KIRIBATI

State of the Environment Report 2000-2002

Government of the Republic of Kiribati 2004

PREPARED BY THE

ENVIRONMENT AND CONSERVATION DIVISION
Ministry of Environment
Lands & Agricultural Development

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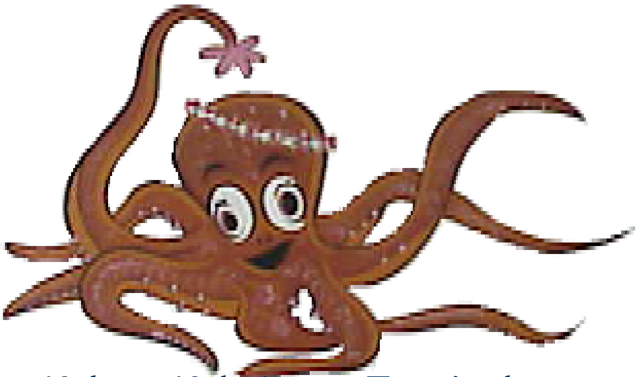

Ngkoa, Ngkai ao n Taaainako

GOVERNMENT OF THE REPUBLIC OF KIRIBATI

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The report has been collectively developed by staff of the Environment and Conservation Division. Mrs Tererei Abete-Reema was the lead author with Mr Kautoa Tonganibeia contributing to Chapters 11 and 14. Mrs Nenenteiti Teariki-Ruatu contributed to chapters 7 to 9. Mr. Farran Redfern (Chapter 5) and Ms. Reenate Tanua Willie (Chapters 4 and 6) also contributed.

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Chapter 1 Introduction

1.1 General

The central Pacific nation of Kiribati is made up of 33 islands, all, except Banaba are atolls. The islands are grouped into 3 main clusters of islands; the Gilbert group with 17 islands; Line group consisting of 8 islands and; finally the Phoenix islands having another 8 atolls. The Exclusive Economic Zone (EEZ) of Kiribati is one of the largest in the Pacific of 3.5 million km^2, but the total land mass is only 811 km^2.

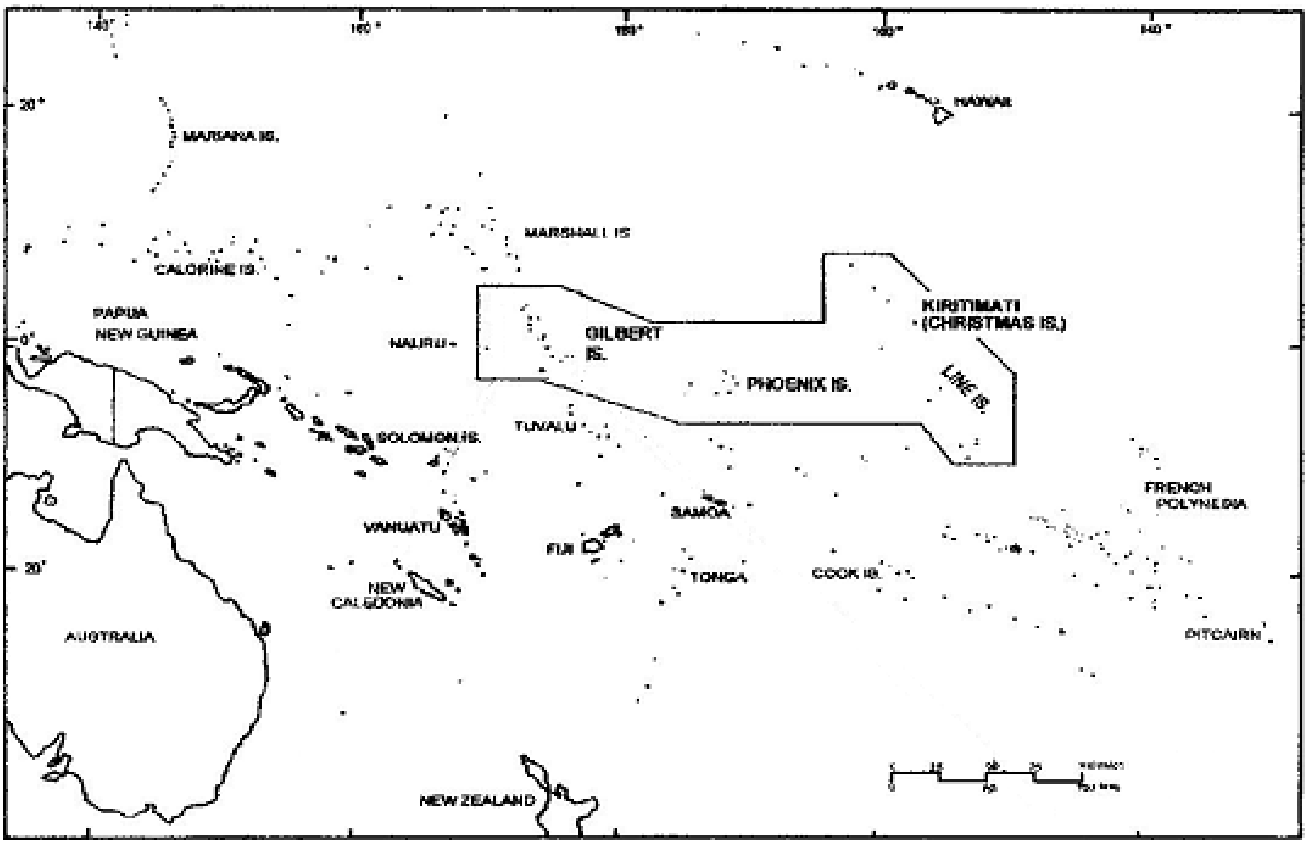

Figure1.1 Map of Kiribati (delineated by box) within the Pacific Ocean (source: MESD, 1999)

The Gilbert Islands contain the bulk of the population (>90%) but have about 35 % of the land mass. All the islands are privately owned by the indigenous people, but most of the land on South Tarawa, the capital, is leased by Government for development purposes.

East of the Gilbert group lies the Phoenix Islands. One of its island, Kanton (also known as Canton) hosts less than 100 people and the remaining 7 atolls are uninhabited, except Orona, which is used for trial to harvest the natural resources for economic gain. All the islands in the group are owned by Government

Further east of the Phoenix and close to the Hawaiian Islands, are the Line Group which contain more than half the land mass of Kiribati because of the 388 km^2 land area of Kiritimati, the largest atoll (in terms of land area) in the world. Besides Kiritimati, two other northern Line islands; Fanning and Washington, are the only inhabited islands in the group. Unlike the Gilbert Islands, there are no indigenous people of the Line and Phoenix Islands as the local population are originally from the Gilbert group hence there are no private land titles. Government holds all land titles.

Kiribati has been independent from the British Empire since 1987 and continues to enjoy a democratically elected Government. An elected President is both the Head of State and

Government. The capital of Kiribati is situated in Bairiki of South Tarawa, the southern portion of the island of Tarawa.

1.2 State of the Environment Report

State of the Environment (SoE) Reporting is a system for delivering information about the environment to all sectors of society, such as government, the private sector, non-government organisations and the general public, by identifying environmental issues and assessing actions addressed to deal with them.

The purpose of the SoER is to assist the decision making process and to inform the wider community about major issues affecting the local environment. The following are essential components (ELN, 2001) that should be included:

- Description of the present condition of the environment and identification of problems affecting it;
- Monitoring of changes occurring in the environment over time;
- Investigation and evaluation of the effectiveness of what Government, private and community efforts (if any) are to be undertaken to reduce the impacts; and
- Identification of gaps in knowledge about the local environment

The objectives of an SoER, among others, are to:

- communicate useable information to decision-makers for better management of the environment and to assist in the achievement of sustainable development;
- provide environmental benchmark data for the assessment of cumulative impacts of environmental policies, programs and actions over time;
- identify unresolved issues and emerging environmental problems;
- raise public awareness of environmental issues by providing information in a readily understandable style and format;
- assess the status and conditions of major environment resources for a specified area/region;
- examine environmental trends, including their implications for the environment and human health;
- review programs and activities of public and private sector authorities related to environmental protection;
- examine the trends in economic affairs and their potential impacts on the environment;
- assess the need for future legislative and other action required for the authorities to discharge its responsibilities with respect to protection of the environment and sustainable development of the area under consideration (ELN, 2001).

Regular SoE reporting is crucial for monitoring the environment quality standards and attainment of these standards. Although it is ideal to have annual SoE Reports, this may not be possible in small developing states (SIDS) like Kiribati due to resource limitations. However, a maximum of five years with supplementary reports every 2 to 3 years in between, if possible, would be considered adequate in Kiribati.

The first SoE Report for Kiribati was published in 1994 and to date, no second report has been produced. Many Government developments have taken place within the last 6 years, including a new Government coming into power on the eve of the first SoER circulation. Similarly, many environmental policy programmes, projects and activities have been and continue to be implemented by Government and NGOs, such as the National Environmental Management Strategy (NEMS). These include, among others:

- Creation of another Ministry for the environment, known as the Ministry of Environment and Social Development (MESD);
- Technical Assistances of the Asian Development Bank (ADB) in environmental development areas for example: environmental impact assessment; waste management; coastal management; etc;
- Ratifying and acceding a number of global environmental agreements (UNFCCC, CBD UNCCD, etc)

- Completion of the USAID funded Tarawa Lagoon Management project;
- Implementation of the Kiribati Environment Education programme (KEEP) by FSP;
- Climate change vulnerability studies and programmes;
- Continual public awareness activities;
- Introduction of the Environment Act 1999;
- Expansion and Development of the Environment Unit (EU) into the Environment and Conservation Division (ECD);
- Sanitation, Public Health and Environment (SAPHE) loan project from the Asian Development Bank (ADB).

In Section 6 (1) of the Kiribati Environment Act (1999), the Functions of the Minister include (d) *the development of national standards to promote sustainable development and to monitor those standards through environmental auditing*; and (h) *ensure freedom of access to information on environmental matters*

Section 7 of the same Act requires (d) *revision and amendment of the national environmental management strategies* (NEMS) *and programmes as necessary*; (h) *conduct and promote environmental research*, where SoER becomes useful as a research and information collation document.

It is therefore timely that preparation for the next SoER production is set in motion. Production of a SoER in Kiribati is not easy due primarily to shortage of staff as well as expertise. This is compounded by the lack of data and information, which, if available, are scattered in various departments of Government and other institutions. The task of compilation is tedious, let alone analysing the available data. This very problem was encountered in the course of collecting and updating data for this report.

The format of this report follows the standard SOE reporting system (IUCN, 1992; EPA, 1993; ELN, 2001) that contains:

1. STATE: describes the current conditions of the local environment. This provides baseline information against which future trends can be compared;

2. PRESSURE: accounts for the various impacts on the environment resulting from human activity;

3. RESPONSE: indicates the work being undertaken by Council, other Government agencies, industry, NGOs and the community to reduce these pressures.

The bulk of this report contains the state of the environment, then secondly it assesses changes from the first SoE report and beyond depending on data availability, in terms of key changes or key environmental indicators that are known to be critical.

The overall structure has five main sections. The first section (I) contains the introduction, Chapter 1 that gives a general setting and Chapter 2 covering many general aspects of planning, policy and legislation and an inventory of some of the information resources in maps and imageries.

Section two (II) covers the physical setting of climate, geology, land and water resources from Chapters 3 to 6. The third section (III) contains the biodiversity of flora and fauna as well as the coastal ecosystems in Chapters 7 to 9. Section four (IV) covers health and demographical aspects in Chapters 10 to 11. The final section (V) looks at special issues which deserve more attention, not only because of their important contribution to the environment but they are critical in supporting human settlements particularly in urban centres.

The final chapter considers which indicators are most critical for Kiribati and identifies indicators that are already critical but for which data may have not yet been collected and recommends the process in preparation of the next SoER.

Chapter 2. General Environmental Situation in Kiribati

2.1 Policy Statements

2.1.1 Government

From 1994 to 1998, the main policy goal of the Government was "improving the quality of life of an I-Kiribati". This had been seen in raising Government's revenue to meet the increased expenditure (Fig. 2.1) on the improvement of living standards, among other things.

Figure 2.1 New House of Parliament at Ambo, Tarawa (ECD, 2000a)

His Excellency, Te Beretitenti Teburoro Tito delivered the Government Policy Statement during his inauguration for his government on coming into power again for a second term for the period 1999 to 2002. One of the main policies is safeguarding and improving the environment of Kiribati through continuing the support of public awareness programmes on environmental aspects; promoting an environment Act to ensure that future development activities are environmentally sound; and maintain a strong stand on the international scene against activities which have contributed to and caused global warming and other drastic climatic changes potentially harmful to small island developing states or SIDS (GOK, 2000b).

2.1.2 Environment and Conservation Division

The Environment and Conservation Division (ECD) of the Ministry of Environment and Social Development (MESD) states its mission as safeguarding the natural environment; air, water, land – upon which life depends, and to protect human health (ECD, 2000).

The Aims are to ensure (ECD, 2000b) that:

environmental protection contributes in making communities and ecosystems diverse, sustainable and ecologically productive;
the people of Kiribati are protected from significant risks to human health and the environment;
laws protecting the environment and the well-being of the people are enforced fairly and effectively;

all parts of society – communities, individuals, businesses, non-government organizations – have access to accurate information sufficient to accurately participate in managing human health and environmental risks;

The Mechanisms (ECD, 2000b) are:

- Being open and consultative about ECD's work;
- Basing decisions on sound information and knowledge;
- Monitoring and recording environmental change;
- Preventing and controlling pollution through a system of licensing;
- Regulating and improving waste disposal;
- Introducing a system of evaluating development that considers the environment;
- Protecting and conserving natural resources;
- Setting priorities and working out solutions that society support.

2.2 Legislation

Prior to 1999, Kiribati did not have an environmental legislation. A review of environmental-related legislation in 1992 (Pulea & Farrier, 1994) showed that general environmental stewardship was scattered to many governmental authorities in many cross sectoral issues thus requiring a collective responsibility of the various arms of Government. The Kiribati Constitution lacks provisions that guarantee its citizens a clean environment or oblige the Government to ensure that development is ecologically sustainable; however, there are no substantial consititutional impediments to Government seeking to achieve these objectives through legislation.

The Environment Act 1999 (GOK, 2000a) provides for the protection, improvement and conservation of the environment of the Republic of Kiribati and for connected purposes. The main objectives of the Act are to:

- Provide for and establish integrated systems of development control; environmental impact assessment (EIA) and pollution control;
- Prevent, control and monitor pollution;
- Reduce risks to human health and prevent degradation of the environment by all practical means including
  - Regulating discharge of pollutants to air, water and land;
  - Regulating transport, collection, treatment, storage and disposal of wastes;
  - Promoting recycling, re-use, reduction, composting and recovery of materials;
  - To comply with and give effect to regional and international conventions and obligations relating to the environment.

The Act also adopts many environmental principles of sustainable development such as:

- Precautionary principle;
- Intergenerational equity;
- Conservation of biodiversity and ecological integrity; and
- Improved evaluation and pricing of environmental resources (GOK, 2000a).

The Act is divided into 5 parts which are:

1. Preliminary matters setting out the objectives;
2. Administration and implementation that shall be in the control of the Minister of the Environment and Cabinet;
3. Establishment of system of control of development using EIA. The system is applicable to both public and private sector development;
4. Prevention and control of pollution and certain measures to be adopted for pollution prevention; and,
5. Miscellaneous matters including protection of inspectors, penalties and fines of offenders, general appeals and regulations to be developed by the Minister responsible for the environment.

The Environment Act 1999 is the realization of the present Government of Kiribati in considering the environment as a priority, but sustainable development must be recognized in the integration of environment protection and economic developments (GOK, 2000a).

2.3 International Conventions and Treaties:

By the start of the new millennium, Kiribati had ratified or acceded to the following environmental agreements:

Agreement	Signature	Ratification/Accession
London Dumping Convention, 1972 (LDC) Prevention of Marine Pollution by Dumping of Wastes and Other Matter		12 July 1979
Treaty on the Non-Proliferation of Nuclear Weapons		18 April, 1985
The South Pacific Nuclear Free Zone Treaty	6 August, 1985	11 December, 1986
Vienna Convention, 1985 (VC), Protection of the Ozone Layer		7 April, 1993
Montreal Protocol, 1987, Substances that Deplete the Ozone Layer.		8, April, 1993
United Nations Framework Convention on Climate Change, 1992 (UNFCCC)	13 June, 1992	8 May, 1995
Kyoto Protocol ???		7 September, 2000
Convention on Biological Diversity, 1992 (CBD)	13 June, 1992	14 November, 1995
United Nations Convention to Combat Desertification (UNCCD)		8 September, 1998
Basel Convention on the Control of Transboundary Movements of hazardous Wastes and their Disposal		7 September, 2000
Convention to ban the Importation into Forum Island Countries of Hazardous Wastes and to control the Trans-boundary Movement and Management of Hazardous Wastes within the South Pacific (Waigani)	16 September 1995	28 June, 2001
Cartagena Protocol to control the Transboundary Movement of Living Modified Organisms resulting from Biotechnology	7 September, 2000	
Stockholm Convention on Persistant Organic Pollutants (POPs)	May, 2002	

(extracted in part from CIESIN, 2000 for compilation)

2.4 Planning documents

The traditional national development plan (NDP) which was normally produced by Government was changed from NDP7, in the mid 1990s, into what is now known as the National Development Strategies (NDS) over a span of four years. To reach objectives of the NDS, medium term strategies (MTS) were formulated

2.4.1 National Development Strategies (NDS)

<u>1996-1999</u>

Government's National Development Strategy (NDS8) within this period primarily focused on economic priorities of Government and on how Government will approach economic development. The overall goal of this period was simply to "**generate a sustained, positive, real rate of economic growth per person**".

NDS8 focused on key reforms in support of economic development, recognizing Kiribati's scarce resources that can not be stretched over an increasing number of varied activities and also recognizing the need to continue to strengthen social and public services and governance in support of development (RoK, 1996).

<u>2000-2003</u>

In promoting improvement in the standard of living for the people of Kiribati, a sustained development and real economic growth are vital. To achieve this, structural and economic reforms within both government and private institutions are required, aiming at bringing in social and cultural improvements and elevate the present standard of living through working together for prosperity and peace (RoK, 2000).

Kiribati aims for a significant increase in real per capita incomes, along with steady growth in employment and gains in improvement of education, health, environmental protection, and social indicators (RoK, 2000). These will be accomplished through public sector reform, creating an enabling environment for private sector development and finally human resources development.

2.4.2 Medium Term Strategy (MTS)

The overall goal of the first National Development Strategy (RoK,1996) is to "generate a sustained, positive, real rate of economic growth per person".

From an environmental perspective, the main goal is sustainable development of a fragile atoll environment through the following medium term objectives (NEMS, 1994):

1) integrating environmental considerations into economic development;
2) improving environment awareness and education;
3) development and protection of the resource base;
4) improving waste management and pollution control; and,
5) balanced development, planned urbanization, and lower population growth rates

The second NDS (RoK, 2000) has identified environmental policy priorities as follows:

- seek awareness, compliance and enforcement of the Environment Act;
- develop process and procedures for development control, environmental impact assessment and pollution licensing;
- conduct community awareness and education programs on protecting the environment, managing natural resources, environmental health and sanitation;
- protect water reserves;
- provide landfill sites for managed waste and refuse disposal to minimize lagoon and coastal pollution;
- protect lagoon ecology; improve coastal protection for threatened areas;

- encourage conservation promotion areas and
- draw attention to detrimental use of foreshore areas.

2.4.3 National Environmental Management Strategies

The Kiribati NEMS began its preparation in the early 1990s through the process of consultation with relevant stakeholders and was finally adopted by government in 1994 but later incorporated in the NDS 1996. NEMS aimed at identifying major environmental issues at the national level and prioritising environmental programmes required to address the issues.

The success of the NEMS, several years after its adoption, could be regarded as moderate due mainly to the lack of adequate resources, financially, human and technologically, at the local level to address many issues. However, a fair amount of progress has been evident in many areas notably integrating environmental considerations into economic development (objective 1), through EIA and the recent enactment of the first Environment Act (1999) and various environmental awareness and education (objective 2) efforts by both government and NGOs.

To a lesser extend, the development and protection of the resource base (objective 3), improving waste management and pollution control (objective 4) and balancing development, planned urbanization and lower population growth rates (objective 5), are not yet well implemented but actions are now gradually commencing by relevant government institutions and other interested NGOs.

Most of the NEMS programmes are beyond the national capability and capacity to implement and hence assistance has been sought externally through various regional organizations like SPREP and SOPAC, as well as international bodies and countries such as GEF, UNEP, UNDP, AusAID and USAID. An estimated 70 % of the programmes have been implemented, of which some do not have a 100 % coverage in scope and content or were not implemented satisfactorily. Some of the programmes are still on-going so the actual success of NEMS cannot be accurately assessed unless a full review is undertaken. However, NEMS can be revised to reflect current situations of the state of the environment of Kiribati.

2.5 Maps

The Lands and Management Division (LMD) has available all topographic maps of all the islands in the Gilbert group, the 3 inhabited islands (Tabuaeran, Teraina & Kiritimati) of the Northern Line group and Kanton in the Phoenix group. The following are available at SOPAC:

Map Series	Year	Description	Scale
28	1995	Bathymetric of Tarawa Lagoon	1:45,000
26	1995	Bathymetric of Temaiku Bight	1:3,500
25	1995	Bathymetric of Tarawa lagoon aggregate resource area	1:8,500
17	1995	Bathymetric of Line Islands - EEZ	1:4,800,000
16	1995	Bathymetric of Phoenix Islands - EEZ	1:4,500,500
15	1995	Bathymetric of Gilbert Islands - EEZ	1:4,800,000
Report 137	1991	Sampling cruise for manganese nodules and cobalt crusts in Gilbert Islands	
Report 131	1990	Report on cruise of Kiribati EEZ Aug. - Sept. 1989	

Also available at SOPAC are:

1. A GPS Control Survey (Teakle & Biutoko, 2000) of South Tarawa,
2. Abaiang Atoll map (Smith, 1999) on:
    i. Bathymetry

ii. Surface temperature distribution
iii. Lagoon salinity distribution
iv. Dissolved-oxygen (mg/L) distribution
v. Lagoon turbidity (m)

2.6 Aerial photographs:

These are currently available:

Set ID	Location	Scale	Altitude	Year	Agency	Colour	Snaps
8	S. Tarawa - Bairiki		5,000'	[1968]		No	0
9	Tarawa			1943		No	0
10	Tarawa		17,000'	1943		No	0
11	Tarawa		5,000'	1943		No	0
12	Tarawa			[194-]		No	0
13	Tarawa		20,000'	1945		No	0
14	Tarawa			1968		No	0
15	Tarawa			1968		No	0
16	Tarawa			1969		No	1
*	Kiritimati	1:8,000		1957			
*	Kiritimati	1:10,500		1955			
*	Kiritimati	1:15,000		1957			
*	Kiritimati	1:25,000		1958			
*	Kiritimati	1:34,000		1958			
*	Kiritimati	1:50,000		1957			
166	Kiribati			1968/69	Aust. Central Photo Establishment	No	0
167	Tarawa	1:10000		1945,1959, 1968/69	UK. Directorate of Overseas Survey	No	0
168	Kiribati	1:10000	5,000'	1969	Fiji. Lands Department	No	0
169	Kiribati	1:10000	5,000'	1969	Ditto	No	0
170	Abaiang-Tebunginako			1968		No	0
247	S.Tarawa-Nippon Causeway	1:3000 approx	3,000'	1992	SOPAC	Yes	0
248	S.Tarawa - Betio	1:3000 approx	3,000'	1992	SOPAC	Yes	0
249	S.Tarawa - Bairiki	1:3000 approx	3,000'	1992	SOPAC	Yes	0
250	S.Tarawa - Temaiku	1:3000 approx	3,000'	1992	SOPAC	Yes	0
251	Kiribati - S. Tarawa	1:3000 approx	3,000'	1992	SOPAC	Yes	0
252	S.Tarawa -	1:3000	3,000'	1992	SOPAC	Yes	0

	Bikenibeu	approx					
253	S.Tarawa - Bonriki	1:3000 approx	3,000’	1992	SOPAC	Yes	0
254	Abaiang - Tebunginako	1:1300 approx	1,300’	1993	SOPAC	Yes	4
255	Abaiang - Tabontebike	1:1300 approx	1,300’	1993	SOPAC	Yes	6
256	Nikunau-Tabomatang	1:1300	1,300’	1993	SOPAC	Yes	15
257	Beru - Taboiaki	1:1300	1,300’	1993	SOPAC	Yes	10
266	Tarawa		6,350’	[1968]		No	0
276	Kiribati			1989		No	0

(Source: Http://www.sopac.org.fj/Data/Aerial/Index.html & * from Jenkins & Foale, 1967)

2.7 Satellite imagery/Geographical Information System:

SOPAC/SPOT Images:

1. Abaiang, Kiribati, im0022
2. Tarawa, Kiribati,
3. Rawannawi, Kiribati, im0021

There may be other images and maps available but were not sighted during preparation of this report.

Chapter 3. Climate

3.1 Introduction

3.1.1 General

The weather in Kiribati is typical for its location in that it is warm all year round with characteristic wet and dry months occurring in a typical year. This bi-annual mode is largely controlled by the earth's path around the sun with the wetter and warmer months from November through to April and the drier months from May to October. The seasonal movement of the Inter-tropical Convergence Zone modulates the rainfall in the country as it passes to and fro over the equator.

The situation of the country in respect with the equator means that the predominant wind direction is from the South-East. This is due mainly from the returning limb of the Hadley Circulation as it travels over the surface from the mid-latitudes. The coriolis effect deflects this returning body of air so that it results in a south-easterly flow from around 5^{o} South of the equator. The same is true of the northern component of the Hadley Cell, resulting in a north-easterly flow just north of the equator. These are better known as the trade winds. This flow over the country is disrupted periodically during ENSO episodes when the Walker cell breaks up and moves east towards the International Dateline, resulting in strong westerlies over the country. During El Nino years, most of the country is wetter than normal as the low pressure areas north of Australia and over Indonesia, move east towards the International Dateline passing over the country. This phenomenon is characterized by warm sea-surface temperatures spilling over the tropical pacific from the west, reaching as far east as the central pacific. During this time, the weather is characterized by brisk westerlies with occasional strong storms passing through the country bringing with it more rain. The opposite is true during La Nina events when the reverse occurs and the country is drier than normal leading to droughts as these become extreme.

