UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

KIRIBATI GOVERNMENT

INITIAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

SEPTEMBER 1999

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MINISTRY OF ENVIRONMENT AND SOCIAL DEVELOPMENT

TARAWA, KIRIBATI

SEPTEMBER 1999

Prepared by
Ministry of Environment and Social Development in collaboration with
the Country Climate Change Study Team and noted by the Kiribati Government

Preface

There are certain premises that underscore Kiribati' grave concern about climate change. The premises are that climate change is occurring, its impacts include a rising sea level, therefore low lying atolls would progressively submerge. The premises are based on IPCC Assessment Reports which give a global scenario for sea level rise to be between 15 cm and 95 cm by the end of the 21 st century, and the inadequacy of existing commitments to reduce greenhouse gas emissions to the level that would achieve stabilisation of atmospheric concentrations at a safe level. They are also based on available information about the sea level around the region, and around Kiribati. More significantly, people in Kiribati are observing extensive coastal erosion taking place, not only of the beach but also of the land, displacing now some of them from their traditional house plots since the early 1900, and felling coconut trees and other varieties of vegetation at the coastal areas.

Kiribati government and the people are extremely worried and also scared by the potential for the sea level to rise as a result of the enhanced greenhouse effect, and recognise at the same time that there is very little that that they can effectively do to prevent global warming or to effectively adapt to the accelerated sea-level rise. The threat their atoll country is facing from the climate change typifies a global problem that requires international cooperation in planning for effective measures to address the problem of climate change. It is for this reason that Kiribati has all along participated fully, to the extent of its capability, in the implementation of the United Nations Framework Convention on Climate Change. Therefore, in fulfillment of the reporting commitment under the UNFCCC, arts. 4 and 12, Kiribati government is submitting this initial communication.

Several organisations and ministries have contributed towards the production of this report. In Kiribati, the National Climate Change Study Team prepared the initial draft and further revisions leading to this report. External assistance for production, and publication of the report was provided by South Pacific Regional Environment Programme's (SPREP) Publication Unit, and immediately by the PICCAP Management Team. Funds required to meet the costs of the enabling activities to produce the report were provided by the Global Environment Facility. As Minister responsible for climate change issues and on behalf of Kiribati government, it is an honour for me to express to them all my appreciation and gratitude.

Hon. Kataotika Tekee
Minister of Environment and Social Development

Foreword

"This report has been prepared by the Climate Change Study Team and noted by the

Government of the Republic of Kiribati. The Team was established in 1995 under the US In Country Climate Change Studies Initiatives Programme as an interdisciplinary and interministerial committee to develop Kiribati capability to implement the United Nations Framework Convention on Climate Change. It continues to function for this purpose under the Pacific Island Climate Change Assistance Programme (PICCAP) when this project was implemented in Kiribati at the beginning of 1998. The PICCAP objectives were more focused on enabling the Pacific island countries participating in the programme to compile their national communications as required under Art. 12 of the United Nations Framework Convention on Climate Change (UNFCCC), and as far as possible using guidelines given in Conference of the Parties (COP) 2 decision in document FCCC/CP/1996/L.12.

Under the PICCAP, training programmes on methodologies for assessing greenhouse gas emissions, the vulnerability of key sectors and for identifying adaptation options, as well as consultancy work to assess mitigation options were provided. In addition, some public awareness raising activities were undertaken in the form of radio programmes, newsletter, and workshops. These activities have enhanced Kiribati capability to generally implement the Convention and to complete this report."

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Executive Summary

The Republic of Kiribati is a small island state with a total land area of 800 sq. km distributed unequally between 32 low lying atolls and one raised limestone atoll. The 32 atolls are generally within any heights from less than a meter to four meters above the mean sea level. Eleven of these atolls are uninhabitable because of their small size and lack of ground water lens. The atolls spread over a total Exclusive Economic Zone of 3.5 million sq. km.

It became independent in 1979, and is a least developed country. In 1995 the population was 78000, and the great majority of the population live off the limited productivity of the sandy land, and the high productivity of the marine area.

The Republic of Kiribati is among the most vulnerable countries to adverse impacts of climate change and accelerated sea-level rise. Kiribati people sense their being very vulnerable to sea level rise. This explains the continuing efforts made by Kiribati to participate in global action programmes to address climate change and its adverse impacts.

Kiribati is a party to the United Nations Framework Convention on Climate Change. It intends also to sign and ratify the Kyoto Protocol. This report is a requirement of the UNFCCC, and the contents are geared to present the special circumstances of Kiribati as an atoll nation, and a least developed country.

Kiribati government undertakes its climate change activities in collaboration with SPREP and other regional partners. This has to be the strategy because of Kiribati special circumstances, a small island state of low lying atolls, and least developed.

There are also gaps in information and knowledge, such as about the formation and reshaping of all the atolls, datum and trend of mean sea level, and scenarios on climate change and sea level rise. From Kiribati standpoint, these gaps contribute more to the vulnerability of these atolls, rather than alleviating it.

There is a growing sense in Kiribati that they should do what they can to mitigate and adapt to impacts of climate change. The strategies identified are in the energy sector, adoption of more appropriate technologies, upgrading of existing energy generation to more efficient level, and introducing steps necessary to reflect environmental costs in the production and distribution of goods and services. For adaptation strategies, the sectors considered important are coastal zone, water resource, agricultural systems and public health.

Planning for climate change and sea level rise is planning for sustainable development. This requires that the planning process should be participatory. Public awareness raising, and cooperation in scientific research are important programmes for capacity building strategy. They are considered as important elements in national action programmes to address climate change.

A list of projects is included in the report. Brief explanation of the rationales is given, but the designing and full justifications of the programmes and projects are to be developed in a time line that fit in with the overall national project planning.

Contents

Introduction

1.1 Global Action on Climate Change

From the late 1980s, the world community of scientists first raised their concern about the increasing trends in the global temperature, sea level, and of the atmospheric concentrations of greenhouse gases, principally carbon dioxide, from industrial processes. In response, the World Meteorological Organisation and the United Nations Environmental Programme in 1988 jointly established the Intergovernmental Panel on Climate Change (IPCC) which produced in 1990 its first assessment report on the science and impacts of, and response to, climate change. In this report it is suggested that on balance of evidence global warming could be linked to enhanced greenhouse effect arising from anthropogenic emissions of greenhouse gases.

In keeping with IPCC's activities and convergence of scientific opinions on key issues on climate change, a number of United Nations General Assembly Resolutions on climate change issues were adopted also in the late 1980s. These include resolutions on a mandate establishing the Intergovernmental Negotiation Committee (INC) on a framework convention on climate change, and on the recognition of threats to small island states from impacts of sea-level rise.

The INC held its first negotiation session early in 1991, and at its fifth session in May 1992, it adopted what is now known as the United Nations Framework Convention on Climate Change (UNFCCC). Heads of Governments from many countries including Kiribati signed this convention during the United Nations Conference on Environment and Development (UNCED) held in Brazil in June 1992. It entered into force on the 21st March, 1994 for countries which had before then ratified the Convention, and for Kiribati on the 8th May, 1995.

1.2 National Policy on Climate Change

Kiribati is vitally concerned about impacts of global climate change and the need to monitor these impacts. Recognising that this is a global problem to be addressed at the international level, and yet sensing its vulnerability to the impacts from sea-level rise as a low lying and least developed atoll country, Kiribati decides to participate in international forums addressing the wide ranging issues on climate change. It is desirous too to build up its national capability to deal with any adverse impacts. The objective of socio-economic development planning is to generate a sustained, real rate of economic growth, which should be seen against the recognition of global warming and sea-level rise (National Planning Office, 1997).

Kiribati government is enacting a framework law on the management of the local environment, establishing a responsible authority, procedures and mechanisms for public participation in the management, ensuring further that socio-economic development is on sustainable path, and making a commitment to implement any international or regional conventions and agreements on the global environment of which Kiribati is a party.

1.3 National Activities on Climate Change

Kiribati attended some of the first meetings of the IPCC which led up to the production of the first IPCC Assessment Report in 1990. It was also represented at the Ministerial level at the Second World Climate Conference, and at meetings of the small island states on climate change and sea level rise. Consistently, Kiribati has aired its serious concern about a bleak prospect for the future that it now faces under climate change and sea-level rise scenarios.

Other small island states would not hope for a better future and this shared concern about the future has led to the formation of the Alliance of Small Island States (AOSIS) and its recognition in the INC and now the UNFCCC processes.

Kiribati participated at the INC sessions, and continues to do so in the UNFCCC Conferences and some of the meetings of the Subsidiary Bodies. The costs of attendance at these meetings have normally been paid for from the UNFCCC Special Funds, and at times by bilateral donors which in the past included New Zealand. It also continues to participate at some of the conferences and workshops arranged by IPCC.

In 1993 Kiribati government formulated and adopted its first National Environmental Management Strategy. One of the objectives is the protection of the natural resource base through programmes which include vulnerability assessment and coastal zone management. It should be noted that at the time, there were no clearly understood methodologies on how to undertake a vulnerability assessment study. Equally there had not been a clear understanding in Kiribati about coastal zone management, although certain laws contain provisions for designating any part of the foreshores for the purpose of regulating, through permitting system, the removal of beach materials. Furthermore, there are provisions on procedures for land reclamation activities, and on land use planning.

A specific programme for climate change is the vulnerability assessment and coastal zone protection which has these aims:- "a) To review works already done on Kiribati's vulnerability to projected sea-level rise, and advance it to a level where it is possible for economic and resource planners to generate appropriate coastal zone management strategies. b) To institute early protection measures against coastal erosion through coastal vegetation establishment and rehabilitation." (Kiribati Government. 1994 p.26). As with all the programmes listed in the NEMS, there was no funding to implement in a systematic way these activities.

Monitoring of weather conditions is carried out by the Meteorological Division with surface and upper air observing stations in Tarawa, and limited surface observing capabilities are maintained on Butaritari, Banaba, Beru, Arorae, Kanton, Kiritimati, and Tabuaeran. The sites were selected possibly to meet the need for civil aviation, but now with greater need to understand the climate change, the Meteorological Division would want to establish more observing stations. The arrangement for reporting rainfall only from the other atolls is not satisfactorily carried out.

The Meteorological Division has benefited from limited technical and technological cooperation through some work programmes of the WMO, and through regional and bilateral initiatives. Kiribati is not a member of WMO and is considering applying for membership at the next opportunity.

United States National Oceanographic and Atmospheric Administration maintains automated equipment for monitoring wind profiles from Tarawa with the cooperation of the Meteorological Division. Another equipment is maintained on Kiritimati.

New Zealand National Institute for Water and Atmosphere maintains equipment for solar radiation measurement at Tarawa in close collaboration with the Meteorological Division.

Australia South Pacific Sea Level Monitoring programme was started in the early 1990s, and a tide gauge has been installed at Tarawa. This programme is managed by the Australian National Tidal Facility (NTF) based at the Flinders University in South Australia. Under this programme short training courses have been organised in the region and also at the NTF Headquarters. This programme was Australian government's response to heads of governments of the Pacific Island states concern about climate change and sea level rise which they expressed at one of the FORUM meetings in the late 1980s.

Kiribati participated also in the US Climate Change Country Study Programme. Through this programmes, a National Climate Change Study Team was established in 1995. A first greenhouse gas inventory was compiled for the year 1990, a vulnerability assessment of the water supply for South Tarawa, including some level of training, and also of the coastal area of some parts of South Tarawa were undertaken. Data base on climate statistics was updated to include data fron observing stations throughout the country, in particularly, at the Line and Phoenix stations.

Pacific Island Climate Change Assistance Programme (PICCAP), a regional programme, has enabled Kiribati to produce this report which is based to a significant extent on works done by nationals. These include those of the nationals who have undertaken trainings on specific methodologies such as for greenhouse gas inventories, and for vulnerability and adaptation assessments. Public awareness programmes, in the form of workshops, radio programmes, and a newsletter were also initiated. The aim is to inform the public about climate change issues so that they can meaningfully participate at a planned workshop to develop a national policy and action programmes to enhance adaptation, and also to mitigate climate change.

National Circumstances

2.1 Introduction

The Republic of Kiribati attained political independence in 1979, before which time it was a British colony since the early 1890s. The only major economic resource, phosphate, mined since 1900 was exhausted at the time of independence thus creating a challenge for the new republic to face in its aspiration for economic growth and a reasonable standard of living for its people.

Kiribati remains a least developed country, with a steadily increasing population which in 1995 was about 78000 compared to about 64000 in 1985. Except for one raised limestone island (see section 2.3, p 11), Kiribati is all atolls, land formation which is low, most vulnerable to sea-level rise, and poor in land based resources. The atolls are sand, gravel, and limestone, with thin soil to support limited agricultural crops.

The predominant tree is the coconut tree, which the Kiribati people have found many uses to support their subsistence lifestyle. Kiribati people have their own unique culture, including their own language, traditional knowledge and skills related to their immediate environment. The link between culture and the environment is very strong.

Kiribati economy is based on government expenditures, foreign aid, and on the service sector in the country. There are few small manufacturing industries, and the import bill far exceeds the export bill, which is based on copra and some fish products. Very little specialisation exists within the small service and industrial sectors.

The level of education, and of technical skills of the people for industrial development is not as high as those of the more developed Pacific island States.

In conclusion, Kiribati is low lying atolls, least developed, and very vulnerable to unfavorable conditions in the world economy and the world environment. It is most vulnerable to climate change and sea-level rise.

2.2 Coral atoll formation

Atoll formation involves geological time horizon, over which synergy of natural phenomena took place. Sea level changes occurred consistent with the cycles of glaciation and interglaciation, the subsidence of the volcanic islands continued, coral growth at its rims, formation first of the coral fringing reefs, and finally the barrier reefs forming the present land in the atoll had also occurred. Other theories of atoll formation include stable island structure, planed off and truncated with formation of reef building organisms during the cycle of glaciation and interglaciation.

The atoll formation can conveniently be considered in three phases. The first stage was occurring during the rapid rise of the sea level during the period from 8000 to 6000 B.P when coral reefs were growing vertically at a rapid rate also. From 6000 to 3500BP the reef formation took place, the period too when the sea-level was stabilising at its current level (Woodroffe and McLean,1992 cited in Wilson, 1994).

Submerged barrier reefs exist in some atolls, for example Tarawa (Paulay, et.al 1995). Elevation area exists as an extension, at the western side, of Nonouti atoll. Is this a new island forming or is it the reef base of a disappeared island?

