Fairbairn & Fairbairn 1985; Fairbairn & Va'ai 1994; GS 1999a; GWS 1984; 1987a; 1990a; 1992a). These export products are subject to a number of constraining factors, such as price instabilities, high transport cost, lack of overseas markets, and harsh weather conditions (Fairbairn & Fairbairn 1985; Fairbairn 1991; 1993; GWS 1987a). Hence, despite extensive efforts in agricultural and industrial developments in the last few decades, economic growth in Samoa has been disappointing (Fairbairn 1991; Fairbairn & Va'ai 1994, GWS 1992a; 1993c; Shankman 1993). Besides the above constraints, poor commodity prices, a narrow economic base, and poor management were also identified as contributing factors to the poor economic performance (Fairbairn 1985; 1991; GWS 1988; 1990a; 1992a).

Subsistence production continues to be significant to the country's economy today (Fairbairn 1973; 1985; 1987; 1993; Fairbairn & Va'ai 1994; GWS 1987a; 1990a; 1992a). Even though it is difficult to measure (Fairbairn 1985), subsistence is considered an integral component of the national economy and must be promoted (Fairbairn 1985; 1987; GWS 1980; 1984; 1987a; 1991b; 1992a).

Samoa's economy also exhibited a strong surge of industrial activities in the last two decades (Fairbairn 1991; GS 1998c; 1998d 1999a; GWS 1984; 1987a; 1992a). Government support for developing this type of endeavour is manifested in the establishment of the Department of Trade, Commerce and Industry (DTCI) under the Trade, Commerce and Industry Act, 1990. The primary role of the Industry Division of the DTCI is to create and enhance more industrial activities and opportunities through an incentive scheme (GS 1998d; GWS 1993c).

Table 1.3 GDP at Market Prices, by Industry (in WS$1000.00)

Industry (at current prices)	1994	1995	1996	1997	1998
Agriculture	66,011	50,898	53,950	73,849	68,318
Fishing	20,562	19,252	24,198	33,477	41,263
Food & Beverages	17,825	22,465	28,225	31,551	27,239
Other Manufacturing	80,826	75,859	73,038	72,791	71,023
Construction	33,310	37,318	39,715	45,009	44,804
Electricity & Water	12,838	13,464	14,266	14,781	15,369
Commerce	58,471	64,987	78,309	91,874	107,457
Hotels, Restaurants	11,180	11,090	13,850	14,390	15,560
Transport, Communication	45,926	50,702	59,473	65,782	77,556
Public Administration	45,525	45,800	48,100	54,550	61,169
Finance & Business Services	27,800	28,963	33,968	38,850	43,489
Less: Enterprise share of FISIM	-2737	-2743	-2950	-3246	-3880
Ownership of Dwellings	19,973	20,659	21,646	24,076	26,633
Value added at market prices	471,640	476,558	526,798	601,496	643,831
At constant 1994 prices					
Agriculture	66,011	80,310	79,716	69,063	68,482
Fishing	20,562	20,508	22,019	26,641	33,930
Food & Beverages	17,825	23,574	28,241	29,502	23,542
Other Manufacturing	80,826	74,749	70,619	64,746	58,278
Construction	33,310	35,889	36,856	39,534	38,229
Electricity & Water	12,838	13,338	14,285	14,717	14,525
Commerce	58,471	64,175	72,964	79,557	87,078
Hotels, Restaurants	11,180	10,921	13,238	12,656	12,697
Transport, Communication	45,926	50,086	57,384	59,652	65,899
Public Administration	45,525	46,729	50,066	54713	59,491
Finance & Business Services	27,800	28,609	32,739	34942	36,914
Less: Enterprise share of FISIM	-2737	-2708	-2835	-2862	-3154
Ownership of Dwellings	19,973	20,395	20,806	21,225	21,653
Personal & other services	34,129	37,799	39,571	40,252	40,943
Value added at 1994 market prices	34,129	504,373	535,670	544,339	558,508

Source: Treasury Department (GS 1999a).

Table 1.4 Exports by Commodity (WS$000).

Export	1994	1995	1996	1997	1998
Talo	83	162	98	99	125
Coconut Cream	4006	4833	4913	4772	3864
Kava	0	0	7.4	8.0	11.0
Copra	0	2193	4078	7882	6078
Coconut Oil	0	6431	6825	6761	4153
Banana	216	699	724	474	178
Taamu	23	128	190	74	105
Copra Meal	3	365	622	608	215
Coconuts	95	262	279	123	149
Vegetables	0	5	7	16	8
Samoan cocoa	4	65	116	190	70
Timber	92	208	831	124	5
Fresh Fish	209	431	2246	12327	28401
Dried sea-cucumber	129	73	31	28	25
Samco snacks	11	55	116	190	70
Purified water	9	19	0	0	1
Beer	1123	1129	1107	1603	2355
Cigarettes	658	698	268	0	0
Corned beef	239	0	134	0	67
Garments	119	16	282	83	6
Scrap metal	174	58	192	45	97
Total	7193	17830	23066.4	35407	45983

Source: Treasury Department 1999.

The sector performance of Samoa's local economy in the last few years is depicted in the Tables 1.3 and 1.4.

1.5 Agriculture

Agriculture has always played a critical role in the subsistence livelihood of the Samoan people, and, more recently, in export production (Bell 1985; Fairbairn 1973; 1985; 1987; 1993; GS 1998c; 1999a; GWS 1984; 1990a; 1992a). The results of the 1989 Agricultural Census have indicated the participation of about 72% of the population, at varying degrees, in agricultural activities. The census also showed that only 19% of the households belonged to the home consumption only category while nearly 50% derived both food and income from agricultural activities. The distribution of households, classified under agricultural active and non-agricultural active categories, between the urban and rural regions, also presented markedly different outcomes. Whereas only 30% of the urban households participated in agriculture, 94% in the Rest of Upolu and 97 percent in Savai'i were agriculturally active.

Government development plans have always stressed the significance of village agriculture in promoting the national economy (GS 1999c; GWS 1980; 1984; 1987a; 1992a). One of the fundamental factors in these plans was the acknowledgement of the fact that most of the lands are still controlled by the villages. The government has also recognised rural community support as a salient component in development planning and implementation (GWS 1992a; Taule'alo 1993a; 1993b). Despite its purported weaknesses, traditional agriculture is still important to the economic base (Fairbairn & Va'ai 1994; GS 1998c; GWS 1987a; 1992a; Hassall & Associates 1988) and it thus deserves support to ensure successful future development. Current government economic strategies promote community participation via an enabling environment to undertake a partnership in agricultural projects.

1.6 Fisheries

Before European contact the Samoans derived most of their protein from fish and other lagoon and reef products (Bell 1985; 1989; Fairbairn 1985; Kramer 1901). Although early reports indicated that Samoa's inshore fisheries were abundantly endowed (Kramer 1901; Turner 1884; Von Bulow 1902), Samoa lacks continental shelves (Johannes 1982a). This means that its inshore fisheries are very much restricted to near-shore reefs and lagoons which enhance their vulnerability to over-fishing. Samoans were long aware of this and understood the finite nature of their main source of protein (Elliot 1973; Forsberg 1973; Johannes 1982b; Klee 1980). As a result, they placed a high priority on husbanding their marine resources and devised techniques that enabled sustainable utilization through many generations (Elliot 1973; Johannes 1977; 1981; 1982a; 1986; Klee 1980). More recent studies, however, have shown a general decline in fish landings from the reefs and lagoons (Bell 1985; 1989; GWS 1990a; 1992a; Taule'alo 1993a; Zann 1991a; 1991b).

The Government is consequently developing a more effective and sustainable management strategy for its inshore fisheries which involves strengthening the physical and human resources of the Fisheries Division and soliciting community participation through extension services (Cook, Gilmour & Johannes 1993).

In addition, the Government is also establishing more appropriate regulations and enforcement mechanisms to ensure an effective rehabilitation programme for these important resources (GWS 1992a). The Fisheries Division with assistance from AusAID is currently undertaking a fisheries extension and training program in both urban and rural areas to promote fisheries potential. A strong and productive inshore fisheries has the potential to reduce the import bill and encourage self-sufficiency (Fairbairn 1993; GS 1999b; Zann 1991b).

Despite continuing degradation, inshore fisheries is still a significant source for subsistence and income earning in many rural villages (Fairbairn 1993; GWS 1990a). The 1989 Agricultural Census has shown that 68% of the households in rural Upolu and 67% in Savai'i were engaged in fishing. In contrast, only 14% of the urban households have participated in fishing activities. The census has also shown that 33% of all households derived part of their cash incomes from fishing with 20% selling more than half of the catch (GWS 1990a).

Due to the lack of appropriate technology, the offshore fisheries in Samoa has been underutilized (Bell 1985). It was not until the mid-1970s that strong development in offshore fisheries began. This was, however, only made possible with the help of an FAO/UNDP funded boat building project channeled through the Government Rural Development Programme (Fairbairn & Fairbairn 1985; Zann 1991a). Further UN assistance set up fish aggregating devices- FADs. During the late 1970s, these FADs were deployed in specific areas in the surrounding ocean which led to increased fish landings (Bell 1985).

Samoa has the smallest 200-mile EEZ in the whole Pacific Region (Bell 1985; Zann 1991a). As a result the offshore fisheries do not possess the abundance of most popular fish species as in other Pacific countries (Fairbairn 1991). Nevertheless, Zann (1991a) and Fairbairn (1991) noted that several potential areas of offshore banks and seamounts are still untapped. They claimed that these could be economically viable if properly developed. There is also evidence of high concentration of skipjacks and baitfish within Samoa's EEZ that the Government regards as having potential for future development (GWS 1987a).

Fish landings from offshore fishing are increasingly potential as a foreign earner. There has been a resurgence of this type of fishing in the last decade, which has an emphasis on long lining. The Fisheries Division has been instrumental in this revival and has also designed and implemented a registration system that safeguards fishermen safety while at sea.