3.1.2 Availability of Data

The data used in this report is obtained mainly from the meteorological records from the Meteorology Office in Betio, Tarawa. These are for the main climatological parameters of rainfall, temperature, surface pressure, wind, relative humidity and sunshine over the period 1946 to 2002. Much of this data is not complete for the outer islands including that of the Line and Phoenix group, though enough of what is present is sufficient for the purposes of this report.

All this is also supplemented by information obtained from the various reports published in the recent past mainly for water related projects and activities and the Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC)

3.2 Present State of the Environment

3.2.1 Temperature

Air temperature on land is fairly constant throughout the year, with variation of only a few degrees; mean temperature is about the same for all islands and very slightly higher for the southern Gilbert Islands. Likewise, air temperature at sea is also similar. Sea surface temperature of ocean is almost constant throughout the year, with slight variations occurring on a bi-annual basis. This variation is enhanced by the sea-saw of warm pool as it swings to and fro across the pacific during ENSO episodes. Temperature range records according to the sea level monitoring indicate a range of 29 - 30^{o}C year round with an increase of around 1 - 2^{o}C during El Nino years.

There are very small seasonal differences. Low variations in temperature are due to constant sea temperature throughout the year. Average daily minimum temperature is 25^{0} C and daily maximum lies between 31^{0} C to 33^{0} C and rarely exceeds 34^{0} C (Shalev, 1999).

3.2.2 Atmospheric pressure

All of the islands in the Gilbert group lie close to the Equator and in the equatorial belt of low pressure with little seasonal change and regular diurnal changes of small magnitude (Sachet, 1957) as table 3.1 shows.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	10083	10086	10091	10095	10096	10097	10097	10099	10101	10100	10090	10083
High	10111	10108	10123	10128	10116	10118	10117	10118	10120	10117	10126	10106
Low	10059	10059	10074	10078	10080	10080	10079	10082	10083	10084	10076	10061

Table 3.1: Atmospheric pressure at surface recorded at Betio, Tarawa for the period 1947 – 2000.

3.2.3 Humidity

The relative humidity has a high range of 75 to 85 % for the Gilbert but lower in Kiritimati. In such high temperature and humidity, adequate ventilation is essential for personal comfort.

3.2.4 Solar radiation

Annual sunshine was estimated from mean monthly cloud amounts from satellite observations. The estimates only give an indication of the annual sunshine and appear to understate the actual value by about 10% (Shalev, 1999). Records for solar radiation at Tarawa since 1979 and Kiritimati (NORPAX) are available in Table 3.1 as mean daily values.

Table 3.2 Mean daily solar radiation at Tarawa

Island	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tarawa	207	214	214	201	198	193	191	208	243	225	234	200	211
Xmas	5.19	5.47	5.67	5.58	5.45	5.20	5.42	6.03	6.03	5.98	5.57	5.12	5.56

(Shalev, 1999: Units – Tarawa (0.1 megajoules/sq.m) – Xmas (kwh/sq.m)

Table 3.1 shows the highest radiation level occurring in February and March (during the first half of year) and September in the second half of the year, as the sun reaches its highest elevation at noon. It is least in July and December when the sun does not pass directly overhead (Shalev, 1999).

3.2.5 Wind

Butaritari and Beru stations record daily wind speed at 0600 hrs while at Tarawa, Arorae and Banaba observations are made daily at 0900 hours. Of the five stations, Tarawa which possesses an anenometer, records the most reliable data (Shalev, 1999). Kiritimati records the same and has data from 1953 to 1981.

Wind speed ranges from 5 to 10 knots, where the highest is normally experienced during February and March, especially on Tarawa. Winds generally prevail from between north-east and south-east.

Strong winds, faster than 22 knots (22-27 knots & gale >= 33 knots), are rare and

occur on average 2 or 3 days per year. Variation of speed is diurnal and usually highest in the early afternoon. The annual average wind energy density for the region based on navigational reports, ranges from 140 to 160 watts/sq.m. at 15 m above mean sea level (Shalev, 1999).

3.2.6 Cloudiness

Sky in the Gilbert is characterized by scattered or broken clouds, fog is unknown, and haze is rare. Deep blue skies and brilliant sunshine is typical of the islands' climate (Sachet, 1957). This applies to the rest of Kiribati, in the Line and Phoenix groups.

3.2.7 Rainfall

Annual volume of rainfall varies from island to island, with the northern islands of the Gilberts group being generally wetter than the central region while the southern Gilbert Islands are the driest. This general pattern of rainfall is highly modulated by ENSO episodes with higher rainfall occurring during El Nino years and less during La Nina events. Figure 3.1 shows typical annual rainfal at representative locations around the country including Butaritari in the northern Gilberts, Tarawa in the central Gilberts and Arorae at the southern Gilberts, as well as Kiritimati in the Line Islands.

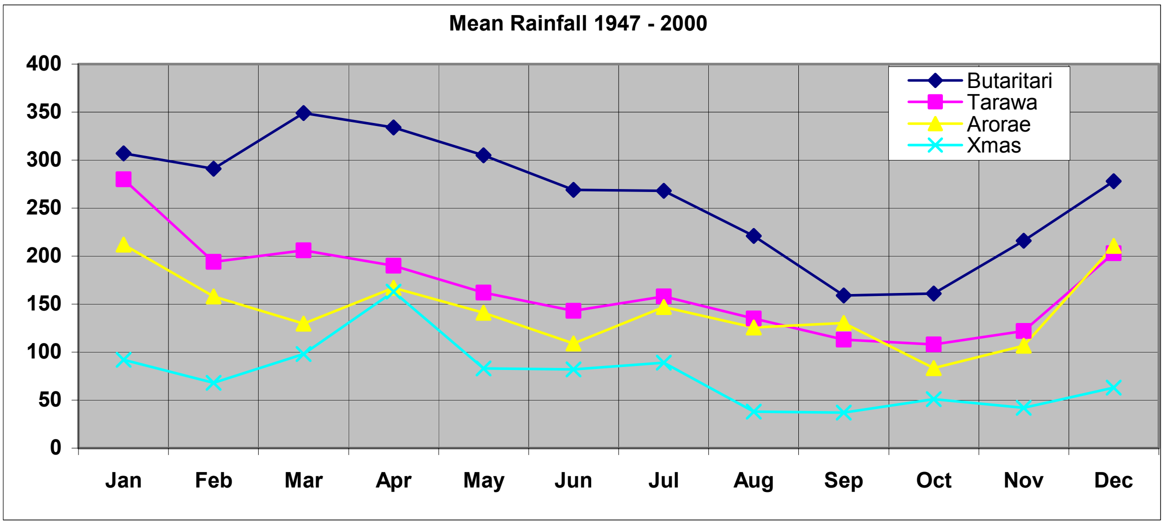

Figure 3.1 Mean annual rainfall for representative islands in the country for the period 1947-2000

A summary of rainfall data obtained from the Meteorolgical Service Center in Betion for the second half of the twentieth century indicates that, in an average year, annual rainfall ranges is as shown in Table 3.3.

Table 3.3. Summary of rainfall in an average year from 1950 - 2000

Region	Rainfall (mm)
Northern Gilberts	3099.7
Central Gilberts	2011.4
Southern Gilberts	1892
Line Group	811.4

Rainfall distribution, in terms of mean and distribution patterns, varies significantly from island to island throughout the country. Long droughts of up to 16 months are relatively common and yearly rainfall in the Gilberts ranges from 3,000 mm in the northernmost islands to 1300 mm near the equator.

Preliminary rainfall data of some of the Gilbert Islands for the 20th century is illustrated in Figure 3.2.

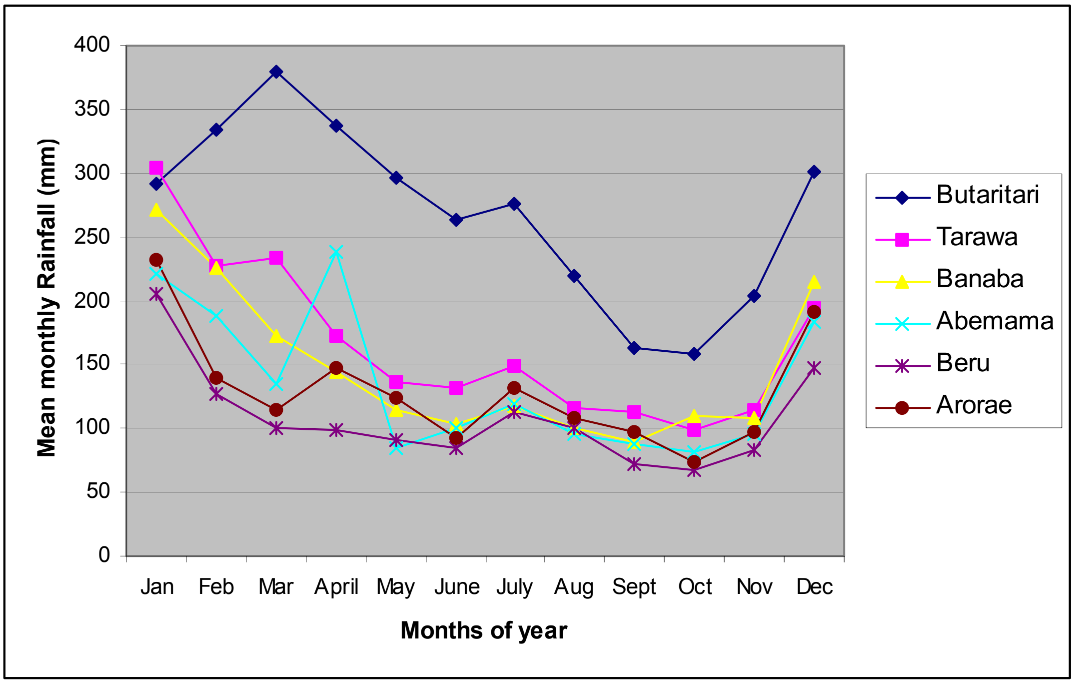

Figure 3.2 Mean Monthly Rainfall from 1951-1980 (source: Shalev,1999)

Figure 3.2 shows the mean monthly and annual rainfall (mm), during 1951-80 for some islands of the Gilbert Group as obtained from the 1987 report on climate published by the New Zealand Meteorological Service. In normal years the wettest months are December to February and the driest from August to October (Clouds, 1952).

3.2.8 Droughts

Rainfall is strongly correlated with ENSO events leading to periodic, prolonged droughts. During droughts, over-extraction of water, direct evaporation through crops such as coconuts, breadfruit and pandanus or inappropriate abstraction methods and storm surges can salinise the freshwater lens and result in the death of crops such as breadfruit (White & Falkland, 2001).

Severe droughts have occurred in the central, southern Gilberts, the Phoenix group and Kiritimati, lasting many months, when annual rainfall can be as low as 3 to 20 in. These periodic droughts are from 5 to 7 years in cycle. Severe droughts had reportedly (Sachet, 1957) occurred in 1925, 1926-27, 1938-39, 1950 and 1955. A more recent drought period occurred in 1998-99 when the Government declared that Kiribati was in a national state of emergency.

3.2.9 Natural hazards

Storms and cyclones are rare, but a record of a hurricane crossing the Gilbert islands in December 1927 that hit the two most northern islands of the Gilbert group, Little Makin and Butaritari. On both islands, severe southeasterly gales lasted for nearly 12 hours in January of 1928 that did considerable damage to property and coconut trees and fortunately there was no life loss (Sachet, 1957).

There are no similar events within existing records apart from exceptionally high spring tides resulting in “overwash” of the low lying atolls.

3.2.10 Evaporation

Evaporation rates are low in June and December and high in March and September.
In summary the range is from 130 to 250 mm a month. This is illustrated in Figure 3.3
Of the monthly evaporation for Betio from 1982 to 1988.

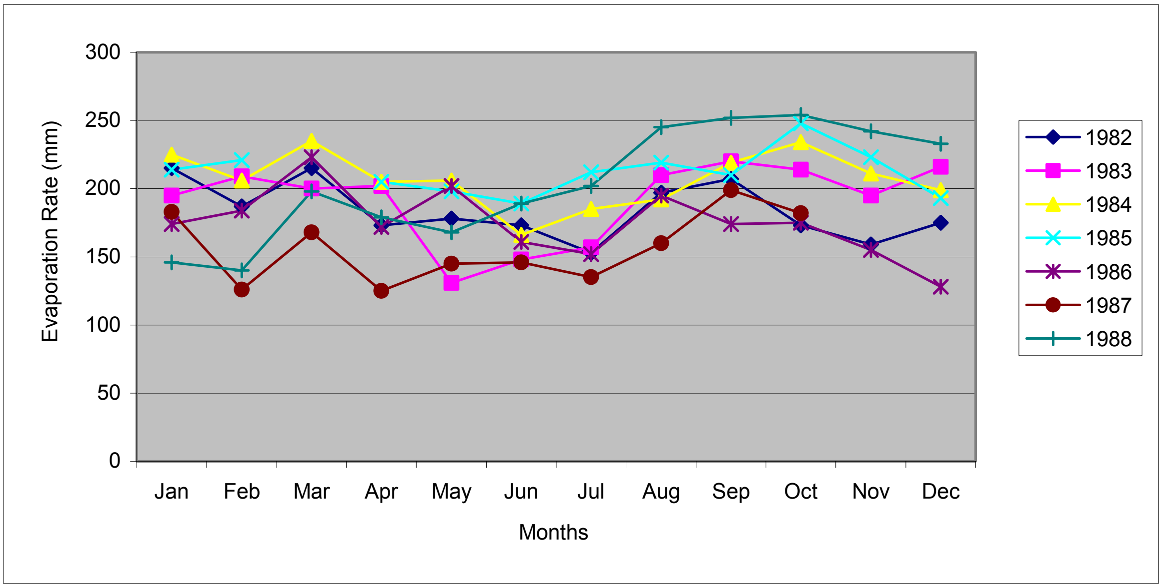

Figure 3.3 Mean Monthly Evaporation rate at Betio (Shalev, 1999)

Potential evapotranspiration can be obtained by multiplying pan evaporation with an appropriate pan coefficient (normally 0.8), expressed in units of water depth (mm). Evapotranspiration and rainfall interactions forms the basis for soil water balance (Shalev, 1999).

3.2.11 Sunshine

For the equatorial islands, sunshine hours are high with average length of daylight remains between 11.75 and 12.25 hours, giving a uniform distribution of radiation all year round.

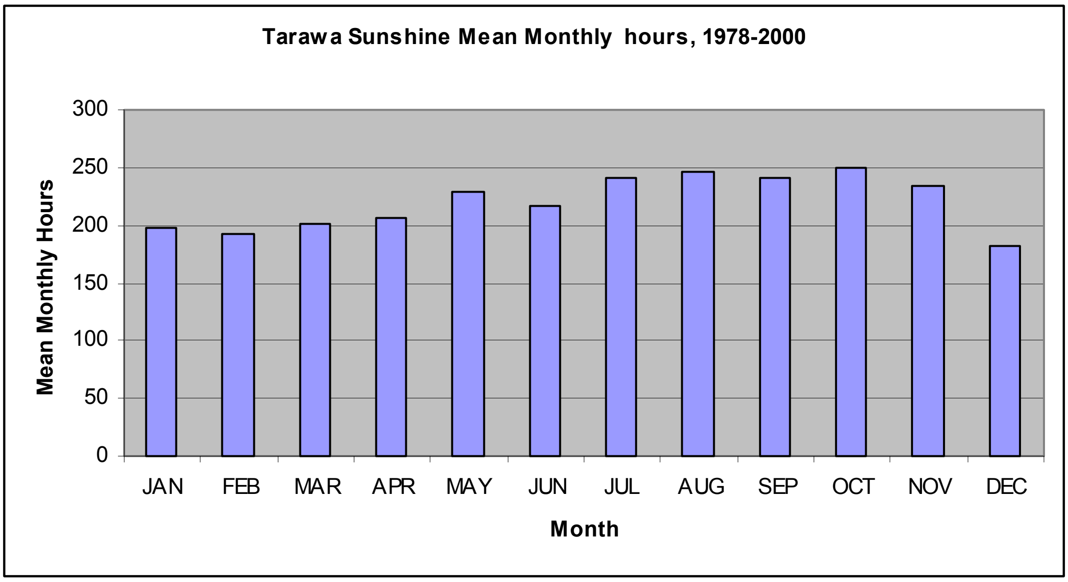

Figure 3.4 Mean monthly sunshine hours, 1978-2000 (ECD, 2001)

Tarawa's sunshine hours per month from 1978 to 2000 and daily average from 1995 to 2000 are illustrated in Figures 3. 4 and 3.5 respectively. From May to November, hours of sunshine exceeds 200 while December to April are below 200 hours of sunshine.

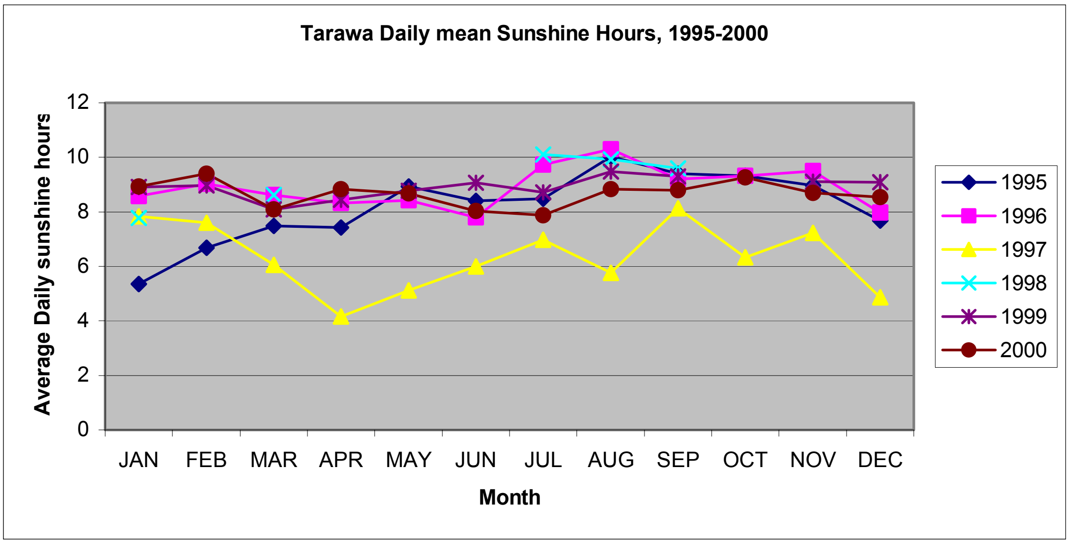

Figure 3.5 Mean daily sunshine hours, 1995-2000

3.3 Data Gap

Information on sunshine and radiation is limited due to short period for which records have been kept.
Temperature for Butaritari, Beru, Arorae, Kanton
Quantitative data on humidity, cloudiness, temperature inversion, etc.

Chapter 4 Geology

4.1 Introduction

4.1.1 General

Kiribati consists of geologically young coral atolls with low elevation above mean sea level and generally flat. With the exception of Banaba and some sites in Kiritimati, elevation ranges of the islands rarely exceed 4 m above mean ocean water level. The islands are elongated and so narrow that it is possible to see both the ocean and lagoon sides of the island from the middle of the island. This makes them entirely coastal, with regard to their influence by the sea, geographical disposition and their relative relief.

A summary of the relative time scale during which most of the islands were formed is given in Table 4.1 below. Most of the Islands in Kiribati forms at these epochs most commonly during the Pleistocene and recent Holocene epochs

Table 4.1 Timeline for some Kiribati Islands Formation Relative Geologic Time Scale

Era	**Period**	**Epoch**		
Cenozoic (New life) -66 m.a to the present	Quaternary	Recent (Holocene)	Human life exists	
		Pleistocene (Ice age)	Recent Ice ages	
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene		Tarawa Atoll formation
Mesozoic (Middle life) -245 m.a	Cretaceous Jurassic Triassic		Dinosaurs flourished	
Paleozoic (Old life) -545 m.a	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian		Abundant and complex life indicated by fossils (creatures with shells or other hard parts)	Kiritimati Island forms Horizontal layers of the Grand Canyon forms
Precambrian Time				

(Plummer & McGeary,1996)

4.1.2 Availability of Data

SOPAC's technical reports on coastal studies in South Tarawa have exceeded 50 in number. These reports have identified sources and amounts of sediment production, historical shoreline changes, beach dynamics through beach profiling, coastal processes, mapping and management with few studies focusing on the outer-islands of the Gilbert group.

The Ministry of Natural Resources Development (MNRD) houses copies of these SOPAC reports and provides raw data on beach profiling twice every year on South Tarawa. Through the Mineral Management Unit, efforts are being initiated to cover the outer-island surveys.

A few studies had been undertaken on various islands. Onotoa in the southern Gilberts has been studied for its geology and marine environments (Cloud, 1952). Kiritimati in the Line Islands has also been studied for its environment during its plantation period in the 1960s (Jenkin & Foale, 1968). Soils of Abatao Islet in North Tarawa has been studied in some detail (Morrison & Seru, 1985) simultaneously with the Holocene growth of Tarawa (Marshall and Jacobson, 1985). Later, the developments of the atolls in the Gilberts of western Kiribati were studied (Richmond, 1992) followed by the geology and hydrogeology of both Tarawa and Kiritimati (Falkland & Woodroffe, 1997), but more recently Makin island of the northen Gilbert was studied for its reef accretion and soil development (Woodroffe & Morrison, 2001).

Several other reports like Woodward (1982) had also covered a considerable scope of the topic in Kiribati but were not sighted during literature research for this report.

4.2 Present State of the Environment

4.2.1 Geomorphology

Atoll islets in the Gilberts are some of the youngest and most dynamic of Earth landforms. Makin island, the most northern in the Gilbert group, was found to be geomorphologically simple, consisting of one large reef island with a residual lagoon, and several smaller sandy islands (Woodroffe & Morrison, 2001). Like most atolls of which are young soils by geological standards (Morrison, 1990), Makin could be geologically young (Gillie, 1993).

Tarawa atoll is roughly triangular in shape and has chains of small islets along the south which houses the capital, South Tarawa, and northeast sides that partially enclose a lagoon the islets are generally between 2 to 3 m above present sea level (Marshall & Jacobson, 1985).

The basic sequence of islet development has been summarized (Richmond, 1992) as follows:

1) Development of a reef platform at about mean low tide level;
2) Formation of sub-aerially exposed and cemented storm deposits of remnants or emergent reef;
3) Further accumulation of reef detritus around the sub-aerial deposits coupled with stabilization of the islet.

Cementation is common within stable inter-tidal ocean side deposits. Islet development of the basic sequence varies widely (Richmond, 1992), in part dependent upon local oceanographic conditions, storm magnitude and frequency, local sea level history, neo-tectonics and reef ecology (Cloud, 1952).

Kiritimati in the Line Islands, one of the older Pacific archipelagos, was formed between the Cretaceous and Eocene divisions of the Late Mesozoic and Early Cenozoic periods on a line of submarine volcanoes (Menard, 1964 in Jenkin & Foale, 1968).

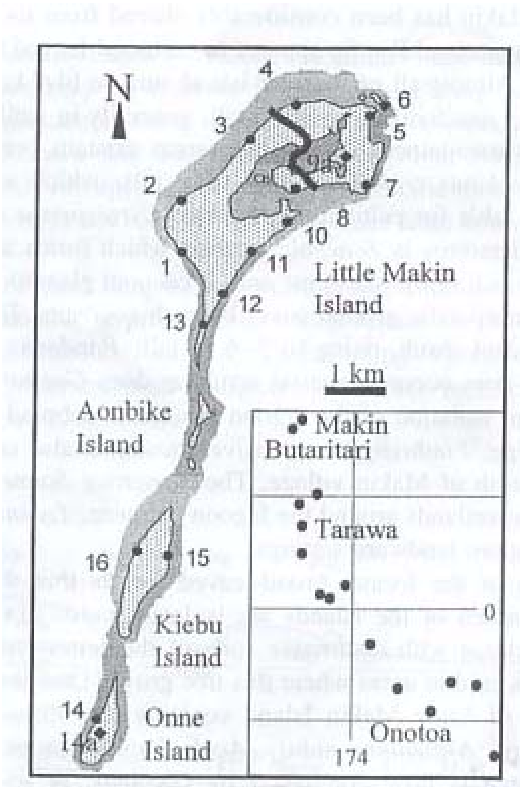

Figure 4.1 Makin Island (Woodroffe & Morrison, 2001)

4.2.2 Sediments & soils

Generally, atolls of Kiribati are fairly uniform in composition, mainly of sand of coral origin, but predominantly foraminifera, resting on a reef platform. The main components found in soil are coral and organic matter (Catala, 1957).

It has been suggested (Woodroffe & Morrison, 2001) that sediment on Makin is transported rapidly from its area of production on the reef flat to the beach face. Accretion began in the center of the reef platform some 2500 years ago and has prograded gradually to the west. Towards the east though, a more complex pattern of accumulation must have occurred, encapsulating a lagoon.

The beach sediments are derived almost entirely from carbonate production within the overall reef eco-system (Burne, 1983). Typically the sands are composed predominantly of foraminifera, with lesser proportions of coral, mollusks and coralline algae (Woodroffe & Morrison, 2001). Reef islands depend on growth of foraminifera, and calcareous green algae, especially *Halimeda*.

Tarawa similarly has coral sand as its surface material. Cay rock which is cemented reef top sediment existing with outcrops on the edges of the islets forming a terrace of approximately 2 m above sea level. The island's lithology comprises a common sequence of cemented reef top sediment (cay rock); unconsolidated sediment of sands and gravels; corals and leached limestone (Marshall & Jacobson, 1985).

Tarawa is on top of a seamount which rises steeply from 4000 m of water (Marshall & Jacobson, 1985). Below 30 m of depth, Pleistocene limestone lays but its thickness is unknown and comprises of skeletal wackestones and packstones (Falkland & Woodroffe, 1997).