Marshall and Jacobson (1985) suggested that Tarawa atoll was formed 2500 BP. They also observed that the change from coral reef top sediments (rapid reef growth) to unconsolidated

sediment could have occurred even at different periods. The latter facie were formed after the coral had ceased to grow when they reached the sea surface. Tops of these coral growths, below the surface of the ground, occur also at varying depths. This information could suggest complex formation of atolls, with implications for any vulnerability assessments.

Woodroffe and McLean (1998) suggested that Kiritimati atoll has been a stable atoll because Pleistocene limestones are found within the land surface and part of the shore of Kiritimati. Further more it was experiencing a latest fall in sea level over the last 1500 years, since coral fossils at levels between 0.5 and 1.5 m. above the same species of living coral were dated to about 1500 yrs old. This information would suggest that Kiritimati atoll could be less vulnerable than other atolls in Kiribati, but this would be so if the sea level around Kiritimati were not to rise by the year 2100 contrary to what Kiribati senses from IPCC global scenarios of sea level rise.

Geological studies of the island have been useful in establishing the past sea level, and whilst there are evidence that it could have been higher in the past there had not been work to establish features of islands that had then existed. Secondly, climate change and sea-level rise that are at issue are not for time horizons in millennia but within decades and a century.

Corals are sensitive to sea-temperature, the depths of water, and the amount of light that gets to them. Other conditions would include sediment load, exchange of seawater between the ocean and the lagoon, turbidity, and productivity. These other conditions could easily result from domestic actions. Some evidence of coral bleaching has been observed in Tarawa lagoon, but these have occurred in areas where conditions have been altered by human activities.

2.3 Geophysical features

The Republic of Kiribati consists of 32 low lying atolls and 1 raised limestone island (Banaba known also as Ocean island). They are scattered within the part of the Pacific Ocean bounded by two parallels at about 5^0N and 7^0S, and by longitudes at 168^0E and 168^0W. The total land area is about 800 sq km compared to the total Exclusive Economic Zone of about 3.5 million sq km., and the distance between the most westerly situated island and the most easterly situated island is about 4000 km.

The 32 atolls and one oceanic island (Banaba) cluster into three groups. The Gilbert group in the west has 17 atolls (including Banaba); the Line group in the east has 8 atolls, and the Phoenix group with 8 atolls lies in between. Kiritimati atoll, in the Line group, is the largest atoll in Kiribati with a land area of 363.7 sq km, but the second largest atoll is about a tenth of that size. The rest of the atolls have varying areas from as little as a few square kilometers. In the Gilbert group, the smallest atoll has a land area of 4.7 sq km with a population of 1181 in 1995 and a density of 250 persons per sq km. The atolls in the Gilbert group, and three atolls of the Northern Line group are inhabited; the rest of the atolls are uninhabitable, although a small number of government employees maintain communication facilities at Kanton in the Phoenix group. Part of Tarawa atoll known as South Tarawa is the capital "city" of the country.

The atolls are generally elongated in a north-south orientation, with the eastern side facing the predominant easterly winds. Several passages separate islands in most of the atolls, and these have allowed exchange of seawater on the two opposite sides of the atoll to take place. Intertidal reef platforms with varying widths (150 –200 m.) exist around table reefs and at atolls with lagoons on the side facing the prevailing winds. Intertidal mud platform extends seaward from the lagoonal beach to the lowest low water mark beyond which the platform slopes to the seabed. The maximum depth of Tarawa lagoon is about 25 meters (Paulay.1985).

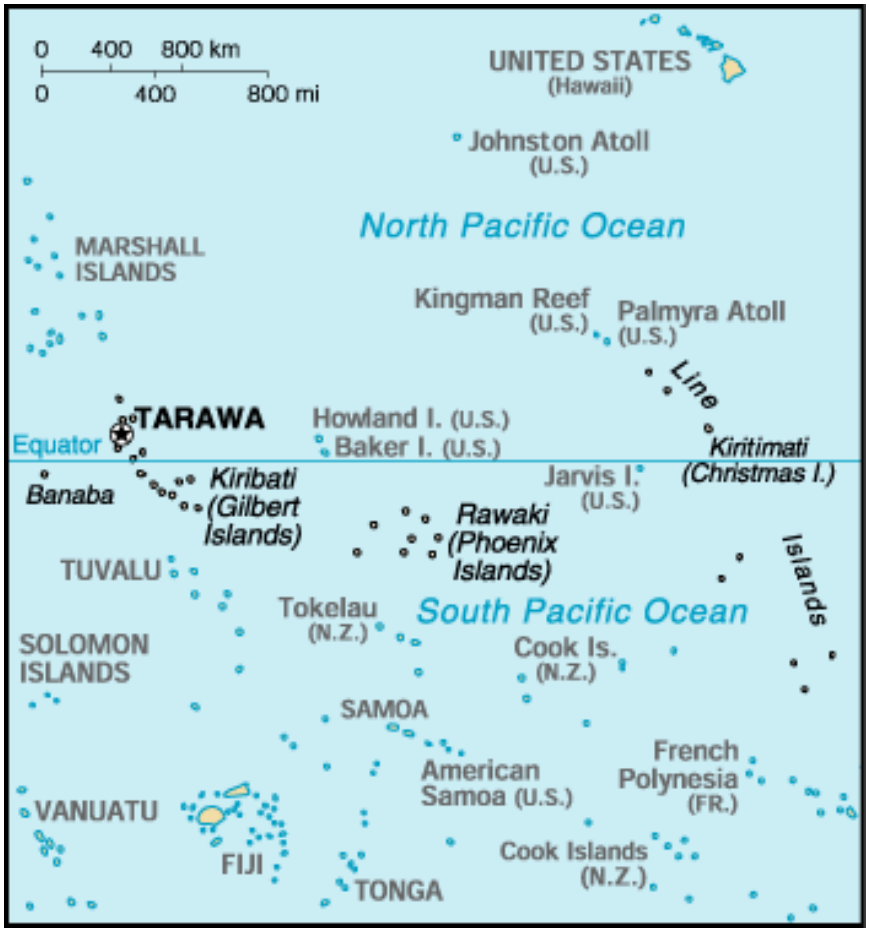


Fig.1 Map of the Pacific Ocean and scattered small islands. The islands of the Republic of Kiribati are shown in bold letters.

Patches of coral reef with varying surface areas, and depths below the sea level are scattered within the lagoon. In some atolls, few of these reefs form shoals. In the case of the reef platform the seaward edge is marked by slightly raised ridges and grooves, also the region of lowest low water mark and of wave breakers.

The table below shows the inhabited atolls in the Gilbert group, the length of the shorelines, and widest widths.

Table 1: Gilbert atolls - shoreline lengths and widths of land.

Atolls and islands	Lengths of shoreline in km	Widest widths in m.	Average widths in m.
Makin	32	1700	600
Butaritari	98	1200	350
Marakei	75	2100	500
Abaiang	111	800	300
North Tarawa	135	1400	500
Urban Tarawa	69	2000*	450
Betio	11	2000	430

Table 1: Gilbert atolls - shoreline lengths and widths of land continued from previous page.

Maiana	84	1100	400
Kuria	27	3700	1700
Aranuka	55	1600	770
Abemama	103	1200	710
Nonouti	178	900	400
Tabiteuea North	123	2300	700
Tabiteuea South	98	2000	650
Onotoa	75	940	420
Beru	62	1800	800
Nikunau	38	2600	1300
Tamana	11	1100	900
Arorae	20	1100	800
Total	1698		

Source: Lands and Survey Division.
*includes Ananau causeway reclaimed area.

Fig.2 Atolls barely surface above the sea

The ocean side (normally eastern) of the atolls are slightly higher than the lagoon sides. Variation in heights of the land surface across the atoll is quite small, but stretches of berms at the edge of the atoll on the ocean sides are quite visible in parts of the atoll where erosion has not occurred. The land surface is probably within 1 meter and 4 meters above the reef platforms and the lagoonal mud platforms.

Width of the land varies along the atoll; the widest part of the atolls of the Gilbert group is 3.7 km. Some of the settlement areas are not on the wider part of the atolls, but they are generally on the sheltered edges of the atolls, usually the western sides. Traditional land tenure restrict also the more rational use of the land.

The soil is very poor, a thin layer of humus is at the surface, and in some areas cay rocks and rubbles and boulders are the dominant features. Sand of varying sizes form much of the surface of the land.

2.4 Climate

Traditional knowledge in Kiribati is that there are two seasons. One season is the "Aumeang" (northerly wind season), occurring concurrently with the visibility from Kiribati of the constellation "Pleiades." This is also the beginning of the apparent southward movement of the sun, and as explained in traditional knowledge, the sun does so to make way for the "Pleiades" to appear. The other season is the "Aumaiaki" (southerly winds season). It is also explained in a similar way but relative to constellation "Scorpion". Conventionally it is from October to March when the first of the seasons occurs, and the second season occurs from April to September. The "Aumeang" is also rainy while the "Aumaiaki" is a dry season.

Analyses of surface winds in Tarawa for the period 1978 to 1983 indicates that from December to May winds from the east and north east predominate, and from April to Novermber winds from the east and south east prevail. The former are generally stronger (Burgess,1987 cited in Gilmour et al., 1990). The recollection of older people indicates that, in the past, strong westerlies normally occurred during December and January. The cause of this strong wind would appear to be different from any anomaly in the weather that may be attributable to El Nino (ENSO), since also the latter seems to have been more frequent.

In conventional meteorology, there are two systems influencing the climate of Kiribati. First is the Intertropical Convergence Zone (ITCZ), north of the Group and influences the rainfall pattern particularly of the northern atolls. Secondly, the South Pacific Convergence Zone (SPCZ), south of Kiribati, influences also the rainfall pattern particularly of the southern atolls. In addition, two anomaly phenomena are the El Nino and La Nina which are associated with marked atmospheric and oceanographic circulation, and sea surface temperature distribution across the central Pacific. During El Nino, the ITCZ moves closer towards the equator, whilst during the La Nina it moves away from the equator (Porteus et al., 1996). The former brings heavy rainfall to Kiribati in particular to Kiritimati atoll, while the latter when persistent is associated with severe drought. These anomalies are indexed by normalised pressure differentials between northern Australia in the west and Tahiti in the east (Southern Oscillation Index).

The northern atolls of the Gilbert, and of the Line groups except Kiritimati have higher rainfall than the southern atolls. For Kiribati as a whole, rainfall varies between 1000mm per year to 3000mm per year (Wilson,1994). The Phoenix group is much drier with annual rainfall of about 800mm (Porteus et al.,1996). Our analysis of the climate data of Tarawa from 1947 to 1995 shows

that no maximum of rainfall in any year has occurred in May and June, thus we would suggest that these months are regarded as the driest months in any one year (Teuatabo, et al.,1996), even among the months of the generally regarded dry season, May to September. It is during May to June too when the South Equatorial Current and the Counter Equatorial Current are weak (McLean,1989). The wetter months in the Gilbert group are generally from October to April.

Drought occurs intermittently, and has serious impacts on food and water. But there is no definition of a drought, and this fact has presented some difficulties for water management. Traditionally drought is regarded as a period when coconut trees progressively wither because of insufficient rainfall or soil moisture. Royds Consulting engineers (Royds Consulting et.al. 1996) suggested that 2000 mm rainfall in a year with supplemental rainwater catchment should be required for urban Tarawa.

The mean annual temperature throughout Kiribati varies from about 26^0C to about 32^0C (Wilson,1994). In the Line islands, the highest mean sea surface temperature occurs in the middle of the year, also the driest part of the year when the ITCZ is at its most northerly position (Porteus et al.,1996).

In the atolls, air surface temperature is greatly influenced by the sea surface temperature, and not markedly by the annual variation in the solar radiation. Nonetheless, the warmest months are from September to November, whilst the coolest months are from January to March. On the basis of available data on air temperature at Tarawa covering the period 1951 to 1995, simple trend fitting indicates a negligible temperature increase of 0.0008^0C per year. On the other hand, the global temperature has increased by between 0.2 and 0.3^0C over the last 40 years (Houghton et al.,1996. p.26). These imply that over the past 40 years the trend in the temperature recorded in Tarawa has been a factor of ten below the global temperature trend.

2.5 Hydrogeological situation

The islands in the Gilbert group except Banaba, and the atolls of the Northern Line islands have limited ground water lenses at places along the atolls. Potable ground water in wells within village areas and in some cases away from the villages provides water supply for the people.

Ground water lenses may exist below the ground surface. A minimum width of 300 meters of the land is required for the water lens to exist (Marshall et al.,1995). Another important requirement is the presence of unconformity layer between the generally younger Holocene unconsolidated materials on top, and the older Pleistocene layer of coral limestone below. In the case of Tarawa, an unconformity layer between the two layers is found to exist 10 to 15 m below the mean sea level. The Holocene sediments above the unconformity layer are less permeable to sea water than the coral limestone which allows more readily sea water to flow through, and this difference in permeability favours the formation of water lenses within the Holocene sediments (Falkland,1992).

The water table is generally about 0.5 m above the mean sea level, and the vadose zone (between soil layer and water table) is generally 2 m thick. The water table oscillates on a daily basis with the tides, and in the long term with the mean sea level (Marshall, et al.,995). These imply that the water table is between 1.5 m and 2.5 m below the ground surface (Falkland. 1992), implying land surface to be between 2 to 3 meters above the mean sea level.

The ground water supply in South Tarawa is dependent on the recharge, and also on the area of the land. Withdrawl, including leakage, from the supply is a function also of demographic,

technological, and economic parameters. The sustainable yield estimate of the galleries supplying potable water in South Tarawa is about 1300 cubic meters per day, which means that about 26000 persons can be supplied with water at 50 liters per head per day. With leakage in the system and the use of water by institutions including hospital, and training institutions, it is estimated that the sustainable yield is sufficient for about 20000 persons. This implies that the water supply for the population of 28350 in South Tarawa falls short of the recommended WHO standard of 50 liters per person per day.

The ground water situation in Tarawa may be similar to some island situations on other atolls. However, there has been inadequate research carried out on the other atolls in Kiribati.

2.6 Oceanographic conditions

In traditional knowledge according to an informant, there are two distinct types of surface waves; waves in the open ocean referred to as the "bones" of the ocean, and land attracted waves known as "land waves". The former stretches longitudinally and moves from east to west, being also the direction of the predominant wind. The latter are other waves coming to the land.