1.7 Forestry

Most traditional land uses and cultivation in Samoa, as in many Pacific Island Countries, had never been developed individually. Forestry, agriculture, buildings, medicines, handicrafts, and the production of other goods were all components of an integrated system designed to sustain the environment, and to meet the community needs. In Samoa, these traditional systems adopted a style of agroforestry that employed a mixture of root crops, tree crops and trees either planted or saved for conservation or for unique cultural purposes.

The transformation from subsistence to a cash-oriented economy combined with the rapid population expansion, however, have forced a change from the environment-friendly traditional systems into an intensified and extensive cultivation of root and tree crops at the expense of the forest (GWS 1992a; Pitt 1970; Thomas 1984). Such a massive shift in cultivating behaviour involving these land-use practices was difficult to control largely because of the following (Fairbairn 1985; GWS 1993a):

- the nature of the customary land tenure system that governs more than 80% of all land in Samoa,
- the limited resources that constrain other non-agricultural development,
- a strong government subsidy scheme for agriculture that promoted further deforestation, and
- under-pricing of the forest products.

So consequently, intensified agricultural activities coupled with commercial logging underpins the rapid rate of indigenous forest depletion in Samoa (Fairbairn 1991; GWS 1987; 1992; 1993; Iakopo & Reti 1990).

It was not until the last two decades that the Government acknowledged the multiple uses of the forests, including the need for conservation (GWS 1980; 1984; 1987; 1992). The NEMS Report for Samoa accentuated this need and also pointed out that the fast rate of forest depletion was, at the time, the most critical environmental problem in the country that must be addressed immediately with prudence.

Hence, the Forestry Policy (GWS 1994) has been developed which stressed the need for balanced utilisation of forests and forest lands as indispensable components of an integrated land-use system. This emphasis can provide an enabling environment with potential to raise economic growth, to meet the socio-economic needs of an increasing population and to ensure that the cultural aspirations are accommodated. The emphasis also guarantees a long-term vision that benefits both the present and the future generations through ecologically sustainable development.

1.8 Water Supply and Resources

The water supply system in the Apia urban area provides the urban population of more than 45,000 people with piped water (Taule'alo 1993a; World Bank 1995). At the national level, between 90% and 95% of the population have access to piped water (GWS 1992a). Approximately 70% of the population are supplied from surface sources while bore holes and rainwater account for the other 30% (GWS 1992a; Taule'alo 1993a).

Despite expensive upgrading of the urban water supply system, water shortage and dirty water are not uncommon (Taule'alo 1993a; World Bank 1995). The following are among the major constraints to water supply and resources in Samoa:

- high permeability of most Samoan rocks,
- diminishing forest cover due to fast rate of deforestation,
- land tenure – disputes have occurred over land with water resources,
- inappropriate pricing due to the absence of suitable policies for effective cost recovery, and
- excessive use of piped water.

There are only three water filtration treatment plants in Samoa which are located in the Apia urban area. The absence of treated water in other parts of the country is a serious concern for consumers as this can enhance vulnerability to water related diseases.

The National GHG Inventory

Table 2.1 Initial National GHG Inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol 1994

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O
Total (Net) National Emissions (Gigagram/year)	**20.22073**	**3.303743**	**1.260135**
1. All Energy	**102.20193**	**0.017078**	**0.000872**
Fuel Combustion	102.20193	0.017078	0.000872
Energy and Transformation Industries	8.7906676	0.000360	0.000072
Industry	0	0	0
Transport	70.7483473	0.014148	0.000604
Commercial-Institutional & Residential	22.6629158	0.002570	0.000196
Other (please specify)			
Biomass Burned for Energy	na	na	na
Fugitive Fuel Emission	0	0	0
Oil and Natural Gas Systems	0	0	0
Coal Mining	0	0	0
2. Industrial Processes	**0**	**0**	**0**
3. Agriculture	**0**	**2.140598**	**1.244289**
Enteric	0	0.899218	0
Rice Cultivation	0	0	0
Savanna Burning	0	1.145879	0
Other (soil)	0	0	1.2427131
4. Land Use Change and Forestry	**-81.9812**	**0**	**0**
Changes in Forest and other woody biomass stock	-240.19	0	0
Forest and Grassland Conversion	125.2084	0	0
Abandonment of Managed Lands	-26.5833	0	0
Soil	59.58333	0	0
5. Other Sources (Waste)	**0**	**1.146067**	**0.0104974**

na – not available

2.1 Introduction

This chapter highlights only the main features of Samoa's GHG Inventory, which identifies the potential GHG sources and sinks and provides estimates of major GHG in Samoa in 1994. The GHG Inventory constitutes a major part of Samoa's National Communication to the COP of the UNFCCC.

This inventory closely follows the methodology provided in the IPCC Guidelines for National GHG Inventories (IPCC 1996, Vol. 1-3). The data collection phase of the inventory process was particularly difficult due mainly to the inadequacy and poor quality of the available data. Consequently, estimates were made for those data that were not locally available using default values provided by the IPCC guidelines. This was inevitable, although it raised concern regarding the level of confidence. This simply means that the more the inventory relies upon estimated characters, the less its level of confidence becomes - a situation that the NCCCT tried to minimize.

This constraint, in fact, was anticipated, especially since the inventory, encompassing a wide scope and unique requirement, was the first of its kind to be undertaken in Samoa. Despite these circumstances, some positive aspects actually emanated during the tenure of the project. One of the amazing features was the reawakening of the awareness that "*what we derive from or dump into the biophysical environment without proper control is always accompanied by a deleterious effect*". Hence, there is always a need for wisdom and vision whenever we utilize the biophysical environment otherwise we face undesirable consequences.

Community indifference was strong in the initial stages of the inventory process. Persistent consultation and raising awareness about the greenhouse effect, however, resulted in enthusiastic participation and strong community support. The experience gained is useful in promoting awareness about the global warming and an increased appreciation by the public that they also are responsible for the alteration of the natural course of climate patterns.

2.2 Data and the Basis of Calculations

All the inventories compiled in this report were calculated using the set of methodologies provided in the Revised 1996 IPCC Guidelines for National Inventories. This revised version replaces the IPCC 1995 Vol. 1-3 which has been one of the main bases used in most developed countries for their GHG inventories.

The compilation of the greenhouse gas inventories depends on acquiring "activity data" and "emission data". The former data type encompasses information such as the following:

- consumption of various forms of fossil fuel,
- the number and type of domestic livestock,
- the type and quantity of agricultural development including crop production, conversion of forest into agriculture and land use,
- type of industrial/manufacturing operations and the rate of production,
- the quantity of waste water and sewage generation, and
- the amount of waste dumped into landfill sites.

Technical data specific to those prescribed by IPCC Guideline categories is very limited in this country. This feature has been identified in a recent survey conducted by the Government of Samoa under the Department of Statistics (GS 1998a; 1998b), which reflects the limited resources for data management, the lack of skills or both.

Emission data on the other hand defines the close association between the activity and the production of GHG. For example, the quantity of carbon dioxide emitted after burning a specific mass of fossil fuel. Since activity data is a function of the domestic and external demands there is a tendency for it to vary from year to year. Emission data, however, tend to be uniform for those emissions originating from fuel combustion as this is determined by the chemical composition of the fuel and, to some extent, the nature of the combustion process.

Emissions and removals from sources such as Livestock, Waste and Land Use Change, although subject to variation, occur in a much longer time period when compared to the activity time change. Further, the temporal relationship between activities like biomass decay or waste decomposition and the subsequent greenhouse emissions or removals is complicated. The time lag between the activity and the resultant greenhouse emissions or removals may take a period of more than twenty years for some categories, especially Land Use Change, Waste and Agriculture. Hence, emission and removal values for these categories are often calculated from averages of several years.

2.3 Levels of Confidence

According to the IPCC Guidelines countries need to identify the levels of confidence in their inventories (IPCC Revised 1996). The Samoan GHG Inventory adopts three different levels of confidence summarised in Table 2.2 below. It must be pointed out that the definition of the levels is totally conceptual. This simply means that the levels of confidence were not derived from a statistical analytical procedure, but were based purely on a professional judgement of the task force that compiled the inventories. It is for this reason that uncertainties are not assigned to activity data during the computation phases. They are only assigned to the final outcome of the emissions and removals.

Table 2.2 Levels of Confidence

Level of confidence	Code number	Energy, Industry	Agriculture, Land Use, Waste, Industry
High	1	uncertainty< 10%	uncertainty< 30%
Medium	2	uncertainty 10-50%	uncertainty 30-80%
Low	3	uncertainty> 50%	uncertainty> 80%

The quality of the available activity data is very much reflected from the levels of confidence assigned to the different categories. Further, in assigning the levels of confidence, consideration was given to the relationship between the activity and the emissions. This is illustrated in the Energy category in which the quality of some data is quite accurate and the relationship between combustion and emissions is not complex. Under this circumstance, the levels of confidence is rigorous compared to the other categories.

The majority of the data and, hence the consequent emissions and removals, has been assigned a low level of confidence. In fact, this was expected because of the poor quality and the limited quantity of available data. The only outcome with a high level of confidence arises from the Reference Approach for CO_2 emissions in the Energy category. This arises from the high quality of the import record of fossil fuel into the country.

2.4 Special Characteristics of the Inventories

2.4.1 Missing Features

This inventory excludes all contributions to the greenhouse effect from CFC and other "ozone depleting substances". An inventory of these pollutants has already been compiled for Samoa, and the subsequent Refrigeration Management Plan is close to completion, hence the exclusion from this report. Further, no estimation of SO_2 emissions was made in this inventory. Without the appropriate information about the petroleum products imported into the country the risk of achieving an extremely low level of confidence associated with SO_2 emissions was seen to be too high if estimation procedures were to be applied. Hence, SO_2 emissions and its associated share of the warming effect are excluded from this report.