A soil map of Abatao islet in North Tarawa at scale 1:10,000 (Figure 4.2) was prepared by Morrison & Seru (1985) through a training workshop of soil classification. The soils are highly calcareous with high pH and problems of micronutrient deficiencies that limit agriculture. Some top-soils are high in organic carbon and nitrogen but these elements are low in all sub-soils. Phosphorus and potassium are generally low (Morrison & Seru, 1985).

Cloud (1952) found that only a few types of soils were recognized on Onotoa namely:

1) Loose limestone with well-marked humus layer;
2) Loose lime-sands without humus layer known as younger dune sands;
3) Tight-packed, low-lying, generally damp and brackish lime-silts and very fine grained lime-sands;
4) Indurated phosphatised lime-sands or older dunes;
5) Coarse gravels;
6) Pebble gravel.

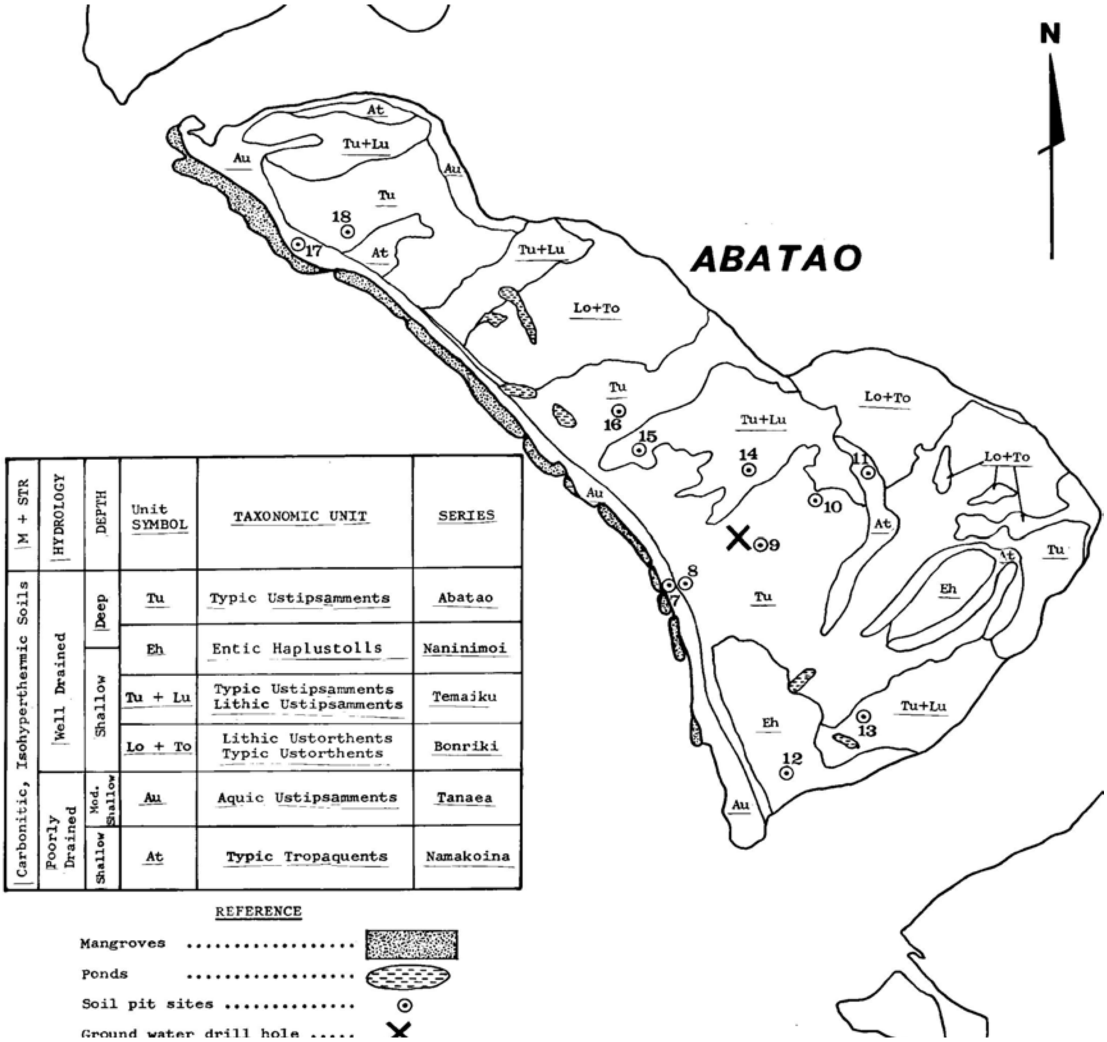

Figure 4.2 Abatao Soil Classification (after Morrison & Seru, 1985)

Organic sediment producers are fish, echinoids and holothurians in lagoon sedimentation. The calcareous joints of the green alga *Halimeda* dominate lagoon sediments. Foraminifera shells and joints, coralline algae, tests of ostracodes and spicules of gorgonians and other alcyonarians, including detritus products, contribute to lagoon sediments due to abrasive wave action (Clouds, 1952).

4.2.3 Stratigraphy

The formation of atolls based on the sea level subsidence theory corresponds to three phases of Holocene development (Falkland & Woodroffe, 1997). During the first phase, when the sea level was high, the reef rapidly grew vertically, followed by the second phase of reefs catching up with sea level thus reef flat formed and finally the formation of reef islands in the last phase. Most atolls rise from an ocean floor that is probably >4,000 m deep. Variations in subsidence history are reflected in stratigraphy of the atolls as illustrated in Tarawa and Kiritimati.

4.2.3.1 Tarawa

From bottom to surface of the atoll, the ascending order is a basal, leached, reefal limestone; a coral unit; consolidated sand and gravel; and cemented conglomerate or cay rock (Falkland & Woodroffe, 1997).

Cay rock is cemented by aragonite making it extremely coherent. Skeletal components of cay rock and unconsolidated sediment consist of gravel-size and sand-size fragments of corals, coralline algae, mollusks and echinoids and abundant tests of the reef foraminifera *Calcarina*. Cay rock commonly outcrops above sea level and extends to depths of 3 m below mean sea level in places. The unconsolidated sediments beneath the island extend down to 12 m below the surface. Cay rock, now known as cemented conglomerate, is like beachrock which is a product of marine vadose cementation with well-developed meniscus cements and smoothly rounded pore outlines (Marshall & Jacobson, 1985).

Coral sequence starts from 2 to 12 m thick, consisting of coral heads up to about 1 m high interspersed with fragments of branching corals and sand. Some extensive encrustation of branching coral framework by coralline algae exist with infilling of both intra-and inter-skeletal cavities by internal sediments and cements of acicular aragonite, Mg-calcite micrite and peloids to form a reef rock (Marshall & Jacobson, 1985).

From drillhole logs (Figure 4.3) the distribution of various lithologies, the position age of samples and the present day lower interface of the freshwater lenses were shown.

Corals show progressive stages of diagenesis with depth; some indicative of freshwater vadoes diagenesis; others show progression from freshwater to marine phreatic environment while corals in the latter retain their aragonite mineralogy (Marshall & Jacobson, 1985).

4.2.3.2 Kiritimati

Kiritimati Island, the largest atoll in the world is an unusually large coral atoll with a remarkably extensive large land area in particular. An uncharacteristic large proportion of the reef platform and of the surface is presently sub-aerial and radiocarbon dating indicates that these lagoonal reefs flourished between 4500 and 1500 radio-carbon years BP. Wentworth (1931) indicated that he considered the island to have been developed under a slightly higher sea level. Surveying confirms that sea level was 0.5-1.0 m above present at that time, with sub-aerial exposures resulting from Late Holocene emergence. With the Holocene and last inter-glacials which has resulted in a minor thin-covering of coral over older limestone surfaces, Kiritimati Island is considered characteristic of an atoll that has not experienced significant subsidence through the Late Quarternary. (McLean & Woodroffe, 1998).

The island is comprised of coral limestone above the volcanic basement which is about 120 m thick but can be as little as 30 m thick at the western end of the island. Pleistocene limestone crops out on the surface on Kiritimati island. Isolated limestone outcrops have lithified and recrystallised containing sparse coral clasts existing within the elongated, infilled lagoon along the northern coast of the island (Falkland & Woodroffe, 1997).

Mollusc-rich calcareous marls dominate the subsurface of the island interior. The top 18 m is predominantly aragonite. Unconsolidated sediments and older, harder limestone is at 10 – 20 m. The hyper-saline lakes are fringed by coral and *Tridacna* assemblages (Falkland & Woodroffe, 1997).

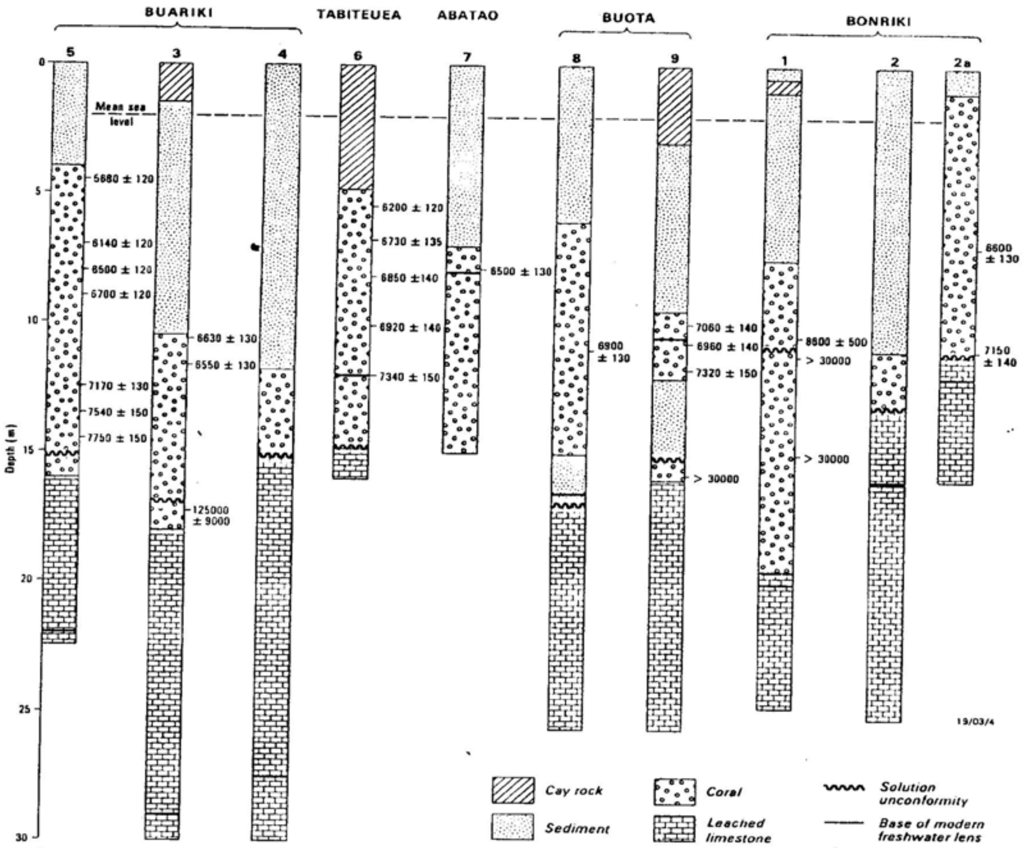

Figure 4.3 The distribution of various lithologies in Tarawa (after Marshall and Jacobson, 1985)

4.2.4 Mineralogy

Apart from soil phosphate deposits associated with bird attraction to tall vegetation (Woodroffe & Morrison, 2001), land mineralogy is limited to calcite and aragonite (Morrison & Seru, 1985) as illustrated at Abatao (Fig. 4.2), an islet in rural North Tarawa.

Deep-sea minerals, e.g., manganese nodules and cobalt-rich manganese crusts are the only potential resources of Kiribati. A survey of the EEZ of Kiribati was undertaken in 1987, 1989 and 1991 as part of the Japan/SOPAC deepsea mineral resources programme (Kojima, 2001).

4.2.4.1 Phoenix group waters

Manganese nodules occur discontinuously in general. The high-abundance area (>10kg/m^2) is limited to the southeastern part of the survey area, which is the southernmost boundary on the Nova Canton Trough extending from the eastern edge to the east-northeast, covering approximately 6600 km^2. The average values of the samples analysed and abundance ranges and average composition are given in Table 4.1.

In 1987, five seamounts were surveyed for cobalt rich crusts; they are mainly composed of basalt, pyroclastic rocks and limestone, associated with phosphate rocks and foraminifera. The cobalt crusts were found (Kojima, 2001) to be well developed, except for limited distribution at one site. Crust generally occurs at top and along the slope of seamounts. The average and range of the crust thickness at all sampling stations (32) with the average chemical composition of analysed samples (123) are shown in Table 4.2.

4.2.4.2 Line Island Waters

The eastern region has higher manganese nodule abundance than the western side. Average abundance of eastern area is 6.56 kg/m^2 but in the western area is 2.94 kg/m^2. The highest abundance and average abundance, together with the average composition data are given in Table 4.1.

Table 4.1 Chemical composition and average abundance of Manganese nodules at surveyed areas

Manganese Nodules	Average Values (%)			Average abundance (kg/m^2)	Abundance range (kg/m^2)	
	Co	Ni	Cu			
Phoenix	0.22	0.60	0.60	4.45	0	34.74
Line	0.20	0.84	0.57	4.37	<2.5	>10.0
Gilbert	0.23	0.96	0.96	1.54	<5.0	<5.0

(extracted from Kojima, 2001)

Six seamounts were surveyed (Kojima, 2001) around the Line Island Ridge, Vostok and Flint Islands. They are mainly composed of basalt, hyaloclastite, pyroclastic rocks, paleo-sediments and limestone. Average crust thickness is 19.5 mm. Sampled crusts vary in thickness from a patino to 200 mm. Thick crusts were found at the summits and upper part of slopes in water depths below 1500 m and on substrates of sedimentary rocks, pyroclastics, phosphorite and hyaclastite. Substrates of basalt and limestone had thin crusts. The average chemical composition of the analysed samples is shown in Table 4.2.

4.2.4.3 Gilbert Group Waters

Manganese nodules abundance found in this area is less than 5 kg/m^2 (Kojima, 2001). The average abundance from 46 stations is much lower than those of the Line and Phoenix survey areas. Averaged chemical data on samples are shown in Table 4.1.

Five seamounts in the chain and around Tarawa were surveyed; they are mainly composed of basalt, hyaloclastite, pyroclastic rocks, limestone and sandstone. These rocks are predominantly overlain by unconsolidated sediments such as foraminifera-bearing sand ooze (Kojima, 2001).

The average and range of the crust thickness of the surveyed seamounts are in Table Y. The thickness of crusts generally increases as the water depth increases and is thickest at depth range 3000-3500 m. Substrate of basalt, limestone and hyaloclastite have thicker crusts than other substrates, such as tuffs, tuff breccias, conglomerates and phosphorites (Kojima, 2001). The chemical composition of the analysed samples is also given in Table 4.2.

Table 4.2 Average thickness and grade of cobalt-rich crusts at Survey Areas

Cobalt-rich Crusts	Average chemical composition (%)					Crust thickness range (mm)		Crust thick Average (mm)
	Co	Ni	Cu	Mn	Fe			
Phoenix	0.78	0.66	0.11	25.38	14.48	A patina	80	17.0
Line	0.62	0.60	0.12	20.59	13.99	A patina	200	19.5
Gilbert	0.69	0.58	0.10	22.87	17.95	A patina	65	12.0

(extracted from Kojima, 2001)

4.3 Pressure on the State of the Environment

4.3.1 Disturbance of reef flat ecology for reef build-up

The traditional practice of removing coral boulders, including beach rock for home and sea wall construction is very destructive. Due to low population in the past, such practices were rare and hence exploitation of the reef resources was quite low. With growing population and urbanisation, particularly on South Tarawa, construction materials are more intensely needed, thus accelerating exploitation of these long-term depositional natural resources.

4.3.2 Mining of sand and gravel

Sand and gravel are traditionally vital materials for home beautification. Building of permanent shelters/houses requires the same materials but in higher volumes. Brick making and construction of large infrastructures has warranted the mining of sand and gravel along the shore and reef flats. This had and continues to have impact on shoreline stability; with weakening at some locations along South Tarawa, dry land has been invaded by sea, particularly during exceptionally high tides.

In 1998, LMD started to enforce regulations controlling the mining of sand and gravel. The record (LMD, 2001) showed 1998 with 30 licencees, followed by 34 in 1999, 11 in 2000 and so far 6 in 2001. The record may show a decline in licences, but it is difficult to police this activity, particularly after working hours, suggesting that many miners may be operating illegally. Other arrangements may be made between operators and land owners concerned that were outside Government procedures. This procedure adds revenue to Government of $100 per annum (or $25 per quarter). Figure 4.4 shows the number of licenses issued over the years as managed by the LMD

4.3.3 Blasting of reef for boat channels

Another human disturbance activity at reefs is the construction of channels for boat and canoe passage for navigational and fishing purposes. Blasting the reef with dynamite is very destructive, interfering with a whole range of physical, geomorphological and ecological processes (Kaly & Jones, 1991)

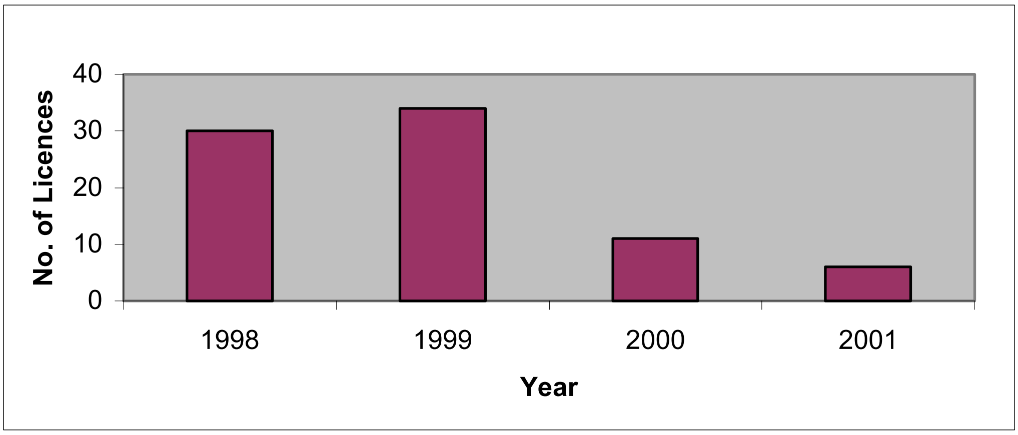

Figure 4.4 Number of Licensed Sand Extractors

4.3.4 Clearance of natural vegetation

It has been found (Morrison & Seru, 1986; Woodroffe & Morrison, 2001) that alteration of land use such as clearance of natural vegetation (Figure 4.5) and maintenance of coconut plantations by burning, contributed to the uniformity of soil, thus weakens soil development throughout the islands.


Figure 4.5 Vegetation clearing at Bonriki (ECD, 2001)

4.4 Responses to Pressure on the Environment

4.4.1 Foreshore Management Committee

Relevant representatives from Government and stakeholder groups on South Tarawa make up the Foreshore Management Steering Committee. Management strategies are being explored to minimize the destructive resource extraction activities of the various interest groups. Effective policing of conservation regulations is a key strategy (Redfern, 2001).

4.4.2 Offshore Extraction of Sand and Gravel

Through the Mineral Development Unit of MNRD and SOPAC, efforts are underway to designate offshore sites for mining sand and gravel in order to relieve the pressure on South Tarawa (see Chapter 12).

Government has plans to establish its new Aggregate Company soon. The main purpose for the proposal of this Aggregate Company is to discontinue the mining of sand beaches on the island of Tarawa and to replace these operations with the mining of sand from the Vinstra Shoal deposit, an offshore deposit located in the Tarawa lagoon approximately 3 km north of Betio in less than 10m water depth. (Cruickshank & Morgan, 2001)

4.5 Data Gaps

- Total volume of sand and gravel extracted thus far by various user groups are unknown and incomplete

5. Land

5.1 Introduction

5.1.1 General

Land is highly valued by the I-Kiribati people because they inherited land from their ancestors who did not purchase it with money but obtained it with their own blood and died for it during the ancient tribal wars.

The total land area is 800 square km with a coastline of 1,698 km (GOK, 1999). The ratio of land area to that of sea is approximately 1:4,000, which reflects the smallness of land available. Land in the Gilbert (Kiribati) islands group, which is 286 sq.km. (GOK, 1999), is privately owned and the rest, i.e., the Line and Phoenix islands, belongs to Government except land that has been sold to resettlers in Fanning and Washington islands in the Line Group.

5.1.2 Availability of Data

A number of regional programmes managed by SPREP have collected and identified much environmental information on Kiribati such as chemical profiles, persistent organic pollutants (POPs) and contaminated sites. Other information on development projects have been made available by various Government department like Rural Planning Unit (RPU) and Land Management Division (LMD) of the Ministry of Home Affairs and Rural Development (MHARD), Foreign Investment and Industry of the Ministry of Commerce, Industry and Tourism (MCIT), Energy Planning Unit (EPU) of the Ministry of Works and Energy (MWE), where lists of projects and commercial undertakings are continually updated.

The Environment and Conservation Division (ECD) keeps its own register of environmental evaluation activities and public complaints during the course of routine work. Many of these databases are still incomplete hence information is continually being updated daily when necessary.

5.2 Present State of the Environment

5.2.1 Classification

5.2.1.1 Land Classification

Land has been classified (Catala, 1957) based on the density of productivity of coconut plantations including:

Depth of the soil in the surface horizon, and its organic matter content
Nature of the coral components (sand, gravel, etc.) which make up the soil structure
Nature of the subsoil water (fresh, brackish, saline).

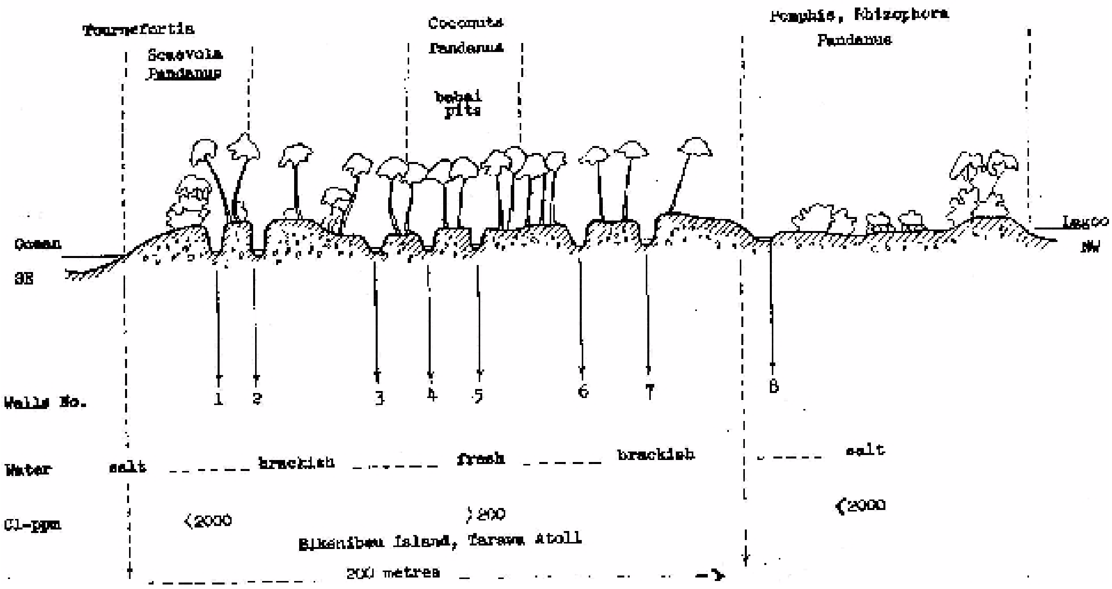

Figure 5.1 Distribution of salinity and vegetation in Bikenibeu (after Catala, 1957)

In light of these criteria the following types of land can be defined (Catala, 1957):

Good quality land – deep soil with a well developed "A" horizon rich in organic matter, parent material for greater part of sand, ground water fresh to slightly brackish;

Medium quality land – deep soil with an "A" horizon of medium development, and a moderate supply of organic matter, the parent material sand and gravel, groundwater slightly brackish to brackish;

Poor quality land – thin soil layer resting on a rocky platform near the surface where it may show through in places, composition of soil being for the most part gravel or coarse sand, poor in organic matter, ground water brackish to salty.

Illustrations of the possibilities are shown in Figures 5.1 & 5.2 (Catala, 1957) respectively.

5.2.1.2 Land Units

Urban planning is controlled by the Land Planning Ordinance (Cap 48), which provides for the Minister (of MHARD) to designate areas for the purpose of planning. General Land Use Plans (GLUP) have designated the following zonings as follows:

Port Marine and Related Areas
Government Areas
Clinic Uses, Open Space and Cultural Sites
Residential;
Commercial and Industrial Areas
Churches and
Areas of General Environmental Significant (Redfern, 2001).