Waves approach the atoll coastlines at various angles depending on the wind direction and the coastline alignment. The "bones" of the ocean persistently approach the reef edge on eastern side of the atoll, while the "land" waves approach the remaining parts of its shoreline.

Wave breaker and the intertidal zone around the atoll act as natural protection to the shoreline. Some parts of the coastline are also protected by natural beach rocks and conglomerates parallel to, and as terraces along the beach. In some places, they are perpendicular to the beach and lies across the reef platform. The beaches, berms, and coastal vegetation provide additional protection of the land from wave action.

Two sets of alternating pairs of high and low tides occur within the day. Furthermore, spring tides occur during the full and new moon phases, while neap tides occur during the quarter moon phases. Spring tides during the "Aumeang" months are generally higher than when occurring in the "Aumaiaki" season. An implication of this traditional knowledge is that the tide levels are determined by the phases of the moon, and that the variation in heights of spring tides is associated with positions of the moon relative to those of the sun in the course of the latter's apparent zonal movement in a year.

Wave heights, frequencies, and the depths of the sea determine also the forces of the waves on the shoreline. Storm surges occurring during spring high tides are occasionally experienced. Waves overtop part of the coastal land and cause flooding and destruction to settlement areas and fruit trees. Cyclones and hurricanes occurring close to Kiribati generate waves that impact in destructive ways on the atolls.

There are no quantitative measures of oceanographic data for the islands except for Tarawa. Depths of Tarawa lagoon are generally between 6 m and 22 m (Gilmore et.al. 1990). Paulay (1995) gave the maximum depth of 25 m. The tidal range is between 0.55 m and 1.71 m.

However, "the maximum height of waves recorded in the Tarawa atoll and its vicinity are 5 meters according to the Pilot Chart of the North Pacific Ocean" (Japan International Cooperation Agency, 1985. p.2-4.). In another study and a more recent one by the same agency but relating to the ports development in Kiribati, the estimated maximum height in the lagoon is 0.5 m for about 90% of the times, whereas the height of ocean waves is 1.5 meters (Japan International Cooperation Agency,1995.). In some parts of Tarawa, ocean wave heights on reaching

the beach have been as high as 3.5 meters (Burgess,1987 cited in Gilmore et al.,1990) and this height has proved quite destructive. The land surface is at any height of less than 4 meters above the sea level.

2.7 Mean Sea Level

A tide gauge was installed and monitored by the University of Hawaii at Tarawa in 1974. In 1992 Australian National Tidal Facility installed a Sea level Fine Resolution Acoustic Measuring Equipment at Tarawa. However, it had not been possible to re-establish the earliest national datum; a new datum has therefore been fixed using UN Hydrological datum and referenced to some existing bench marks located on land at Betio islet.

In his analysis of records from the University of Hawaii tide gauge, Solomon (1997, p.16) concludes that "sea levels are generally higher than the original mean sea level which indicates a rise in the mean of up to 0.078 m over the 23 year dataset". This implies an increase of about 33.9 cm per 100 years. Etuati (1994) in her B.Sc (Hon.) thesis observed also that from the US tide gauge data set sea level would have risen by 4 mm per year. In comparison, the global sea level has risen by about 10 to 25 centimeters over the last 100 years (Houghton, 1996 p.29), that is between 1 and 2.5 mm per year.

Criticism has been expressed that simple trend fitting is sensitive to a selected time frame. The National Tidal Facility has estimated that trends on incremental time basis of the mean sea level have shown a decrease in more recent times, reversing the increasing trends over the earlier but shorter time frame since the tide equipment was installed in the early 1990s. Moreover, our own analysis of the maxima of the sea level indicates that there has been an increasing trend over the period for which the trend in the mean sea level has been decreasing.

A longer series of sea level data is needed to enable an accurate assessment of the state of the sea level in Kiribati. While these data include residuals, due to atmospheric and other sources of forcing apart from the gravitational force of the earth- moon-sun system, extreme records are discarded but would merit analysis to establish their nature as these would have significant impacts on the Kiribati atolls.

The natural variability of sea level, El Nino and La Nina effects on the sea level, could subsume any signal of global warming induced sea-level rise around Kiribati. Subject to accuracy of the University of Hawaii tide gauge, there appears to be good reason to note that sea level around Tarawa has increased over the last 23 years at the rate faster than the global rate over the last 100 years. This accords with the more general sense of the people of Kiribati.

2.8 Ecosystems of the Atolls

Overflying Kiribati atolls, one observes levelled tops of leaves of coconut trees (*Cocos nucifera)*. This is the ubiquitous tree of numerous uses in Kiribati. Other trees and plants for which rights of ownership are respected include pandanus trees (*Pandanus tectorius)*, giant taro (*Cyrtosperma chamissionis)* grown in swampy areas dug out to depths below the water table, and breadfruit trees *(Artocarpus sp.)* normally grown within villages and settlement areas.

Other lesser dominating trees, plants and herbs that grow naturally on the atolls include *Scaevola taccada (te mao), Tournefortia argentea (te ren), Morinda citrifolia (te non) Guettarda speciosa (te uri), Pemphis acidula (te ngea*), and species of mangroves. They have several uses but grow wildly that they are not regarded as being owned by land owners,

and are freely exploited. However, in Tarawa where the monetary system is gaining dominance there is increasing awareness of the situation that these trees belong to the owner of the land on which they grow. Few of these trees tend to dominate a limited area starting from the shoreline across inland for few meters.

Although the atolls are very narrow, an indeterminable region around the shoreline is "coastal area". The major part of this area in the seaward direction is the beach which slopes downwards to the intertidal platform. In certain parts of the coastal areas of some atolls, mangrove species grow naturally. They have vital functions in the atoll system although there are no programmes to conserve and protect them.

Beach rocks, boulders, aggregates and coral sand constitute the natural beach. Conglomerate parallel or longitudinal to the shorelines form part of the beach. Their function in stabilizing the beach has traditionally been recognised, but it is also realised that they provide good materials for causeways, seawalls, and other construction works. Stability of any beach depends on the types of materials constituting it.

The intertidal zone, and the contiguous sea bed and sea beyond provide natural habitats for marine living resources. These include 600 to 800 species of finfish and about 200 species of coral (Wilson,1994. p.14). Marine resources have traditionally been considered to be plentiful and would never be depleting. In the late 1970s government began to monitor the status of the marine resources in particular of Tarawa. Some finfish and invertebrate species were noted to be depleting, for example, bone fish (*Albula vulpes)*, sprangled emperor (*Lethrinus nebulosus)*, and giant clam *(Tridacna gigas)*. Overfishing in inshore areas has been attributed to be the cause of the depletion of these species (Beets, 1995).

Shell fish is also an important food for Kiribati people. In South Tarawa, the dominant species is *Anadara uropigmelana*. However, abundance is recognised as being variable over time, even by geological time frame (Tebano, et al. 1995). With excessive exploitation, this source of food supply for the urban population might not be sustainable.

Marine resources of other atolls are not exploited to the same extent as the resources in Tarawa. Nonetheless, commercial fisheries are also starting on some of those islands, and monitoring of these resources, for example, grouper and sea cucumber, has become an important activity of the government.

2.9 Demographic situation

The total population was 77658 recorded during the latest census in 1995. 71757 of this population live on the 17 atolls of the Gilbert group with a combined land area of 286 sq. km. South Tarawa has a population of 28350. The densities vary between islands; the highest density is 1799 per sq. km of South Tarawa, and the lowest density is 54 per sq. km of Banaba, but this island is owned by I-Kiribati (Kiribati people) by descent, most of whom now live at Rambi island in Fiji.

The rest of the population lives in the Line Group at Kiritimati (Christmas), Tabuaeran (Fanning), and Teraina (Washington). Kiritimati has a total area of 388 sq. km with a population of 3225, therefore a population density of 8 persons per sq. km. Teraina has a population density of 102 per sq. km whilst Tabuaeran has a density of 48. Kanton in the Phoenix group has an area of 9.15 sq. km. Only a handful of government officials and their families, maintaining air communication infrastructure on the island, live there. One of the constraints for permanent settling in the islands in the Phoenix group is the lack of ground water.

Atolls in the Line and Phoenix groups are owned by the Republic. They are inhabited by people from the Gilbert group who have worked for many years on those atolls, or were resettled there in the case of Tabuaeran and Teraina in a resettlement scheme of the late 1980s. This scheme arose from the need to populate the two atolls, and not related to any adaptation plan for climate change and projected sea level rise. The scheme was ended when it was considered that optimum population levels for each of the atolls has been reached.

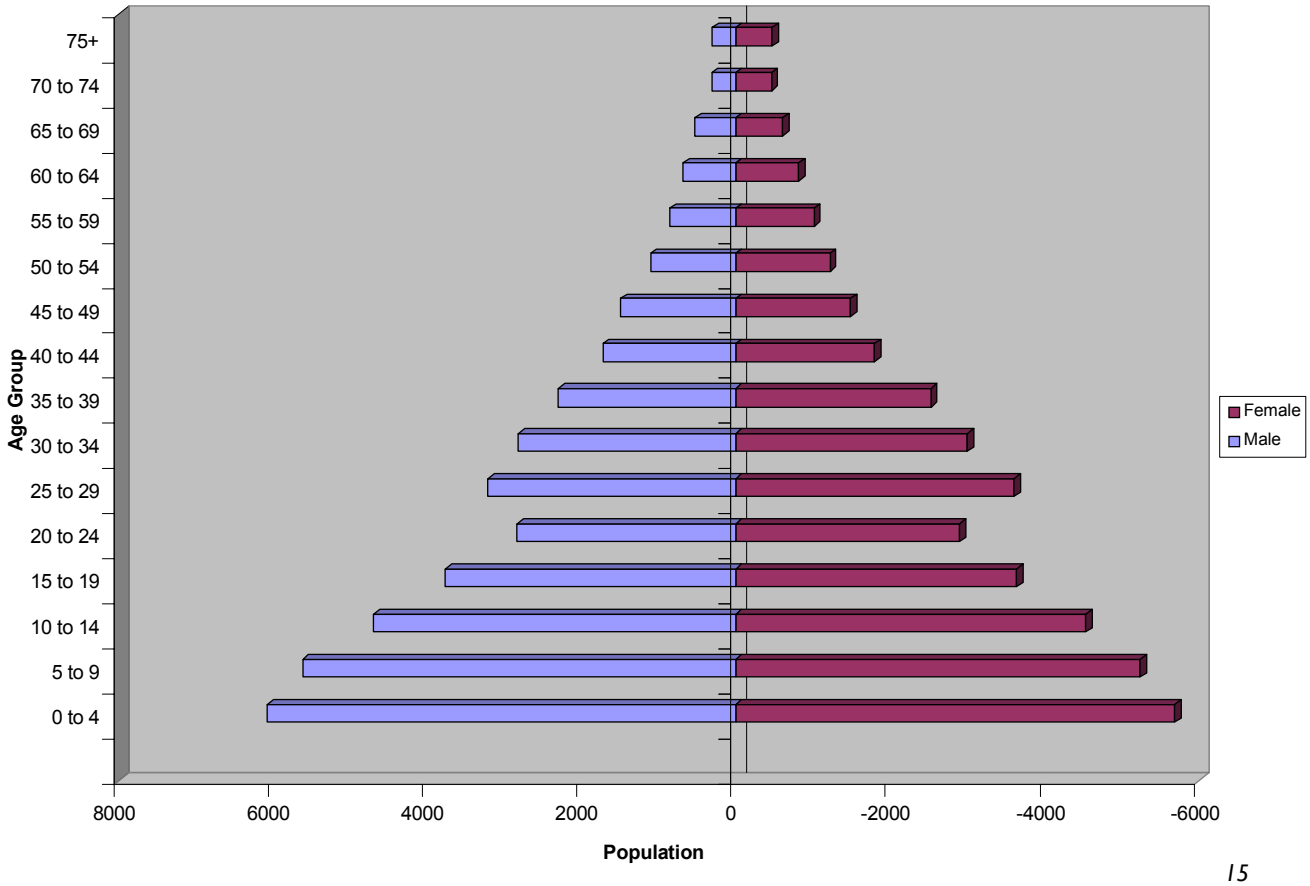
Population age structure shows that 15% are under 4 years of age, and that 41% are under 15 years of age. About 50% of the population are between 15 and 50 years of age, and only 10% are over 50 years of age.

Households are also important units in demography. In the 1995 census, the total number of households was 11920, implying an average of 6.5 persons per household for Kiribati. It was the same as for the Gilbert group, and a little less than the average for Line islands which was 6.6. These averages were lower than the averages for urban Tarawa and for Kiritimati which were 8.0 and 7.2 respectively. These are the two urban areas in the country.

The previous census was in 1990 when the population was then 72333. The estimated intercensal natural growth rate was 1.42% per annum. During that period the population of South Tarawa had increased by 2.2% per year. But the increase of the population of the Line islands was 4.2% as a result of the resettlement scheme noted above.

There has been very little migration to overseas countries, but of the total air departures of 8418 from Tarawa to other countries, 58% of this number were by I Kiribati. The main purposes for departures by I Kiribati would be for government businesses, conferences, training, or employment overseas. Yet for such purposes, the total departures do not come to the 58% of all departures, which might suggest that there was some migration of I Kiribati for the purpose of resettling in other countries.

Figure 3: Population Age-Sex Structure 1995



2.10 Level of education, training and skills

First level of education is from the ages of 6 to 14. In 1995 census, the population over 25 years of age who had not attended primary education was 0.8%, compared with 9% in the case of those of over 25 years in 1990 who had never attended schools (Demmke,A.et.al.1998.) In 1977 primary education was made compulsory by legislation, and this could have the effect on the improvement of the level of education.

The improvement in the overall level of education appeared minimal and government has rightly given more attention to the school systems, moreover it is encouraging community initiatives to establish preschools for the age group between 3 and 5.

Indigenous persons of ages from 15 years and above are regarded as employable. It is estimated that in 1995, 7848 of these persons are in cash employment, taking up occupational categories as follows:

Table 2: Employees by Occupation Categories, 1995

Occupation Categories	Number of employees
Legislators/Officials	516
Professionals	1512
Technicians and associate professionals	1251
Clerks	1011
Service workers	1490
Agricultural and Fisheries	472
Trades workers	696
Plant and machine operators	331
Elementary Occupations	420

This represents 17.7% of all persons in the active age group, and only 2.8% of those who are in cash employment have received training at tertiary level. This would suggest the critical shortage of trained manpower.