A questionnaire survey was conducted to collect information about the use of fuel wood in Samoa. The need arose because of the apparent significance of this fuel type in the local economy. There has been no formal record available to the NCCCT of the use of this fuel type. The IPCC guidelines specifically pointed out that the CO_2 arising from biomass or fuel wood burning is to be excluded from the national totals. The team acknowledged the rationale provided, but it is worth raising the point that the outcomes of the survey reflected a high reliance of Samoans on the use of this fuel type. The survey outcomes indicated that the rural communities, in particular, are utilising enormous quantities of biomass for cooking and for drying copra, cocoa and peanuts. Consequently, the share of the CO_2 emitted from this source, is relatively significant. This share cannot be calculated unless the following are known:

- relevant dry matter mass for the various fuel wood types, and
- net calorific values for each wood type.

Soil erosion is another anthropogenic-induced activity that has not been given any consideration in this report. This activity is not required under the IPCC guidelines, however discussions with the MAFFM have shown that soil erosion is a problem associated with many land developments, in particular, agriculture and commercial logging. The effect of soil erosion is not well documented in Samoa (GWS 1993b, Saifaleupolu 1996, Zann 1991a, 1991b) but its contribution to the removal of carbon from the natural carbon cycle may be significant. It may be necessary that this feature can be included as part of Samoa's GHG inventories in the future because of the increasing dependence of the population on the land to meet their everyday sustenance.

2.4.2 Emissions, Removals and Net Emissions

Of the five categories included in Table 2.1, only the Energy and the Land Use Change and Forestry categories recorded contributions to CO_2 emissions and removals in 1994. The Energy category, with a net emission of 102.2019 Gg, was clearly the strongest source of CO_2 in Samoa. Land Use Change and Forestry, although emitted an amount of 184.792 Gg of CO_2 in the same year, indicated a net CO_2 removal of 81.9812 Gg due to the strong intake of CO_2 through photosynthesis by forests and trees. This feature is important because it indicates that the atmospheric concentration of CO_2 can be humanly controlled.

CH_4 and N_2O, on the other hand, were emitted from three of the five categories in Table 2.1. Compared to CO_2, all the three categories – Energy, Land Use Change and Forestry and Waste – generated very insignificant quantities of CH_4 and N_2O into the atmosphere.

2.4.3 Energy

Energy is the only category with good quality data. The main data source - the Customs Department - has a very accurate and up-to-date database that includes petroleum products. Keeping an accurate record of these items is very important because the government pricing process for petroleum products depends on it.

The Transport, Residential/Commercial, and the Energy Transformation were the three major components of the Energy category that contributed significantly to its share of the CO_2 emissions in 1994. Of the total CO_2 emissions from the Energy category in 1994, the Transport sector accounted for nearly 70%, followed by Residential/Commercial with 22% while only 8% came from the Energy Transformation. The CH_4 and N_2O emissions from the Energy category were relatively insignificant.

2.4.4 Agriculture

Generally, the GHG Inventory data from the Agriculture category is scarce and out of date. Some estimates used in this inventory were based on a study undertaken 10 years ago (GWS 1990). Ironically, the majority of the Samoan population rely heavily on agriculture to meet their everyday needs (Fairbairn 1985, 1991, 1993; Saifaleupolu 1996). Despite the strong emphasis placed by the MAFFM in collecting agriculture-based data, rural agriculture is still poorly understood (Fairbairn 1985). Hence, it is an issue that requires immediate addressing.

Samoan agriculture involves shifting cultivation that employs a fallow system. This feature is recognised in this inventory under the Land Use Change and Forestry category in the Land Abandonment sector. Most of the lands used for the taro industry have been put to fallow since the incidence of the taro leaf blight in 1993. A large portion of these lands are found in the wet and moist areas a fair distance from the farmer's residence.

Most crop residues are non-combustible. These are usually left to decompose at the plantation sites. The lack of quantitative data about these items, however, excluded them from the inventory. The only residues that are good fuels are the coconut husks and shells. These have been used as part of the inventory under the Field Burning of Agricultural Residues sector.

It is important, however, to point out that these residues are very rarely burned in the field because they form a significant part of Samoa's biomass fuel. Nonetheless, their inclusion is important because it gives a truer indication of the emissions of GHG from the Agriculture category. It is also interesting to note that the Agriculture category emitted only CH_4 and N_2O – no CO_2.

2.4.5 Land Use Change and Forestry

Land Use Change and Forestry was identified as a major sink for carbon in 1994. Two sectors within this category were recorded as net sources of CO_2 - Forest Conversion and Soils. The other two sectors - Changes in Forest and Other Woody Biomass, and Land Abandonment - were net sinks for carbon. Available literature, in particular the GWS (1993a) and Forenco Consultants Ltd. (1995), although few, provided some insight of the amount of deforestation due to commercial logging in the past, present and the future.

Land Use Change and Forestry has been assigned a high uncertainty due mainly to the absence of quality data required for Inventory purposes. Minimising this uncertainty depends very much on the Forestry Division in soliciting the required information for future GHG inventories. Although Land Abandonment has been included in this inventory, there are unclear boundaries within this sector. Field observations indicated that there are many once well-managed lands, in particular, the coconut plantations, that appeared to be abandoned but owners are still collecting coconuts from them. These land types are not included in the inventory under the Land Abandonment sector, although some are already overgrown with secondary forests.

Forest burning, purely for forest fire safety precaution, is virtually not done in Samoa, although early writers of Samoa reported the use of fires to clear land for agricultural purposes. Forest fires, on the other hand, although rare, do occur. Other type of burning which is not defined in the IPCC Guidelines but is observed to be a regular habit in many villages today, is the burning of grass cutting from family lawns and village greens. This feature is practised throughout the country, and although its contribution to the greenhouse effect may be insignificant, it is worth noting for future planning and management purposes.

2.4.6 Implications

The emissions of GHG in Samoa are relatively insignificant by world standards. Notwithstanding, Samoa is among the most vulnerable countries to the impacts of the greenhouse effect. It is ethical, therefore, that Samoa should recognise its obligation toward reducing GHG emissions.

A crucial constraint reflected from the inventory is the lack of quality data. It is important to acknowledge this as urgent, hence, Samoa needs to address this issue properly and promptly. Data management is also identified to be generally poor which makes it a priority issue that must be rectified. If these constraints are resolved, an improved GHG Inventory will be guaranteed. As a result more realistic estimates of GHG emissions and removals will become available and accessible. This information is important to planning and policy making purposes, both in the government and the private sector.

Another salient feature identified with this GHG Inventory, is the need to incorporate participation from all sectors of the national economy. Improvement of the above issues is dependent on a well coordinated system where sufficient quality data can be easily accessed and managed. Addressing this issue therefore calls for an integrated system that employs comprehensible and user friendly mechanisms that allow for closer cooperation between the key government and non-government agencies.

The GHG estimates, despite being relatively small quantitatively, will definitely increase with population growth and the fast pace of economic development that requires the use of high energy equipment. Thus, in the absence of a proper control mechanism, GHG emissions are likely to be enhanced in the future.

However, it is evident from the inventory that, CO_2 alone can be controlled manually, either by allowing more lands to be converted back to forests, or by improving land use techniques or slowing down the rate of deforestation or a combination of these. So despite increased CO_2 emissions, an enhanced uptake of CO_2 by the increased forests and tree crops is likely to offset emissions.

Other strategies are also available for controlling the emissions of all GHG including CO_2. These include regulatory measures that set up a piece of legislation that controls the importation of fossil fuel, cars etc., or enacting a regulation that activates a monitoring system for the emission rate of greenhouse gases.

The underlying rationale for all these implications is to ensure that Samoa, within its own territory, can provide an optimum environment for its people. There is compelling evidence, that the greenhouse effect and CC are intimately linked. So for Samoa to produce the best for its people in terms of a favorable environment, it must prevent undesirable CC from occurring, and simultaneously the people need to be more responsible by co-operatively engaging in measures to reduce CC and activities at all levels..

Mitigation

3.1 Steps taken by Samoa to Implement the UNFCCC

Samoa, as a non-Annex I Party has already taken steps towards implementing the objectives of the UNFCCC. The Government, through its NCCCT, in close collaboration with the DEC, MAFFM, MFA, MOT, TD, SWA, NGOs, private businesses and the local community, has completed its GHG Inventory and the V&A Statement. These two documents form the major part of this National Communication.

The GHG Inventory, which was completed in February 1999, has indicated several salient issues that require urgent addressing. It is vital to acknowledge that the approach used to address these issues must clearly identify a vision that it forms a fundamental component of an integral national effort to adapt to and to mitigate CC adverse impacts. It is also important at this stage to point out that the methodology adopted by Samoa when undertaking its GHG Inventory is that provided by the IPCC. Since this is the first inventory of its kind, it is important to acknowledge that the primary problem encountered in the GHG Inventory was the difficulty associated with baseline data. Underlying this problem are the basic constraints due to the following:

- the data, in general, are incomplete and incomprehensible,
- management of data is generally poor, and is further aggravated by the lack of physical management resources, and
- the scarcity of data management skills and capabilities.

Therefore, establishing a reference point for baselines, although constrained by the above factors, is clearly identified as a real and urgent problem in Samoa, and was promptly dealt with during the inventory compilation phase.

With the enhanced greenhouse effect as a major contributing factor to the CC, the current situation regarding data quality, quantity and management is a matter of great concern. This is especially so when there is sufficient evidence to link CC extreme events, such as severe hurricanes, to an increase in both frequency and magnitude of precarious threats to human life and to the bio-physical environment. From the economics perspective, severe cyclone damage due to tropical cyclones Ofa in 1990 and Val in 1991 dominated poor economic growth over the following two years. Fairbairn and Vaai (1994) have indicated a drop in the GDP from WS$180,000,000 in 1989 to about WS$172,000,000 in the 1992/1993 period, a fall of 4.5 per cent, or just over a 1.0% per annum. Commercial agriculture (including fisheries and forestry) was identified to have been among the most severely affected during the 1990-1992 period, which included the cyclone phase. So undertaking the GHG Inventory is therefore timely and very appropriate for Samoa, a small island country that is highly vulnerable to CC and enhanced SLR.