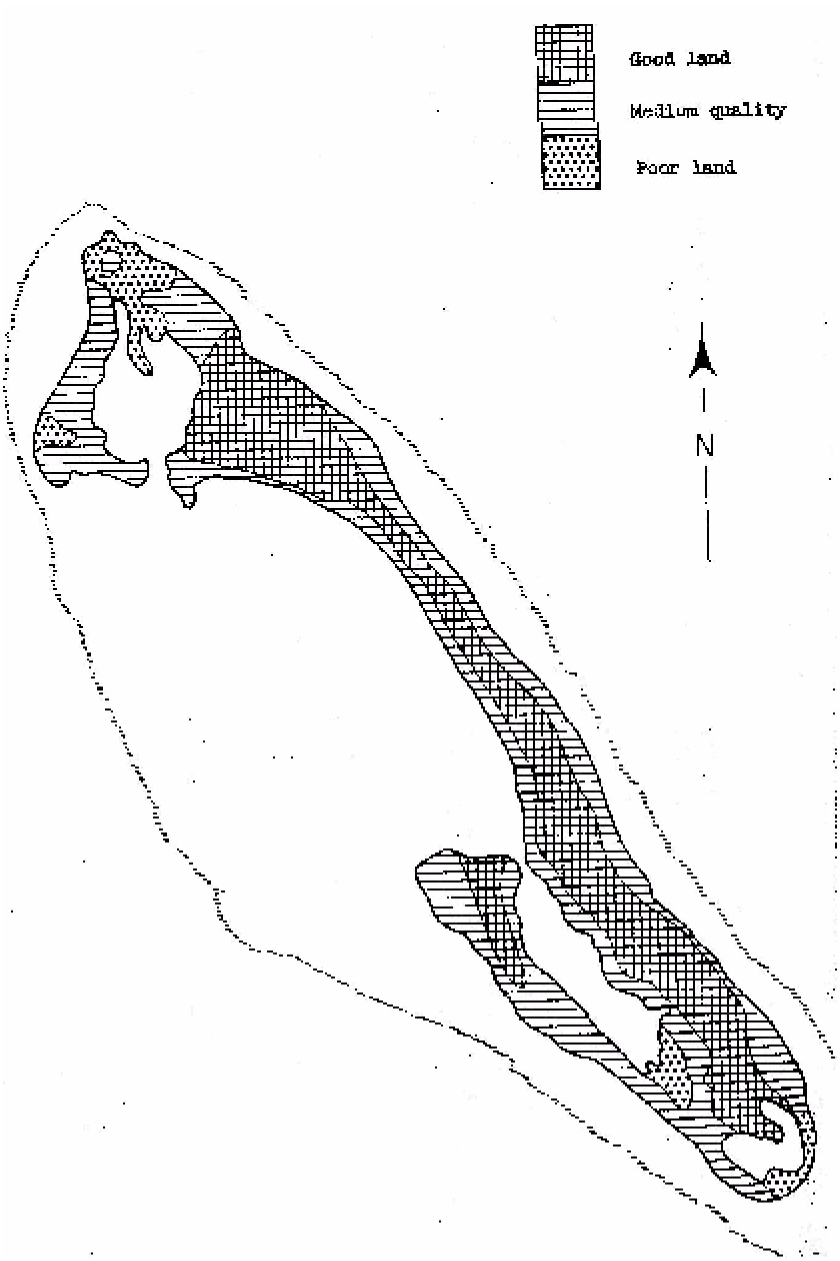

Figure 5.2 Land classification on Beru Atoll (after Catala, 1957)

A few areas and islands in Kiribati possess GLUPs such as Bikenibeu, Bairiki, Nanikai and Betio in urban South Tarawa, rural Makin, Kiritimati Island, Teraina and Tabuaeran. Local Planning Boards for each planning area are responsible for developing Detailed Land Use Plans (DLUP).

5.2.2 Development projects

The main developer in Kiribati is the Government. Generally, just as in many countries, environmental concerns usually take second or third place to economic and political priorities. In the late 1990s, however initial environmental evaluations and preliminary environmental assessments began to go hand in hand with some development activities.

Private developers used to carry out their own activities though on smaller scales. These activities proceeded at times without seeking Government's consent although there are regulations in place. Policing and enforcement mechanisms have been lacking.

Figure 5.3 shows a general overview of government developments that are likely to impact on the environment towards the end of the 20^{th} Century. These developments are mainly permanent infrastructure constructions and extraction of natural resources whether live or processed. These data were obtained from the Government annual development expenditures (MFEP) and the rural planning (RPU) database. The databases did not cover many private small-scale enterprises because a system of recording such, has not yet been established. However, this may be overcome by controlling all developments under the Environment Act 1999.

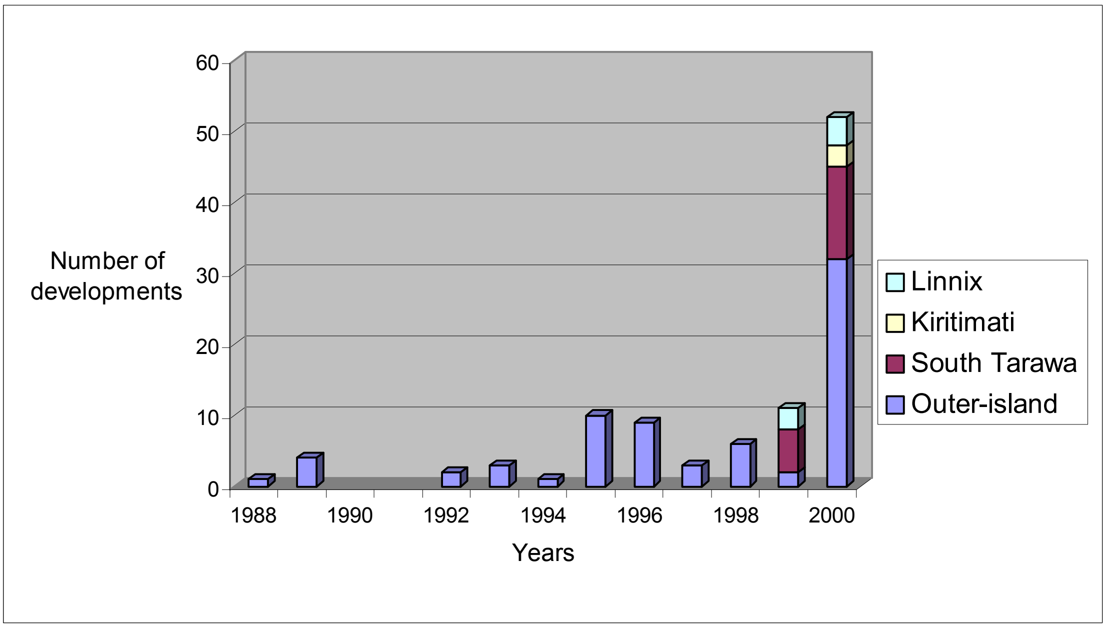

Figure 5.3 Development projects likely to impact the environment (source: MFEP)

Data for the period 1990 – 1991 are lacking and some inaccuracies are known to occur for data in the period 1988 – 1994 with 1995-1998 because records were not readily available. Hence it is impossible to give an accurate picture of past development activities that were likely to affect the environment.

Although South Tarawa is the centre of urbanization, the distribution of developments (Fig.5.3) was scattered to the outer islands in the Gilbert and Line groups. However, if developments were considered on a per island basis, South Tarawa would lead in development activities.

In addition, data on foreign investments (Figure 5.4) on land alone, over the entire country, show an obvious concentration on Tarawa. Though these foreign investments do not indicate the scale of operation, most were worth at least a hundred thousand (AUD) dollars. The Foreign Investment Commission (FIC, 2001) database dates back to around the 1990. All these investments were likely to impact the environment because their nature lies in tourism, logging, complex infrastructure buildings and processing of marine resources, including aquaculture.

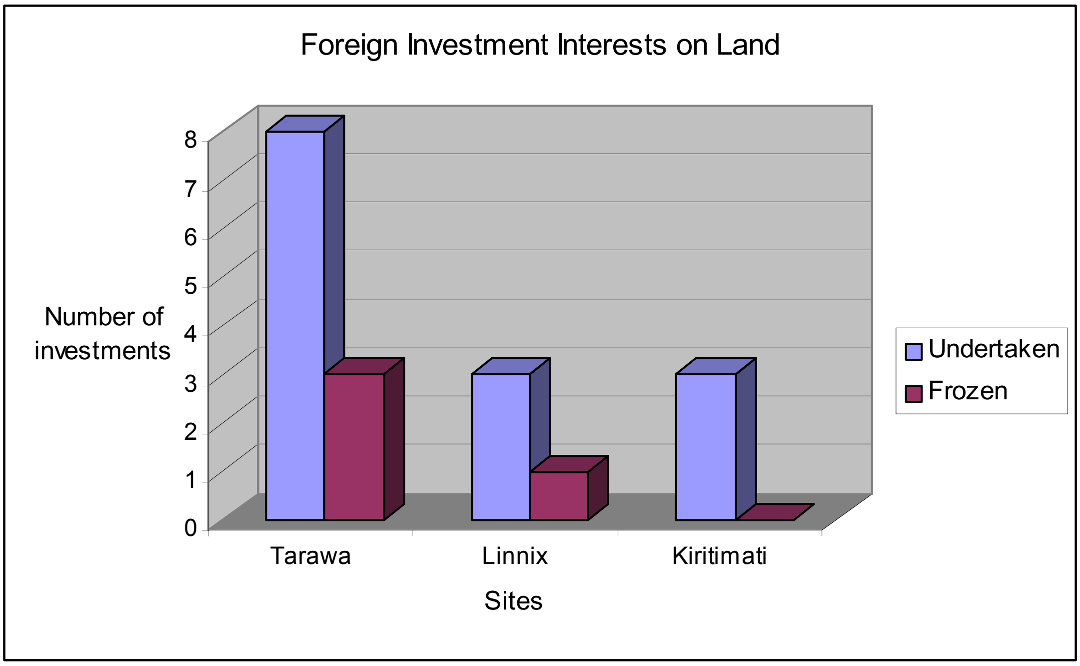

Figure 5.4 Number of Foreign Investments on Land (source: FIC, 2001)

A few proposals never actually started (frozen) either due to loss of interest of investors or suspension by Government because of their likely competitiveness to existing local ventures (per.comm., Motiti Koae).

5.2.3 Extractive Industry Operations

Kiribati lacks any resources extractive industries that may significantly affect its fragile environment. Apart from phosphate mining on Banaba that ceased in 1979, the only extractive industry on land is sand and aggregate mining from the coast for infrastructure construction and land reclamation through seawalls. Aggregate mining has exacerbated coastal erosion in many sites (refer to Chapter 12) and hence management is warranted (Redfern, 2001).

The foreshore, up to the high tide mark, belongs to Government and hence miners of these coastal resources have to get approval from Government as well as landowners of land pieces adjacent to mining sites. On South Tarawa, this license requires a fee of $25 for 3 months or $100 annually and royalties of $2.00 per cubic meter, that is managed by the Lands Management Division (LMD of the MHARD). Refer to Section 4.3.2.

Other small, cottage and small scale industrial operations, now recorded by the Industry Management Division (IMD) of MCIT, will be unlikely to impact on the environment, because some (3) are recycling facilities and the rest are just goods and services industries. However, not all industrial and commercial activities are known and controlled by IMD, in particular private businesses which are managed by Banks like the Development Bank of Kiribati (DBK) and the Bank of Kiribati (BOK). By 2002, IMD is likely to complete its inventory of these activities at the national level.

5.2.4 Land Use Potential.

The land classification in section 5.1.1 shows that Kiribati generally does not have any ‘normal’ arable land nor permanent pastures. It has been estimated (CIA, 2000) for most islands that approximately 3 % containing forests and woodland, 51% used for permanent crops and the remaining 46 % is for house settlements and other human developments. See Section 5.2.7 for scenic sites that possess potential for tourism.

5.2.5 Potentially Contaminated Land

In a survey by Burns *et al* (1998) for a national chemical profile and an inventory of persistent organic pollutants (POPs) in Kiribati, a number of major sites of stockpiles and contamination were identified (Table 5.1).

Table 5.1 Overview of Significant Stockpiles and Contaminated Sites

Sites	Details	Quantity
Agriculture Storage Shed, Tarawa	Unwanted fertilizers + small volume of mixed pesticides	12,000 kg
Agricultural Station, Kiritimati	Unwanted fertilizers	1,300 kg
Animal Health Storage Shed	CCA sludge	1,000 kg
	Mixed veterinary + expired medicine	2,000 kg
In-service transformers, Tarawa	Potentially PCB contaminated transformer oil	5,500 litres
Kiribati Teachers College,	Unwanted photographic chemicals	150 kg
Tarawa Central Hospital	Expired photographic chemicals	65 litres
AMAK Office, Tarawa	Unwanted caustic soda	55 kg
Former British Bulk Fuel Depot, Kiritimati	Fuel tanks	1,000,000 litres (empty tanks)
Bonriki International airport,	Waste bitumen	100,000 litres
Tarawa	Contaminated soil	1300 m^3
Bikenibeu (Tarawa) + Kiritimati	Waste bitumen	100,000 litres
Various sites, Banana	Waste bitumen	100,000 litres
in Kiritimati	Contaminated soil	600 m^3
Betio Power Station, Tarawa	Waste oil	7,000 litres
	Contaminated soil	800 m^3
Bikenibeu Power Station,	Hydrocarbon contamination	300 m^3
Tarawa	Waste oil	7,000 litres

(Source Burns *et al*., 1998, POPs in PICs, Kiribati Report,)

A complete list of Waste and Obsolete chemicals and chemical contaminated sites in Kiribati is provided in Appendix 5.1.

South Tarawa is probably the only highly contaminated location in Kiribati due to spillage of petroleum products from many petroleum storage facilities. Sadly, this will not remain so for long.

Figure 5.5 shows that the number of sites of petroleum storage on the outer islands is on the increase throughout the islands, thus there may be more incidences of contaminated soil on the outer islands that may result in contamination of groundwater by petroleum products, as is now the case on many sites on South Tarawa.

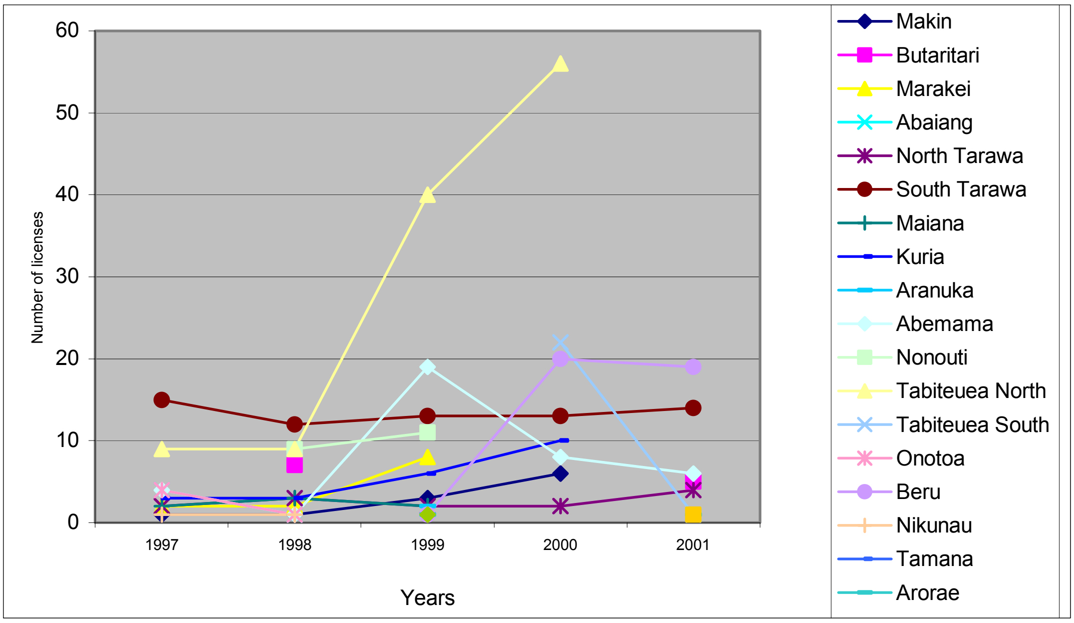

Figure 5.5 Number of storage petroleum licenses in various Kiribati Islands (source: EPU, 2001)

5.2.6 Public Complaint Register

The ECD (formerly Environment Unit) began in 1999 to record incoming complaints from the public on South Tarawa as the public started to consult the environment authority on many environmental issues. The main causes of public complaints are pollution related problems caused by both the public sewerage system and animal farms. An overall assessment of the public discomfort is mostly degradation of land on South Tarawa where many developmental activities are centered.

5.2.7. Scenic Sites and Landscapes:

Kiritimati Island, uninhabited islands of the Line and Phoenix groups, and the inhabited island of Washington where resettled populations of people are sent, still possess unique scenic sites of ecological, economic and scientific significance as follows:

Beach sanctuaries and Lagoon islets of Cook Islet, Motu Tabu and Motu Upua.
First Millennium dawn landmarks at Millennium (formerly Caroline) Island:
Beaches of Kiritimati and other uninhabited islands
Coral Rubble Ramparts along Bay of Wrecks at Kiritimati
Limestone Hardpans at Y-Site and Frigatebird Reserve of Kiritimati
Sand Dunes at Kiritimati
Only inland Lake at Washington (adapted from Thaman *et al.*, 1996)

5.3 Pressure on the State of the Environment

5.3.1 Urbanization on South Tarawa

Not only is overcrowding (refer to Section11.2.4) adding tremendous pressure on the limited land area but intense construction of infrastructure complexes, human settlements and many commercial enterprises are concentrated on South Tarawa. The important institutions like the utility company and other commercial undertakings that are required for servicing the bulk of the population have not yet integrated environmental management and protection in their many operations. The desire to build more commercial enterprises and other major developments is reflected by the majority of development applications under that category in Appendix 5.3

5.3.2 Development applications

Since the enforcement in 2000 of the Environment Act 1999, the ECD of MESD has begun to control all kinds of public and private development activities from small-scale magnitude to larger operations. To the middle of 2001, more than thirty development applications had been lodged at the ECD and each has been carefully scrutinized before approval was given. Some were approved with conditions, e.g., sand and gravel extractors are permitted to mine materials at sites, which are not eroding but are obviously accreting. Where erosion is slightly detected, mining should cease. Analysis of the applications showed the following:

Type of Development	2000	2001	2002
Marine resources exploitation	5	4	4
Sand mining	9	9	52
Gravel mining	na	3	11
Seawall (reclamation)	11	9	21
Infrastructure construction	10	6	9
Fuel storage	0	2	1
Dredging	0	4	19
Reclamation	0	6	6
Food industry	0	1	0
Others	0	2	3

All these applications are likely to impact the environment to different extents.

5.4 Responses to Environmental Pressure

5.4. 1 Mandating Environmental Impact Assessments

With enactment of the 1999 Environment Act, which requires all projects to be screened for environmental impacts, almost all public and private developments are integrating environmental considerations in their planning. However, it is believed that many projects still went ahead without prior development controls. Appendix 5.4 shows a list of 12 completed environment assessments and appraisals up to 2001 of both public and private developments. These development projects are highly likely to impact the environment considerably to different extents. However, the developers had integrated environmental planning and management as component of the "mainstream" development instead of a separate aspect.

5.4.2 Contaminated Land Assessment

In establishing guidance for undertaking environmental audits under the Environmental Act 1999, audit protocols had been completed for three sites, namely: the PUB powerhouse at Betio; the Bonriki International Airport bitumen site and the Kiribati Oil Company (KOIL) depot at Betio. The procedure was developed by the Environmental Scientists of the SAPHE project, as a mechanism for the ECD to make an inventory of remedial actions that the institutions under investigation should undertake to minimize environmental degradation of their sites and vicinity.

5.4.3 Resettlement schemes

Government has completed its resettlement scheme whereby a number of families from the Gilbert Islands have been moved to the sparsely populated islands of Fanning and Washington in the Line group. Although the scheme showed negative population growth (1995-2000) on almost all the Gilbert Islands (see Section 11.2.2), and thus relieved some of the pressure on limited land, South Tarawa, did not show any negative growth, rather an increase in urban migration occurred.

5.5.Data Gaps

- Consolidation of all development projects before and during the 1990s.
- Estimate volume of coastal resources (aggregates) mined thus far in South Tarawa
- Inventory of all private commercial and industry undertakings from BOK & DBK.

Chapter 6 Water Resources

6.1 Introduction

6.1.1 General

Kiribati, consisting of 33 small-scattered low-lying coral islands is extremely vulnerable to climate change with increasing occurrence of violent storms and long droughts and thus is faced with continual water shortages. The scarcity of this resource is rather ironic considering the fact that Kiribati is surrounded by water, having been endowed with the largest EEZ in the world, a vast ocean encompassing about 3,506,400 square kilometers.

In South Tarawa, where almost half of the country's population live with a population growth of 5% per annum, a population density with an order of magnitude higher than in any other place in Kiribati, drinking water supply from the existing reticulation is insufficient, and often restricted to a few hours a day, but even worse, this restriction can be for less than 10 minutes only to most households. At the same time, the fragile groundwater lens and unreliable rainfall is unable to keep up with the demand.

Furthermore, groundwater extraction is increasingly coming under threat from pollution through inappropriate toilet facilities, a seawater based sewerage system, pigsties built nearby homes and an encroaching human population that has stretched the capacity of the system to the limit. The result is insufficient drinking water less than 30 litres per day – well below the supply of 100 litres per day considered adequate. (Island Business, 2002). It is therefore in South Tarawa that the importance of water as a scarce resource could never be emphasized enough.

Water has been a free but also precious commodity in Kiribati, so it has been used carefully. Traditionally, water has not been given a financial value and hence the expectation by consumers nowadays is that it should be freely available at the expense of Government which has been providing social services (e.g., health and education) free of charge with heavy subsidies. This traditional concept may explain the general public's lack of cooperation to conserve the scarce water resources.

The main potable water resources in Kiribati are limited to underground water lenses and rainfall. Without the latter replenishing the former, as in severe droughts, the resultant salinisation puts on more pressure on the only source of freshwater.

6.1.2 Availability of Data

The Water Engineering Unit of the Ministry of Works and Energy (MWE) houses hydro-geological data of all inhabited islands and other water related information, including the draft master water plan (Shalev, 1999) that is continually being updated and revised. Both MWE and Environmental Health Inspectoral of MHFP undertake monitoring of the water quality of the reticulated water supply on South Tarawa, but this quantitative data could not be accessed during data collection for this report. Though PUB has relevant data on its reticulated water system, access was also not possible as well.

In addition to Government sources, a number of ADB studies (Royds, 1996, Morrison, 1995, etc) and the SAPHE project have provided much of the information contained in this Chapter. Other water projects reports (Falkland, 1997, White et al., 1999abc) undertaken by various consultants provide useful reference material.

6.2 State of the Environment: Water Resources of Kiribati

6.2.1 Rainfall

Rainfall is used as drinking water as well as for other purposes such as bathing and washing. I-Kiribati people regard rainfall as a better source of drinking water than well or reticulated tap water. It is collected in water tanks off the metal roof gutters of permanent houses. Because rainwater can be scarce at different times of the year and particularly during drought periods, it is recognized and regarded by the I-Kiribati population as a precious resource (Shalev, 1999).

To date however, rainwater collection by individuals and institutions, which could substantially alleviate the shortage of drinking water, is not widespread enough, in spite of existing regulations, and many existing roof-collection installations are inoperative or under-utilised. (Metai, 2002)

6.2.2 Groundwater resources

Fresh groundwater occurrence is generally limited to larger islands where lenses of freshwater "floating" on seawater developing underground. Figure 4.1 shows a typical cross section of the freshwater lens on a coral island.

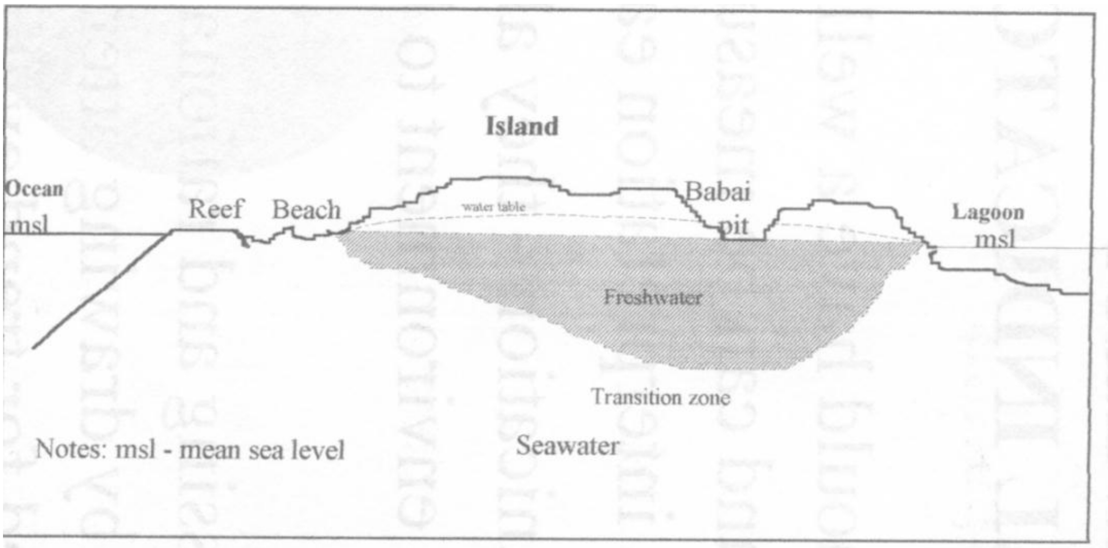

Figure 6.1 Typical Cross-Section of Freshwater lens on a Coral island (after Shalev, 1999)

Few islands exceed 2 km in width and are more than 3 to 4 m above mean sea level. Lenses are present where the island is more than 300 m wide. The freshwater lenses form the basis of the island water supplies (Marshall & Jacobson, 1985). The depth of water wells varies from 0.5 to 3.0 m, behaving in accordance with the Ghyben-Herzberg theory (Shalev, 1999). The water table beneath the islands oscillates daily with the tides and, with longer sea level changes, over decades (Marshal & Jacobson, 1985).

6.2.2.1 Tarawa Island

Investigations of the ground water lenses of Tarawa began in the early 1960s by British, Australian and UN agencies. Early studies were limited to water levels and water chemistry at dug wells aimed at siting infiltration galleries for populations on the capital (Falkland & Woodroffe, 1997).

Sizeable lenses of freshwater exist in urban South Tarawa at Betio, Bairiki, Teaoraereke and Bonriki and also at rural North Tarawa in Buota, Abatao, Tabiteuea and Buariki. The other islets (villages) of North Tarawa have smaller volume lenses at Tearinibai, Nuatabu, Taratai, Kainaba and Nabeina (Shalev, 1999).

In the early 1970s, water was provided mainly through public standpipes on South Tarawa. After the cholera outbreak in 1977, an urban water reticulation system, known as Tarawa Water Supply System (TWSS) and managed by the Public Utilities Board (PUB), was installed. TWSS continued extracting water from South Tarawa lenses throughout the 1980s. Consequently excessive salinity and contamination resulted from excessive pumping exacerbated by human settlements close to the Betio and Bairiki lenses and thus these were no longer used for human consumption. The water lens at Teaoraereke was also over-pumped, and has not been utilized since 1987.