2.11 Social milieu

Kiribati people have their own unique culture, including their own language, forms of entertainment and expression, crafts and skills that are naturally linked to their environment and its resources. Close kinship ties within and between the family units find its expression in the readiness of people to share consumables and the use of few things that they possess.

A mix of market and subsistence systems characterises the lifestyle of the people of Kiribati. They are not mutually exclusive, but the former is more characteristic of the life in urban Tarawa and Kiritimati, while the latter is more typical of the people on other (outer) islands.

The natural resources support the subsistence livelihood of the people, and where these resources are subjected to excessive exploitation and environmental pollution, and in the absence of effective management systems as it is the case of South Tarawa, the level of subsistence livelihood is much reduced and impoverished. Dependency on the monetary economy is becoming increasingly important, also as a matter of necessity.

On the outer islands where the natural resources are more abundant, and where exploitation of these resources is not as intensive as in urban Tarawa, except for some commercial species such as grouper, sea cucumber, clam and mud worm, the people there depend largely on the subsistence form of livelihood.

Subsistence lifestyle is the traditional way of life. Basic human needs, food and shelter, are supplied by available resources and traditional knowledge, skills and activities at the household level. The distribution of labour within the household and across the households for community obligations had evolved and well established. Cash and imported commodities have long been introduced and with their utilities the subsistence way of life of village households are greatly improved. For the unemployed (in cash employment), life at the outer islands could be a better option than life on South Tarawa.

Village community at island levels is a recognised social unit. However, the traditional solidarity and social norms of the people within the village under one "maneaba" have been modified by affiliation to different religious organisations. In urban Tarawa where the great majority of people do not belong to any of the traditional villages there, the latter has more influence on the people than the former.

Traditional forms of social controls tend to be weakened in urban Tarawa and Kiritimati due in part to the dislocation of people from their traditional villages, and to their experiencing new utilities available from the cash economy.

It is often said that economic development has also bad effects on people and culture. In urban Tarawa, crimes have increased in numbers and complexities, and signs of struggling for survival are also evident. The traditional sense of dignity, and the rationales of an egalitarian society have been lost, as new values based on acquisition of material wealth are dominating.

Life expectancy at birth is 58 years for men and 65 for women. Infant mortality rate is 62 per thousands birth, while crude birth rate is 33 births per thousand of the population (Demmke,A. et.al.1998). These rates are high.

2.12 Economic Conditions

Gross domestic product is used as measure of national wealth. However, subsistence activities and products, and those that do not enter into the formal market system are generally difficult to value.

Capital formation consists of infrastructures such as roads, wharves, buildings, machineries, and ships. Land is a precious asset to Kiribati people and in the Gilbert group it is owned privately by an individual, an individual with his brothers and sisters, or owned jointly by a number of individuals. In the Phoenix and the Line groups, land is owned by the state.

In South Tarawa, rentals for land leased by government from landowners is at the rate of $A850/acre for non commercial areas, $A1200/acre for commercial areas, and $A638/acre for water reserve areas. In 1999 this is estimated to cost $A917232. Land transactions in the open market indicate a wide range in the prices of land from anything between few units of thousands to tens of thousands an acre (Nikora, 1999. personal commun.).

There are traditional knowledge and skills forming the basis, together with natural resources, for subsistence way of living and activities. Significant cultural sites have also spiritual values but which are not subjective to evaluation based on monetary measure.

Comparison of GDPs at constant prices over the years from 1990 to 1995 indicates an annual growth rate of about 3%, from $A40.6 million to $A49.2 million (National Planning Office. 1997). Per capita GDP shows also an annual growth of about 2%, from $A567 to $A614.

Inter-annual fluctuations in the GDPs are largely explained by changes in copra world prices and fishing licenses for distant water fishing nations. With the "Trade" sector, the primary sector is second to Government expenditures in its contribution to the GDP. Contribution from private housing sector has steadily increased which could reflect increased aspiration for western type of housing than traditional housing. Transport appears to be steadily increasing.

The highest contributor to the GDP is government spending or the public sector. In other words, the economy of Kiribati is dominated by the public sector. In 1990 the government expenditure was 75.6% of the GDP, and in 1995 it was 89.3%. The increase is due to the increase in expenditures in the social services. However, in terms of cash employment, the public sector accounted for about 79% and 67% for the years 1990 and 1995 respectively. This drop might indicate an increase in the private sector employment relative to the public sector.

The table below shows the contributions of sectors to the GDP during the period from 1990 to 1995.

Table 3: Gross Domestic Products at market prices in $A'000s Constant Prices at 1991

Sector	1990	1991	1992	1993	1994	1995
Agriculture	765	1193	1342	1410	1606	1451
Fisheries	1572	2318	2009	1714	1740	2108
Manufacturing	397	365	193	321	356	513
Electricity	736	737	748	776	834	839
Construction	1213	1988	969	845	1030	882
Trade	6501	6655	7395	6754	6760	6857
Transport	3847	3934	4091	4440	5539	5176
Communication	1313	1348	1419	1490	1561	1632
Financial	2094	2486	1917	1887	1821	1817
less Imputed Bank charges	1825	1770	1687	1617	1609	1018
Housing	944	1153	922	844	1229	1081
Gov't and other Community Services	11309	11841	12572	12710	14125	14937
Plus Indirect Taxes	7384	7122	7272	8237	7741	10192
Less subsidies	694	669	683	774	727	957
Subsistence fisheries	5088	4759	4281	4065	4205	4294
Total GDP at Market Prices	40647	43460	42761	43102	46211	49205

(Source: Statistics Office)

Dependency of Kiribati on foreign aid for development is an important aspect of the economy, particularly in financing trade deficits. Currently indebtedness is not a problem. However, in recent years, foreign aid has been decreasing, and the contribution to GDP from this source is also declining.

The only significant export commodities from Kiribati are copra, and fish. Copra production increases from 4682 tons in 1990 to 13,159 tons in 1995, the highest production since 1979. This might be a response to the high subsidy paid for copra since 1995. It also indicates that there is real potential to increase copra production. On the other hand, the volumes of export of fish and other marine products declined over the same period, and the annual import bill has always been higher, creating annual deficits in the balance of trade, since independence and the ending of the mining of phosphate from Banaba.

Imports of machinery and transport equipment in 1990 was valued at $A400,000 and in 1995 it increased to $A657,000 (Rouatu. 1996). Import of passenger cars was higher in 1995 than it was in 1991. However, the trend reverses in the case of imports of buses. They are used in public transport. Development of public transport is also affected by the condition of roads, and town land planning.

2.13 Regional economic differences

Development activities and benefits concentrate on South Tarawa and Kiritimati.

The small island of Betio in South Tarawa has an area of about 1.7 sq. km, and is the main port, industrial and commercial center. The population was 10344 in 1995, implying a density of 6085 per sq km then. In 1978 the population was 7626, and in 1990 it was 9443. This increase in the population is alarming, and government is embarking on structural strategic planning for Betio with plans to cover also the rest of South Tarawa which has a population of 18000 in 1995. Ministry of Home Affairs and Rural Development (Urban/Land Planning Unit. 1993 p.1) warned that “of all the islands in Kiribati, Betio faces the most pressing environmental, economic, and social problems.”

Betio is connected to the rest of South Tarawa by a 3.4 kilometer causeway, with a small opening for a channel to allow fishing skiffs to access between the lagoon on one side and the ocean on the other side of the causeway. Tar sealed main road runs along the edges of the islands on the side facing the lagoon.

On other atolls, natural passages separating the islands are connected also by causeways and in some cases with culvert openings. Unsealed roads run along the edges of the atolls.

Services and opportunities for investments are better on South Tarawa. Yet the living condition of people in this urban area might not be healthier than that of those in the rural atolls and islands. One reason is that the natural resources of South Tarawa have been overexploited, and subsistence life style which feed on these resources is therefore increasingly impoverished. Cash dependant lifestyle is the alternative that some enjoy, but with low monetary GDP, as well as with the strong traditional mutual support system among related members of the community, the majority of the people must be just barely meeting their basic human needs.

Kiritimati is a different story. Land area is half that of the total area of all the other atolls and is owned by government. The area of the lagoon is large, and the population is small. Natural resources are comparatively under exploited, although there is a general decline in the abundance of land crabs and of birds. There are no traditional inhabitants and so the lifestyle

developing is one of a new making. But ground water lens is very limited and is a major constraint on the development initiatives for the island.

The natural environment includes birds and bone fish. Kiritimati is accessible from Hawaii and both tourism and game fishing are being promoted at this atoll.

2.14 Summary

With the above circumstances, Kiribati is rightly recognised as a least developed small island state. It should also be recognised as groups of low lying coral atolls.

Greenhouse gas emissions and mitigation

3.1 Introduction

Under Articles 4.1 a) each of the country parties has an obligation to report on its greenhouse gas emissions by sources and removals by sinks. Comparable methodologies should be used and Intergovernmental Panel on Climate Change has provided guidelines on such methodologies..

Kiribati prepared its greenhouse gas emissions for the years 1990 and 1994. Needless to say that technical and financial resources were made available from bilateral and multilateral sources respectively for each of the two years in question. The 1990 inventory was prepared as part of the US Country Study Programme, and 1994 inventory was undertaken as part of the Pacific Island Assistance Programme funded by the GEF.

3.2 Methodology

IPCC methodology for national greenhouse gas inventories was used. However, due to lack of data at activity level, it is only possible to use the Reference Approach. Default conversion factors were used. These default values need to be replaced by more appropriate subregional or national data.

Greenhouse gases included in the inventories are carbon dioxide, methane, nitrous oxides, oxides of nitrogen, and carbon monoxide. There are no estimates of NMVO, HFCs, PFCs and SF_6. CO_2 is assumed to be produced solely from the burning of fossil fuels, and that according to IPCC Guidelines (IPCC.1995) this is on the high side due to the assumption that other gases emitted finally turned into CO_2 and further that not all fuels were completely burned.

Due to the lack of data related to Land Use Change and Forestry we have assumed that there were no emissions from activities in this sector, and also from the industrial sector. The latter is a more realistic assumption than the former, as continually changes in the land use are taking place, in particular on South Tarawa and Kiritimati. Population increase and the increasing level of development imply land use changes, but data on acreage producing, through human activities, increment or loss of carbon stock are not available, nor the rates relating to different types of vegetation cover are known.

Details of the inventories following the reference approach are given in Annex 1 of this report.

3.3 Lack of data, and in particular country specific data for emission factors

Kiribati contribution to global emission of greenhouse gases was estimated in 1994 to be 18.566 Gg CO_2, and 0.425 Gg. methane. These are insignificant and the accuracy is also dependent on the extent that de fault values would match local conditions and technologies. Clearly there is need to develop emission factors for Pacific small island states that should also reflect their different physical environment and level of development.

Data on land use change and agricultural practices are not available. These imply data on change of different vegetation cover.

3.4 Assessment and evaluation of emissions by sectors

The sole source of CO_2 is from the burning of fossil fuels. All fossil fuels are imported into Kiribati. There are only two importers namely Kiribati Oil Company Limited and the British Petroleum Company. The former imports all types of ground fuels and some aviation fuel while the latter supplies only aviation fuels for the small internal air service and a very irregular international flights connecting Tarawa, Nauru, Majuro and Nadi. Small importers include Kirigas Company which imports LPG, and occasionally government departments which have imported bitumen.

Much of the fuels are used in the urban areas, South Tarawa and Kiritimati, for the generation of electricity, and in the transport sector. Kerosene is widely used for cooking throughout Kiribati, and for lighting especially on the rural atolls and islands.

Table below shows a comparative figures of imports of the different fuels for the years 1990 and 1994.

Table 4 Imports of fuels in 1990 and 1994

Fuel Imports for 1990 and 1994		
Fuel Types	Quantity in toe	
	1990	1994
Secondary Fuels		
Gasoline	1755	2148
Jet Kerosene	1027	1260
Other Kerosene	496	995
Diesel Oil	5700	5656
Residual Fuel Oil	0	12
LPG	25	39
Ethane	0	
Naphtha	0	
Bitumen	61	
Lubricants		190

Fuel imports have increased over the four year period and this may be reflected in the increases of the total contributions to the GDP from the Electricity and Transport sectors over the same period. Relative to other sectors, growth in the electricity sector shows a slight decrease, whereas the transport sector indicates a slight increase. These patterns of their respective contributions to GDP would appear consistent with government policies which emphasizes social services over infrastructure.

The objectives of the energy sector are to supply "efficient" electricity "in urban areas for domestic and commercial consumers, and (facilitate) greater utilisation of renewable energy systems which are proven to be technically and economically viable" (National Planning Office. 1997, p.72). The combined available capacity of the generation plants in South Tarawa is 2.8 MW, and electricity tariffs are 32c per unit for domestic use, and 39 cents per unit for commercial and industrial consumption.

Electricity is supplied by Public Utilities Board, a self financing parastatal corporation.

Sea and air transports are important services to maintain communication between atolls and the groups, in particular between South Tarawa and Kiritimati, and Tarawa and the rest of the atolls. The objectives in these sectors are to provide safe, adequate, and reliable services. Kiribati is also mindful of the need to limit environmental pollution that can be caused by shipping services. Air Kiribati is the only air service operator and there is no competition so that the cost to the travelling public may not also reflect efficiency in the operation. The implication is that emission levels per utility could be high.

There are few small shipping service operators besides the government owned Kiribati Shipping Company Ltd. More participation from the private sector is encouraged, and the effect of this on fuel consumption and emission is not clear, so long as Kiribati remain unable to use the detailed technological approach for the greenhouse gas inventory.

For road transport, it is estimated that the total length of all the main roads on the atolls is around 500 km. The total road in South Tarawa is about 30 km and is tar sealed. On Kiritimati much of the length of the road is also tar sealed. Roads on rural areas are constructed of sand and gravel topped by compacted reef mud. Since independence, Kiribati has on two or three occasions mounted national programmes of road upgrading and improvement. Quality of roads on rural atolls would have implication on emissions from road vehicles.

The number of vehicles imported into Kiribati each year for the period between 1990 and 1994 has fluctuated. Whilst the cumulative year by year total vehicles would increase, this appears not clear from the registers kept by the local governments in the urban area. There is no policy on imports of vehicles and it is likely that it will steadily increase.

Skiffs and out-board motors are increasingly replacing traditional canoes and sails in inshore fisheries and for insular marine transport. Out-board motors are imported and the quantities fluctuates between years, but the recent estimate in 1995 of the total number in Kiribati is around 930 (Tiroa.1997).