Among the priority areas looked at during the GHG Inventory are the need to:

- identify the major sources and sinks of GHG,
- estimate quantities of individual GHG,
- estimate uncertainties associated with GHG emitted and/or removed,
- identify existing trends in emission/removals of individual GHG during the inventory period,
- make comparative analyses of individual GHG based on existing trends,
- provide comparative assessment of Samoa’s contribution to overall global warming, and

- ensure transparency, since without this, it is impossible on the one hand to make any logical analysis of the country's contribution to the greenhouse effect, and on the other to provide a comprehensive mechanism to compare Samoa's GHG emissions to those of other countries.

It is also worth noting that public awareness plays a major role during the GHG Inventory phase. Compiling the GHG Inventory for Samoa relied, to a very large extent, on the owners of the data. That is, those with a clearer understanding of the need for a GHG Inventory were very supportive and were quick to respond positively. On the other hand, those with little or no understanding about the greenhouse effect and its intimate relationship to the CC were uncooperative and indifferent. Clearly therefore, promoting public awareness about the greenhouse effect and its impact must be granted a high priority to enhance community cooperation and support – a much needed ingredient for assuring good quality data and information.

3.2 Infrastructure

The Government has become conscious of the need to ensure that its assets, both infrastructure and natural, are safely protected from the impacts of CC and SLR. The Apia seawall, which provides protection for the best part of Government assets, is an obvious indication of this awareness. In more recent development activities, the PWD has embarked on constructing a series of seawalls in Savaií to provide protection for the seaside main roads. According to the PWD, more than 90% of all seaside main roads in Savai'i are already protected by seawalls (Faalogo Iosefa pers. comm. Sept. 8, 1999). Faalogo also said that there are plans to undertake similar programmes in Upolu, with assistance from the World Bank.

There is also evidence of community-based efforts focused on mitigating the impacts of SLR, enhanced storm surges and wave activities at the village level. Some villages have solicited help from the Government and other donor agencies to assist in their seawall projects. In some cases, villages, of their own accord, have initiated their own seawalls to provide some protection during cyclone seasons. Most of the latter efforts, however, are incomplete and lack the necessary structural engineering that provides lasting endurance.

The Government of Samoa has also stressed the need to improve the processes involved with the construction of buildings to ensure maximum human safety during tropical cyclones and other severe impacts of CC.

A village-based seawall project in Savai'i.

3.3 Policy

Samoa's commitment to the UNFCCC and the Kyoto Protocol may further be reflected by the development of environmental policies and undertaking joint researches in various aspects of the environment. The NEMS Report for Samoa indicated a need to formulate enlightened policies in 12 priority areas. Four of these areas:

- Population,
- Water,
- Waste Management, and
- Land-use

have been addressed with draft policies now awaiting Cabinet approval. The Bio-diversity and the CC and SLR are currently being addressed by Cabinet appointed committees coordinated by the DEC.

The information gaps which have become salient features of both the GHG Inventory and the V&A Statement, are addressed appropriately in the drafted policies. However, while awaiting Cabinet approval, there is an urgent need to improve the current situation as identified in both chapters 2 and 3 of this National Communication. For planners and policy makers to come up with prudent and practical national strategies and policies, they must have access to good quality data.

Another glaring issue that also requires addressing in this initial National Communication is the threat posed by oil spills. Besides presenting a potential danger to both human and other components of the bio-physical environment, oil spills also enhance emissions of GHG. The oil spill in mid-August, 1999 in Apia, although regarded as minor, must be heeded as a forewarning of what might occur in the future if no imaginative policy or regulation is promptly established and adhered to.

3.4 Regulations

There are already suggestions regarding the development of regulations under the Customs Department Act (CD) to provide import control of appliances which take ozone depleting substances (ODS). By the same token, an effective regulation that prohibits further importation of ODS has been highly recommended. Import of refrigerants, refrigerators/freezer/air-conditioners should be tightly controlled under the CD Act which must be modified to accommodate the need to allow only those which are ozone-friendly.

Further suggestions for a regulation under the CD Act have also been made to ensure that allowing second-hand motor vehicles into the country must be subject to stringent scrutiny based on both age and model. That is, old vehicles and outdated models should not be brought into the country because they are big GHG emitters.

New regulations through either the DLSE or the MAFFM were part of a recommendation made by the Bio-Diversity National Committee to ensure that Samoa's natural resources are safely protected from foreign bio-prospectors. This suggestion also underlies the need to protect the fast diminishing ecosystems from other human activities as well as from the impacts of CC and SLR.

3.5 Projects and Surveys

A vision into the future prompted the Government of Samoa to take the initiative in providing a mechanism to control unsustainable land-use practices in watersheds. The rising frequency of harsh climate patterns – particularly heavy rains and anomalously long drought periods - necessitates the Watershed Management Programme at the Vaisigano area. The project provides a leading role in promoting better and more suitable landuse practices, such as agroforestry, and simultaneously discourages poor development activities.

The Government, with financial assistance from FAO, has also launched the Food Security Project. The project is geared towards assuring the availability of sufficient local food items all the time. Included in the project is the need to identify fast crops that could be harvested within a period of at most seven months so that the maximum damage imposed by tropical cyclones and other climatic elements are minimised.

Further, under the New Zealand bilateral assistance programme, the Community Forestry Project is now a major part of the Forestry Division of the MAFFM. The focus is now upon developing community capacity in managing their own forests and forest products. The project also considers impacts from CC and SLR so proper forest development and management are also highlighted.

The DOS and the MAFFM are planning an Agricultural Census at the end of the year 1999. The census is both timely and very useful since it will provide the necessary information that has been identified to be either lacking or incomplete in both Samoa's GHG Inventory and V&A Statement.

A World Bank funded project, known as the "Ïnfrastructure Asset Management Project" is about to begin in Samoa. It is also regarded as both CC- and SLR-oriented. The project will highlight the need to provide better management mechanisms for the Government's infrastructure assets. The scope of the project also includes collection and analysis of data from Geographic Information System (GIS), topography maps, coastal profiles, integrated coastal zone management, and infrastructure engineering.

3.6 Education - School Curriculum

Government preparations for the environment issue, including CC and SLR have also pervaded the education system, for example, in the school curriculum. The junior secondary school curriculum for Environmental Science is close to being finalised. At the tertiary level, there are courses and programs already approved by senate but awaiting council sanction, which will address the environment issue including CC and SLR. Although programmes at both levels are still on hold, there are indications that they will raise public awareness and enhance appreciation of Samoa's vulnerabilities to CC and SLR, hence, the need to adapt accordingly and to start implementing proper mitigation measures.

The outcomes of the GHG Inventory and the V&A Statement have identified a need to educate and to train Samoans about the need to adapt to current CC and SLR. A large percentage of the problem will be resolved if the communities recognise this need in keeping with changes in climate patterns and trends as well as increased SLR.

3.7 UNFCCC Mitigation Assistance

This National Communication clearly presents a setting that reflects a need for Samoa to act with prudence and vision regarding its preparedness to adapt and to impose mitigation measures against possible adverse impacts caused by CC and SLR. Despite Samoa's initiative in this respect, it is evident that external assistance is urgently required to fulfil its obligations and commitments under the UNFCCC and the Kyoto Protocol. Sections 5.3.1 and 5.3.2 describe some of the possible projects that can be implemented under this assistance. Samoa is fully committed to the UNFCCC objectives and it embraces all opportunities to fulfil them. It also welcomes support from the global communities who share the same need to make the world a better place to live through establishing suitable adaptive and mitigative mechanisms.

Vulnerability and Adaptation

4.1 Introduction

Samoa's GHG Inventory indicates that its GHG emissions are relatively very small. This, however, does not imply that it will not be adversely affected by the impact of CC. The devastation inflicted by tropical cyclones Ofa and Val as pointed out previously is a reminder of the high degree of Samoa's vulnerability to the impacts of CC. Samoa, as a result, needs to take prompt and proper actions, to ensure everyone understands that the adverse consequence of CC has the potential to endanger human life and imposes a threat to the biophysical environment, which sustains the livelihood of our communities.

There is compelling evidence that CC not only threatens the biophysical environment but it also increases potential vulnerabilities of the people as well as the socio-economic structures and activities.

An important aspect of this National Communication is to identify both the vulnerability of Samoa to the adverse effects of CC and the possible adaptation options. Samoa's V&A adopted the IPCC Technical Guidelines to examine present conditions and to generate scenarios of possible CC and SLR in Samoa. These scenarios were used to project the vulnerability of Samoa to CC and SLR.

The main limitations of Samoa's V&A statement are the existence of many information gaps, and the lack of necessary resources. Collected data indicated several gaps and there is also a parallel lack of appropriate models required to produce suitable scenarios for Samoa. This V&A statement is based on Samoa's known and predicted vulnerabilities to CC.

4.2 Population and Food Security

Samoa's changing food production systems and high population density especially in urban areas have posed a threat to food security in the country. This problem arises mainly from the high food demand and the rapidly expanding population. A survey conducted in 1996 has shown that the total food energy requirement has increased by 0.5% per annum due to the population expansion. This increase is distinctly pronounced in urban areas. Despite a series of extreme events associated with CC plus pest and disease outbreaks, agriculture has shown resilience and the capacity to adapt. Still, there is an urgent concern about future food security, largely because of the inevitable impact of the deteriorating condition of the biophysical environment.

4.3 Urbanisation and Water Resources

Urbanisation and over crowding is an increasing problem faced by Samoa as more and more people move into the urban areas. The Apia urban area has a very high population density of about 565 persons per km^2. As pointed out earlier, although the majority of the urban area has access to piped water, many urban dwellers still experience frequent water shortages and supply interruptions. Water consumption is excessively high and is a major contributing factor to water shortages and low pressures for some sectors of the community. Heavy rains exacerbate problems associated with water supplies, in particular, the high degree of turbidity. Prolonged dry spells encouraged by the ENSO phenomenon, on the other hand, have drastically reduced water supplies. This has special implications for areas in the northwest of Savai'i Island, where water supplies were cut off for periods of up to eight months during these drought conditions.