Currently the underground water lenses at Bonriki (Fig. 6.2) and Buota are still supplying good freshwater quality towards TWSS. Smaller water lenses on North Tarawa have been identified and tapped for water supply to some rural villages (Shalev, 1999).

The computation and modeling of sustainable yield of the water lenses at Tarawa (in 1992) were as follows:

LENS NAME	YIELD (m3/day)
Bonriki	1000
Buota	300
Abatao	250*
Tabiteuea	300*
TOTAL	**1850**

(Source: Shalev, 1999 Note * denotes preliminary estimate only)

Figure 6.2 Aerial view of the Bonriki Water Reserve, with South Tarawa in background (Royds, 1996)

In 1996, it was reported (Royds, 1996) that TWSS generated about 36,000 cubic metres of water each month, yet billing at PUB gave only 10,000 m^3 in 1995 and 9,000m^3 in 1996. This showed that there were large "un-accounted for" water volumes estimated at between 30% and 50 %, resulting from illegal connections and system inefficiencies such as leakages.

The reticulated water supply currently servicing over one third of the national population is continually pumped from infiltration galleries in groundwater protection zones on Bonriki and Buota islets, extracting a total of 1000 m3/day. The average electrical conductivity (EC) is about 700 μS/cm water but ranges from 400 μS/cm after heavy rains to >900 μS/cm during dry times. Current supply is estimated at 30L/capita/day of freshwater although the system was designed to provide about 40 L/head/day (White *et al.*, 1999c). Significant administrative, social, economic and legislative issues regarding the use of private land for public water supply purposes are currently experienced (White *et al.*, 1999b). Traditional land ownership also guaranteed ownership of groundwater.

The population on South Tarawa is growing at a very fast rate (5% per annum) according to the recent population census in the year 2000. Based on that trend the population of South Tarawa could reach 47,000 in the year 2005 and 60,000 by the year 2010. With the limited water resources, it would be very difficult to provide this number of people with clean and potable water and would put more demands on the already overused resource.

According to calculations made by Metai (year??), using 2 scenarios, viz high (5% annual growth) and low population (3% annual growth) projections and water demand based on 40% litres per day, it appears that the current water sources at Bonriki and Buota using the low population projections, can cope with the water demand to the year 2010, a little more than 7 years away. However using the high population projections which is also a more likely possibility, it appears that these 2 current water sources are currently inadequate to supply the whole of the South Tarawa with safe potable water.

6.2.2.2 Kirimati Island

Five major lenses have been located but not all have been utilized for years (Shalev, 1999). Excessively high salinities were observed in water pumped from two, mainly due to over utilization. The computed sustainable yield of these lenses are:

Lens Name	Yield m^3/day	Yield * m^3/day
Decca	80	80
Four Wells	80	170
Main Camp	100	100
Banana	180	400
New Zealand	380	520
Total	820	1270

(source: Shalev, 1999 * denotes preliminary estimate only)

It has also been calculated that the yield of these lenses could be increased by 120 % by coconut clearing, except at Decca and Main Camp, because these areas are almost cleared of coconut trees (Shalev, 1999).

6.2.3 Water quality

For many years, there were many concerns expressed over water quality, particularly lagoonal and ground water in Tarawa. The cholera outbreak in 1977 and subsequent investigations (Johannes et al., 1979 in Morrison, 1997) showed that groundwater, nearshore lagoon water and shellfish from the lagoon were all contaminated by microorganisms.

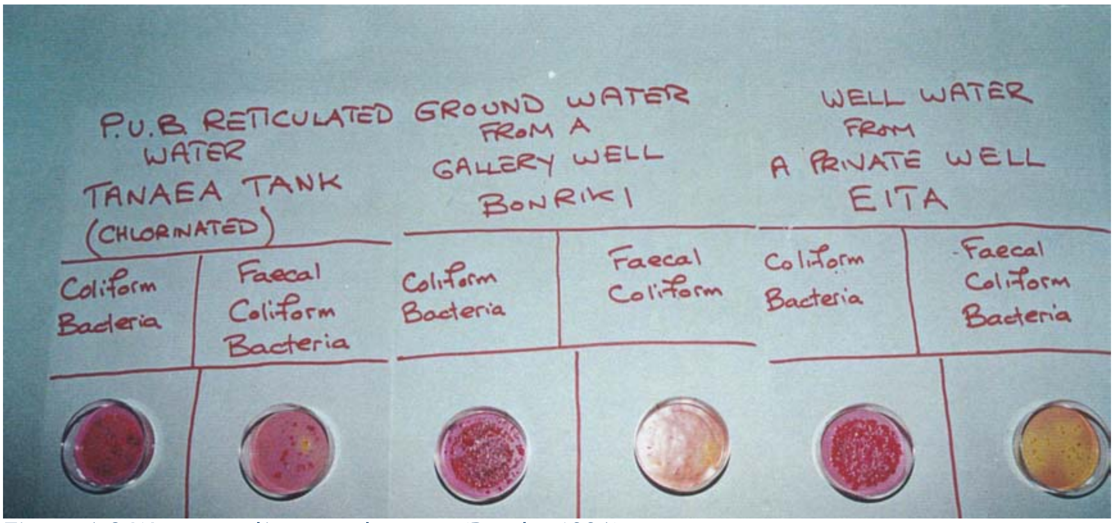

Figure 6.3 Water quality sample tests (Royds, 1996)

The degree of contamination had continually increased up to 1993 (Kelly, 1993 in Morrison, 1997). Groundwater wells were examined (Gangaiya, 1994) and all 18 tested exceeded the WHO guideline for faecal coliforms in drinking water. When tested for nitrates, well water was found to exceed the WHO guidelines too.

Royds (1996) reported that the quality of reticulated water on South Tarawa was still poor. Three aspects of the problems were:

- Bacteria associated with human faeces have been found in both the untreated water and the disinfected supply;
- Presence of hydrogen sulphide (H_2S: reduction of sulphate in groundwater) produces odorous by-products when chlorinated;
- White filamentous sulphide oxidizing bacteria (family *Beggiatoaceace*) have been found in water galleries and water reticulation system. Although harmless, when combined with H_2S, requires higher demands of disinfection hence an increase cost of chlorination (Royds, 1996)

In urban South Tarawa, water quality analyses are undertaken by the Environmental Health Inspectoral Section of MHFP including total coliform count, faecal coliform count (Fig. 6.3) and residual chlorine. In cases where presence of coliform bacteria is detected, additional bacteria counts are made. Samples of TWSS drinking water are regularly analysed, twice a month by the Health and Water Ministries (Shaley, 1999).

The reticulated water system on South Tarawa is chlorinated at the source and re-chlorinated at the other end of the pipe in Betio. Although the reticulated water may be of good quality, diarrhoeal cases are still prevalent due to the poor quality of water and sewerage systems in South Tarawa (WHO, 2000). Many people are suspected to be using water from unprotected dug wells close to various sources of contamination, for domestic purposes, thus becoming prone to water related diseases.

On the outer islands, the water is not treated since the sources are at some distance from human settlements, outside the villages. It was also reported (Mourits, 1996; Shalev, 1999) that water quality on less populated islands is generally quite good.

6.2.4 Water use

Water utilization is mainly for drinking and domestic uses and thus water demand is planned for domestic purposes in the national Water Master Plan (WMP). Agricultural and industrial uses are given low profiles in view of limited potable water alternatives (Shalev, 1999).

Various predictions on average domestic per capita water demand for South Tarawa have been up to 100L/day depending on house level distributions while an estimate of 50/L/day for Kiritimati and 14 to 30L/day to the outer islands. The NWP projections based on the population record and calculation into the future envisaged a supply 40L/day per capita at all times, even during droughts on South Tarawa. The outer island rural population needs 30L/day, while village shallow wells and seawater will continue to be used for other purposes beside domestic needs (Shalev, 1999).

6.2.5 Other Water Production and Supply Systems

This section contains several types of water systems which are more common in rural areas but still used on urban areas as well.

6.2.5.1 Open Hand-dug Wells

Traditional open hand-dug wells are common throughout Kiribati. These wells are about 1 to 2 m in diameter and can be as deep as 30 to 50 m below groundwater table. Stones support the inside well which are usually left uncovered for scooping water (with bucket) whenever needed. A drawback to these wells is the close proximity to sources of contamination such as domestic animals and pit latrines, making well water unsafe for drinking (Shalev, 1999)

6.2.5.2 Covered Dug Wells.

Walls of traditional open hand-dug wells are later supported by concrete rings which are placed up to half a metre above the ground level with an apron of concrete casted around the well to prevent seepage of mud into the well water and a concrete cover (Shalev, 1999).

6.2.5.3 Covered Dug Well with Hand Pumps

Hand pumps are an additional element to the covered wells, mounted on top of the well cover. These pumps can be either the semi-rotary type, the diaphragm suction pump or a potable so-called “Tamana” pump (Fig. 6.4). The latter proves to be the best type so far, as shown in its popularity in Kiribati.

6.2.5.4 Collection Trenches or Open Galleries

In Kiritimati Island, several open trenches, of about 150 m in length by 3 m in width, are dug to about 50 cm below the water table, from which water is pumped by diesel-powered horizontal pumps. Slabs of coral stone support the trench sides and covered with sheet metal or timber boards. Like covered wells, water is vulnerable to contamination (Shalev, 1999).

6.2.5.5 Gallery System

In addition to a hand dug well, a slotted PE pipe (100 mm in diam) called a gallery, is extended on either side of the well to between 20 to 60 m. The pipe is laid at a depth of 30-50 cm below the water table, and the trench is refilled with gravel. Freshwater is skimmed from the uppermost layer of the water lens and from a larger water table area thus reducing the risk of up-coning of the underlying seawater. The well and gallery are located a few hundred meters from the village on the outer islands for two purposes:

Figure 6. 4 Well water with “Tamana “ pump (ECD, 2000a)

- To put distance between the sources of pollution in the village and the source of water.
- To extract water from the lens at a location where its thickness is largest, usually at some distance from the village.

Extraction of water from the well is done by means of suction hand pumps or solar systems or even windmill pumping systems (Shalev, 1999).

6.3 Pressure on Water Resources

6.3.1 Population growth

Continual urbanization on South Tarawa has already exceeded the carrying capacity of the densely populated islets and villages regarding the minimum drinking water requirements. Plans are underway to identify more underground water reserves at more distant islets of North Tarawa for the populated South Tarawa.

During droughts, as in 1998 to 1999, water scarcity severely impacted the populated South Tarawa the most. (Section 3.2.9)

6.3.2 Water catchments

There are very few water catchment facilities such as underground water tanks or water recycling facilities in Kiribati. Rainwater catchments which are limited, are not common at private buildings. Public buildings which may have these facilities could well be non-functional due to lack of maintenance. Rainwater is under-utilised because of the lack of collection facilities, mainly on outer islands.

6.3.3 Leakage in the underground reticulation system on South Tarawa

It has been reported that underground pipe connections were leaking, leading to a considerable amount of scarce water resources being lost. The main cause of the leak is likely to be punctures or ruptures in the distribution main. Tests have shown that losses of approximately 70 % were observed when the system was put under pressure during the night. This could have been caused by sharp and abrusive stones on which pipelines were embedded. There were also defective sections of the system mains including leaking elevated tanks and weathering out of booster pumps (Royds, 1996).

6.3.4 Water contamination

Squatters living on Water Reserves at South Tarawa have been a socially and politically sensitive issue prior 1980. Human settlements are continually encroaching to Water Reserves areas at Bonriki in South Tarawa. Most of these cases are pending as court cases, yet permanent private houses have now been constructed within the vicinity. This is threatening the continued supply of uncontaminated water. Vandalism of existing water reservoirs at Bonriki is also common.

The highly permeable soils, large rainfalls and shallow watertables (<2.0 m) make groundwater in Kiribati extremely vulnerable to surface contaminants (Dillon, 1997 in White & Falkland, 2001). The surface sources of contamination, especially from animal and human wastes, could affect the groundwater supply rapidly, within less than 24 hours. The traditional crop cultivation of digging pits right to the water lenses can be a source of contamination to outer island water lenses (Shaley, 1999).

Other sources of water contamination include burials, fertilizers, pesticides, industrial discharges and other contaminants. In addition to external contamination, internal contamination is also present in the reticulated system on South Tarawa itself where bacteriological films inside the pipelines, existed despite added disinfectant which may not be effective (Royds, 1996).

6.3.5 Salinisation of Potable water supply

The maximum salinity limit for potable water is 2500 μS/cm (Falkland, 1992 in Mourits, 1996) which is approximately an equivalent chloride concentration of 600 mg/L. Public Works Division uses 3000 μS/cm as limit for potable water in Kiribati

Excessive or inappropriate methods of freshwater extraction from lenses, such as traditional vertical wells or bores, can cause seawater intrusion and hence salinisation of the potable water supply (White et al., 2000).

Inundation by the sea during storm surges is another means of salinisation of the freshwater lenses. In addition, unusual drought spells can also prevent the replenishment of underground water lenses, also leads to salinisation. These drought periods are correlated with ENSO events (Falkland & Woodroffe, 1997; White *et al*., 1999).

6.3.6 Trees and food crops

Coconuts, breadfruit, pandanus, pawpaw, bananas and swamp taro or babai, are direct users of groundwater. The soil is excavated to the watertable for swamp taro pits. A coconut tree can consume up to 150 L/day, as much as a household of 5 people (White *et al*., 2001). It has been suggested that removal of coconut (Shaley, 1999) and pandanus trees from water reserves could increase significantly the availability of water (Falkland, 1992). The water requirements of market gardens are unknown.

The tourist and fishing industries are also putting demands on the water supply with over a fifth of the country's Gross Domestic Product (GDP) dependent on foreign visitors; which is of crucial importance to an economy with few natural resources. (Island Business, 2002)

6.4 Responses to Pressure on Water Resources

6.4.1 Water supply maintenance and improvement

On South Tarawa, rehabilitation of the existing water supply and improvement of water supply will be undertaken during the Government current loan project from ADB, Sanitation and Public Health and Environment Project (SAPHE). Rehabilitation of the existing PUB system will include (Royds, 1996), among others:

- swabbing the rising main;
- leak detection and repair;
- community education to encourage efficient use of PUB water;
- rehabilitation of distribution mains and valves;
- rehabilitation of elevated tanks and booster pumps;
- new salinity monitoring boreholes at potential lenses at North Tarawa for future use.

The SAPHE water improvement projects shall aim to provide for projected future water demands including:

- new rainwater tanks;
- new storage facilities at populated areas which are distant from existing storage facilities;
- rehabilitated house connections;
- new reservoir and treatment plant at Bonriki;
- new 19.5 km rising main (225 mm diam.) from Bonriki to Teaoraereke;
- new gallery at Bonriki;
- airport run-off collection;
- new galleries at Abatao and Tabiteuea (Royds, 1996).

SAPHE commenced in 2000 and is estimated to run for about 5 years. The outcome of these recommended improvements for water supply remain to be seen at the end of project period but it is expected to improve the present and future water supply (Table 6.1) systems for the populated Capital

Table 6.1 Existing and Potential Future Water Sources

Water Sources		Production (m3/day)
Groundwate r	Bonriki and Buota	1,500
	Abatao & Tabiteuea	550
	Artificial lens at Temaiku	300
Desalination	Betio, Otintaai Hotel, Hospital, Parliment	200
	Future	800
Rainwater		400
Shallow wells	25,000 population X 30L	750
Total		**4,500**

(Source: PPK, 2001)

6.4.2 Multilateral and Bilateral Aid

The outer islands community water supply program funded by the United Nations capital Development Fund (UNCDF) began in 1987 by installing water pumps at wells including the gallery type, situated outside villages to minimize the risk of contamination by human activities (Mourits, 1996).

A bilateral aid development project on the assessment of groundwater resources on some outer islands for suitability and location for provision of reliable and safe source of freshwater has been initiated with funding from Australia. This will assist with ground water development, provide monitoring facilities for water supplies and provide capacity building for local institutions in resource assessment, development and monitoring (White, et al., 2000).

On-going research work (White & Falkland, 2001) will investigate the impact of agriculture on groundwater quality and quantity and the impact of groundwater extraction on permanent crops and will provide techniques and training for assessing sustainable groundwater extraction strategies, drought risk assessment and crop production under a range of small island conditions.

At recent meetings, jointly organised by Asian Development Bank and the South Pacific Applied Geoscience Commisssion (SOPAC), the Pacific Island nations agreed on a regional action plan for sustainable water management, which called for a collaborative approach in the areas of water resources management; island vulnerability; education; technology; institutional strengthening and financing. (Island Business, 2002).

6.4.3 Desalination

Although desalinization was not a high priority in water resources planning alternatives in Kiribati, a break through in options came about during the unusual drought stricken period of 1998-99. To abate the situation, Government purchased three small desalination plants to alleviate water shortages on Banaba and South Tarawa. These were purchased from Japanese firms and are currently in operation. A couple of small plants on South Tarawa are currently servicing populated Betio and the Otintaai Hotel in Bikenibeu. An assessment of the mechanical plants effectiveness is yet to be made although the plants capacity is not even enough to meet the full water demand on South Tarawa.

6.4.4 Prohibition of agricultural activities on water reserves

To protect groundwater sources, Government have set aside land as reserves and have proscribed activities, such as horticulture, to avoid contamination (Metutera, 1994 in Falkland, 2001), but such exclusions alienate traditional land owners, restrict agriculture and lead to conflicts and costly and lengthy disputes (White *et al.*, 1999a).

However, search for additional water sources in the other islets of North Tarawa provides an opportunity to examine opportunities for expanding agriculture, for involving local communities in resource use and for reducing potential conflicts (White & Falkland, 2001).

6.4.5 Appropriate Technologies

Demand management is important for water resources management on small islands including Kiribati where the context is for groundwater and rainwater as the most appropriate conventional water sources. On South Tarawa, with a limited freshwater resources demand management should include an appropriate pricing policy plus consumer education on the reduction of waste.

On the other hand, for the outer Islands of Kiribati, hand-pumping systems and solar pumping systems installed in the 1990's with funding assistance provided by the UNCDF, United Nations Capital Development Fund. The water sources for these systems use a modern infiltration gallely design with perforated pipe as a conduit.

Also on South Tarawa, other measures may include reduction in water supply pressure, a problem closely associated with limited freshwater resources, to minimum levels and the use of water conserving devices. To increase the water pressure one has to run the water supply system 24 hours a day so that the water reaches all consumers on the reticulation system. However, since this will obviously lead to excessive water usage and wastage, the constant flow method of water distribution is an answer to the present low water pressure problem in South Tarawa and has been successfully implemented in Kiritimati Island as well.

The method or system of constant flow of water distribution ensures that each household receives a constant but low flow of water that is fed into small tanks and stored until required. Different sized flow restrictions can be provided according to household water needs and monthly charges can be set accordingly. (Metai, 2002)

6.4.6 Conclusions

Kiribati, with its small atoll islands water means survival. Throughout the world all economic activities will surely halt without water. As for the local population, water consists of 91% of the body; it is the bloodline. People may live for days or even week without food – but their bodies will grow weak or even could die within hours without water. Sustainable development in terms of water resources is linked instantly with people's need – the need for water.

Let us all hope however, that plans, and proper technologies such as explained above will allow observers to once again say without bitter irony of Samual Taylor Coleridge's ancient mariner – 'Water, Water Everywhere, Not any drop to drink…Alone on a wide, wide sea.'(Island Business, 2002)

6.5 Data Gap

Data on water quality cannot be accessed during the information collection period, however, these should be available at the Environmental Health Inspection Unit of MHFP.

Chapter 7. FLORA

7.1. Introduction

7.1.1 General

The indigenous flora of Kiribati is extremely poor (Thaman *et al.*, 1996) due to the extremely poor and harsh environmental conditions of an atoll. Unfavorable environment and climatic factors that provide constraints and determine the overall flora diversity include small land mass (limited land area of the islands), low rainfall, low soil fertility, high infiltration rate and high pH of the soil. Soils are among the poorest in the world. The soils in Kiribati are limiting in most of the essential elements (eg. Iron (Fe), manganese (Mn), copper (Cu), etc). The relative isolation of Kiribati to seed dispersal is also a constraint on the flora diversity.

Many soil enrichment activities, research and introduction of many plant trees and vegetables have to be undertaken in order to improve the food plant varieties so the growing population can have many choices in growing food crops to enrich their diet rather than depend on costly imported foods.

7.1.2 Availability of Data

Information on the flora of Kiribati and other related developments is available at the Division of Agriculture (DA) of Ministry of Natural Resources Development and other regional institutions like the University of the South Pacific (USP), the Secretariat of the Pacific Community (SPC). The flora of Kiritimati Island has been extensively documented by Thaman *et al* (1996).

FSP, an NGO has undertaken numerous projects on nutritional plants through promotion of home gardens to complement various activities of the Agricultural and Health Ministry. There may be extensive research by various agencies but were not known during the course of data collection for this report.

7.2 Present State of the Environment

7.2.1 Terrestrial Flora

The flora of Kiribati is ecologically critical, being limited to a coral atoll's typical coastal strand communities of shrubs, mangroves, marsh vegetation with remnant stands of inland forest and pinnacle vegetation of limestone escarpments (MESD, 1999). A list of the plants of Kiribati (Appendix 7.1) has been compiled by the Division of Agriculture.

The flora of the Gilbert group consists approximately 306 species, only 83 (27.1 %) of which are possibly indigenous; there are no endemic species. Yet these indigenous species are dominant in some disturbed habitats and constitute most of the culturally and ecologically important species. Around 40 of the 83 species are severely restricted in distribution, endangered or possibly extinct, due to removal and severe habitat modification or limitation (Thaman & Whistler, 1996).

Eight indigenous species are widespread pantropical or paleotropical pteridophytes or ferns. There are no indigenous gymnosperms (conifers). Indigenous monocotyledons are restricted to pandanus and a range of sedges and grasses. The indigenous dicotyledons are salt-tolerant, widely dispersed plant, pantropical coastal species (Thaman *et al.*, 1995)

Exotic species make up 73 % of the current flora of the Gilberts, mostly of the ruderal and houseyard vegetation. 22 % of the flora are food plants, many of which are restricted mainly to numbers and utility due to the unfavourable environmental conditions (Thaman *et al.*, 1995).

The current flora of Kiritimati (Thaman *et al.*, 1996) has about 104 species, 22 of which seem to be indigenous. Due to the generally dry conditions of Kiritimati Island, neither indigenous nor introduced ferns and gymnosperms are present, but a number of ferns are found on the wetter atolls of the Line and Phoenix groups. The Tree Heliotrope is the main native tree and grows to a maximum height of approximately twenty feet. Other trees such as *Pisonis grandis* (**Te Buka**), *Barringtonia asiatica* (**Te kanawa**) and *Casuarina Equisitifolia* (**Te Burukam**) are also present. Of the 22 monocotyledons present, 7 might be indigenous such as grasses (Cyperaceae) and sedges (Poaceae), possibly the coconut and pandanus. Of about 82 dicotyledons, only 15 are possibly indigenous.

7.2.2 Marine Flora

The marine flora comprises of seaweed and sea grasses, much of which has not been studied well, except the marine algae of Kanton. The most important of the indigenous species is sea grapes (*Caulerpa racemosa*) known to be very common only in Tarawa Lagoon. Other sea flora known include the long filamentous algae (*Spirogyra spp*.), coralline algae (*Halimeda spp*.), *Thalassia hemprichii*, and the red algae of the *Galaxaura spp* and *Turbinaria spp*. (Thaman *et al*., 1996; Awira, 2000).

A well known introduced commercial seaweed is the Euchema seaweed (*Eucheuma cottoni*, properly *Kappaphycus alvarezii*) which has been a competing rival of copra as a cash crop at sea. (See Section 8.2.3.3)

Some marine algae has been reported by Degener & Degener (1959) and Dawson (1959) to be present at Kanton that includes lists of species (Appendix 7.3) of Cyanophyta, Chlorophyta, Phaeophyta and Rhodophyta but mosses, ferns and lichens were not found. Although research may have not extended to the rest of Kiribati, it is assumed that the same species exist throughout the equatorial waters of Kiribati.

7.2.3 Threatened and endangered species

A number of plants had been identified (MESD, 1999) as either extinct or endangered or rare. A preliminary listing (Table 7.1) of the status of the flora in Kiribati shows that the Gymnosperm family have the highest numbers of species that are extinct, endangered and rare.

Table 7.1 Status of Flora of Kiribati

Plant family/groups	Number of Extinct Species	Number of Endangered Species	Number of Rare Species
Pteridophytes	-	1	6
Bryophytes	-	3	3
Gymnosperms	22	56	23
Babai	2	8	10
Food Crops	-	5	17
Ornamental Plants	-	4	13
Shrubs	4	12	10
Creeping plants	-	7	6
Woody, (coastal)	3	16	5
Grasses	-	6	3

(Extracted from MESD, 1999 Section 1.8)

A number of the flora of Kiribati have been considered endangered while some are of particular cultural importance (Appendix 7.2). These plants need protection in reserves because of their educational purposes and utility in Kiribati

7.2.4 Habitat diversity

The flora diversity is confined to coastal ecosystems of mangrove swamps, marshland, secondary and cultural vegetation of coconut palms, giant swamp taro (*Cyrtosperma chamissonis*) pits, as well as house yard and village gardens (Thaman et al., 1996; MESD, 1999).

7.2.5 Species Distribution

Due to the smallness of atolls, the entire islands are regarded as coastal areas and hence the natural distribution of plants is fairly simple on each island. A typical atoll would have most of the natural vegetation described in Section 7.2.6

However, climate also plays a significant role in determining the presence or absence of certain plant species and their varieties (cultivars). For instance, the wetter islands of Little Makin and Butaritari in the northern Gilberts tend to have more varieties/species of breadfruits and mangroves present but the drier islands in the southern Gilberts and the rest of Kiribati tend to have less or even none at all, but this could be hard to observe due to human interference of transferring plant species from island to island (AD, 2000a).