Kerosene stoves are widely used in South Tarawa and Kiritimati, and to some extent on the outer islands. In 1995 the total number imported was around 1420 which could be an increase from earlier years. Electric cookers and gas stoves are also used in South Tarawa and Kiritimati.

Carbon Dioxide emission is estimated to have increased from 13.4 Gg in 1990 to about 18.5 Gg in 1994. 98% of the total emission in 1990 comes from diesel, 0.3% from gasoline, 0.2% from kerosene, 0.1% from LPG, and 1.2% from lubricants. The distribution in 1994 are: 42.1% diesel; 26.5% gasoline; 29.9% kerosene; 0.12% LPG; and 0.01 lubricants (Metai et. al. 1998). These distributions may reflect contributions by sectors to the overall national emission. Diesel is used for electricity generation and, also with gasoline for transport. Kerosene and LPG are used for home cooking.

Methane, Carbon Monoxide, Nitrous Oxides, and Oxides of Nitrogen are produced from biomass burning. Much biomass is also used for cooking, especially in rural areas. It is estimated that methane from this source has almost trebled in 1994 from what it was in 1990. Garden waste consisting of dead leaves and branches of trees, bushes and grass are also occasionally burned, instead of being buried, as this was a more traditional way to dispose this stream of waste.

Methane emission from landfills and domestic livestock shows little increase in 1994 over the level in 1990. Wastewater produces also methane, but it was considered that the amount of wastewater would be very insignificant. This might prove to be an underestimation.

Increases are also noticed in the emissions of the other three gases. All these emissions are from biomass burned in cooking, and the increase reflects the population increase and availability of fuel wood.

3.5 Problems faced in identifying mitigation options

A least developed country such as Kiribati implies limited natural resource base, lack of diversification in the economy, low level of specialisation, and lack of trained manpower. These attributes limit Kiribati options for mitigation. In recognising this problem, Kiribati would not presume that this report exhausts options for mitigating climate change.

The lack of, or inaccessibility to information on appropriate technologies that can be transferred to Kiribati, even for the purpose of replacing existing technologies and machineries in use, is also a constraint to be able to identify potential options for mitigating climate change.

Data and information system for environmental management is not in place. On the other hand, high technological tools in use elsewhere to acquire, store and display any kind of data required for management purposes could also benefit Kiribati. Identification of activities, areas and ecosystems that could benefit from appropriate management measures with benefits also for mitigating climate change is made difficult without good data and information.

Climate change is still viewed as a separate problem, that could be left to the Environment Ministry to take care, whilst economic development within the traditional paradigm of the unchanging climate is being pursued at sectoral, and national planning levels. Opportunities to incorporate mitigation measures in any economic development programmes could have slipped.

Climate change and sea level rise scenarios at the local level have not been developed to a degree of confidence that would enable government to give full attention to the need to mitigate climate change and to adapt to its impacts. Kiribati contribution to the global emission is insignificant, and it needs to develop economically. However, government recognises that as yet there is confidence in the scenarios for the whole globe, and will fully participate in any specific global action to mitigate climate change.

3.6 Mitigation options

Fossil fuels imported are for the types of the technologies and machineries that are in use in Kiribati. Information on appropriate technologies is required so that practicable options for transfers of those that are more efficient in terms of fuel consumption, and emission levels per output could be encouraged through appropriate policies.

Import tariffs could be made to reflect preferences for cleaner machineries and type of fossil fuels. Currently there is no duty on home use kerosene, a negligible tariff rate is charged for aviation fuels, a four cents Australian per liter is charged for diesel, and 12 cent per liter is charged for motor spirit (gasoline). Furthermore, kerosene and gasoline are included in the price control regulation. These policies need evaluation in terms of cost to the global environment that they impute through the emission of greenhouse gases.

Electrification of urban Tarawa is supplied by two power plants with the total supply of 2.8 MW. Power loss from the plant, distribution cable, and transformer is unavoidable. However on occasions the plants emit smokes which indicates inefficiency with regard to the use of

fuel. Between 1990 and 1994 power losses have varied between 13.8% and 21.6%. Option for mitigation that has been identified is energy saving at end uses.

It is also recognised that the electric grids were designed when demand was lower. Power factors have also decreased especially over recent years, after 1994, which may imply that the electricity may not be optimally produced.

Evaluation of the electricity generation system is also a mitigation option.

Reticulated water supply is provided for residents on South Tarawa and on Kiritimati. As a conservation measure, water supply is rationed. In the past, consumers were charged for the amount of water they used but maintenance and monitoring of the system had proved problematic and was discontinued. Water meters and rates would provide better means of monitoring consumption at the end use level.

Photovoltic cell systems are used in some rural areas to provide lighting for community buildings and some traditional houses. On some islands, solar pumps are installed to bring water from wells located away from the village areas closer to the households. Solar water pumps are also installed at the secondary schools in rural areas. This system has discouraged the inevitable increase in the use of small power generators at the rural areas. Solar energy technology, its development, and application should be encouraged.

In South Tarawa, the Public Utilities Board (PUB) has a monopoly in the generation and distribution of electricity. The current policy is to encourage competition to supplement the PUB's supply (National Planning Office. 1997).

There is an increase in the number of vehicles running on the road. The number of private passenger cars is increasing faster than the number of vehicles currently used for public transport. Import tariffs for the former are higher than for the latter. However, the tariffs do not distinguish between new vehicles and used vehicles. Tariffs could be made to reflect more of the contributions that the different vehicles are expected to make to the greenhouse gas emissions.

Trees and plants that are recognised as being owned by landowners are well managed and protected. But other trees and shrubs are freely exploited, or simply cleared, and are not replanted. Grasses are normally weeded out as they are considered as waste. This traditional attitude about cleaning is being discouraged through radio programmes and replanting of these wild trees and shrubs is encouraged through biodiversity programmes. Public awareness programmes to extend value systems to include environmental resources should contribute to the mitigation of climate change.

Waste disposal in the urban area of South Tarawa is in the form of open dump. The site is normally at the shoreline and in a number of cases waste streams disposed have been used as fill materials for land reclamation. Open dumping and other engineering methods for managing waste disposals would have different emission factors. Alternative forms of waste disposal could produce less methane than open dumping.

Research on the atoll system and human activities, including agro-forestry, shore based fisheries activities, and waste disposals should also provide knowledge leading to the recognition of other potential options for mitigation.

3.7 Further requirements towards definitive options, and plausible implementation strategy

The Climate Change Study Team should be strengthened. Its terms of reference should be reviewed. The Team would be a core group of technical personnel to work with a proposed Climate Change Monitoring Center listed in chapter 5 below.

Management system for data and information on all sources and sinks of greenhouse gases needs to be established. Raw data on imports and consumption of fossil fuels are available, but consumption at detailed technological level including end use appliances would require some research work.

Kerosene stoves are widely used in addition to the use of biomass for cooking. Assessment of emissions from these activities could lead to development of appropriate and cleaner technologies for home cooking.

Evaluation of the electricity generation system in South Tarawa and on Kiritimati could be useful. Such exercise would help to identify components of the system that are not operating at their designed optimal level or whether there are better alternative options for their replacements.

Waste disposal is a major problem on South Tarawa. Decomposition of the biomass depends on weather conditions, but as the waste is left in the open and unprotected it could release much more greenhouse gases to the atmosphere than the case would be if soil adsorption could be enhanced. More research work is required to assess the best option for waste disposal.

Vulnerability and adaptation

4.1 Introduction

The atolls of Kiribati are most vulnerable to the impacts of climate change which include accelerated sea-level rise. This is because of their small sizes, low lying topography, limited resource endowment, and also because Kiribati is a least developed country. This implies that these atoll systems would not be able to adjust to the adverse impacts of climate change and sea-level rise without serious repercussions on the national socio-economic circumstances. It also implies that some of the atolls would soon be unable to support human habitation. Sea-level rise poses a serious threat to Kiribati. President Tito explains this sense in these words, "Our hopes in celebrating a 'Millennium in Harmony with Nature' are being shattered by the failure of the KYOTO Conference to give sufficient guarantee for a secure future in the next millennium for low-lying islands like Kiribati" (Sawada, undated. p.5).

In several workshops at which climate change and sea level rise were presented as new factor to take into account in planning for management measures for the atoll ecosystems, a persistent question for which offered answers never satisfied participants was "what is Kiribati government doing about climate change?" In truth, people in Kiribati get worried to hear climate change and sea level rise, but are anxious to be able to do something for themselves. They do not think that the Kyoto Protocol target of about 5% reduction of greenhouse gases on the 1990 level is "sufficient for a secure future" for Kiribati.

Adaptation is taken to mean any activities that either reduces adverse impacts of the global warming, or enhances any consequential adjustment of Kiribati peoples lifestyles to fit in with the adverse impacts. IPCC has suggested three forms of adaptation to sea level rise. They are accommodation, protection, and retreat. A fourth option should be external resettlement but this is an option to signal the failure of the human race to have used and managed the global environment wisely. Accommodation in Kiribati case would include internal migration, and this option would depend on more detailed assessment of the varying degrees of the vulnerability of the different atolls.

Planning for adaptation is clearly complex. There are non-climatic factors which would either adversely, or positively affect the ability of Kiribati people to adapt to yet climate change and sea level rise scenarios. The former situation is more likely to be the case.

4.2 Methodologies

IPCC framework for vulnerability assessment involves seven steps:- step 1: delineation of study area and specification to ASLR scenarios; step 2: inventory of study area characteristics; step 3: identification of development factors; step 4: physical changes and natural system responses; step 5: identification and specification of response strategies; step 6: vulnerability analyses; and step 7: identification of tasks and needs. These steps were followed in a preliminary study confined to a small area in South Tarawa. The result of this study has led to the realisation by Kiribati government that a comprehensive assessment, in terms of coverage of the country and sectors, is required (Abete, 1993).

A comprehensive assessment is not feasible at this stage, and the vulnerability analysis would imply even a discipline on its own, incorporating underpinning disciplines in sectors selected, availability of data, and models that may be employed. The lack or inadequacy of data on the environment of Kiribati limits the use of appropriate models on impacts and vulnerability.

Qualitative information is therefore equally important in the analysis. This approach has also been used, in combination with any quantitative analysis approach that may have been adopted,

in the vulnerability assessment on the selected sectors. Such a mix of approaches should nevertheless be identifiable and consistent with IPCC 7 steps for Vulnerability Assessment which are listed above.

4.3 Climate Change and Sea-Level Rise Scenarios

IPCC have published global scenarios for global temperature and sea level rise in its 1990 Assessment Report, and updated these in its 1995 Assessment Report. They relate to the time of the equivalent doubling of the carbon dioxide atmospheric concentration from the pre industrial level. The updated scenarios and the doubling time are better than those given in the 1990 Assessment Report, one reason was an improvement in understanding of the roles of aerosols. No scenarios have been given at a regional or subregional level because there is no confidence in the models at this high resolution level. This gap in the information is the cause of a dilemma in any vulnerability and impact assessment for any country.

US Country Studies Management Team (1994) explains one methodology to develop regional scenarios for climate change is by extrapolating scenarios at grid points containing the region or place of interest to obtain scenarios for that location. Kiribati efforts to obtain appropriate grid point scenarios were unsuccessful. Likewise its effort in seeking advice on scenarios from institutions in the Pacific region was of no consequence.

With that situation, it is understandable that some of climate change and sea level rise scenarios that have been used for vulnerability and adaptation assessments would not receive the consensus of scientists, particularly within the South Pacific region. This fact would also explain why earliest studies on vulnerability and adaptation assessment in Kiribati have tended to be vague about scenarios against which the assessments were made. Recent studies are more definitive about the scenarios that they use.

All the study areas are on Tarawa, and the sectors that have been studied include coastal areas, water lens, agricultural systems and public health. The latest study was by nationals as part of the training course they attended at the International Global Change Institute at the University of Waikato, New Zealand.

The table overleaf shows the scenarios that were used by different authors, location of exposure units, and sectors.

In all cases, Kiribati should experience sea level rise. At the current rise of 4mm per year (Etuati, 1994; Solomon, 1997), it is estimated that by the year 2025 sea level would have risen by 10cm; consistent also with the scenarios by Jones (1998).

Table: 5: Vulnerability and Adaptation Assessments since 1992.

Author	Year	Title of the report	Location	Sectors	Sea level rise scenarios	Climate change scenarios
Woodroffè, C.D, & McClean, R.F.	1992	Kiribati Vulnerability to Accelerated Sea-Level Rise: A Preliminary Study	Buota islet in Tarawa.	Coastal area	30 cm - 100 cm by 2100 but dismissed as unlikely.	Not clear.
Solomon	1998	Assessment of the Vulnerability of Betio, Kiribati to Accelerated Sea Level Rise.	Betio islet in Tarawa.	Coastal area	MSL*: 30cm, 50cm, 95cm by 2100. HHT:1.8m, 2m, 22.5m.	Not considered.
Alam, K and Falkland, A.C	1997	Vulnerability to Climate Change of the Bonriki freshwater lens,Tarawa.	Bonriki in Tarawa.	Water resource	Current MSL* with varying % reduction of rainfall and one with reduced pumping also. Increased MSL with 25% rainfall reduction, and one with a reduced island width also. MSL of 1m, current rainfall and reduced island width.	As indicated in the Sea Level Scenarios.
Jones, R.	1998	An Analysis of the Impacts of the Kyoto Protocol on Pacific Island Countries Part one Identification of Latent Sea-Level Rise within the Climate System at 1995 and 2020 A research report prepared for the South Pacific Regional Environment Programme.	South Pacific Region.	Sea level rise	Scenario 1 based on IS92a, with emissions of ghg from various sources in 1995, but reduction in emissions by 2000. With various climate sensitivities: 1-12cm 2005-2025;5-12cm 2020-2025. Scenario 2 IS92a for 2000, then KP: 14-32 cm by 2050.	
Ubaitoi, I & Taeuea, T.	1998		Kiribati in general.	Agriculture, Public Health, Water, Coastal hazards	9.3cm-19.7 by 2025; 19.8-39.7 cm by 2050; 48.9-94.1 cm by 2100	0.5-2.50 C by 2025; 0.9-2.2 by 2050;1.5-4.5 by 2100

*Mean Sea Level is equated to a zero mark used in the Australian National Tidal Facility equipment located at the Betio wharf, South Tarawa. In fact the assessed MSL is 1.6 m above this zero mark.4.4 Socio-economic scenarios

4.4 Socio-economic scenarios

There has been no attempt to quantitatively establish any socio-economic scenarios. One possible consequence of this information gap is to obscure the human dimension of the vulnerability. Equally it could result in being too presumptuous about the impacts of climate change on Kiribati, by attributing the cause of any environmental degradation to climate change.