4.4 Landuse, Deforestation and Land Degradation

Prior to the incidence of the taro leaf blight in mid-1993, the most dominant land-uses were agriculture and commercial logging which have been responsible for the conversion of a very large portion of the indigenous rainforest into arable land. Current deforestation for agriculture is negligible, hence, land clearance today, which is mostly in higher inland areas, is almost completely timber-oriented. The absence of proper management during these land clearing activities has enhanced severe soil erosion and flooding during heavy rains.

The increase in use of fertilizers and agricultural chemicals for agriculture activities has been identified as potential threats to both water catchments and water supplies (Suluvale 1998). The expanding population has also created an increasing use of forest products for building purposes. Often, these activities lack proper planning thus contributing to land degradation.

4.5 Coastal and Marine Resources

The increase of development activities, urbanization, increased resource use and population growth are continuously putting pressure on the coastal zone environment. Most Samoan villages are located near the sea with an average coastal population density of about 75 per km^2 (Chase & Veitayaki 1992). The impacts of tropical cyclones Ofa and Val have caused some coastal areas to suffer more from storm surge attacks, causing inundation of low-lying areas and serious damage to the infrastructure. Several coral reefs are still recovering from the damage caused by these natural disasters. Further, the same events have been responsible for the relocation inland of many households including two neighbouring villages, Falealupo and Papa in northwest Savai'i. Development in the fishing industry is also identified with severe degradation of the marine and coastal resources.

Poorly planned tourism activities are also contributing to the deteriorating condition of the coastal environment.

Plate 1.

Plate 1 depicts the deserted traditional residence of the village of Papa. Today only one house is still standing there. The village has been relocated to higher grounds further inland, due to the impacts of storm surges and wave activities.

Other human activities such as sand mining, and land reclamation, are also inducing stress on the coastal environments and the marine resources (Taule'alo 1993b; Saifaleupolu 1996)

4.6 Climate and Health

Little is known about the relationship between health and CC in Samoa. The last major tropical cyclones caused loss of lives, thus highlighting Samoa's vulnerability to natural disasters which may be an increasingly prevaling trend with global warming. Vector-borne diseases, such as dengue fever, can significantly enhance health problems, especially in high population-density areas infested with inadequate sewage and drainage systems. Another significant CC-health concern is the increase of water-borne diseases for example, gastroenteritis and diarrhoea, which are identified with poor water quality and flooding during rainy seasons.

4.7 Sensitive Sectors and Exposure Units

Samoa has a wide and rich diversity compared to other small islands, but its biophysical and socio-economic systems are very sensitive to current changes in ocean and atmospheric conditions. Five areas of focus are examined in this study, and these include Coastal environments, Health, Water, Agriculture and Bio-diversity. They have been specifically selected, because of their high priority and high sensitivity to CC and noting that they are all interrelated and interdependent.

4.7.1 Coastal Environments and Systems

Most of the economic activities, infrastructure and human settlement are located in the coastal areas. These activities, have had adverse impacts on the coastal environment, particularly the lagoons, coral reefs, mangrove forests and the shoreline (Bell 1989; Zann 1991a). In addition, the past two cyclones have devastated the coastlines including traditional village sites causing whole village relocation as explained in the previous section.

This has now prompted the Government to build a seawall. Apia is the most densely populated area, it also hosts most Government and business infrastructure. It is now surrounded by a high seawall, which provides protection from SLR and storm surges. Most coastal villages, however, lack robust seawalls, hence are still vulnerable to SLR. Observations have shown that coastlines are continually eroding and inundated due to the absence of any form of protection.

4.7.2 Human Health

Samoa's human health trend is similar to other Pacific Islands experiencing noticeable changes in lifestyles and diets. Although the country's morbidity is now stable, there is still concern about the noticeable increase of people contracting non-communicable diseases particularly diabetes, hypertension and obesity, which are classified as diet- and lifestyle-related. There have been two outbreaks of dengue fever in the recent past. However, developing a correlation between the outbreaks and CC was not possible due to the absence of the relevant data.

4.7.3 Water Sector

Samoa has significant access to an acceptable level of surface and underground water. The resource is dependent mainly on rainfall that averages about 3000 mm per year. Prolonged drought spells in the recent past have highlighted Samoa's vulnerability to the potential increase of drought conditions through global warming. Stringent measures were put in place during the dry spell to ensure all households receive some water everyday.

Bore water is generally good except for those bore holes close to the sea and those located where the rock formation is porous. Surface water on the other hand increases in turbidity during heavy rains. Deforestation is identified with increased soil erosion, which is a major causal factor to the deteriorating water quality and reduction in quantity.

4.7.4 Agricultural Activities

Agricultural activities are classified into two divisions: livestock and crops. These divisions and the forests are all affected by exposure to units of alien/invasive pests, diseases and weeds. Soil is also an important exposure unit for these divisions' sustainability. The main crops of Samoa are coconuts, cocoa, kava, bananas, giant taro, yam and taro (the latter is no longer in mass production due to the leaf blight).

4.7.5 Biodiversity

Traditionally, the people of Samoa depended entirely on Samoa's natural biodiversity for their very livelihoods (Fairbairn 1985; Meleisea et al. 1987; Saifaleupolu 1998). Today, Samoa's biodiversity still contributes to a large percentage of the economy (GS 1998c; 1999a). At the global level, Samoa is classified under the Bio-geographical province number 9–a region hosting similar combinations of plants and animals to those found in Samoa. Among the 226 islands of the South Pacific Region, the Samoa islands rank fairly high in terms of their conservation value.

Human activities unfortunately are increasingly threatening all the existing ecosystems. In addition, several species are already endangered by CC extreme events. This assessment, however, employs a general approach with no specification to clarify the impact of CC to Samoa's biodiversity.

4.8 Climate and Sea-level Scenarios for Samoa

It is important to point out that there is still uncertainty associated with the models used for future climate projections, especially in the case of small island countries such as Samoa. The IS92a emission scenario by the IPCC was used for this assessment because it is the IPCC "*best guess*" with less uncertainty relative to the other scenarios IS92e-IS92f (defined in Annex 1). For the extreme event projection, historical analogs were used due to the lack of appropriate models.

None of the following scenarios are specific predictions of climate and sea level change for Samoa. They are however regarded as a basis for asking "what if" questions in relation to the sensitivity of the country to future CC and SLR.. Uncertainties with the projections remain due to the lack of data and reliable models used for the Pacific Region.

4.8.1 Temperature and SLR

There is a linear trend of temperature with the projected years. The IS92a "best guess" scenario projected that by the year 2100 there will be an increase in temperature of 2 ^{0}C. The IS92a emission scenario for sea-level rise assumes that the sea level will increase by 49 centimetres by the year 2100.

4.8.2 Precipitation

The Scengen model was used for projecting precipitation scenarios. According to the time horizon used, there is an increasing trend for precipitation. The CSIRO9M2 IS92a projection shows that there will be a "best guess" increase in precipitation by the years 2050 (2.2%) and 2100 (4.1%). The HADCM2 IS92a projections show an increase in precipitation by 3.7% in the year 2050 and 6.8% by year 2100. If there will be an increasing trend of ENSO events that bring long dry periods in the future, then this increase in precipitation projected by the models is uncertain.

4.8.3 Extreme Events

There is limited knowledge available to determine the relationship between CC and extreme events. In fact in the past decade, there has been a change in the trend of natural disasters in the Pacific region. There have been frequent occurrences of cyclones, ENSO and intense drought, and Samoa is vulnerable to all of them. Taking into consideration the present trend of the cyclonic occurrences in the Pacific, Samoa will most likely be affected by more cyclones in the future.

The ENSO weather pattern has become more frequent since 1977, bringing an increase in rainfall in the northeast Pacific and rainfall decrease in the southwest where Samoa is situated. The last ENSO event in 1998 caused significant climate variations in Samoa. It was associated with increases in temperature and long dry periods, causing approximately 8 months without rain in some parts of the country in that year.

4.8.4 Carbon Dioxide

Carbon dioxide buildup has recently been identified to reduce coral reef development by a predicted 8% –17% by the year 2050 (Klelpas *et al*. 1999). High concentrations may reduce the advantage of metabolism based on four-carbon (C4) over three-carbon (C3) compounds in grasses. In view of these higher temperatures, growing crops with crassulacean acid metabolism, e.g. pineapple, where carbon dioxide is fixed under lower night temperatures may be a favoured option.

4.8.5 Ultraviolet Radiation (UV-B)

Ozone depleting gas concentrations are only just peaking about the year 2000 and their indirect effects, due to UV-B radiation, on organisms and the food chain will continue beyond the year 2100 (Fraser & Prather 1999).

4.9 Environmental and Socio-economic Scenarios

4.9.1 Population Growth

It is difficult to predict with accuracy the future composition of the population in Samoa mainly because of the considerable under-registration of births and deaths (GS 1999c). It appears that there is a reduction in emigration as more Samoans are returning to the homeland with the intention of staying permanently (GWS 1992a). At zero net out-migration, the Spectrum model has projected that by the year 2100 Samoa's population will be 1.3 million. In 2011, the population is projected to be 263,069, which is fairly close to the Department of Statistics projection of 260,069. Provided this projection is accurate, greater demand will be placed on the biophysical environment thereby amplifying stress on these resources in the future.