7.2.6 Significant Ecosystems

Terrestrial and cultural ecosystems that constitute major resource-use zones in Kiribati, which could also serve as the focus for community-based and national biodiversity conservation include:

7.2.6.1 Natural Vegetation:

Prior to the setting up of conservation areas, documentation of the natural vegetation in North Tarawa (Thaman et al., 1995) and Kiritimati (Thaman et al., 1996) was prepared as an inventory of what both atolls hold. All of these vegetation types are found on Kiritimati but some are also common on the rest of Kiribati. In general, the vegetation on Kiritimati is sparse, with few native species of plants. Extensive areas are open with low or scattered scrub, which varies from year to year depending on the rains.

7.2.6.2 Pisonia Forests:

These consist of Te buka (*Pisonis grandis*) trees, which is well-known as the most important seabird rookery species in the Pacific, there are only 3 remaining single species stands throughout Kiritimati at:

a. Near K site, just inland from Southeast Point, with an estimated 200 or more large trees;
b. The north central part of Motu Tabu, with 70 – 100 trees;
c. Northern part of island, southeast of NASDA, with a small stand of trees.

However, in a later study (Woodroffe & Morrison, 1999) the Pisonia forests in c. above were not sighted or absent. This may had resulted from clearing for the HOPEX project. The same study located Pisonia forests on Little Makin, the most northern island in the Gilbert group.

In most cases, the littoral forest is the most common type of vegetation found along the shores of islands in Kiribati. This is typified by dense forest that is sometimes dominated by a single tree species. Common trees in this plant community include *Cordia subcordata* (**Te kanawa**), *Barringtonia asiatica* (**Te baireati**), *Guettarda speciosa* (**Te uri**), *Calophyllum inophyllum* (**Te itai**) and *Hernandia sonora* (**Te nimareburebu**).

7.2.6.3 Lepturus Grasslands:

These are favourable bird nesting sites for shearwaters (*Puffin spp.*) and bobbies (*Sula spp.*). The dominant species is *Lepturus repens* (Te uteute), with varying amounts of important species *Tribulus cistoides*, (Te maukinikin), *Boerhavia repens* (Te wao). Other trees, which appear in scattered clumps or individually are *Tournefortia argentea* (**Te ren**) and *Scaevola taccada* (**Te Mao**), commonly covered with the epiphyte *Cassytha filifromis* (**Te ntanini**), hence giving an appearance of a savannah type of vegetation. The sites are:

I. Just north of Tabakea village;
II. Centre of northern part of island between Northwest Point and cape manning;
III. East of Cassidy Airfield toward Northwest Point

IV. South of Aeon Field and near Dakota Strip extending to west on southeast peninsula;
V. West of Tahiti and south of Te Kaba (New Zealand Airfield);
VI. Poland Plains, just north of Poland village in southwest;
VII. Lagoon islets of Cook Islet, Motu Tabu and Motu Upua.

7.2.6.4 Scaevola – Tournefortia Littoral Forests:

This is located on the seaward edges of coastal forests. These are less favourable drier, hardpan or more exposed sites, but still are important nesting sites for frigatebirds, bobbies and noddies. The dominant plants of this community are *Scaevola sericea* (**Te mao**) and *Tournefortia argentea* (**Te ren**).

7.2.6.5 Tournefortia woodlands and scrublands:

They are common in some areas and are important nesting sites for sooty terns, common black and brown noddies, white and fairy terns, and the red-tailed tropicbird.

Littoral scrublands are common on windy coastal ridges and on the seaward margins of the littoral forest. It is dominated by shrubby species of up to two metres or more in height, but these are sometimes prostrated by the action of strong, salty sea winds. The boundary between this plant community and the littoral forest is distinct but often the two intergrade into each other.

7.2.6.6 Scaevola Scrubland:

Similar to the other littoral forests, these are less favourable drier, hardpan or more exposed sites, but still are important nesting sites for frigatebirds, bobbies and noddies. Areas at the Y Site housed the red-footed booby

7.2.6.7 Mixed Herblands:

This is common in Kiribati where nearly all the land surfaces are formed by sand islets. This vegetation strand occupies the upper portion of sandy or rocky beaches, which are often limited inland by the littoral
forest or littoral shrubland and seaward by the high-tide mark of the sea. Typically, in mixed herblands, the dominant species are herbaceous creeping vines such as *Ipomea pes-caprae* (**Te ruku ni maeao**), *Vigna marina* (**Te ruku**), but grasses such as *Thuarea involuta* (**Te uteute**) and *Lepturus repensn* (beach bunch grass- **Te uteute**) are also frequently found here.

Figure 7.1 Breadfruit tree on Tarawa (ECD, 2000)

Like the other littoral forests, these are less favourable drier, hardpan or more exposed sites, but still are important nesting sites for frigatebirds, bobbies and noddies

7.2.6.8 Heliotropium – Portulaca Herblands:

Such as the other littoral forests, these are also less favourable drier, hardpan or more exposed sites that are important nesting sites for frigatebirds, bobbies and noddies. The blue-grey noddy nests in the camouflage of the herblands on Cook Island and Motu Tabu

7.2.6.9 Coconut and Household Gardens:

This type of man-made forest or traditional agro-ecosystem combines native and alien species. This is an area with cultivated or planted trees and some wild plants that forms an artificial forest with associated understories of shrubs and herbs. The cultivation of useful herbs, shrubs, trees and other important ornamental flowering species has significant impact on the natural broadleaf forests in most inhabited islands in Kiribati. Coconut plantations are widespread for copra production and constitution of the main staple diet. Other important trees beside coconut (*Cocos nucifera*) are:

Pandanus or te kaina (*Pandanus tectorius*);
breadfruit (Fig.7.1) or te mai (*Artocarpus altilis & A.mariannensis*),
tropical almond or te kunikun (*Terminalia catappa*);
native fig or te bero, (*Ficus tinctoria*);
te itai (*Calophyllum inophyllum* **);**
te kanawa, (*Cordia subcordata*);
te uri, (*Guettarda speciosa*);
te non, (*Morinda citrifolia*);
te kiaiai, (*Hibiscus tiliaceus*);
frangipani or te meria (*Plumeria spp.*)
sebesten plum (*Cordia sebestina*);
hibiscus or te roti**,** (*Hibiscus rosa-sinensis*);

lantana or te kaiboia, (*Lantana camara*);
hedge panax or te toara, (*Polyscias spp.*) and a small range of ornamental plants (Thaman, *et al.*, 1996).

7.2.6.10 Mangroves

Mangrove swamps are known to be common in most islands of Kiribati. Mangroves usually occur on muddy reef protected areas that are periodically inundated by sea- water. According to Metz (1995), the mangroves of Kiribati represent "Natural Monuments" that depict a virtually undisturbed indigenous vegetation type, unlike most of the native land habitats, which have been heavily modified by human activities in Kiribati. The limited land area of mangrove wetlands represents approximately 1 % of the Gilbert group vegetation type.

Figure 7.2 Mangrove stand adjacent to Bonriki Airport (Royds, 1996)

An assessment (Metz, 1995) of the mangrove resources of Kiribati on Tarawa, Aranuka, Butaritari and Maiana atolls was performed to determine, among other things, the general distribution, stand structure and composition. Apart from this study, there is no other available data for mangrove resources on the other islands like Makin, Abemama, Nonouti, Beru and Onotoa (Ward, 1999). Mangrove species that are found (Metz, 1995) in Kiribati include: *Rhizophora stylosa* (te tongo), *Sonneratia alba* (te nikabubuti), *Bruguuiera gymnorhiza* (te buangi) and *Lumnitzera littorea* (te aitoa).

Mangroves on the atolls assessed by Metz (1995) occurred along the shorelines of sheltered lagoons. An estimate of mangrove area is: 166 ha in Butaritari; 57 ha in Tarawa; 21 ha in Maiana; and 14 ha in Aranuka.

Rhizophora stylosa is the only species present at Tarawa, Maiana and Aranuka. There there have been reports (see Section 9.2.1.6) that Tarawa have the *Lumnitzera littorea* and the *Bruguuiera gymnorhiza* species also. Butaritari mangrove wetlands have mixtures of *R. stylosa, Bruguiera gymnorhiza, Sonneratia alba* and *Lumnitzera littorea*. The mangrove stand structures generally range from stunted, shrub-like trees to 12.5 and 30.0 cm diameter at breast height (dbh) with heights between 6 and 20 m (Metz, 1995).

Butaritari hosts the largest mangrove wetland in the Gilbert group. It represented Kiribati's most diverse mangrove forest (Fig.7.3). The four species can be found in various structural and composition arrangements. The mangrove vegetation types include the following estimations:
17 ha of short, shrub-like stands of mangroves smaller than 12.5 cm in dbh with crown closure of main canopy less than 30 % (MN0L);

Figure 7.3 One mangrove swamp in Butaritari (after Breeven, 2000)

56 ha of short, shrub-like stands of mangroves smaller than 12.5 cm in dbh with crown closure of main canopy between 30 and 70 % (MN0M); and 93 ha of trees averaging between 12.5 to 30.0 cm at dbh with crown closure of main canopy between 30 and 70 % (MN1M). This class of mangrove area was recommended (Metz, 1995) as a proposed Mangrove Forest Reserve.

Mangroves areas are vital for shoreline protection in minimizing adverse impacts of coastal erosion, coral reefs smothering from land-based pollution, strong waves and wind and seawater (salt) spray. They are also sites for breeding and nursery grounds for many marine organisms such as milkfish and few edible crabs during different stages of their lifecycles.

In Kiribati, mangroves are priceless sources of materials for construction, local medicine, traditional handicraft, firewood and decorations. The local people have been using this resource for granted without much consideration of its conservation or sustainable use. There have been efforts (Metz, 1995, Ward, 1999 & Krauss, 2001) to strengthen research work and develop management plans for the conservation and sustainable utilization of the limited and scarce resource.

7.2.7 Introduced Flora

Most of introduced plants are exotic dicotyledons for food, ornamentals and weeds while some are useful. This includes food crops like breadfruits, pawpaw, lime, sweet potato and other agricultural crops like citrus fruits and vegetables; ornamentals such as frangipani and bougainvillea; and useful trees for instance, casuarina and leucaena in providing shade and timber.

7.2 Pressures on the flora (Environment)

7.3.1 Pests

Common pests are insects as well as non-insects. Table 7.2 lists the different pests, their hosts and significance of the pest impact

Table 7.2 Common Pests, their hosts and status in Kiribati

Present Insect Pests	Hosts	Significance
Bettle (Papuana huebneri)	taro and babai	Very serious on capital
Egyptian fluted scale	breadfruit and pandanus	Occasionally serious
Flat moth	Coconut	Occasionally serious
Mealy bugs	Coconut	Occasionally serious
Green striped semilooper	Cucumber and tomato	Serious on leaves and fruits
Spiraling white fly	Vegetables, coconut, breadfruit, pawpaw & ornamental plants	Serious damage to fruits and vegetable leaves
Mango fruit fly	Pawpaw, breadfruit, kuava, jujube & mango	Serious damage

(Adapted from MESD 1999, Section 1.6 Page 10-11)

Non-insects pests include red spider and vegetable mites, slugs, crabs and rats (*Rattus rattus*). A more comprehensive and update list of these and previous pests are detailed in Teuriaria (2000) available at the Division of Agriculture of MNRD.

7.3.2 Vegetation Clearing

Human disturbances such as clearing natural bushes and vegetation began prior to the 1970s. This includes the conversion of naturally vegetated areas to monoculture practices of coconut plantation, nuclear testing since the 1950s and migration of people through resettlement schemes from populated islands (Gilbert group) to almost uninhabited atolls (Line and Phoenix groups).

This alteration of land use has contributed to the uniformity of soil, where the stable-vegetation soil complex is broken up that usually result to a rapid decline in soil organic matter with the formation of thinner A horizons (Morrison, 1990). In contrast undisturbed *Pisonia* and *Hernandia* forests stands that attracts seabird, are associated with localized phosphatic soil as found on Makin (Woodroffe & Morrison, 2001). These soils could turn into phosphate rich soil with distinct layering features of cemented material, the so-called Temoseries (Morrison, 1990).

Vegetation impact on soils is important (Morrison & Seru 1986, Morrison, 1990). The production of litter on wetter soils is considerable leading to well developed organic-rich A horizons. Soil fertility is highly dependent on organic matter to lower the soil pH, to capture and recycle plant nutrients and to retain water in the excessively fast draining soils. Plant nutrition is dependent on the humus cycle and the maintenance of the vegetation cover (Ruatu, 2002). However, on drier atolls, organic matter addition to soils leads to thinner less well developed surface horizon. This could lead to deep, very dark organic layers as can be found under very compact canopy of *Guettarda sp* and *Cassythra filiformis* (Morrison & Seru, 1986).

Vegetation clearing or deforestation along the coast has also exposed coastal areas to direct and strong sunlight, desiccating effects of salt sprays, damage from strong winds and high spring tides, and land destabilization.

7.3.3 Agriculture

Domestic agriculture is limited to a range of cultivated and protected wild trees, a limited number of non-woody plants and livestock are raised within a relatively dense and homogeneous matrix of coconut palms (Thaman, 1990b). Scattered throughout the predominant coconut stretch are pandanus, breadfruit and the native fig, along with pantropical species such as *Scaevola serivea*, *Tournefortia argentea*, *Guettarda speciosa* and *Pemphis acidula*.

Coconuts are categorized according to whether their mesosperm is edible (te bunia) or non-edible (te ni), though the latter is more common. Coconuts with juicy flesh or the quality and sweetness of their toddy (karewe) as in Figure 7.4, are among the many criteria for selecting coconut varieties to grow.

Other cultivated non-woody crops and fruit trees are pawpaw or papaya, bananas, lime (*Citrus aurantifolia*), lemon, guava and mango though the latter two are difficult to grow and fruit well (Thaman, 1990b). The other cultivated food plants around homes were sugarcane (*Saccharum officinarum*) and hibiscus spinach (*Hibiscus manihot*) but nowadays chaya, nambele, and drumsticks are more common. A comprehensive coverage of these flora and their usefulnesses have been extensively provided in Thaman (1990b).

7.3.4 Stresses on Mangroves

Mangroves have undergone considerable stress due to the following natural and man-induced activities (Metrz, 1995):

- Deforestation of mangrove forest for domestic purposes;
- Rapid and increase infrastructure development on coastal areas (e.g. road and causeway constructions);
- Alteration of lagoon circulation, freshwater diversion and inter-channel blockage, resulting in changes to near-shore currents, sea and fresh water mixing, water temperatures and salinity levels;
- Damage to roots and hampered physiological processes caused by excessive pollution, sand deposition and hazardous material spills;
- Coastal erosion;
- Mechanical damage to trees trunks and limbs resulting from storm systems, tidal surge and vandalism;
- Addition of toxic compounds to the ecosystem;
- Increasing population hence more coastal reclamation;

Figure 7.4 A man cutting toddy from a coconut tree (ECD, 2000a)

7.3.5 Degradation and loss of habitat

Other causes of flora degradation and loss of habitat are:

- Traditional methods of land clearance (e.g. the use of fire);
- The expansion of coconut plantations for export production of copra;
- Land based sources of pollution from spilled and waste oil, etc;
- Habitats used as waste dump;
- De-vegetation and removal of plants for many purposes including human; settlements without reforestation or revegetation;
- Stray animals particularly pigs, which could forage freely on plants such as young coconut trees, bwabwai plants, etc.

7.3.6 Plant Diseases

Limited data is available on the diseases and types of pathogens that attack plants including food trees and ornamental crops. Table 7.3 provides a preliminary list.

7.4 Responses to Environment Pressure

7.4.1 Establishment of Conservation Areas

Two conservations areas (CAs) were established called the North Tarawa Conservation Area (NTCA) and the Kiritimati Atoll Conservation Area (KACA). Both CAs were established with financial assistance from the Global Environment Facility (GEF), channeled through the South Pacific Regional Environment Programme (SPREP). Funding to sustain the ongoing activities will expire soon

Table 7.3 Major diseases of plants

Hosts			**Pathogen**		**Pest Status Remarks**
Scientific Name	Family	Common Name	Scientific name	Common Name	
Artocarpus altilis	Moraceae	Breadfruit	*Collectotrichum sp*	Fruit rot	Affecting fruits & dead branches
Carica papaya	Caricaceae	Papaya	*Pseudocercoporani gricans*	Leaf spot	Affecting leaves
Coco nucifera	Arecaceae	coconut	*Pseudocpicocuum cocos*	Brown leaf spot	Affecting leaves
Cucumis sativus	Cucurbitace ae	Cucumber	*Virus*	Cucumber mosaic	Affecting leaves and fruits
Cucumis maxima	Cucurbitace ae	Pumpkin, Squash	*Virus*	Watermelon mosaic	Affecting leaves and fruits
Lycopersion	Solanaceae	Tomato	*Myrothecium*	Leaf spot	Affecting leaves, leaf curl
Musa spp	Musaceae	Banana	*Deightoniella torulosa, Mycosphaerella musicola*	Black tip disease of fruit Sigatoka disease	Affecting fruits, Affecting leaves
Plumeria rubra	Apocynacea e	Frangipani	*Glomerella cingurata*	Leaf spot	Affecting leaves

(source: Teuriaria, 2000)

7.4.1.1 North Tarawa Conservation Area

NTCA was first set up in 1995 and encompasses the entire length of the rural or northern part of the capital island, Tarawa, (that is, approximately half of the coral atoll island). Both marine and terrestrial components of the segmented islets were declared CAs. The principle of the CA is sustainable development that allows exploitation of its natural resources but on a sustainable basis, such as re-vegetation. The CA is administered by a coordinating committee consisting of representatives from various stakeholders of all the villages in North Tarawa, meeting once every quarter.

Activities involved awareness workshops, making an inventory of the terrestrial flora, land gardening competitions, conservation of mangrove resources, replanting schemes of rare and endangered plants including trees important for house and boat construction, and passing bye-laws which control over-exploitative harvesting of the natural resources.

7.4.1.2 "Maurin Kiribati" Botanical Garden

The Federation of the I-Kiribati traditional healers known as the "Maurin Kiribati" set up a botanical garden in 1997, because the native vegetation and shrubs are continually being removed due to the encroaching human settlements, as well as private and public developments on South Tarawa. Their botanical garden is established at Teaoraereke, close to the site of Atoll Research Program (ARP) which is an extension of the University of the South Pacific.

The garden contains locally found medicinal shrubs and vegetation, particularly the threatened species that traditional healers depend on for local medicine, treatment and witchcraft. The close proximity of the botanical garden to ARP reflects the latter's role in facilitating the initial establishment of the Maurin Kiribati Federation and research capacity in Kiribati for the analysis of plants and marine organisms on their healing elements for their efficacy (Teitonga, 2000).

There are further plans to develop botanical gardens in all the islands to ensure availability of resources for traditional medicine uses and for the preservation of threatened species. Development and documentation of pictures and information on marine fauna and flora, including their chemical properties, botanical and lay names together with their traditional uses (Teitonga, 2000).

7.4.2 Kiribati National Biodiversity Strategy and Action Plan (NBSAP) November 1999

The Government of Kiribati has recognized the significant contribution of conserving biodiversity to the people of Kiribati and has ratified the Convention of Biological Diversity (CBD) on 16th August 1994. As a Party to the CBD, Kiribati is able to secure financial assistance from the Global Environment Facility (GEF) to undertake an enabling activity, which is the Kiribati National Biodiversity Strategy and Action Plan (NBSAP) project at the national level.

There are six main objectives of the NBSAP:

1) Identification of current status of pressure and options for priority actions for the conservation and sustainable use of biodiversity by stakeholders;
2) Formulation of a National Biodiversity Strategy and Action Plan and the production of a national report for submission to the CBD's Secretariat;
3) Complimenting, building on and strengthening the National Environment Management Strategy (NEMS) and the National Development Plan that is currently known as the National Development Strategies 2000- 2003, and other sectoral plans through a participatory process involving representation from different sectors of society;
4) Raising community awareness on sustainable use of biodiversity in outer islands that are not covered by the NEMS project, hence creating a wider understanding and greater responsibilities amongst grassroots communities towards biodiversity conservation;
5) Expedition of the processing of law enforcement mechanisms to safeguard the richness of biodiversity in closed areas and protecting rare terrestrial and marine flora and fauna species from over-exploitation and extinction in more accessible ecosystems;
6) Development of research projects and activities that would provide useful information for the enhancement and sustainable use of biodiversity particularly on the island of Kiritimati.

The Project has a multi-discipline Steering Committee (administrative arm of the Project) and Planning Team (technical arm of the Project), in which members are drawn from respective key Government Ministries and prominent NGOS that affect biodiversity in their daily operations. Below is a set of objectives that comprises the national action plans and strategies for biodiversity conservation as tabled and endorsed by the Planning Team and the Steering Committee:

- Improvement of formal and informal public education and awareness at the grassroots level to enable their participation in the decision making processes of biodiversity conservation;
- Sustainable use and management of land and terrestrial resources that are in line with traditional and customary land and marine tenure systems;
- Biological resources shall be enhanced, used and managed to maintain biological diversity in the short and long term run;
- Available data and information on national biodiversity shall be expanded and made available to policy makers and the public;
- Activities that pollute and threaten biodiversity shall be minimized.

Current strategic action plans and activities of the NBSAP Project that directly address the environment pressures that affect fauna include:

- Inventory surveys and stocktaking assessment on terrestrial and marine flora and fauna in Butaritari, Nonouti, Nikunau and islands in the Line and Phoenix Groups;
- Formal and informal public education and awareness on biodiversity significance and associated issue targeting local communities (women, youths, grassroots people);
- Implementation of general measures for in-situ and ex-situ conservation (pipeline);
- Documentation of biodiversity related knowledge of indigenous and local communities embodying traditional lifestyles (pipeline);
- Methodologies to evaluate and mitigate specific threats to biodiversity components (pipeline);
- Development of a national biodiversity website to facilitate information sharing and dissemination at national and international level (pipeline);
- Revegetation/ replanting schemes of indigenous plants/trees that have important cultural utilities (pipeline).

7.4.3 Kiribati Mangrove Management Plant

Metz (1995) proposed a draft Kiribati Mangrove Management Plan (KMMP) that identified three categories of mangrove classification namely:

Mangrove Forest Reserve: two sites designated in Butaritari and Aranuka to preserve unique and dynamic mangrove wetlands;
Mangrove Conservation Area: two sites designated in North Tarawa and Aranuka, designed to conserve mangrove wetlands and biodiversity while providing for traditional needs;
Mangrove Special Emphasis Area: sites are dispersed including South Tarawa, designed to contribute to the ecological and socio-economic needs of Kiribati.

Although the draft KMMP is yet to be adopted nationally, some work have already began that are in line with the plan. An NGO, the Foundation of the People's of the South Pacific (FSP), has already embarked on further mangrove research (Krauss, 2000) on Butaritari, community outreach and additional replanting schemes. An independent individual, Baiteke, at Nawerewere on South Tarawa planted his own seedlings or approximately 1000 propagules to spell his name in an aerial arrangement. (Krauss, 2000).

7.4.4 Control and Management of Pests

The usual practice of using chemical insecticides for controlling pests has been found unsuitable to atoll conditions, as the chemicals would eventually leak towards the groundwater causing contamination. Alternatively, the Agriculture Division has been working on other strategies of crop protection that are safe, cheap and effective, through cultural and biological control.

A classic example of biological control that was funded by the Australian Centre for International Agricultural Research (ACIAR), is using an Australian ladybird beetle (*Rodolia limbata*) on the breadfruit mealy bug (*Icerya aegyptiaca*), a pest that suck sap of leaves and hinders the photosynthesis process in leaves. With the introduction of the ladybird beetle, the mealy bug began to decrease in density on breadfruit trees on islands where both insects are present. It has been observed that there is no negative impact of the beetle yet on other insect fauna and flora (Teuriaria, 2000).

7.4.5 Quarantine

Apart from the two serious pests, taro beetle (*Papuana huebneri*) and ship rat (*Ratus ratus*) present in Abaiang, Butaritari, Tarawa and Tabuaeran, Kiribati is still free from very serious animal and plant pests and diseases. Hence stringent quarantine measures are now in force to prevent the spread of these pests to the other islands. There is also an emergency response plan regarding quarantine matters, in particular the eradication of the exotic fruit flies (AD, 2000a).

7.4.6 Kiribati Eco-forestry Project

Attempts have been made by FSP with funding from the European Union, aimed at increasing the capacity of local population of South Tarawa, where there are no extensive stands of indigenous trees for timber production, to sustainably manage their forest and tree resources (Tilling & Holzknetch, 2001).

The project concentrated on demonstrating different ways of conserving and enhancing the use and appreciation of native trees and shrubs and increasing the practical agro-forestry skills of various groups and government officials and encouraging the re-establishment of mangroves. Sites targeted for agroforestry were public parks along accreted land parcels adjacent to causeways and many public Government land holdings including various institutions, communities such as church groups and NGO centers.

The native trees replanted consist of native shrubs and trees including:

- Varieties of the coconut whose husk is edible (te bunia)
- Fruit trees like *Morinda citrifolia* and *Pandanus tectorius*
- Mangrove spp. from Butaritari

Public awareness through radio programs, workshops and educational pamphlets was raised to complement the implementation process (Tilling & Holzknetch, 2001). The project resulted in many home and community gardens (Fig. 7.5), for instance the FSP garden on South Tarawa.

7.5 Data Gaps

- Baseline data and status on mangroves in the remaining Gilbert Islands (Makin, Abemama, Nonouti, Tabiteuea, Onotoa, etc) that have mangrove resources.
- Baseline data on Living Modified Organisms (LMOs)/ Genetically Modified Organisms (GMOs).
- Sea grass information.
- Thorough agreement on definitions and listings of Vulnerable, Endangered and Extinct species by relevant bodies at the national level.


Figure 7.5 A typical backyard garden in Tarawa (ECD, 2000a)

Chapter 8. FAUNA

8.1 Introduction

8.1.1. General

The limited number of terrestrial habitats for fauna on atolls in Kiribati is reflected in a limited diversity of terrestrial fauna, except the avifauna diversity and abundance at the sparsely populated Line and Phoenix Islands. The fauna of Kiribati is limited to mammals, birds, reptiles, amphibians and invertebrates.