In Kiribati case, we consider that important consideration for the formulation of socio-economic scenarios could be based on demographic and economic projected trends and adjusted for any foreseeable influences of national policies and external factors. We can only assess these in qualitative terms.

Over the past twenty years, Kiribati infant mortality rate has improved from 120 to 65, and life expectancy has also increased from 49 to 63 years. Nonetheless these improvements are below current levels that are enjoyed by more developed Pacific Island states (National Planning Office. 1997 p.86). It is further noted that family planning remained below targeted levels, and that only social and economic factors would be deciding factors on the population trend. Intercensal population increase rates have fluctuated to the lowest level of 1.42% per annum over the recent intercensal period, 1990-1995. This was a drop from the earlier intercensal period, 1985-1990, when it was 2.26%. Based on these facts, we consider that the population will continue to increase; it is not possible to say whether a stable population will be achieved over the next 100 years. If such a situation should arise, then it would be because of natural limitation, including on food and water supplies, rather than any conscious policy of government to limit population size.

Population increase implies greater pressure on environmental resources. It also implies greater demands on government services, and high rate of economic development to maintain per capita real income. Being a largely traditional community and society, requirements for economic development would imply greater and sustained efforts in education and other modernizing processes to go on. Aspiration for better infrastructure would increase. Economic development where there is limited opportunity would imply greater dependence on foreign aid, or a fall in the standard of living. Consequences would be overseas migration, or reverting to subsistence lifestyle to create more pressure on traditional resources.

An alternative assessment would be economic policies that are less responsive to the developmental needs of the increasing population. Pressure on environmental resources would still be a force to reckon. But government services could be restricted to some minimum level, and economic development be considered solely in terms of the amount of GDP. In this case reliance on traditional and subsistence lifestyle would prevail, and under the scenarios of bigger population would imply a even more impoverished subsistence livelihood.

The two variants of economic development strategies and their interaction with population would alternately be dominating factors in determining socio-economic scenarios. For Kiribati, as one of the most vulnerable low lying atoll countries, adverse impacts of the sea-level rise on the atoll systems would override any impacts of the socio-economic development.

Few population projections were sighted. Ministry of Home Affairs estimated that in 2010 the population of South Tarawa would be 46,000 (Ministry of Home Affairs and Rural Development,1995). A range estimate given in Kingston Morrison for the same year is between 35000 and 47500 (Kingston Morrison,1996).

In summary, socio-economic scenarios would be about demographic trends, GDP trends, and the state and trends of the abundance and use of the traditional resources. External factors include foreign aid in the form of capital, technology, knowledge and skill which would contribute to GDP growth. Population would also increase. But traditional resources including skills and knowledge would become more wanting. On per capita basis, the national welfare would tend to decrease. Overall, Kiribati will remain in the least developed countries categories through the foreseeable future. When adverse impacts of climate change and sea level rise become well demonstrated, Kiribati people would have already experienced greater hardship and costs caused by climate change and sea-level rise impacts.

4.5 Atoll system and some selected sectors

Each of the inhabited atoll is an ecosystem on its own. No two atolls are similar, except for their general features of being small in land area, generally flat with the land surface at any height from less than a meter to about 4 meters above the sea level. Yet vulnerability assess-

ment studies that have been carried out were limited to few areas of South Tarawa. The results would therefore be generalised to all atolls, but significant differences in the case of any other atolls would also be pointed out

Water Lens

From their study of Bonriki (in South Tarawa) water lens, Alam and Falkland (1997) considered that water lens would be more sensitive to the amount of rainfall, the width of the island, rather than to a rise in the sea level. The effect of the sea-level rise would raise the water lens but without any significant change in the depth of freshwater limit. A 50 cm rise in sea level would raise the water table by approximately the same amount so it was thought there could be a slight increase in the thickness of the freshwater lens. A 1 meter rise would most likely cause inundation of the island near the sea. A combined impact of a rise of 1 meter in sea level, erosion by 12.3%, and current rainfall would be 10% reduction in the water lens.

During the latest period without rain, experienced from May 1998 to March1999, a drought condition was declared by Kiribati government. La Nina conditions prevailed also in 1998. Rain came in late March and continued during April and May 1999. With the coming of rain, a widespread diarrhea struck South Tarawa to claim some life. If the freshwater lens would rise with the sea level rise and to cause inundation, impacts on the health of the people would be anticipated.

Limited freshwater lens exist on all of the inhabited atolls except on Banaba (Ocean Is.). Tarawa atoll at which the study area is located has a lagoon like other atolls, but there are table reefs charaterised by fringing reefs all around and non existence of a lagoon. These types of atolls include Makin, Nikunau, Tamana and Arorae, in the Gilbert group.

With the sea-level rise scenarios, it would be most likely that a pattern of erosion and accretion would evolve that could change also the distribution of ground water lens. There are no scenarios established for rainfall; it is however probable that rainfall may not change but that its intensity could increase in which case land coastal erosion from rainfall would exacerbate..

In summary, water lens would be affected through erosion that might be associated with sea-level rise, but intense rainfall would tend to improve the quality of the ground water lens within the atoll. There could be problem when the water lens get very close to the land surface.

Fig.4: Coastal indeterminable boundary between land and the sea across the atoll. However, traditionally the narrow strip of land parallel to the shoreline and few meters inland is regarded as "Mataniwin te aba" which has the literal translation of "leadership land".

Coastal area and hazards

There is no hinterland on atolls, and coastal area is evidently the whole of the atolls. In Kiribati the average width of the atolls is about 667 meters and sea spray freely circulate

The earliest studies (Woodroffe et.al 1992) concluded that complex patterns of erosion and accretion have already occurred at Buota islet on, separated from Bonriki by a narrow natural passage, because of coastal structures such as causeways and seawalls built along South Tarawa, including Buota islet.

The total coastline of South Tarawa is about 69 km, and we estimated that about 18.9% is covered by seawalls, wharves and causeways. Whilst this could be considered to be the cause of the complex pattern of erosion and accretion, it might equally be viewed as a response already taken by the public and the private sectors to adapt to impacts of climate change and sea level rise.

Throughout South Tarawa, complex pattern of erosion and accretion has been occurring. As a result, individual islets and any stretch of land would either have gained or lost in area. This is the case also of other atolls in the Gilbert group.

Solomon (1997) analysed tide records from the University of Hawaii equipment and from the Australian National Tidal Facility tide gauge. The former were installed in 1974 while the latter were installed in 1992. He concluded that the sea level has risen by 3.3 mm per year, but that the total land area of Betio according to other research, including Gill 1993, has increased. This is an admonition against the simpler view that sea level rise would simply cause land inundation and erosion. However, we observed that 45% of the shoreline of Betio is covered by coastal structures which might explain why the land area has increased.

The whole of Betio is leased from landowners by government so that much of structural change on the coast were initiated by government to provide and protect infrastructures, including housing, buildings, roads, and wharf. Betio is also the commercial centre in Kiribati and heavily populated. Moreover, it is part of Tarawa atoll, and might not be adequately represent the adverse impact of the observed sea-level rise on the total area of the atoll.

With the sea level rise having been observed in Betio, but at the same time with much coastal structural protection, which may be viewed also as spontaneous mitigation, having been constructed, it is difficult to isolate which is the cause of the increase in the land area.

However, the same study suggested that Betio would be vulnerable from overtopping. This is in relation to the scenario of sea level of 1.5 meters above the IPCC scenarios of 30 cm, 50 cm, and 95 cm by the year 2100. The 1.5 m was based on the current mean sea level and the maximum of the residuals according to the Australian National Tidal Facility data. We should note however that the current mean sea level was above the zero mark of the tide gauge, whereas the scenarios were based on IPCC scenarios added on to the current mean sea level presumed now to be equal to the zero mark. The study could therefore be optimistic, but even as it is some parts of Betio islet would be subjected to overtopping and in extreme storm conditions "all but the highest parts of the western shore would be overtopped by runup" (Solomon. 1997, p.50).

Overtopping from storm surges has regularly occurred in some parts along the shore of Betio, even in areas where there are seawalls. Overtopping destroy breadfruit trees, and few other fruit trees that may grow on the coastal area. However, storm surges need not necessarily result in erosion. But complex pattern of change in the land formation would most likely occur; nonetheless such a scenario is equally destructive and costly to any atoll, since the land area is very small and options for land utilisation are constrained by that fact.

Climate change may also result in the change in frequency of El Nino, and La Nina. Rainfall pattern may also change. A drought from May 1998 to late March 1999, concurrent with the La Nina conditions, seriously affected Kiribati. Coconut trees, and breadfruit trees were dying particularly in South Tarawa but also on outer islands. An informant recollected the drought in 1930s involved a longer period without rain, few years, before it became so hard for them. Resilience of trees to drought conditions may have decreased, which might suggest that evapotranspiration might have already been stressful for trees. Positive linear trends in surface temperature records from observing stations in Kiribati have been demonstrated.

In conclusion Kiribati atolls are most vulnerable to climate change and sea-level rise. It is most likely that complex patterns of erosion, accretion, in association also with coastal protection work, and gradual retreat along the width of the atoll, would take place. In the meantime, the atolls are vulnerable to extreme weather conditions such as storms, and drought to occur now under a reduced length of the period without rain.

Fig.5: Atolls are most vulnerable to sea-level rise

Agricultural System

Trees and plants are most sensitive to weather conditions. Important tree crops are coconut trees (*Cocos nucifera)*, pandanus trees (*Pandanus tectorius)*, giant taro (*Cyrtosperma chamissionis)*, breadfruit (*Artocarpus sp.),* and banana *(Musea sp.)* on the northern atolls. With abundant fish, these trees support the subsistence life style of the people.

Climate change and sea-level rise would have major impacts on the agricultural system. Traditionally people have learned that heavy rain in a short length of time followed by intense period of sunshine have the effect of warming the water captured within the leaves at the shoots. Such types of rain could be more harmful to the coconut trees and pandanus trees.

With the introduction of copra trading, coconut trees would appear to have received more attention than the pandanus tree. The former tends also to survive longer and had been used to mark boundaries of land plots for the guidance of later generations. Along the coast, the particular appearance of the canopy from the sea had been used also to guide direction to known fishing grounds. On some parts of South Tarawa and other atolls, aged coconut trees had been uprooted in the process of coastal erosion.

A coconut tree replanting scheme in the late 1960s based on the assumption that coconut trees would grow better and more productive if their roots were also to be within reach of the water lens proved to be a failure. If the water lens were to be lifted up as a result of the rise in the sea level, then the coconut trees could be less productive. This assessment would also be consistent with the experience that the coconut trees in damper soil, as for example, in the northern Gilberts are less productive than on those of the drier South.

Certain varieties of pandanus trees are found on some atolls, whilst still other varieties are found in some other atolls. An attempt to disseminate these varieties to atolls where they are not found proved unsuccessful, implying that small differentials in the climate between atolls exist and that these trees are sensitive to such small differentials in the amount of rainfall, and temperature.

Giant taro planted in dug out pits reaching the water lens would be adversely affected. It is known that where the pit is within a thin water lens, uprooting a giant taro causes the infiltration or the "upwelling" of salt water into the pit. In the northern Gilbert many large pits (few acres) are owned by a number of families, and these pits would be affected by the sea-level rise.

Some islets in Tarawa are disappearing, and with drought and sea-level rise the vegetation structure are changing. Coconut trees along the "coastal" area (mataniwin te aba) withered and die while undergrowths of salt bush (*Scaevola sericea*), beach heliotrope *(Tournefotia argentia)*, beach mulberry *(Morinda citrifolia)*, and varieties of low grasses were succeeding them. These types of vegetation are also first to appear on new accreted lands. With the anticipated complex change in the pattern of erosion and accretion to occur from the sea-level rise, there would also follow changes in the succession of trees and plants. Human intervention would be directed to the planting of the traditionally more valuable trees in new accreted land, but might not be extended to planting other trees and plants as a conscious effort to protect coastal and land erosion.

Mangroves thrive also in the intertidal zone along parts of some atolls. These plants have essential functions to protect the beach. Where they exist, it is considered that the beach would be stable. Whilst this may be true in many cases, an informant said of the mangroves along a particular beach section in Tarawa, in connection with the claim that they protect the coast, that they were encroaching onto the land as the shoreline retreated.

Economic development provides incentives for diversification of tree crops and for growing short term vegetables. This has success on South Tarawa, and at the northern atolls of the Gilbert group. Also traditional management of the long term tree crops is being encouraged, but this is facing the challenge from the changing value system about agriculture arising from some level of modernization taking place in the country. Short term cash earning from copra and other products of the coconut trees, pandanus trees, and other plant are preferred than the sustainability of the land productivity. Pandanus trees might receive increasingly less attention, yet this is an important tree for local construction and home amenities.

Demographic factors have impacts on agriculture through the traditional land tenure system, land sizes, and distribution. Population densities in rural islands reflect not only spatial area of settlement but also the distribution of resources that are normally obtained from the land. Land is not equally distributed, so that there may be under-utilised lands and overexploited lands.

In summary, it is suggested that the pattern and intensity of the rainfall, the feature of the water lens would greatly affect the agricultural system. The latter would also be affected by the width of the land and, with the predicted complex change in the pattern of erosion and accretion even to be caused also by the sea-level rise, the land productivity might decrease.

To maintain the current level (late 1990s) of land productivity, the future population of Kiribati would have to work harder.

Diseases

Through impacts of climate change on the atoll ecosystems, Kiribati people would ultimately face the downstream effects such as lifestyle diseases.

A start of an unexpected period of rain in late March 1999 and through to May, after a short period of drought referred to above was associated with a form of diarrhea spreading in South Tarawa, causing some deaths across all ages. The disease was not identified but the health authority believed that it was a form of virus that would get cured through the patient developing natural antibodies (Radio Kiribati. 26th April, 1999: Health Announcement). Precaution measures advised include the boiling of drinking water.

Drinking water from wells can be contaminated through leaching of pollutants, runoff from nearby grounds during raining periods, salt intrusion from salt water underneath the water lens. Sources of pollution are the wastes on the land, coastal areas and the sea. Guidelines on how to protect wells should be developed and widely distributed; the wells should additionally be monitored for quality.