4.9.2 Population Distribution

The current trend associated with internal migration indicates that more rural people are moving to urban areas, and that this will most likely continue in the future. Better job opportunities, better education, and better health services spur this urban drift. More and more people seem to be moving back to Samoa to stay permanently and to cultivate their lands. The coastal areas are already under stress with development activities, which are shifting inland, increasing pressure on land unsuitable for agriculture and water catchment areas. The Government proposal to develop the township at Salelologa, on the island of Savaii, will alleviate pressure caused by the skewed population distribution in the future. Population redistribution is expected once development is completed, creating new jobs and enhancing social services which are currently under-developed in Savai'i.

4.9.3 Economy

Economic development is taking place at a rapid rate with more improved infrastructure and a wide range of investing opportunities. The Government has begun its planned reforms that

favour the expansion of the private sector while simultaneously contracting the public services. Industries such as fisheries and manufacturing are increasing production while in comparison, agriculture is performing at a modest level partly because of the impacts of natural disasters and diseases. Subsistence agriculture has always been important in Samoa and will continue to play a significant role in the future. A properly planned tourism industry has a promising future. As more tourists visit Samoa, there will be an increasing demand for more local human and biophysical resources in this industry. The new township proposed at Salelologa has the potential to boost both the national economy and to raise the standard of living for those living on the island of Savai'i.

4.9.4 Changes in Landuse Patterns

Tropical cyclones Ofa and Val devastated a large portion of the merchantable forests. It is estimated that only 14% of the remaining forests is merchantable with the balance providing protection for water catchments and to conserve the biodiversity. While the increase in population pressure and land development will most likely reduce the remaining forest cover, a parallel resilient reforestation programme undertaken by the Forestry Division and the local communities is predicted to provide an overwhelming opposite impact.

4.9.5 Social Changes and Health Problems

Samoans are moving away from traditional and subsistence lifestyles and have adopted some (not all) western and introduced values and lifestyles. The increase in the incidence of lifestyle-related diseases is probably a result of the change in diet and behavioural patterns. Migration to the urban areas poses problems, both social and environmental. Significant percentages of the population consume more imports and processed foods. There is a threat to food security as people are more dependent on imports and fewer continue to grow significant home gardens. Pressure on water resources is evident and will increase in the future, as the demand increases from the public and industry.

4.10 Effects of Climate Change and Sea-level Rise

Gaining a better understanding of the implications of CC and SLR to Samoa's biophysical environment is constrained at the national level largely by the lack of quantitative data and limited analytical capability. However, the few studies already undertaken have enabled some fair judgements and assessments of what may be expected.

4.10.1 Coastal and Marine Environment

Frequent extreme events in the future are expected to affect the coastline drastically, as it did during tropical cyclones Ofa and Val. The impact of storm surges is expected to severely change the coastlines. The Falealupo coastline for example has changed due to more materials being deposited, making it higher than it was before. The SLR will possibly cause erosion and retreat of beaches and marshlands. There will be a reduction of some coastal habitats, and increased exposure of structures like roads to wave activities. It is also anticipated that there will be increased flooding in the low-lying flat lands during heavy rains as the water table is expected to rise (Chase & Veitayaki 1992).

4.10.2 Human Health

A predicted temperature increase of 2^{o}C will directly affect human health not only from the heat stress but also because of the amplified vulnerability to possible outbreaks of vector borne diseases. Similarly, an increase in rainfall and flooding, which provides favourable conditions for waterborne diseases, can also increase human vulnerability to CC. This human vulnerability is highlighted by the tragic outcomes of extreme events. For instance, tropical cyclone Val in 1991 killed fifteen people. Hence, an increase in frequency of these events amplifies the potential danger to human life.

4.10.3 Water Resources

Observations have shown that very few rivers run all year round regardless of high rainfall. The availability of water in Samoa is heavily dependent on heavy rainfall, land-use practices and user demand. An increase in rainfall intensity, which some models have projected, will increase runoff, enhance soil erosion on cleared land, and accelerate sedimentation in the existing water supplies (Chase & Veitayaki 1992; Saifaleupolu 1996; Suluvale 1998). Not only will such an event reduce the potential of catchments to retain water, but it will also exacerbate water quality.

The long dry periods associated with the ENSO phenomenon have serious direct impacts on water supplies. The most recent ENSO event in 1997/1998 has been identified with water shortages in many parts of the country. Tropical cyclones and storm surges also affect water supplies by damaging water supply infrastructure.

Similarly, SLR will enhance intrusion of salt water into freshwater lenses thus reducing the quality and the quantity of potable water. Underground water and coastal springs will consequently become more vulnerable with increase in SLR.

4.10.4 Agricultural Activities

The SLR would force home gardens and other agriculture developments further inland. A similar agricultural shift is very likely to occur with a temperature increase. That is, a temperature increase of 2°C would shift the cultivating zone further into higher elevation. This means that crops that are sensitive to low temperatures like coconuts can be introduced into higher elevations with this temperature rise. Although this may seem a viable alternative, a closer examination indicates that the landforms at this altitude are mainly steep slopes, appropriate only for protection forests, and unsuitable for agriculture. Any form of cultivation at this altitude is therefore ecologically unsustainable and uneconomically viable (ANZDEC 1990).

Although rainfall may increase about 4% in the “best guess” scenario, it would be more than offset by increased evapo-transpiration at higher temperature. This is particularly true in areas with very low rainfall like the northwestern coastal zone of Savai’i where soils are generally shallow and droughts are normal occurrences. The higher night temperature, in particular, has been reported to increase respiration from soils (Beardsley 1998), which would reduce soil organic matter and soil fertility. Higher rainfall would also increase the loss of soil nutrients due to leaching, especially with the decreased protection of soil organic matter.

Drought tolerant pastures, e.g. *Panicum maximum* varieties, of guinea/green panic grasses have been recommended (Reynolds 1995). Likewise, drought intolerant Hereford cattle have already been cross-bred with Brahman to no more than one-eighth Hereford, and Droughtmaster cattle breed has also been introduced.

4.10.5 Biodiversity

The projected CC with an increase in rainfall and temperature may be favorable for the richness of diversity. This is because a warmer world has greater potential for plant productivity together with a movement of many species towards higher latitudes. Some species, however, will die out or become extinct, as temperature exceeds their tolerance limits. Sufficient water supply will mean enough water for plants and animals for their survival and production. An increase in SLR, on the other hand, will affect the coral ecosystems as they may not keep up with the increase in sea level thereby rendering coral reefs more vulnerable to bleaching.

The CC and SLR could have enormous impacts on forest and tree resources in Samoa. Forests that are adapted to lower temperatures could be replaced progressively by tropical species over a period of about 50 to 100 years. On Savai'i, in particular this may mean merchantable forest growing increasingly inland to where there are currently *'asi (Syzygium inophylloides),'a'amatia (Eleocarpus tonganus)*, and possibly the main highest elevation *vivao* situated (Reynoldsia sp.) (Imo & Cable 1996).

Different forest types, varying in tree species composition, will be affected by likely CC and SLR in the future. During prolonged dry spells, the forest areas are very sensitive to fire. The 1998 forest fire during the ENSO period, affected up to 15,400 acres of land, which include s agriculture plantations.

Plate 2.

Plate 2 shows part of the Savai'í forests damaged during the 1998 forest fire that coincided with the ENSO event.

Salt spraying is quite noticeable in coastal areas and this problem could be extended further inland with CC and SLR.

4.11 Effects of Environmental and Socio-economic Changes

Continuing environmental and socio-economic changes are already having adverse effects on Samoa, and are expected to continue into the future. The effects of the environmental and socio-economic scenarios are briefly considered in relation to the possible direct effects of climate and sea-level change identified in the previous section.

4.11.1 Coastal and Marine Environment

The increase in fishing activities and the movement of people to the coastal area has rendered the coastal environment more vulnerable to human induced stress. For example, increased reclamation activities affect the coastline and the natural coastal protection. In addition, waste problems will be an occurence inevitable in the future if not controlled. The increased generation of waste will cause pollution to the coastal environment. Uncontrolled tourism activities also can contribute negative impacts on beaches, coastal vegetation, lagoons and reefs.

4.11.2 Human Health

The increase in both population and population density coupled with urban development encourages favourable conditions for epidemic outbreaks of dengue fever. It is also likely that poor sanitation and diet change will enhance the vulnerability to dengue fever and water-borne diseases. Careless disposal of packaging of consumable goods has provided breeding sites for vectors such as the mosquito carrying the dengue fever virus (Saifaleupolu 1996). Although there has been some significant improvement in the waste management, there are still problems that need to be rectified. This is compounded by the poor drainage system in the country especially in the densely populated area of Apia.

4.11.3 Water Resources

Inappropriate land-use approaches employed in water catchment areas, in particular plantation activities, cattle farming and solid waste disposal are seriously reducing water resource potential to retain water and to prevent deteriorating water quality. The increase in economic activities, especially the manufacturing industry, is contaminating the water resources (Gangaiya & Wele 1994). Agro-chemicals are of particular concern in catchment areas. Not only do they contaminate the immediate water resources, there is also concern about land based pollution found in the lagoons, which may affect river intakes.

The increase in population is also likely to result in a parallel increase of water use demand. In the absence of a public awareness programme focused at proper water management, the current change in life style is also regarded as increasing the water consumption rate. Both the increasing population density and the lack of a proper sanitation and sewage system in the urban area, have placed water resources in this region at a high risk of being contaminated.

4.11.4 Agricultural Activities

Urban migration has been established to have reduced agricultural labour in rural villages. Consequently agricultural products are declining, and agriculture as an industry is no longer thriving. This migration encourages dependency on imported food. Eventually this tends to amplify the import bill and simultaneously enhances the likelihood of contracting diseases associated with affluence.

Besides, urban migration increases both urban population and development pressures in Apia and this has already resulted in the conversion of prime agricultural land into settlement areas. Agriculture, subsequently, is forced further inland and into unsuitable upland areas with lower fertility and steeper soils that erode easily during heavy rains.

An increase in temperature, despite a reduction in humidity, can reduce the ability of farmers to work in agriculture.