There are no indigenous land mammals, while the main indigenous land animals consist mainly of birds and invertebrates. However, the marine habitats of the vast 3.5 million sq. km of EEZ offer a rich diversity of finfish and non-finfish species, which support the livelihood and economy of the people of Kiribati.

8.1.2. Availability of Data

Much of the data and information available on fauna are unpublished preliminary reports from various Divisions (Fisheries and Agriculture) of Government in the Ministry of Natural Resources Development (MNRD) and the Ministry of Environment and Social Development (MESD). Almost all of the marine fauna data are available at the Fisheries library and database. Other comprehensive reports (Thaman *et al*., 1995 & 1996) on conservation areas in Kiritimati and Tarawa are available electronically at MESD and can also be accessed from the SPREP Secretariat.

Other published reports (e.g., Kaly & Jones, 1993) are made available from the authors and donor agencies institutions, which fund the individual studies.

8.2 Present State of the Environment

8.2.1 Terrestrial fauna

The main indigenous land animals are limited to birds, reptiles and invertebrates. Introduced mammals and amphibians include rats, feral cats, dogs, pigs and frogs. Polynesian rats (*Rattus rattus*), are widespread and abundant throughout most islands and are the most common pest on every crop plant (Thaman *et al* 1995; Thaman *et al*., 1996; Sandhu, 1987). According to Garnett, (1983), Black rats (*R. rattus*) has been recorded in the past but no longer persist.

According to Onorio (1979), the reptiles fauna consists mainly of four common species of turtles, which are all locally known as 'Te On' including mourning geckoes (*Lepidodactylus lugubris*), snake-eyed skinks (*Ablepharus boutonii*) and stump-toed geckoes (*Gehyra mutilata*).
Invertebrates include certain species of crabs and the insect fauna. The insect fauna include the disease vectors such as cockroaches, mosquitoes and flies and many were identified (Sandhu, 1987) according to their parasitic relations to crop plants. At the national level, there are approximately twenty- one different insects and five non- insects (mites, slug, crabs and rats) that are of local importance to subsistence and small-scale economic agricultural farmers (Teuriaria, 2001). Table 8.1 shows the number of species and other non-insect pests, according to their association with different crop plants and other items including scavengers. Table 8.2 shows the major insect pests that has been compiled the Division of Agriculture at Ministry of Natural Resources Development.

Table 8.1 Insect and non-insect pests associated with crop plants

Plants	Number of species	Order	Family	Other Pests (Non-insects)
Babai	15	6	10	6 (1 Rodentia + 5 gastropods)
Banana	14	3	7	2 (1 Rodentia + 1 gastropod)
Breadfruit	30	5		Nil
Citrus	9	2	6	Nil
Guava	2	2	2	1 Rodentia
Coconut	54	4	7	6 (2 Rodentia + 2 Gastropods + 1 Chilopoda + 1 Diplopoda)
Pandanus	24			2 (Rodentia)
Papaya	5	3	5	3 (2 Rodentia + 1 Acarina)
Vegetables	28			9 (1 Rodentia + 1 Gastropod + 2 Crustaceans + 2 Acarina)
Stored products	10	2	7	Nil
Scavengers	38			NA

(Extracted from Sandhu, 1987)

Table 8.2 Kiribati Major Insect Pests Lists

Common Name	Scientific Name	Family	Order	Crops attacked
1. Coconut flat moth	Agonoxena argaula	Agonoxenidae	Lepidoptera	Coconut
2. Sweet potato hawk moth	Agrius convolvuli	Sphingidae	Lepidoptera	1.Sweet potato 2. Taro 3. Beans
3. Cutworm	Agrotis ipsolon	Noctuidae	Lepidoptera	1.Chinese cabbage 2.English cabbage 3. Polyphagous
4. Bean aphid	Aphis craccivora	Aphididae	Hemiptera	1.Breadfruit 2. Citrus 3. Legumes
5. Melon aphid	Aphis gossypii	Aphididae	Hemiptera	1.Cucurbits 2. Solanaceous 3. Polyphagous
6. Mango fruit fly	Bactrocera frauenfeldi	Tephritidae	Diptera	Fruits
7. Cotton whitefly	Bemisia tabaci	Aleurodidae	Hemiptera	1.Cucurbits 2.Chinese cabbage 3.English cabbage 4.Polyphagous
8. Whitefly	Bemesia tabaci Nauru strain	Aleurodidae	Hemiptera	1.Cucurbits 2.Chinese cabbage 3.English cabbage 4.Polyphagous
9.Pink wax scale	Ceroplastes rubens	Coccidae	Hemiptera	1.Citrus 2.Polyphagous
10. Purple scale	Crysomphalus aonidium	Diaspididae	Hemiptera	1.Citrus 2.Coconut 3. Pawpaw
11. Green scale	Coccus viridis	Coccidae	Hemiptera	1.Pawpaw 2. Citrus 3. Ornamental 4. Polyphagous
12. Hermit crab	Coenobita spp	Coenobitidae	Crustacea	Vegetables
13. Banana weevil borer	Cosmopolite sordidus	Curculionidae	Coleoptera	Banana (no serious impacts)
14.Cucumber moth	Diaphania indica	Pyralidae	Lepidoptera	Cucumber
15. Spathe weevil	Diocalandra tatinsisi	Chrysomelidae	Coleoptera	Coconut
16.Pineapple mealeybug	Dysmicoccus brevipes	Psendoaccidae	Hemiptera	1.Banana 2. Pandanus 3. Pumpkin

				4. Polyphagous
17.Grey pineapple mealybug	Dysmicoccus neobrevipes	Psendoaccidae	Hemiptera	Same host as in (16.)
18. Sweet potato flea mirid	Halticus tibialis	Miridae	Hemiptera	1.Beans 2. Kumala 3. Cucumber 4.Chinese cabbage 5.English cabbage 6. Polyphagous
19.Corn earworm	Helicorverpa armigera	Noctinidae	Lepidoptera	1.Maize 2. Polyphagous
20.Leucaena psyllid	Heteropsylla cubana	Psyllidae	Hemiptera	Leucaena
21. Taro hawk moth	Hipportion celerio	Sphingidae	Lepidoptera	1.Taro 2. Bwabwai 3. Kumala 4. Ornamentals
22. Sychelles scale	Icerya sychellarum	Margarodidae	Hemiptera	Same as in *I. Aegyptiaca* and *I. purchasi*
Common Name	Scientific Name	Family	Order	Crops attacked
23. Slug	Laevicaulis alte	Gasteropodae	Gasteropoda	1. Vegetables 2. Ornamentals
24. Leafminers	Liriomyza spp	Agromyzidae	Diptera	Vegetables
25.Green vegetable bug	Nezara viridula	Pentalomidae	Hemiptera	1.Fruits 2. Vegetables
26.Coconut mealybug	Palmiculator palmarum	Psendococcidae	Hemiptera	Coconut
27. Taro beetle/ Bwabwai beetle	Papuana huebneri	Scarabaeidae	Coleoptera	1.Taro 2. Bwabwai 3. Banana 4.Chinese cabbage (occasional)
28. Lesser snow scale	Pinnaspis strachani	Diaspididae	Hemiptera	1.Citrus 2. Polyphagous
29.Pacific mealybug	Planococcus pacificus	Diaspididae	Hemiptera	Custard apple
30. Broad mite	Polyphagotarson emuslatus	Tarsonemidae	Acarina	1.Cassava 2. Eggplant 3. Vegetables 4. Fruits
31. Red banded thrips	Selenothrips rubrocinctus	Thripidae	Thysanoptera	1.Citrus 2. Mango
32. Blister beetle	Sessinia livida	Oedemeridae	Coleoptera	1. Coconut
33. Fire ant	Solenossis geminata	Fomicidae	Hymenoptera	1.Eggplant 2. Seeds
34.Cluster caterpillar	Spodoptera litura	Noctuidae	Lepidoptera	Cabbage polyphagous
35.Cluster caterpillar	Spodoptera maurita	Noctuidae	Lepidoptera	1.Sugarcane 2. Cob of corn
36. Mango stone weevil	Sternochestus mangifera	Curculionidae	Coleoptera	Mango seed
37.Aibika leafroller	Syllepte derogata	Pyllidae	Lepidoptera	Okra
38. Red spider mite	Tetranychus cinnabarinus	Tetranychidae	Acarina	1.Eggplant 2. Cassava 3. Polyphagous

(extracted from Teuriaria, 2000)

8.2.2 Avifauna

Kiribati's single reported endemic vertebrate, the Line Islands reed warbler is found on Kiritimati (Thaman *et al*, 1996). This species is also the only resident land bird on Kiritimati Island and are endemic to the northern Line Islands, are common on Washington Island but have recently become extinct on Fanning (Christmas Island Wildlife Sanctuary- Information pamphlet for Visitors). Land, sea and migratory birds of the Line and Phoenix groups constitute one of the riches avifauna worldwide. The indigenous species of Kiritimati is listed in Appendix 8.1 The remaining Gilbert Islands which host the bulk of the nation's population (>90 % since early 1990s), has very few bird species, most probably due to habitat clearing for human settlements.

8.2.2.1 Species distribution

Surveys in the 1960s and 1970s (Thaman *et al*, 1996) indicated that the Line and Phoenix oceanic expanse used to be the world's largest marine avifauna flyways. Birds used the isolated 8 island chains in both groups for feeding, breeding and nesting. In 1996, Kiritimati hosted one of the largest resident populations of the Pacific marine avifauna of eighteen species of seabirds and at least one land bird breed (Thaman et al, 1996).

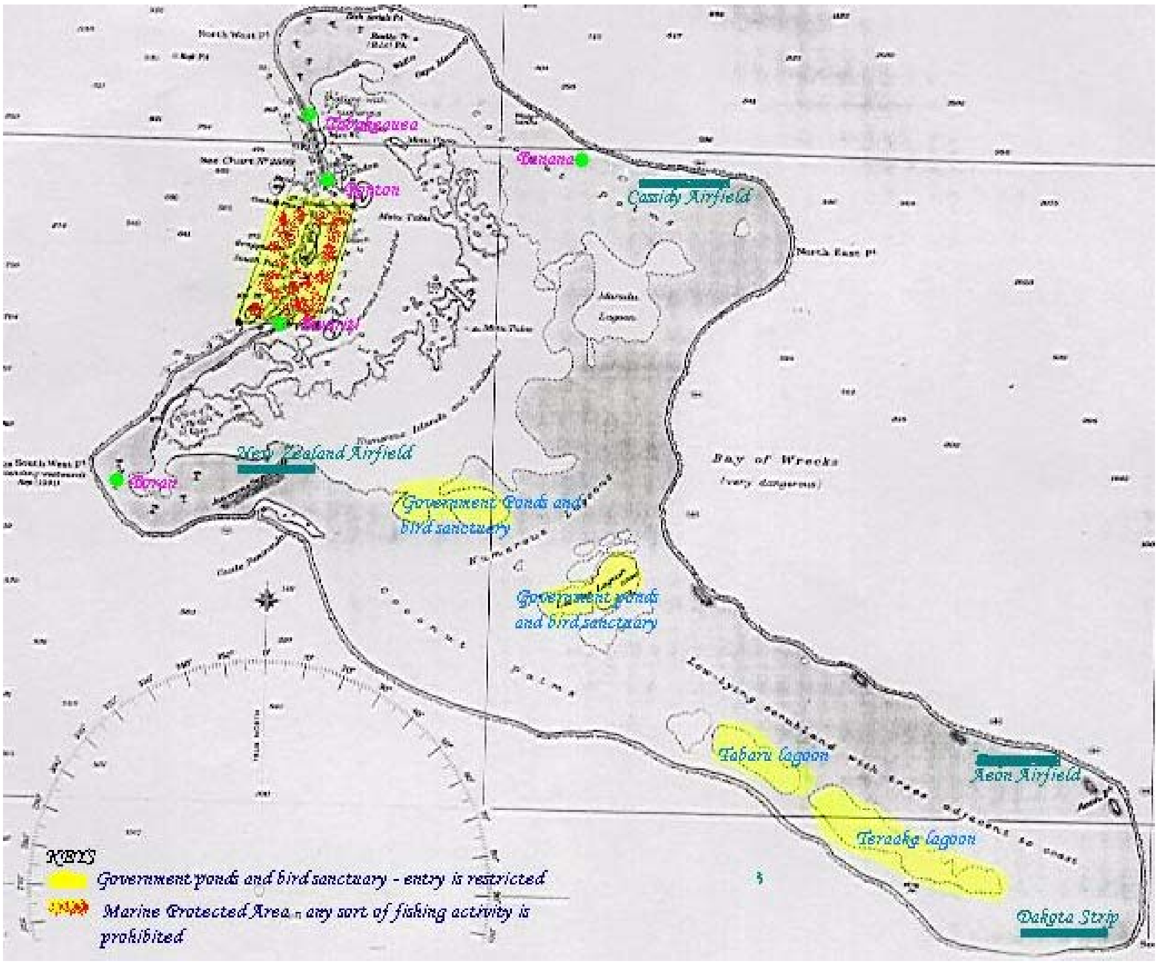

Figure 8.1 Kiritimati Island showing biodiversity conservation areas (Fisheries, 1999b)

8.2.2.2 Status

The checklist and status of bird species on Kiritimati atoll during July 1996 is shown in Table 8.2.

Table 8.2 Checklist of birds reportedly breeding on Kiritimati (Fig. 8.1) and their status during July 1996 (Notes: CK = Cook Island; MC = Main Camp; MT = Motu Tabu; SE = Southeast Peninsula; SLA = Saline Lagoon Area)

Common Name (English)	Scientific Name	I-Kiribati Name	Breeding Observed	Adults	Population Estimate	Location
Phoenix petrel	*Pterodroma alba*	Te ru ru	YES	common	5000 # 25%	MT, CK

Wedgetailed shearwater	*Puffinus pacificus*	Te tangiuoua	YES	common	4000 # 25%	MT, CK, SLA
Christmas shearwater	*Puffinus nativitatus*	Te tinebu	YES	Common	3000 # 25%	MT, CK
Audonbon's shearwater	*Puffinus lherminieri*	Te nna	NO	Not seen		
White throated storm petrel	*Nesofregatta albigularis*	Tebwebwe ni marawa	NO	Not seen		
Red tailed tropic bird	*Phaethon rubricauda*	Te take	YES	Common	5500 # 25%	MT CK, SLA
Blue faced booby	*Sula dactylatra*	Te mouakena	YES	Common	850 # 15%	SE
Brown booby	*Sula leucogaster*	Te kibui	NO	Uncommon	100 # 25 %	Roosting birds-CK
Red footed booby	*Sula*	Te kota	YES	Common	5000 # 15%	SLA
Great frigate bird	*Fregatta minor*	Te eitei	YES	Common	6000 # 15%	SLA
Lesser frigate bird	*Fregatta ariel*	Te eitei	YES	Common	1000 # 25%	SLA
Sooty tern	*Sterna fuscata*	Te keeu	YES	abundant	6 million # 15%	MT,CK, MC, SE
Grey backed tern	*Sterna lunata*	Te tarangongo	NO	uncommon	Not enough info.	Roosting birds, CK, MT
Crested tern	*Sterna bergii*	Te karakara	NO	Common	Not enough info.	Roosting birds CK, MT
Bluegrey noddy tern	*Procelsterna cerulea*	Te raurau	YES	Common	1500 # 25%	MT, CK
Black/Hawaiian noddy tern	*Anous minutes*	Te mangkiri	YES	Abundant	8000 # 25%	MT, CK
Brown/common noddy tern	*Anous stolidus*	Te io	YES	Common	3500 # 25%	MT, CK
White/fairy tern	*Gygis alba*	Te matawa	YES	Common	4500 # 25%	MT, CK
Line island warbler	*Acrocephalua aequinoctialis*	Te bokikokiko	NO	Uncommon	Not enough info.	MC, SE
Scarlet breasted lorikeet	*Vini kuhlii*	Te kura	NO	Not seen		

(Source: Thaman *et al*, 1996)

The Line and Phoenix groups are well known as seabird breeding sites of world importance (Flint, 1999 in Lovell & Kirata, 2000). Kiritimati Island is now the last stronghold for two species, the Phoenix Petrel and the Polynesian Storm Petrel. These species have already been eliminated from most of their other native islands through predation by cats, rats and poachers. If they disappear from Kiritimati, it is possible that they may be gone forever or become extinct (Jones, 2000). Kiritimati has one of the last breeding sites for many seabirds including:

- Phoenix petrel;
- Polynesian Storm-petrel;
- Christmas Shearwater;
- Audubon's Shearwater; and
- Blue-grey noddy.

McKean and Phoenix islands are also hosts of the last breeding sites for the same birds as well as the Bulwer's petrel.

8.2.3. Marine Fauna

There are 3 main categories of marine fisheries resources namely:

i. Lagoonal and reef or inshore fishery
ii.Pelagic and near-shore deep water or offshore fishery
iii.Aquaculture of finfish and seaweed

The first category includes reef fish and other marine resources found within coastal and/or territorial waters surrounding the atolls. Reef fish are typically slow in growth with average weights gains per annum hardly exceeding 0.5 kg. Since reef areas are limited compared to the vast ocean, the species thrive in environments where competition for food is very high. They possess small gonads and hence are relatively less productive. Egg predation is very high in the reef environment and and some species can change sex from male to female and vice versa (Birkland, 1997 in Awira, 1999).

The finfish species of the second category on the other hand, are known for their high productivity and breeds all year round by controlling the release of eggs at different sites. Large gonads containing millions of eggs are common. Growth is fast, for instance, skipjack has been estimated to triple its weight within the first three years. The vast ocean offers abundant food sources. Egg predation is low due to the vast dispersion area. Unlike reef fish, sex change is impossible (Birkland, 1997 in Awira, 1999).

8.2.3.1 Inshore fishery

These include the finfish species and non-finfish species that thrive at coastal marine environments like lagoons and reefs.

8.2.3.2 Finfish resources

Unlike the limited terrestrial fauna, the marine fauna has between 300 and 400 finfish species (Thaman et al., 1995 & 1996). The more important finfish species for subsistence and local markets include:

I. Shallow water snapper, rockcod, grouper or coral trout species
II. Emperors or breams
III. Goatfish
IV. Milkfish
V. Trevally or jacks
VI. Bonefish
VII. Small herrings, sardines, sprats and their relatives

A number of these finfish species are becoming scarce at Tarawa including bonefish, large reef cod (Serranidae), snapper (Lutjanidae), goatfish (Mullidae) and emperor fish (Lethrinidae).

8.2.3.3 Non-finfish resources

These include turtles, crabs, shrimps, prawns, lobsters and other crustaceans such as bivalves and gastropods; holothurians (beche-de-mer); molluscs; invertebrates and others.

Turtles include Green Turtles (*Chelonia sp.*), Hawksbill (*Eretmochely's imbricat*), Logger Head (*Caretta Caretta*), Pacific Ridley (*Lepidochelys olivacea*) and Leather Back (*Dermochelys coreacea*). Of the four species, the leather back turtle is a visitor or migrant to Kiribati waters and most local people are also unaware of this species. The hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) turtles are present in Kiribati (Thaman, et al., 1995). Turtles are considered endangered because of their scarcity. Nesting places for turtles are on some uninhabited islets such as Teirio on Abaiang and Naa islet in North Tarawa.

There are four common species of giant clam, one of which is believed to be extinct globally. Locally, the clams are under great fishing pressure. These are:

- Rugose giant clam or te were (Tridacna maxima): most common
- True giant clam or te kima (*Tridacna gigas*): close to local extinct in some areas

- Fluted giant clam or te were matai (*Tridacna squamosa*):
- Horse's hoof (bear paw or strawberry clam) or te neitoro (*Hippopus hippopus*):

Land crabs (*Cardisoma carnifex*), (*Geograpsus grayii*) and one unkown species, land hermit crabs (*Coenobita perlata*), coconut crabs (*Birgus latro*) and ghost crabs (*Ocypode spp.*) have been reported to be present in Kiribati. Ghost crabs are abundant on sandy beaches. The coconut crab, *Birgus latro*, is considered endangered or overexploited on inhabited islands but reports from Government expeditions to the islands of the southern Line group, stated that crustaceans including the coconut crabs are common, due most probably to low harvesting.

8.2.4 Offshore fishery

8.2.4.1 Offshore and Deep Reefs

Coral formations in deeper water are usually larger and more ecologically fragile than inshore areas as seen in Kiritimati (Thaman *et al.*, 1996). They provide habitats for a variety of marine species such as deepwater snapper, flying fish and billfish, puffer fish and oil fish, all of which are important food fish.

8.2.4.2 Open Ocean (Pelagic)

The deeper ocean is teaming with pelagic and larger finfish species. Tuna and tuna-like species of the Scombridae family, such as skipjack (*Katsuwonus pelamis*) and yellowfin (*Thuunus albicares*) that are abundant, including a range of trevally, amberjack (*Seriola rivoliana*), dogtooth tuna (*Gymnosarda unicolor*), wahoo (*Acanthocymbium solandri*), the rainbow runner (*Elagatis bipinnulata*) and sharks.

These tuna and tuna-like fishes contribute to the bulk of the national economy from foreign fishing vessels which are licensed to fish in Kiribati EEZ.

8.2.4.3 Mariculture or aquaculture

Milkfish farming is a common aquaculture practice mainly by Government and few private farmers. Almost every outer-island Local Council owns a milkfish farm. Government owns major milkfish farms on Tarawa at Temaiku and Ambo and all the hypersaline ponds at Kiritimati.

Temaiku fishfarm covers 80 hectares and has a total of 43 ponds that are further divided into rearing areas, nursery areas and a water supply system (canal) which is connected to the eastern Tarawa lagoon through two sluice gates. The site is located on reclaimed tidal flat land and it is believed that spawning site for milkfish is at a mangrove swamp located on the adjacent tip corner of South Tarawa. Milkfish is purposely farmed as baitfish for artisanal fishermen and produced also as foodfish for local and overseas consumption (FAR, 1998).

Integrated farming was introduced in 1994 to the farm where pigs and chickens are raised at the fishponds in Temaiku. Poultry manure was used as fertiliser in ponds to enhance algal growth as milkfish feed. This practice yielded not only milkfish, but chickens, eggs and pork, which are then sold to the public. Privitisation of the fishfarm is envisaged in future to supply baitfish to Japanese long liners fishing in Kiribati EEZ (FAR, 1998).

The fishfarm at Ambo is used intensively for fry rearing using poultry manure for pond fertilisation, with stock density of 2,000 fry per hectare. Fries are harvested every four months.

Mariculture is only practised as seaweed farming on many islands. Kiribati has a long record of seaweed exports for more than a decade since it first brgan, but Figure 8.2 shows the 1992 to 1998 data only.

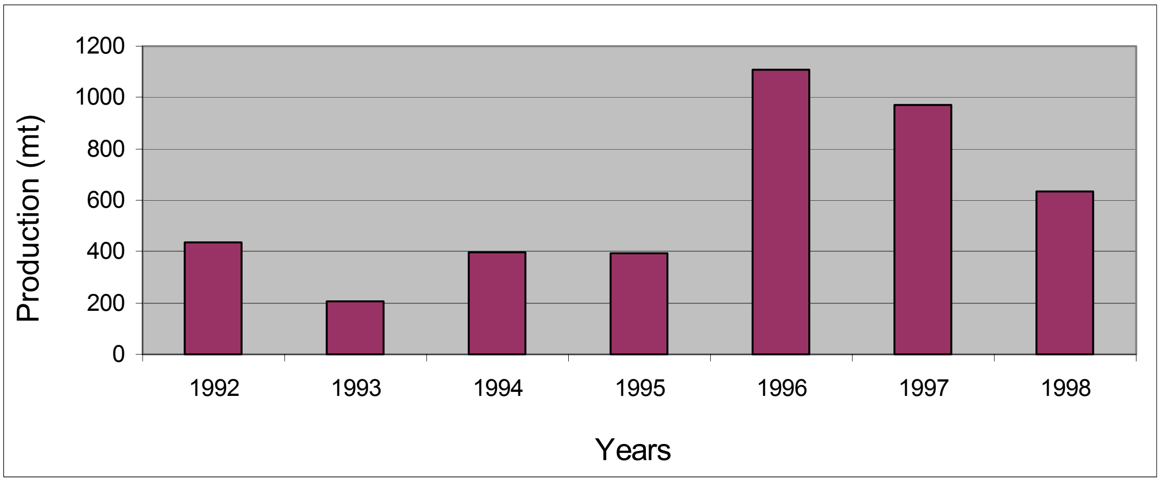

Figure 8.2 Seaweed production (source: Anon, 1997 & FAR, 1998)

8.2.5 Commercial Fisheries

8.2.5.1 Beche-de-mer

Marketing of the sea cucumber began in 1989 (Anon, 1997) to Asian countries including Hong Kong and Singapore. Nine species harvested for commercial purposes are: White teatfish (*Holothurian fuscogilva*); Black teatfish (*H. nobilis*); Prickly Redfish (*Theolenota ananas*); Red Surf (*Actinopyga mauritiana*); Blackfish (*A. miliaris*); Tiger Leopard (*Bohadchia argus*); Brown sandfish (*B. vitiensis*); Lolly fish (*H. atra*) and Green Fish (*Stichopus chloronotus*).

Initial harvesting of the individual species increased to 14 – 40 tonnes in the early 1990s, but declined from 1994 for white teatfish and lolly fish. Similarly the total exports peaked in 1993 to almost 120 tonnes and then declined to about 30 tonnes and continued to decline further to 1998 (FAR, 1998) as illustrated in Figure 8.3.