Traditionally, people know that mosquitoes are more abundant after a period of rain. Prior to the onset of a rainy period, ants and other ground dwelling insects move to sheltered areas including those that they can find inside houses. Flies might also tend to stick around in sheltered areas in houses. Spring tides could also contaminate ground water lens for it is a common knowledge that at the onset of spring tides, babies would normally contact diarrhea. Waste including those of the packaging of imported commodities, garden yard waste, and waste from domestic animals such as pigs and chickens, would provide different levels of attractiveness for vector disease carriers depending also on the amount of moisture from rain or otherwise that they contain.

In the dry season, the range of the vectors could be wider. People are also more mobile. With the impossibility of getting rid of all the nesting places of these vectors, any disease that struck the atolls may spread more rapidly in dry season, for example dengue fever.

Any temporal and intensity changes in rainfall pattern from the traditionally dry (Aumaiaki) and wet (Aumeang) seasons would most likely affect the incidences of the vector and waterborne diseases. The effects would be through impacts on the breeding grounds of the vectors, namely mosquitoes, flies, and other insects.

Increasing trend in temperature has been observed from the observing stations in Kiribati. The trend has been very small, but even then some older people thought that they have felt this change. However, heat waves could not occur in the atolls but the glaring sun could damage eyesight, accelerate aging process, and reduce the general health and productivity of the people.

In summary, should climate change results in any change in the alternating pattern of rainy and dry seasons, in temperature, and in the moisture content of waste, then the incidence of diseases might change for the worse and new diseases might occur. A warmer climate could exceed the optimum climate conditions for Kiribati people.

Marine ecosystems

Corals are important ecosystems for the atolls. Factors affecting their health include sea temperature, depth below sea surface, and amount of sunlight. They are known to thrive better

in oceanic conditions rather than lagoonal conditions (Maragos 1974 cited in Paulay et.al 1995). In the lagoon, nonetheless, patch reefs and shoals exist. Abundance of coral is greater around any natural passages to submerged barrier reefs.

Corals have important functions for adaptation of the atolls to climate change and sea-level rise adverse impacts. A common question that has been raised by Kiribati people is whether corals growth rate would be able pace with the projected rates of the increase of sea-level rise, that is sea-level scenarios. It is for this reason also that geological studies of the atolls are relevant.

The atolls were understood to be formed between 4000 –3000 B.P. This was the period of reef forming when the corals had reached the sea surface, after their rapid growth period in concert with the rapidly rising sea level during the marine transgression period. The rate of coral growth was between 5 mm to 8 mm per year (Marshall et.al. 1985), but during that time the sea level was rising at a more rapid rate of about 15 mm per year (Schofield,1977). Nevertheless IPCC (Bijlsma, et.al 1995) consider a growth rate of 10 mm per year to be more representative. Comparing this growth rate to IPCC scenarios of sea-level rise at a slower rate, it would appear that coral growth could keep pace with the anticipated rate of rise of the sea level.

However, the limiting factor would be sea surface temperature against the tolerance temperature level of 25^0-29^0 C (Nurse et al. 1998). Coleman (1989) quotes an annual mean sea surface temperature of 28.4^0 C around Tarawa. The rate of temperature increase would therefore be an equally critical factor as the sea-level rise in determining the vulnerability of the atolls.

Schofield (1977) suggested that the maximum sea level during the marine transgression period occurred some 200 years after the occurrence of the maximum in New Zealand. There could be still controversy over whether the sea level in Kiribati was higher during that period. This information might suggest to some people that this pattern could repeat itself although the two sea-level rise phenomena arose from different causes. However, land formation and human settlement could occur in a later period and therefore this analogue could not be used to imply anything about the vulnerability of the atolls to climate change and sea-level rise.

Coastal areas would be seriously affected. The protective roles of the reef platforms, ridges, grooves, beach rocks and conglomerates, and patches of reefs and shoals, sea grasses surrounding the atolls would be inadequate for the impacts of the sea-level rise and temperature rise. Stability of the beach rocks and conglomerates under temperature stress has not been assessed, but it has been observed that they get cracked and parts flaked off. Coastal erosion is a common problem throughout Kiribati.

Structural changes in the coast have been attributed as a major cause of the erosion. However for South Tarawa we estimated that about 19% of the shoreline has been modified by engineering structures including sea wall, wharves, and causeways. But there has been negligible modification of coastal areas of some outer islands, yet they too have serious coastal erosion problems.

In conclusion, corals have a crucial role in determining the vulnerability of the atolls to the adverse impacts of climate change and the rise in sea level. In turn, their ability to provide this important function will be determined equally by both temperature increase and sea level rise. Climate change threatens the survival of corals and so too of Kiribati.

4.6 Problems faced in identifying adaptation options

Gaps in data and in knowledge about the atolls contribute significantly to the difficulty faced in trying to identify options for adaptation. Whilst global scenarios of temperature increases and sea level rise are sufficient for global action to be taken to address climate change, sce-

narios at the local level are highly controversial that any adaptation measures based on such scenarios are likely not to be given due consideration. Data and knowledge would therefore lend greater justification to adaptation measures.

Data and knowledge should also guide policy formulation for areas and sectors of the physical and socio-economic environment of Kiribati. Gaps in data and knowledge could misdirect policies towards different focus from areas which when given attention can ensure long term benefits to the economy and environment. If this were to be the case, reactive policies would prevail, thus exacerbating environmental problems and loosing opportunities to adopt effective measures to adapt to the impacts of climate change and sea-level rise.

Shorter and mid term time horizons are immediately more realistic for planning purposes. Even when sustainable development is being acknowledged, any longer term policy measures even where accumulated benefits over cost would be positive, other policy measures with more immediate benefits but at a greater accumulated cost over the longer term period would be preferred. This perspective does not assist in planning for adaptation measures.

In summary, this report should not create any impression that adaptation options identified here are a closed set.

4.7 Adaptation options

General options

Economic development objectives are based on the national aspiration to increase the per capita income of the people. This is a shift from the pre and early independence policy when the objective was self reliance. Productive sectors and infrastructure, and rural development were then given priority.

The current developmental objectives take greater account of the potential of human resource to raise national productivity, and entrepreneurs acumen in developing the nation. Greater resources are being allocated to social services, in particular education, and there is less emphasis on population planning. Restructuring of the economy is being pursued.

These policies have implications for sustainable development. Adverse environmental impacts and consequences of failures of the earlier policies are now being addressed, such as the construction of openings to solid causeways. The current policies based on human resource development and the restructuring of the economy would in future show their impacts, including most likely an over exploitation of environmental resources. This means over exploitation of the land as a living area and habitat for tree crops and vegetation, of the marine areas as habitat for marine living resources. They could be avoided by taking stronger measures in the management of the environment. At the same time immediate benefits from a cleaner environment would be realised. Environmental considerations need to be integrated into economic planning.

The first option would be to enact an environmental framework law, and to effectively implement such laws. Kiribati government is processing environmental Bill through parliament. Environmental Impact Assessment process and pollution controls form important parts of this Bill.

More effort is needed to enhance Kiribati people's awareness of their environment and climate change issues. Furthermore, the level of awareness should be such that it will be possible to redefine some of the motives of people in their activities that have direct impacts on the environment.

Water Supplies

Fresh groundwater lenses are the source of potable water supply to people on rural areas and also in urban areas. For urban Tarawa and Kiritimati, piped water systems should be upgraded through replacement of components (leaks) that are inefficient, and the system extended to cover people who are not served. After this work has been done, water supplied from the system should be metered and users charged. Owners of any building with permanent roofing should be encouraged to install and build rain water storage for the building. Imported rain water tanks with capacity greater than 300 litres are not dutiable, however, the more used concrete tanks are dutiable through the materials that are used for their construction. This disparity should perhaps be corrected.

Private wells in urban Tarawa should be regularly tested and monitored for biological and chemical pollution, and owners advised of the quality of the water and of steps to improve and maintain quality standard.

Drought must be defined, for South Tarawa, Kiritimati, Banaba, and atolls in the Gilbert. Parameters to be incorporated in the definition will include population, and amount of rainfall in a set period, possibly a month. The definition should capture elements of forecast over longer period, say three months.

Coastal Zone and Hazards

Coastal zone management has been strongly advocated as the key planning framework for adaptation. The objectives are to: 1) Avoid development in areas that are vulnerable to inundation; 2) Ensure that critical natural systems continue to function; 3) Protect human lives, essential properties and economic activities against the ravage of the seas. Strategies advocated are: retreat; accommodation; and protection (IPCC Coastal Zone Management Subgroup. 1990).

These strategies should be considered within the overall context of Kiribati, its physical and socio-economic environment. Infrastructure such as roads and causeways, wharves and port facilities, institutional buildings, public housing, electric and telecommunication under ground cables, water and sewerage pipes, and airfields are the responsibility of government. Currently the policy is to protect them from coastal erosion, but efforts have not all been successful. Because land is very limited protection strategy have been preferred, and where these fail, there has been no option but to allow buildings to crumble into the encroaching sea. As for private properties, owners are taking adaptive measures to protect their properties, failing in these they simply accept their loss.

A Coastal Zone Management Plan should be developed. Protection of important public infrastructure such as parts of the roads should now be planned, including seawall construction. In this connection appropriate designed concrete blocks, instead of coral boulders should be developed. Planting of mangroves around the coast should start. In developing Coastal Management Plan, wide public participation is an important part of the process. Human activities that seriously impact on the coastal area, and potential uses of vegetation to protect shorelines are important information for developing the plan. A pilot scheme should start in urban Tarawa, and Kiritimati.

Agricultural System

Traditional agricultural system should be revived, including a reevaluation of traditional value system on products and uses of trees and plants. Economic agricultural policies such as subsidies should be re-appraised as they could insidiously undermine Kiribati culture and the traditional value system underlying agricultural system.

Conservation of biodiversity is a good adaptation programme and should be associated with a sharpened recognition of the values of local trees and plants, followed by a new sense of ownership for trees and plants that are currently regarded to be under the 'commons' regime. This should increase even more Kiribati peoples sense of value for their land, now clearly eroding in the face of demonstrative effects of cash economy. But whilst traditional land tenure system should be kept, other forms of land rights as already exist in law such as leaseholds could be encouraged among indigenous people.

Trees and plants need to be identified to the species details. There are several species of coconut trees, numerous varieties of pandanus trees, few species of breadfruits, several species of giant taro, and few species of each of the other trees and plants. Uses, and potential uses should be listed, and their specific preferred growing environment documented.

Adaptation option would involve a clear vision of the use plants and trees, and to selectively plant species that best suit a particular physical environment of the land, and a particular purpose.

Rice, flour, sugar, and even tinned fish have become the preferred diet of Kiribati people. Whilst in urban South Tarawa, this is explained by the dominating cash economy, the situation in rural areas is different. The prices of rice, flour, and sugar are controlled and this could encourage low price and higher consumption. There may be a need to consider appropriate disincentive policies on consumption of flour and rise and for incentive policies to promote local food.

Subsidy for copra price has been a feature in government policies to raise the standard of living of the seemingly more disadvantageous rural people.

Diseases

Health statistics are currently kept by the Health Ministry. Analyses of the data should be carried out, and a detailed study on the impacts of climate change on human health should be undertaken. Different diseases and prevalence rates should be monitored, pathways through which they can spread should also be explained.

The use of traditional medicines should be facilitated. But this should be limited to herbal medicines from plants and trees that are not known to be poisonous themselves.

People may need to use head gears and sunglasses, and appropriate clothes to protect themselves from the sun.

Marine Ecosystems

Marine ecosystems are crucially important to the people in the atolls. Yet in Kiribati, there is no effective management system in place to protect the marine and intertidal ecosystems especially corals, sea grasses, fish, sediments and aggregates. In South Tarawa and Kiritimati these ecosystems are very vulnerable also to excessive exploitation.

One adaptation option is to reestablish a traditional system of ownership and specific rights on coastal areas, including reef patches and shoals. This option appears to be supported with some qualifications in a workshop conducted on seven rural atolls of Kiribati. This option merits serious consideration.

Removal of materials from the foreshores can be controlled. This is being done under the laws that were framed several decades ago; these laws need to be revised as part of any review of practices, including traditional rights, in the management of marine ecosystems.

Enhancement programmes for fish stocks, and also corals is desirable. Community participation is important in all stages of the development of any such programme.

4.8 Summary

Adaptation in Kiribati should be based on an integrated and comprehensive approach. Local communities should be involved at all stages of the development of an adaptation programmes. A priority area should be coastal and marine areas and an adaptation plan, to be part of a climate change action plan, should be drawn up, implemented, monitored and regularly updated.

Proposed list of Programmes and brief description of concepts

5.1 Climate Change and Sea Level National Monitoring Center

IPCC's scenarios relate to global equilibrium mean temperatures, and global mean sea level. Surprises are not ruled out and occurrences of unpleasant ones should be prevented. Variations in temperature and sea level at regional level from the global scenarios are expected. This is because the current state of knowledge is as yet unable to produce, at equal confidence level as with the global scenarios, regional scenarios. But more immediately and of direct interest to any country is how it would be affected. Kiribati feels that way.

Vulnerability studies are premised on the global scenarios of mean temperatures and sea level rise. When these are downscaled by whatever methods, results would be highly controversial. On the other hand, when requesting experts to provide scenarios for Kiribati, the advice has consistently been that Kiribati should monitor the situation.

That being of a scientific interest, Kiribati interest is just to be able to know and sense the portended progressively perilous global environment of which impacts in all assessments endanger the very survival of small island states which Kiribati interprets to mean atolls first.

The functions and other details of the center will be developed at an opportune occasion, but they should be geared to regional and scientific cooperation in understanding the unfolding climatic and oceanographic conditions. It should also collaborate with ongoing scientific research works in country, and to undertake or cause to be undertaken work on gaps in research areas, including analysis and documentation of extreme or unusual atmospheric and oceanographic events that occur in Kiribati.

5.2 Integrated Coastal Zone Management Plan

Incremental cost is the screening measure for climate change project proposals. This implies that for any proposal incremental cost attributable to climate change or for implementing the UNFCCC should be less than the global benefit, so that if climate change were in fact not occurring, a global benefit would in any case have been achieved. From that minimal requirement, the development and implementation of coastal zone management plan is seen as most appropriate.