4.11.5 Biodiversity

The increase in both population and socio-economic activities have contributed to the degradation of Samoa's biodiversity. If actions is not taken promptly, the biodiversity and ecosystems are likely to be seriously degraded in the future. By global standards, Samoa has very few natural resources. Poorly planned activities, for instance agricultural cultivation for short-term economic gain, create pressure on the activity sites as well as distant regions – usually low altitude sites such as rivers, lagoons and mangrove forests and the associated ecosystems they encompass. Part of the damage to these coastal ecosystems is generated from increasing reclamation.

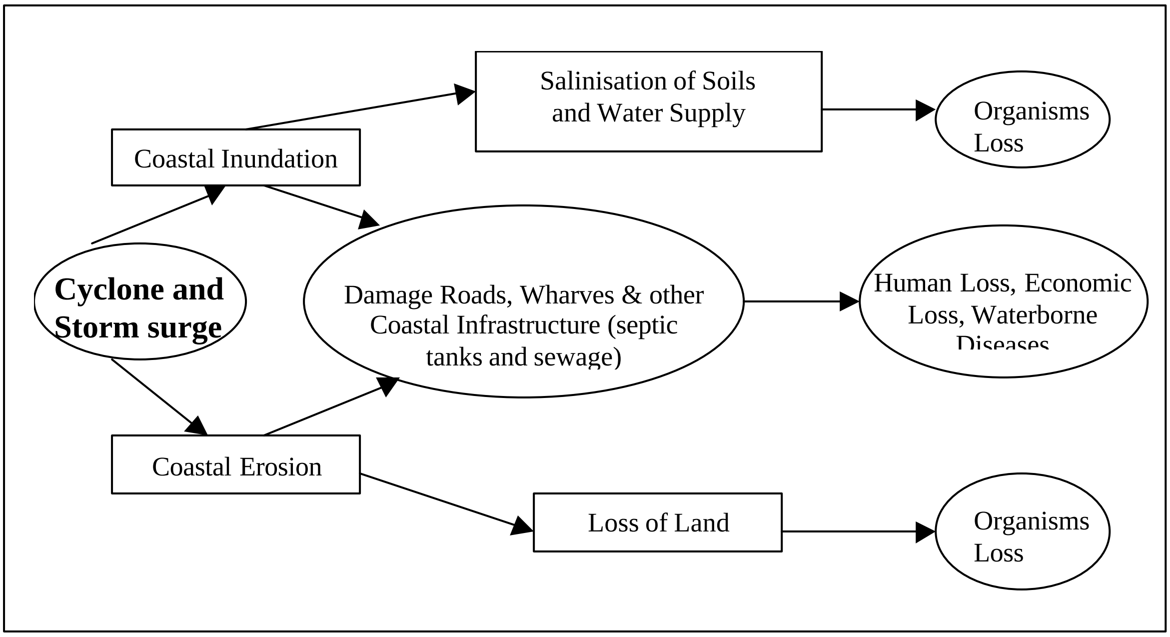
Unsustainable deforestation in the last several decades has depleted the forests and has also destroyed a large portion of the biological diversity they host. There is also concern about indiscriminate deforestation and unsustainable land-use since they accelerate the loss of high value forest and tree genetic resources and encourage the invasion of secondary forest and weeds. The introduction of any exotic species also has adverse impacts on some indigenous ecosystems when competing for food and space. Poorly planned development without an Environment Impact Assessment (EIA) is also a potential threat to the bio-diversity regardless of location in the country.

4.12 Integrated Assessment of Effects

Samoan life and culture are integrally related to the land and ocean. While current studies provide some indications of the likely impacts of CC and SLR on these particular resources of Samoa, the net impacts are very likely to be cumulative. This cumulative effect is determined by the synergistic interaction between the above impacts and the continual environmental and socio-economic changes.

Some of the salient CC and SLR impacts in Samoa and their interactions are identified in the flow chart depicted in Figure 1. No attempt is made to provide a detailed description of the interactions and cumulative effects, however, the flowchart identifies some of the most important inter-relationships. The emphasis of this diagram is to highlight the intimate inter-linkages among all aspects of human and natural systems found in Samoa. The flowchart also underlies the fact that no effect can be considered in complete isolation. There is an urgent need for accurate information to provide an integral understanding of all interdependent effects. It is important to develop integrated assessment methodologies that are appropriate to the unique but highly integrated biophysical, social and economic environments of Samoa.

Figure 1. Flow Chart of Interaction Effects of Cyclones and Storm Surge on Sensitive Sector



4.12.1 Assessment of Adaptation Opportunities

It is important that Samoa's adaptation strategies take a 'no-regrets' approach. These strategies should increase the ability of ecosystems and communities to cope with the present and the ongoing environmental stresses and climate variability. The **"no-regrets''** strategies benefit both society and the environment in the long-term in spite of initial economic costs.

A range of sectoral adaptation measures has been qualitatively assessed, based on the economic and the environmental cost, cultural suitability and practicability (Annex 2). Each of these measures is outlined below.

Coastal Environments and Systems

- Devise a suitable integrated coastal zone management plan.
- Plant more trees e.g. coconut on the coastline to prevent soil loss.
- Conduct public awareness programmes targeting the general audience on issues of reef and lagoon rehabilitation.
- Build houses that are more suitable to CC.
- Initiate and increase government assistance programme for the coastal areas.
- Discourage reclamation practices.

Human Health

- Health education and awareness need to be implemented at a community level. Regular cleaning campaigns for sites and places where the mosquito vector is abundant need to be conducted.
- Conduct research programmes on the use of biological control.
- Encourage development of proper waste disposal methods to minimise the existence of vector breeding habitats.
- A reliable and safe drinking water supply is essential.

Water Sector

- Community involvement and awareness is very important in controlling the use of water in a more sustainable manner.
- Establish new water catchment areas for conservation. A water catchment management programme is in place under the Forestry Watershed Management Division for the protection of water catchment areas. Land-use planning should be modified to control deforestation.
- Improve and maintain water supply infrastructure such as water tanks, pipes etc. Increase the number of water treatment plants to ensure safe drinking water for all people.

Agricultural Activities

- To reduce the inconvenience of activities, agro-forestry/agro-silvo-pastoral systems may be utilised to reduce erosion and run-off on steep slopes. This could also be used to mitigate heat stress and respiration problems and SOM soil fertility loss.
- Crops and livestock and their cultivated varieties/ breeds may need to be more adapted to extreme temperature and events such as alternating more severe ENSO cyclones and droughts.
- Quarantine surveillance should be increased against alien/ invasive species with higher temperature optima and others, which may be adapted to higher elevations.

Biodiversity

- Community based forest conservation projects should be continued particularly in areas where there are remaining natural forests with environmental significance.
- The method of forest management should be done in such a way as to contribute to its proper purpose, which includes national land conservation, water resource conservation, nature conservation, wood production, human living environment conservation, as well as contributing to prevention of global warming.
- Conduct research in developing social-economic system, which can ensure society living in harmony with the natural environment.
- Development of appropriate legislation and policies for the conservation and sustainable utilization of the country's various resources such as forest and mangroves.
- Research tree species that are fast growing and more resistant to insect damage diseases and forest fires.
- Encourage conducting EIAs for any major developments.

4.13 Identifying Vulnerabilities

The *least cost options* (economic, social and environmental) for adaptation to CC are those related to activities that are either on-going or likely to be easily implemented with local resources. The *highest cost options*, on the other hand, are those that would be identified as no-regrets strategies (e.g. sea walls) and are related to the most severe effects, and the greatest vulnerabilities.

Samoans are highly adapted to their biophysical environment. This is reflected in their customs (*faa-Samoa)* and their traditional houses *(fale)*. There has been considerable change, however, due to westernisation as well as the variability of the climate to which the Samoans are still adapting.

Despite the effectiveness of the no-regrets strategies, they are difficult to implement throughout Samoa because they can be expensive. However, with proper planning and good timing these strategies can be realised within a set time-frame. In the case of a coastal area mitigation strategy for example, a high and robust seawall using a "*best guess*" scenario of a 49 cm sea-level rise, a timeframe of about 100 years is required to complete the whole operation. In this particular case, intermediate steps may involve relocation of people to higher land to avoid inundation from storm surges. Simultaneous mitigation strategy work on the seawall must parallel the inland migration to ensure that inundation and beach-erosion is combated. High priority areas need to be identified for the mitigation work.

4.14 Identifying Gaps and Priority Needs

4.14.1 Information Gaps

Preparing the V&A for Samoa has been constrained mainly by information gaps and the dearth of data in the following issues and areas:

- Links between CC and Health.
- Status and health of coral reef ecosystems and their sensitivity to climatic and non-climatic stresses;
- Land elevation and land at risk from flooding and inundation;

- Erosion processes, sediment transport dynamics and areas at risk from erosion, especially in coastal areas;
- Organisms and their climatic requirements;
- Groundwater resources;
- Climate related diseases such as diarrhoea and dengue fever;
- Possible risk of damage from cyclones to housing and infrastructure (due to lack of enforcement of building code and standards;
- Future climate and SL change in Samoa;
- Future climate variability and extremes in Samoa;
- Present cross-sectoral interactions and the possible effect of climate and sea-level changes on these interactions;
- Cumulative effects and indirect impacts of climate and sea-level change effects;
- Costing environmental and social consequences, practicability, and effectiveness of adaptation opportunities, including mitigative measures and policy strategies.

4.14.2 Capacity Building Needs

Further capacity building is needed to promote an awareness of Samoa's vulnerability to CC and SLR impacts, particularly in the following areas:

- Training in vulnerabilities to CC and SLR, especially in coastal areas, and feasible adaptations that are culturally, environmentally and economically acceptable as per Annex 2;
- Public awareness to be prioritised for understanding vulnerabilities and achieving practicable adaptations;
- Strengthening institutions of environmental NGOs (e.g. O Le Siosiomaga Society Inc., and Fa'asao Savai'i) as well as Government Deaprtments and Ministries, especially MAFFM, DOE, DOH, DLSE, PWD, MOT, and SWA;
- Educate communities to appreciate their own vulnerabilities, to make suitable adaptations, and subsequently decide on the best feasible mitigation.

4.14.3 Priorities

Priority needs to allow Samoa to plan and implement appropriate and effective responses to climate and sea-level changes have been identified and are summarized below:

- Improve predictions of extreme events to assure preparedness, thus reducing impacts;
- Better understanding of impacts of CC on agriculture (crops, livestock, forests, cultivars and breeds) adapted to such change, and interactions with invasive/alien species,
- Enhance understanding of coral reef ecosystems, coastal erosion processes, and land at risk from flooding and inundation. This requires an integrated approach encompassing ongoing research, monitoring, capacity building, training, developing local expertise, strengthening institutional capacity and improving integration of traditional and modern knowledge.
- Improve understanding of impacts of extreme events on infrastructure, human health, and agriculture - how the impacts change with shifts in frequency and intensity.
- Develop a national policy framework to facilitate implementation of appropriate and effective adaptation strategies and mitigation measures;

- Incorporate institutional strengthening, community participation, and develop national capacity and expertise locally and regionally;
- Improve regional information on future climate and sea-level change and cumulative and indirect effects of such changes. This will include developing locally appropriate methodologies for analyzing these effects and increasing understanding of current interactions of climate, sea-level variation and environmental and socio-economic effects and changes.

National Analysis
UNFCCC and the Kyoto Protocol

5.1 The UNFCCC

The UNFCCC, signed by signatory Governments during the 1992 Rio Summit, entered into force on 21 March, 1994. Samoa is one of the Parties to the UNFCCC and has already undertaken its associated initial obligations.

The UNFCCC itself is a very useful tool for mankind to achieve its commitment to protection of the global environment by taking specific measures through sustained and deliberate changes in lifestyle and industry, to reduce greenhouse gas emissions into the atmosphere. This message is clearly delineated in the UNFCCC's objective *to reduce the atmospheric concentrations of GHG to a stable level within a specific timeframe to ensure no adverse human-induced interference with CC*. Underlying this objective is the urgent need to allow the vulnerable ecosystems to adapt naturally to CC, to minimise threats to the food chain and other natural productions via ecologically sustainable development.

The UNFCCC already identifies human development activities with the *substantial increase of GHG concentrations in the atmosphere which subsequently generates a warming effect that is intimately related to CC*. The UNFCCC provides a mechanism to accelerate CC understanding internationally, and simultaneously promote positive global responses to the challenging issues generated from CC. The UNFCCC also provides a medium allowing countries to declare their commitment to combat CC through participating in the global effort to reduce GHG emissions and simultaneously increasing carbon sinks. Parties to the UNFCCC can also share resources – finance, technology and expertise - to ensure that the challenges posed by CC are appropriately addressed in a timely manner.

5.2 The KYOTO Protocol

The Conference of the Parties (COP) to the UNFCCC at its third session adopted the Kyoto Protocol in Kyoto, Japan, on 11 December 1997. The Kyoto Protocol not only reinforces the need to achieve the UNFCCC's ultimate objective, but also provides further mechanisms, to elucidate all the processes involved in this pursuit.

Annex I countries which emit more than 55% of all GHG play a crucial role in facilitating the objectives of both the UNFCCC and the Kyoto Protocol. Non-Annex I countries, also play a significant role to ensure that the pursuit of the major objectives of the Kyoto Protocol are successfully realised. Samoa is already a signatory of the Kyoto Protocol and has started initial dialogue among the stakeholders which include Government Departments, NGOs, the business sector, and local communities.

5.3 Meeting the Obligations to the UNFCCC and the Kyoto Protocol

The UNFCCC and the Kyoto Protocol provide a very useful set of guidelines for Samoa regarding the strategic methodologies to combat the impacts of CC and SLR. There are, however, areas where Samoa, on its own, cannot satisfactorily undertake tasks specified within the UNFCCC and Kyoto Protocol. The majority of the problems encountered by Samoa in its endeavour to fulfil its obligations to these two agreements originate mainly from the following constraints:

- Insufficient funds;
- Lack of data and poor information management;
- Inadequate physical resources; and
- Lack of qualified human resource.

The financial mechanisms set up under subsidiary bodies of the UNFCCC, such as the PICCAP, have enabled the Samoan Government to undertake its first GHG Inventory and to produce its Draft V&A Statement. These are only a few of the many tasks required to be completed as part of Samoa's commitment to the UNFCCC and to the Kyoto Protocol. For Samoa to fully implement its obligations and commitments to these two agreements, it will continue to require external financial assistance.

5.3.1 Sources of Funding

Samoa on its own cannot effectively fulfil all the requirements stipulated under its obligations and commitments under the UNFCCC and the Kyoto Protocol. Samoa is one of the least developed countries of the world and one of the most vulnerable to the impacts generated by the CC and SLR. Its limited resources are directed mainly at providing the most essential services and to maintaining developments which engender an improved standard of living for its rapidly increasing population.

Nonetheless, the Samoan Government is fully committed to the objectives and the cause of the Convention and its Protocol. The dialogue initiated between the Government and the other stakeholders in the CC and SLR issue has indicated a strong support for prompt action. But again, since Samoa is constrained by limited financial potential it will not be able to fully implement its commitments unless it gains access to external sources of funds specifically set up for such purposes.

5.3.2 Transfer of Technology

Technology was one of the issues commonly raised during the GHG Inventory exercise. Data quality, quantity, and its management are all major constraining factors, as identified by the Government of Samoa in the implementation of the UNFCCC. An indispensable part of the problem arises from the lack of technical equipment with the capacity and the capability to improve data storage and easy management. This issue has been raised in the GHG Inventory and is addressed again in this National Communication because future UNFCCC-related projects depend to a large extent on the availability of quality data and efficient data management.

Further, Samoa, like most least-developed countries, is still relying upon outdated technologies which are already obsolete in most parts of the world. This is very apparent in the energy and transport sectors. For example, the diesel generators used by the Electrical Power Corporation are fairly old and very low in efficiency. In addition, office and household equipment like refrigerators and air-conditioners, require either proper retrofitting with non-ODS, or total replacement.

In the transport sector, many motor vehicles, both government- and privately-owned, are not operating at maximum efficiency. The old vehicles have not been properly retrofitted to take the newly introduced unleaded petrol (the only petrol available in Samoa now), hence efficiency is expected to be very low.

A reliable database of good quality is urgently needed by Samoa's planners and policy-makers. Quality data is an indispensable ingredient for imaginative and prudent strategic planning and policy-making. In the fight against the current and the projected CC and SLR, Samoa must possess an adequate database of good quality.

For the above and the needs in other sectors, it is necessary to transfer proven, environmentally-friendly, and culturally acceptable technology into Samoa. Article 4.5 of the UNFCCC provides for this necessity. It is vital that the following aspects are taken into consideration during the transfer of technology into the country:

1. To modify the technology to suit the local needs – environmental, socio-economic and cultural - since its only through this process that any technology can be applied with more effectiveness.
2. That the recipients of the technology need to understand and to appreciate the technology. This requires raising awareness through education and training of communities about the benefit and the relevance of the technology to improving their lives.

Technology transfer in the past has tended to neglect these two aspects and thus, has not realised its full potential in the community despite good intentions.

A priority list is provided, of areas where the UNFCCC can provide assistance with respect to technology transfer.

- Energy – research into renewable energy sources including solar, wind, wave, biomass and hydro.
- Energy conservation – awareness and education programmes targeting conservatiive energy-use behaviour.
- Energy replacement
    1. research into the potential of coconut oil to replace diesel oil
    2. research into the potential of methanol from biomass to replace gasoline.
- Refrigeration – conduct workshops on proper retrofitting procedures and recovering of CFC, and increasing appliance efficiency.
- SLR – need technology necessary for adaptation and mitigation including suitable models to provide accurate projections.
- Data management and processing – requires both training human resource and upgrading physical facilities.

The Kyoto Protocol under Article 12 also provides for the Clean Development Mechanism (CDM) which could be employed by the least developed countries like Samoa to accommodate the transfer of necessary technology through a voluntary partnership with an Annex I country. Although the procedures involved are not yet finalised, CDM can be a useful tool for technology transfer which may eventually achieve some of Samoa’s needs for adapting to CC and SLR.

Annexes

Annex 1

Precipitation Scenarios Using SCENGEN Model

SCENARIO	2025 Precipitation	2050 Precipitation	2100 Precipitation
CSIRO9M2			
IS92a (mid)	**1.3%**	**2.2%**	**4.1%**
IS92e (high)	1.9%	5.4%	7.6%
HADCM2			
IS92a (mid)	**2.1%**	**3.7%**	**6.8%**
IS92e (high)	3.3%	6.1%	12.8%

Annex 2

Evaluation of Sectoral Adaptations for Samoa

Sectors/ Exposure Units	Economic Cost	Environ. Cost	Cultural Unsuitability	Impracticability
Coastal Environments and Systems				
Coastal protection structures:				
• Selected area	**	***	***	*
• Entire coast	***	***	***	***
Re-vegetation & vegetation protection	* (*** vs tourism)	*	*	*
Prevent aggregate removal	**	*	*	***
Conservation areas	**	*	*	**
Human Health				
Reduce mosquito breeding sites	*	*	*	**
Mosquito nets and screens	**	*	*	*
Enhance quarantine measures	*	*	*	*
Water Sector				
Protect catchments and storage	***	*	**	**
Enhance ground-water reserves	***	*	*	**
More Treatment Plants	***	**		
Agricultural Activities				
Adopt agro-silvo-pastoral systems	*	*	*	*
Adapted organisms	***	**	**	**
Depend on imported foods	***	***	***	***
Biodiversity				
Conserve & sustainably use	**	*	**	**
Conservation covenants	*	*	**	**
EIA ***	*	**	***	

Key: * = low ** = medium * = high**

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