In Kiribati sense, the local benefit from such plan equates to the global benefit since its geographical location and geophysical features make it one among the first countries likely to register signals and impacts of the sea-level rise for the rest of the world. Coastal structural modifications have altered the natural tendency of erosion and accretion patterns, but also conclusions from studies converge on the understanding that sea-level rise should cause overtopping of atolls, and modification of otherwise a natural pattern of accretion and erosion under no climatic and sea level changes. The problem in isolating the contribution of local coastal modifications from that of the climate change and sea-level rise to the coastal changes in particular erosion is unlikely to be resolved before it will be too late for any useful action to be taken. Kiribati needs to develop and implement appropriate coastal zone management strategies and programmes.

Coastal Zone Plan should consist of integrated components for which responsibilities are allocated to various authorities in line with existing government ministerial portfolios. A coordinating committee is essential, and the Climate Change Monitoring Center should be a member.

Details including of projects and activities shall be developed when an opportune time comes.

5.3 Public Awareness Programme

Public awareness activities have been undertaken as part of ongoing environmental programmes. Methods of public awareness raising that have been used are workshops, radio programmes, a newsletter, school quizz broadcast over radio, and poem and poster competitions on environmental themes. These activities have given Kiribati people a fresh sense and view of their environment.

Public awareness on climate change and accelerated sea level rise had been focused on concepts, and global actions that are taken to address the problems. When these were explained at the workshops, a common reaction was an expressed desire to know any actions that government intends to undertake locally. There is no concrete answer to offer yet.

Future public awareness activities should be on consolidating and fostering public participation in developing, and implementing climate change activities. Furthermore, public awareness should include as an important element, the dissemination of information on researches and on international consensus on issues, that is, on matters initiated by IPCC and UNFCCC processes. Effort should be made to disseminate to policy makers appropriate information, and recommended response measures; the aim is to get acceptance of, and to operationalise the need to integrate such information on climate change and accelerated sea-level rise into national policy formulation and planning.

Details of the Programme shall be developed when an opportune time comes.

5.4 Education and Training Programme

Study of the environment should start at home. Kiribati is all ocean and atolls. The celestial sphere is clearly visible as blue sky forming the backdrop of the cloudy otherwise invisible atmosphere under the powerful sun. At night times, the sky is lighted up part of the times by the moon and at all the times by twinkling and bluish dominating stars. Education authorities should strengthen the provision of curriculum for junior and secondary schools after wider public consultation including with people outside of the education profession.

Atoll environment should be given a little more emphasis in courses at the regional university. Long term scholarship awards for climate change issues should be provided with intakes on the basis of grades in secondary form 6 achievement.

Short-term specific courses should be designed to meet particular areas of concern of atoll countries as they arise. Some already exist and these need to continue.

Details of this programme shall be developed when opportune time arises.

5.5 Research and Information Dissemination

The UNFCCC requires that there is cooperation in research activities to understand climate change. Capacity building is important for this cooperation to be meaningful and fruitful. Whilst education and training programme will develop national capacity to collaborate on scientific research, it is also useful for trained nationals to be associated with scientific research on aspects of the environment of Kiribati. The tendency so far has been to limit this cooperation to the collection of raw data in the field, and not to involve nationals in the analytical and interpretive parts of the research. The cooperation should go further to see that nationals participate in analytic and interpretive work on raw data. Short attachments in a

developed country partner by Kiribati nationals or a short attachment in Kiribati by experts from the developed country partner could be a suitable approach to develop this cooperation.

From the earlier chapters of the report it is obvious that much is required to understand the climate and processes in the atolls. Existing data on Kiribati climate need to be analysed including identifying gaps in works already done with a view to direct research into new areas for which raw data is available.

Appropriate and more efficient technologies, as alternative to some existing technologies even for domestic appliances, need to be developed.

The human vulnerability and resilience, socio-cultural response to climate change and sea level rise and to extreme climatic events including droughts, storms, tidal waves, and inundation need to be understood.

Implications of administrative and regulatory policies for mitigating or adapting to climate change need to be better understood.

Research results should be communicated to policy makers. Technical reports have to be simplified, and copies of the simplified version should be distributed to ministers and secretaries. Whilst this is achieved in the Executive Summary part of the report, not all technical reports include this part.

For members of the general public, a workshop to present conclusions in the study would be useful. Attempts when useful should also be made to translate information into the local language.

5.6 Greenhouse gas inventory Programme

Inventory of greenhouse gases will be regularly updated. But there are recognised gaps in data, nor there is any centralized data base with regular updating procedures. Data relating to vegetation covers and land use change are not available, and emission factors based on local conditions and different technologies in use in Kiribati are not also available. Emissions of greenhouse gases from soil and plantations need also to be assessed.

Waste disposal practices should be assessed for their contribution to the greenhouse gases emissions and for their impacts on water sources and vector diseases.

5.7 Technology transfers Programme

Assessment of the electric generation system in South Tarawa, with regard to optimal efficiency of the system relative to other available options even for different types of generators and cable distribution should be undertaken.

Information on available technologies and any compliance standards for level of emissions of greenhouse gases, if these exist, should be provided to Kiribati.

5.8 Water Supplies Programme

Water supplies available in South Tarawa, Kiritimati, and some outer islands are inadequate in times of drought. Nonetheless there is also loss and leakage in the reticulated system, and from roofing catchment areas. Supplemental village wells need to be monitored in a more systematic way for both health and resource assessment purposes.

Planning and management requirements for water supplies would enhance adaptation measures to address climate change impacts on water. Projects need to be identified and should be considered as an important component of a climate change action plan

5.9 Alternative Energy Sources

The demand for electric power is increasing in the urban areas and also in rural atolls. Power plants in urban areas are becoming inadequate for the growing demand, and increasingly in rural areas small unit generators are being installed by individuals and communities to meet their needs for lighting and other end uses, such as for video and audio equipment.

Renewable energy from the sunlight, wind and ocean waves need technologies, skills and knowledge that are not readily available in Kiribati. Yet there may be real potential for these energy sources to supply future needs for energy in the atoll countries.

Home cooking uses open fire with fuel wood or kerosene stoves. More efficient stoves could contribute to the mitigation of climate change.

Kiribati atolls experience many hours of sunshine, unceasing ocean waves, and steady moderate winds.

5.10 Public Awareness on Health impacts of climate change, and appropriate response measures.

Downstream effects of the impacts of climate change would include a changing livestyle to adapt to those impacts. New stresses and diseases are likely to develop, and health education will be useful to mitigate their effects on the population. Associated with this is a need for more resources to develop and implement effective population policies, and urban physical planning policies.

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Annex

Table 1. Summary of emission

	Year	Gg								
		CO_2	CH_4	N_2O	Nox	CO	NMVO	HFCs	PFCs	SF_6
Energy										
Energy sources	1994	18.556	0	0	0	0	0	0	0	0
Traditional biomass burned for fuel	1994	0.000	8.21E-07	6.77E-09	2.45E-07	8.62E-05	0	0	0	0
Coal Mining and handling	1994	0.000	0	0	0	0	0	0	0	0
Oil and Gas Activities	1994	0.000	0	0	0	0	0	0	0	0
Total for Energy		**18.556**	**8.21E-07**	**6.77E-09**	**2.45E-07**	**8.62E-05**	**0.000**	**0.000**	**0.000**	**0.000**
Industrial Process										
Cement Production	1994	0.000	0	0	0	0	0	0	0	0
Total for Industrial Process		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Solvent and Other Product Use	1994	na								
Agriculture										
Domestic livestock enteric fermentation	1994	0.000	2.32E-02	8.4623E-06	0	0	0	0	0	0
and manure management										
Flooded Rice Fields	1994	0.000	0	0	0	0	0	0	0	0
Burning of Savannas	1994	0.000	0	0	0	0	0	0	0	0
Field burning of Agriculture residues	1994	0.000	0	0	0	0	0	0	0	0
Total for Agriculture		**0**	**0.023214**	**8.4623E-06**	**0**	**0**	**0**	**0**	**0**	**0**
Land Use Change & Forestry										
Change in forest and other woody -	1994	0.000	0	0	0	0	0	0	0	0
biomass stock										
Forest and Grassland conversion	1994	0.000	0	0	0	0	0	0	0	0
Onsite burning of forest	1994	0.000	0	0	0	0	0	0	0	0

Abandonment of managed land	1994	0.000	0	0	0	0	0	0	0	0
Total for Land Use Change & Forest		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Waste										
Landfills	1994	0.000	0.42517755	0	0	0	0	0	0	0
Domestic and Commercial wastewater	1994	0.000	0.00000001	0	0	0	0	0	0	0
Industrial wastewater treatment	1994	0.000	0	0	0	0	0	0	0	0
Total for Waste		**0.000**	**0.425**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Total for All		**18.556**	**0.4483924**	**8.46907E-06**	**2.44859E-07**	**8.62241E-05**	**0**	**0**	**0**	**0**

MODULE			ENERGY						ENERGY				
SUBMODULE			CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)						CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)				
WORKSHEET			1-1						1-1				
SHEETS			1 of 5						3 of 5				
COUNTRY													
YEAR													
			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption	L Carbon Stored	M Net Carbon Emissions	N Fraction of Carbon Oxidised	O Actual Carbon Emissions	P Actual CO_2 Emissions
									(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
FUEL TYPES								F=(A+B-C-D-E)		M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil						0.00		0.00		0.00	0.00
		Orimulsion						0.00		0.00		0.00	0.00
		Natural Gas Liquids						0.00		0.00		0.00	0.00
	Secondary Fuels	Gasoline		2148635.00				2148635.00		1.35	1.00	1.34	4.91
		Jet Kerosene		1260745.00				1260745.00		0.81	1.00	0.81	2.96
		Other Kerosene		995824.00				995824.00		0.71	1.00	0.70	2.58
		Shale Oil						0.00		0.00		0.00	0.00
		Gas / Diesel Oil		5656729.00				5656729.00	2.15	2.15	0.99	2.13	7.82
		Residual Fuel Oil		12780.00				12780.00		0.01	0.99	0.01	0.04
		LPG		39483.00				39483.00	0.03	0.01	1.00	0.01	0.02
		Ethane						0.00		0.00		0.00	0.00
		Naphtha						0.00		0.00		0.00	0.00

		Bitumen						0.00		0.00		0.00	0.00
		Lubricants		190937.00				190937.00	0.06	0.06	0.99	0.06	0.22
		Petroleum Coke						0.00		0.00		0.00	0.00
		Refinery Feedstocks						0.00		0.00		0.00	0.00
		Other Oil						0.00		0.00		0.00	0.00
Liquid Fossil Totals									2.24	5.10		5.06	**18.56**
Solid Fossil	Primary Fuels	Anthracite [(a)]						0.00		0.00		0.00	0.00
		Coking Coal						0.00		0.00		0.00	0.00
		Other Bit. Coal						0.00		0.00		0.00	0.00
		Sub-bit. Coal						0.00		0.00		0.00	0.00
		Lignite						0.00		0.00		0.00	0.00
		Oil Shale						0.00		0.00		0.00	0.00
		Peat						0.00		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel						0.00		0.00		0.00	0.00
		Coke Oven/Gas Coke						0.00		0.00		0.00	0.00
Solid Fuel Totals									0.00	0.00		0.00	0.00
Gaseous Fossil		Natural Gas (Dry)						0.00		0.00		0.00	0.00
Total									**2.24**	**5.10**		**5.06**	**18.56**
Biomass total										0.00		0.00	0.00
		Solid Biomass						0.00		0.00		0.00	0.00
		Liquid Biomass						0.00		0.00		0.00	0.00
		Gas Biomass						0.00		0.00		0.00	0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

(a) If anthracite is not separately available, include with Other Bituminous Coal.

This spreadsheet contains sheet 2 of Worksheet 4-1, in accordance with the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**Agriculture**
SUBMODULE	**Methane and Nitrous Oxide Emissions from Domestic Livestock Enteric Fermentation and Manure Management**
WORKSHEET	**4-1**
SHEET	**2 Of 2 Nitrous Oxide Emissions from Animal Production Emissions from Animal Waste Management Systems (AWMS)**
COUNTRY	
YEAR	

STEP 4

	A	B	C
Animal Waste Management System (AWMS)	Nitrogen Excretion $Nex_{(AWMS)}$ (kg N/yr)	Emission Factor For AWMS EF_3 (kg N_2O–N/kg N)	Total Annual Emissions of N_2O (Gg)
			C=(AxB)[44/28] / 1 000 000
Anaerobic lagoons	0	0.5	0
Liquid systems	0		0
Daily spread	0		
Solid storage & drylot	0		0
Pasture range and paddock	0		
Other	10.7702	0.5	8.4623E-06
		Total	8.4623E-06

This spreadsheet contains sheet 2 of Worksheet 4-1, in accordance with the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**Agriculture**
SUBMODULE	**Methane and Nitrous Oxide Emissions from Domestic Livestock Enteric Fermentation and Manure Management**
WORKSHEET	**4-1**
SHEET	**2 Of 2 Nitrous Oxide Emissions from Animal Production Emissions From Animal Waste Management Systems (AWMS)**
COUNTRY	
YEAR	

STEP 4			
Animal Waste Management System (AWMS)	A Nitrogen Excretion $Nex_{(AWMS)}$ (kg N/yr)	B Emission Factor For AWMS EF_3 (kg N_2O–N/kg N)	C Total Annual Emissions of N_2O (Gg)
			C=(AxB)[44/28] / 1 000 000
Anaerobic lagoons	0	0.5	0
Liquid systems	0		0
Daily spread	0		
Solid storage & drylot	0		0
Pasture range and paddock	0		
Other	10.7702	0.5	8.4623E-06
		Total	8.4623E-06

This spreadsheet contains sheet 4 of Worksheet 6-2, in accordance with the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**Waste**
SUBMODULE	**Methane Emissions from Domestic and Commercial Wastewater and Sludge Treatment**
WORKSHEET	**6-2**
SHEET	**4 Of 4 Estimation of Methane Emissions from Domestic/Commercial Wastewater and Sludge**
COUNTRY	
YEAR	

STEP 4					
	A Total Organic Product (kg BOD/yr)	B Emission Factor (kg CH_4/kg BOD)	C Methane Emissions Without Recovery/Flaring	D Methane Recovered and/or Flared (kg CH_4)	E Net Methane Emissions (Gg CH_4)
	from Worksheet 6-2, Sheet 1	from Worksheet 6-2, Sheets 2 and 3	C = (A x B)		E = (C - D)/1 000 000
Wastewater	0.26889954	0.055	0.014789475	0	1.47895E-08
Sludge	0.04745286	0	0		0
			Total:	0	1.47895E-08