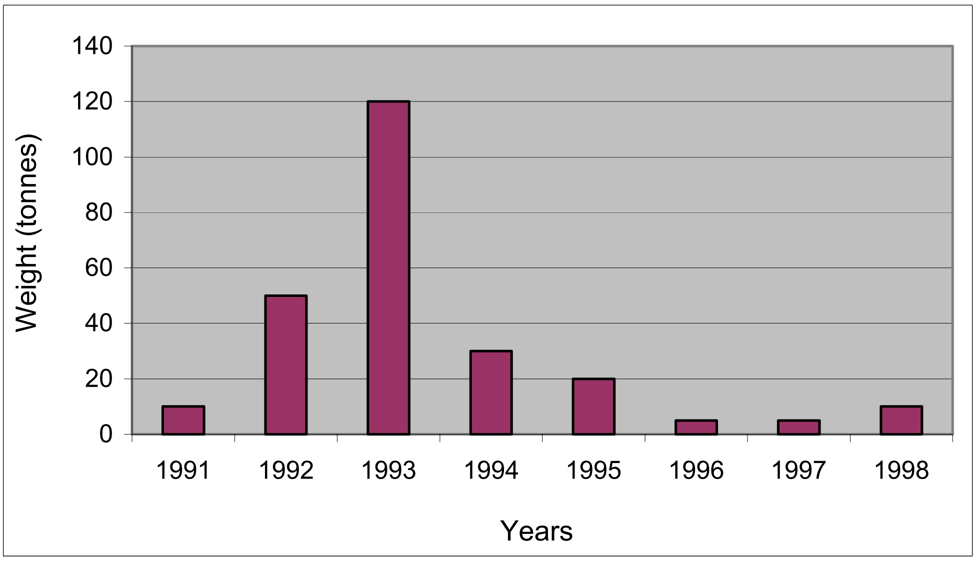

Figure 8.3 Volume of Beche-de-mer Exported from 1991 to 1998 (source: FAR, 1998)

In 1992, seven established companies were involved in exporting of the resource. With the assistance of the Overseas Fishery Cooperation Foundation (OFCF) in 1994, Fisheries Division is now undertaking stock enhancement through land-based hatchery technologies where juveniles produced from the hatchery will replenish the reefs where stocks are known to be declining (Anon, 1997).

8.2.5.2 Lobster fishery:

Kiritimati has a small scale lobster industry that supplies the hospitality industry of hotels and guest houses. Suppliers of lobster are local fisherman. Inspection that no female lobsters have eggs and the minimum size limit is being monitored and maintained by the Fisheries Authority on Kiritimati. It has become increasingly difficult to strictly prevent harvesting of egged females and undersized lobsters through prosecution due to lack of enforcement capacity. The Fisheries Authority recognised that institutional capacity is vital and that regulations need to be broadened to increase the current carapace length so that female lobster would have spawned before being captured and specific lunar periods when female lobsters are ready to spawn are closed for lobster fishing (FAR, 1998).

The same level of commercial lobster operation exists on Tarawa and other islands of the Gilbert group to provide the hospitality industries and restaurants.

8.2.5.3 Sponge

Surveys at Abemama, Abaiang and Marakei by the Fisheries Authority revealed that sponge resources are found to occur in relatively high abundance on both reef flats of the lagoon and ocean. In 1997 farm trials began in Marakei lagoon before farming could be expanded to the rest of the islands (FAR, 1998).
An initial sponge collection had been undertaken (Lovell, et al., 2000) although identification has yet to be done. Details of the database are available at the Fisheries Division at Tanaea on Tarawa.

8.2.5.4 Aquarium-Fish

Export of aquarium fish or pet fish began in the 1980s, initially in South Tarawa but was translocated to Kiritimati where it is in close proximity to market centres in Honolulu and beyond (Anon, 1997). The main fish exported to Honolulu includes: angelfish (Family: Pomacathidae); tangs and damselfish (Pomacentridedae); wrasses (Labridae) and butterfly (Chaetodontidae).

Pet-fish collection licenses in Kiritimati had increased from 4 in 1995 to 6 in 1997 and then 8 in 1999 and this was reflected in the number of petfish exports that also increased from 1994 to 1996 (Figure 8.4).

Depletion of some species may have resulted due to increase in fishing pressure, hence the Fisheries Authority has been monitoring the activities through export data collection and routine checks on divers for usage of proper management gears in order to minimise adverse impacts to the environment (Anon, 1997).

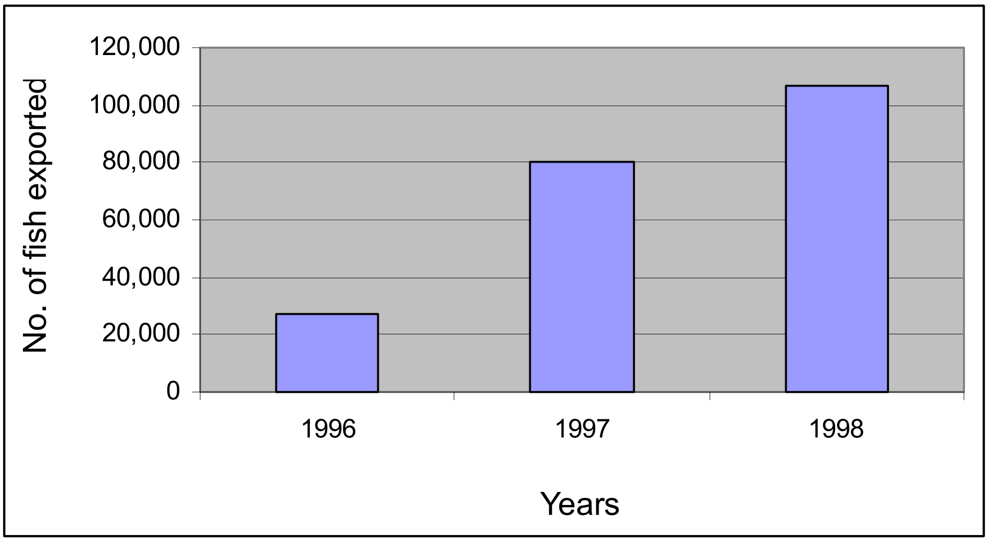

Figure 8.4 Pet fish export from Kiribati (source: FAR, 1998: Table 4)

8.2.5.5 Live Reef Fish Trade:

Non-migratory fish stocks harvested in the live reef fish trade are susceptible to over-exploitation since the species are unique to a particular island and may not be directly related to the same fish stocks from neighbouring islands (Anon, 1997).

Two foreign companies began exporting live fish of the Serranidae and Labridae families. In 1998, the companies were purchasing fish from the local fishermen from the atolls of Butaritari, Tabiteuea, Nonouti and Onotoa. These fish were held in cages prior to transportation by the companies' carrier boats to Asian markets (FAR, 1998).

Fish species targeted for LRFT include: Anyperodon leucogrammicus; *Aethaloperoa rogaa; Epinephelus merra; Epinephelus maculatus; Epinephelus fuscogutatus; Epinephelus cyanopodus; Epinephelus hexagonatus; Epinephelus polyphekadion; Epinephelus lanceolatus; Epinephelus tukula; Variola louti; Chelinus undulates; Plectropomus oligocanthus; Plectropomus areolatus; Cephalopholis leopardus; and Cephalopholis argus* (Lovell& Kirata, 2000).

The amount of fish export during 1998 is shown in Table 8.3

Table 8.3 Amount of live fish exported for 1998

Type of fish	Quantity (tons)
Grouper (Serranidae)	2.141
Wrasses (Labridae)	8.686
Total	10.827

(source: FAR, 1998)

The export of live fish from 1996 to 1998 is shown in Figure 8.5

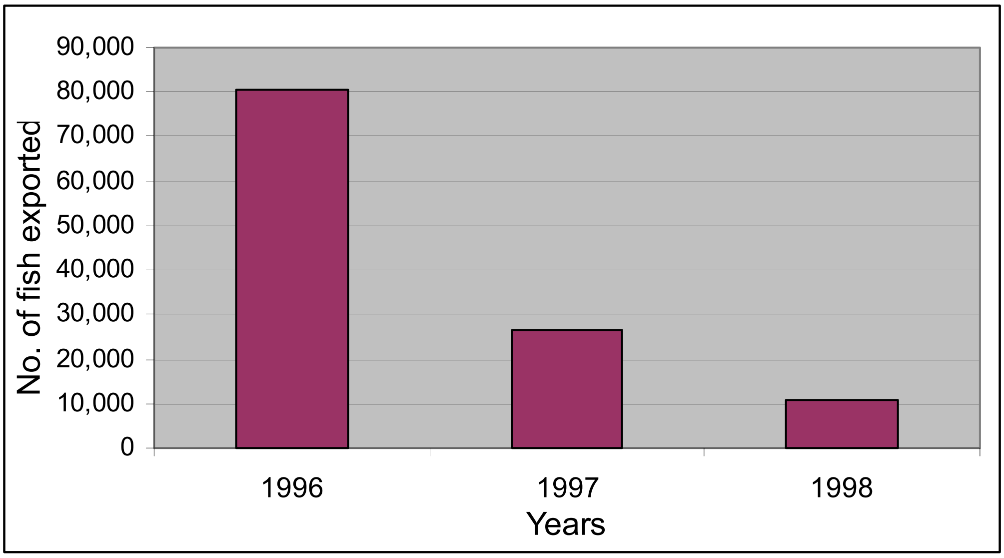

Figure 8.5 Export of Live Fish (source: FAR, 1998)

Although the number of live fish exported has declined significantly, it was found in February, 2000 that the status of these trade fish species were low in numbers (Lovell & Kirata, 2000) at the three Line islands of Tabuaeran, Teraina and Kiritimati where export is relatively high.

Surveys at the targeted islands on the Gilberts group showed similar results. The survey on Onotoa atoll (Kirata, 2000a) showed that numbers of the target fish for the trade were decreasing, hence local fishermen voluntarily decreased their fishing efforts. The locals were concerned for the apparent dramatic diminishing trend of resources.

Surveys of groupers on Butaritari, Nonouti, and Tabiteuea were undertaken by Fisheries Division (Awira, 1999). It was found that the impact of commercial fishing, as shown in the average mean density of serranids, was lower in the surveyed areas as compared to controls or non-targeted islands of Abaiang (Yeeting *et al.*, 1999) and Marakei (FAR, 1998). The live fish trade that was first started in 1995 has shown three years of significant impact and thus yielded the vulnerability of the fishery that needs proper management (Awira, 1999).

There are other marine resources and products that are exported. This includes frozen sea cucumber, frozen octopus, tuna jerky, shark fins, and frozen lobster, etc (FAR, 1998).

8.2.6 Recreation & Tourism Fisheries

Bonefish fishery is the only recreational fishing in Kiribati. Tourists from mainly the United States and Japan go to Kiritimati for the pleasure of bone fishing and diving. This major tourist attraction requires payment of a licence fee of A$25.00 that is valid throughout the period of stay and employs a catch-and-release or no-kill program at designated sites.

Since this recreation fishing does not harvest bonefish in Kiritimati, the target fish is not vulnerable from the tourism fishermen but from the local fishermen. Gillnet fishery that indiscriminately catch fish for food and sale has resulted in a decline of catch by the tourism fishermen.

8.2.7 State of Fisheries

8.2.7.1 Resource and Stock Assessments Surveys

Fisheries Division has a number of on-going stock assessment activities to assess current status of marine resources in terms of relative abundance and distribution, in particular, the commercial species. Stock assessments had been done for the giant clams; *Tridacna species*, black lip pearl oyster, *Pintacda margaritifera* and sponge on many islands of the Gilbert group (FAR, 1998). Blue (*Heliopora*) and brain (*Favidae*) corals on Tarawa had also been surveyed (Awira, 2000). Other species of grouper (*Serranidae*) and wrasse (*Labridae*) for the live reef trade had also been surveyed on Butaritari, Tabiteuea, Nonouti (Awira, 1999) and Onotoa (Kirata, 2000).

Kiritimati Island has been surveyed also in 1985 and 1995 (Kamatie *et al.*, 1995). The latter surveys involved bonefish sampling, marine aquarium petfish assessment and pearl oyster reassessment. It was found that the mean length of male and female bonefish was 42 cm and 51 cm respectively and a sex ratio of 43:1 (female to male) at the tourist fishing sites. The female majority indicated a healthy reproductive population. However, the trend was reversed at sites where local fishermen harvested the species.
More recently, there have been comments by recreational fishermen that bonefish population on Kiritimati is declining. In the 1980s, a fisherman's catch amount to 50 fish per day, but nowadays, the catch is only 10 per day. This has been observed at the Tennesse Primary School location (pers. comm. Iannang Teaioro).

The resource assessment surveys on Teraina (formerly Washington) was first undertaken in 1983 (Anon, 1986) and then later in 1985 by Mees, *et al* using gillnetting, trolling, longlining, drop lining, bouy lining and lobster fishing survey (Anon, 1986). Species composition of the freshwater survey were milkfish, Giant long finned eel (Anguillidae) and tilapia (Cichilidae) and the marine species were grey reef shark, castor oil fish, wahoo, dusky and black trevally, rainbow runner, amber jack, groupers and snappers. The last survey recommended potential resource for development base of freshwater farming for eel (Fig. 8.6) and milkfish, and aquaculture for prawns (*Panaeus monodon*).

Figure 8.6 Fish with moral eel (ECD, 2000)

Tabuaeran (Fanning) was also surveyed in 1985 and later in 1999 (FD, 2000). Unique features observed in the lagoon, were underwater caves and very high rocks standing to over 15 m from the bottom of the sea that are notably absent throughout Kiribati, and was considered a potential for sport fishery.

8.2.7.2 Fisheries Artisanal survey

Artisanal surveys by house interviews are carried out on each inhabited outer island as an approximation of the status of fishery and to monitor the extent of exploitation of the fishery resources. Results of the surveys differ from island to island probably due to fishing methods employed on the outer islands. The most common gear is the hook and line, which is owned by the majority of fishing households (Ukenio, 1999a).

Among the catch landed, tuna, snappers, emperors, bonefish, milkfish and flying fish, constitute the highest compositions. Results of these surveys for all islands can be viewed as separate reports at the Statistical Section of the Fisheries Division of MNRD.

Generally, the subsistence fisheries production is almost triple the commercial catch in both weight and amount, reflecting a dependency of the population on the local fishery (Lovell & Kirata, 2000) as shown in Table 8.4

Table 8.4 Comparison of subsistence and commercial fisheries production

	Production (mt)	Value (US$)
Subsistence fisheries	9,084	13,373,667
Commercial fisheries	3,240	4,770,000
Total fisheries	12,342	18,143,667

(Source: Lovell & Kirata, 2000; p17)

8.2.7.3 Fishing Methods:

Traditional fishing methods consist of:

I. Reef gleaning at during low tide in the intertidal zone;

II. Poling and trolling for schooling fish (eg.tuna) using pearl-shell lures;
III. Gill nets and encircling nets, for catching bonefish, mullet, milkfish, etc;
IV. Handlining for reef and lagoon fish
V. Underwater spearfishing
VI. Scoopnetting for flying fish and other reef fish with pressure lamps at night
VII. Deepwater landlining

Sailing and paddling of traditional canoes is common in deep waters and during high tides otherwise walking on the reef during low tides would be the case

Nowadays, modern methods include improved tackle, outboard-powered boats, nets and ice (cooler) boxes, particularly on South Tarawa where commercial fishing is more predominant than subsistence fishing. Fishing aggregation devices (FADs) deployed by Government, have enhanced fishing. Splashing involving beating the water with crow bars or te ororo is commonly used to scare schooling fish into gillnets. In many instances, scuba diving gears are also used for beche-de-mer collection and pet-fishing activities (Thaman *et al.*, 1995)

8.3 Pressures on the Environment

8.3.1 Population Pressure

The dense population on South Tarawa has increased fishing pressure thus a number of finfish and non-finfish are declining. This is covered in depth in Section 9.2

Figure 8.7 Gleaning for shellfish at low-tide (ECD, 2000a)

8.3.2 Unsustainable harvesting of marine resources

Destructive fishing methods and use of unsustainable fishing gears, particularly for commercial purposes, have contributed to the decline of marine resources. This is also covered in Section 9.3.2

8.3.3 Introduction of predatory alien species

Fisheries Authority confirmed that introduced tilapia has been predating on the popular and farmed milkfish in fishfarms throughout the islands in the Gilbert Group including Tarawa.

More recently fishermen in Tarawa have caught an unknown catfish species in the Tarawa lagoon which is frequented by foreign cargo and fishing vessels. It is believed that like tilapia, the species is predating the declining marine finfish of the Tarawa lagoon

8.3.4 Avifauna populations and habitats disturbances

Avifauna populations and habitats in Kiritimati are diminishing or becoming degraded or destructed by encroaching human settlements due to an increase in human population, human developments and other development projects, for instance the NASDA HOPEX project. The rate of diminishing and degradation is currently undetermined and is open to question. A number of earth removing work and construction have already began and the continual existence of the avifauna breeding grounds is under threat. Poachers including introduced feral animals (cats, polynesian rats & pigs) add more pressure to the survival of avifauna populations. Feral cats and Polynesian rats present a problem faced by the birds, which will take much longer to control, even under the best of circumstances (Jones, 2000).

8.4 Responses to Environmental Pressures

8.4.1 Kiribati National Biodiversity Strategy and Action Plan (NBSAP) November 1999

The Government of Kiribati has recognized the significant contribution of conserving biodiversity to the people of Kiribati and has ratified the Convention of Biological Diversity (CBD) on 16th August 1994. As a Party to the CBD, Kiribati is able to secure financial assistance from the Global Environment Facility (GEF) to undertake an enabling activity, which is the Kiribati National Biodiversity Strategy and Action Plan (NBSAP) project at the national level.

There are six main objectives of the NBSAP:

Identification of current status of pressure and options for priority actions for the conservation and sustainable use of biodiversity by stakeholders;
Formulation of a National Biodiversity Strategy and Action Plan and the production of a national report for submission to the CBD's Secretariat;
Complimenting, building on and strengthening the National Environment Management Strategy (NEMS) and the National Development Plan that is currently known as the National Development Strategies 2000- 2003, and other sectoral plans through a participatory process involving representation from different sectors of society;
Raising community awareness on sustainable use of biodiversity in outer islands that are not covered by the NEMS project, hence creating a wider understanding and greater responsibilities amongst grassroots communities towards biodiversity conservation;
Expedition of the processing of law enforcement mechanisms to safeguard the richness of biodiversity in closed areas and protecting rare terrestrial and marine flora and fauna species from over-exploitation and extinction in more accessible ecosystems;
Development of research projects and activities that would provide useful information for the enhancement and sustainable use of biodiversity particularly on the island of Kiritimati.

The Project has a multi-discipline Steering Committee (administrative arm of the Project) and Planning Team (technical arm of the Project), in which members are drawn from respective key Government Ministries and prominent NGOS that affect biodiversity in their daily operations. Below is a set of objectives that comprises the national action plans and strategies for biodiversity conservation as tabled and endorsed by the Planning Team and the Steering Committee:

Improvement of formal and informal public education and awareness at the grassroots level to enable their participation in the decision making processes of biodiversity conservation;
Sustainable use and management of land and terrestrial resources that are in line with traditional and customary land and marine tenure systems;
Biological resources shall be enhanced, used and managed to maintain biological diversity in the short and long term run;
Available data and information on national biodiversity shall be expanded and made available to policy makers and the public;
Activities that pollute and threaten biodiversity shall be minimized.

Current strategic action plans and activities of the NBSAP Project that directly address the environment pressures that affect fauna include:

- Inventory surveys and stocktaking assessment on terrestrial and marine flora and fauna in Butaritari, Nonouti, Nikunau and islands in the Line and Phoenix Groups;
- Formal and informal public education and awareness on biodiversity significance and associated issue targeting local communities (women, youths, grassroots people);
- Implementation of general measures for in-situ and ex-situ conservation (pipeline);
- Documentation of biodiversity related knowledge of indigenous and local communities embodying traditional lifestyles (pipeline);
- Methodologies to evaluate and mitigate specific threats to biodiversity components (pipeline);
- Development of a national biodiversity website to facilitate information sharing and dissemination at national and international level (pipeline).

Currently Fisheries Division is maintaining and initiating the following programmes:

8.4.2 Monitor fish export through quarantine and licenses of all marine products
Limits on non-commercial marine products to 5 kg per person or traveller

8.4.3 Discourage destructive fishing methods and gears

This was brought about by limiting sale of number of fishing nets per person, e.g., 2 nets per person, and mesh size less than 2 inches

8.4.4 Moving towards establishment of one Marine Protected Area (MPA)

Three MPAs are about to be established at Butaritari, Nonouti and Tabiteuea North in the Gilbert group and on Kiritimati in the Line Group per island at designated parts of the lagoon.

A list of marine protected areas of Kiribati according to IUCN definitions are listed in Appendix 8.3.

8.4.5 Continuation of the general assessment and monitoring of commercial target marine species for baseline data using:

- Underwater Visual Census (UVC) for dominant fish species in coral reef ecosystem;
- Line Intercept Transect (LIT) for coral reef and other benthic organism status;
- Depletion or Catch per Unit effort (CPUE) experiment; and
- Gonad staging and Length/Weight surveys through actual fishing.

8.4.6 Cultivating certain species for spawning

Before release into the wild, certain marine species are cultivated for spawning to replenish stocks. These species include: white teat bechdemer, trochus, and the bivalve cockle or **te bun**.

8.4.7 Ban on fish traps

Prohibition of fish traps and any kind of diving equipment to safeguard coral reef from being destroyed

8.4.8 Strict monitoring of catch and control measures of fishing effort

All foreign and local companies involved in live reef trade are carefully monitored in their catch to control commercial fishing efforts.

8.4.9 Conduct assessments of coral reef fish

Targeted islands for coral reef fish trade by companies are assessment first for their resources prior to issuance of license to commercial foreign operators

8.4.10 Use of local people in the harvests of in-shore fishery resources

For any foreign company operating in Kiribati, local people are employed in the harvesting process since locals do respect their marine ecosystem

8.4.11 Ban of chemicals (cyanide & copper sulphate) and antibiotics

These are now strictly observed in the removal of ecto-parasites and other excessive bacteria, due to their destructive nature to corals. Local and foreign companies found using such methods would have licenses revoked.

8.4.12 Ban of coral trading in Kiribati

Coral trading is no longer practiced throughout the country.

8.5 Data Gaps

- Hardly any studies or surveys have been completed on seagrasses or turtles within Kiribati.
- Offshore and pelagic fishery (confidential) data
- Complete export data on all commercial fishery

Chapter 9. Marine Resources of the Coastal Ecosystems

9.1 Introduction

9.1.1 General

This section will give a general overview and status of the nearshore marine ecosystems of the islands generally and more specifically the focus will be on the 2 major centres, Tarawa and Kiritimati. The former hosts almost half the population (45 % in 2000) of the entire country and hence has severe environmental problems that are rarely seen at the rest of the islands while the latter is the largest atoll in Kiribati and in land area worldwide, being the second major centre of the country where many local and foreign development interests lie.

9.1.2 Availability of Data

Field studies were conducted in the lagoon of the capital island, the Tarawa Lagoon, between April 1992 and July 1994 (Abbott *et al*., 1995). The study focussed on the circulation, ecosystem health, bacterial contamination, finfish and shellfish resources of the Tarawa Lagoon. The study yielded three volumes of report: Project Summary; Technical Scientific Research and; Management Plan for the Tarawa Lagoon

Some years later, some lagoonal studies were undertaken by the South Pacific Geoscience Regional Organisation (SOPAC) on bathymetric estimation at Tarawa and numerical circulation at Abaiang. The majority of SOPAC's joint contribution to a number of marine research cruises centred on exploring the mineral potential in the EEZ of Kiribati.

In the 1995-1997 period, several studies were also carried out at Tarawa prior to the establishment of conservation areas in North Tarawa (Thaman *et al*., 1995) and an environmental impact assessment (Kaly, 1996) of the Kiribati ADB loan project, SAPHE. Within the same period, a number of ADB studies had also been undertaken to justify further developments on South Tarawa to improve the sanitation and public health situation of the overpopulated capital. These studies included the institutional strengthening of the environment section of MESD, followed by a public consultation Morrison & Associates and finally Royds Consulting Ltd. A preliminary state of the environment report was undertaken by Morrison (1995) but was not published. Some of these reports could not be accessed during writing of this report.

More recently a comprehensive survey of the Phoenix islands (Stone et al., 2001) showing near-pristine conditions is a significant baseline source of information prior to human impacts.

9.2 State of the Environment

Many studies in Tarawa have generally shown the degrading state of the environment of Tarawa, particularly the lagoon's water quality and marine biodiversity. The present state is a function of the population on South Tarawa and the techniques used for exploiting marine resources.

9.2.1 Biological oceanography

9.2.1.1 Bacterial Contamination

Concern for lagoonal contamination has been expressed for many years due to its use traditionally for defecation. The outbreak of cholera epidemic in 1977 and subsequent investigations showed nearshore contamination by microorganisms. Investigations in 1987-8 showed that the lagoon water quality close to villages had not improved and that contamination of shellfish ('te bun') was above levels safe for food consumption (Naidu *et al*, 1991).

It had been also shown (Abbott, 1995) that the lagoon reef flats still had high bacterial contamination. The median (88 %) fecal coliform (FC) values exceeded 43 FC/100mL. These same water samples (44 %) also exceeded 200 FC/100mL. All shellfish collected within 25 metres of the shore all exceeded 240 FC/100 g meat, the currently accepted standard for human consumption, but shellfish collected >1,000 metres from the shore contained no measurable FC. All water samples tested had unacceptable levels of coliform contamination.

9.2.1.2 Coral

Coral cover and diversity in the Tarawa Lagoon was found to be decreasing from west to east and from north to south because of the one-sided opening of the western side of the atoll as well as natural passages still existing along North Tarawa (Abbott, *et al*., 1995). Algae were abundant and the reefs were dominated by fragmenting coral species in the central lagoon. Most reefs appeared to be healthy, except mortality noted along the barrier reef and in the south-eastern lagoon where opening to the ocean is lacking. It was suggested that this reef kill was probably a consequence of the urbanisation of South Tarawa.

Previous surveys (Awira, 2000) in 1990 and 1995 at the Tarawa Lagoon using scuba diving gear found that the relative abundance of blue corals at the reef flats, reef fronts and the lagoon were significantly low (<10 %). This low population in the lagoon resulted from harvesting of corals for export as shown by the distinguished barren marks left on stony corals and broken portions of blue coral.

9.2.1.3 Finfish

Finfish resources studied by Abbott *et al*. (1995) included, bonefish (*Chanos chanos*), goatfish (*Upeneus taenogutatus*), mullet (*Mugillide*), snapper and small baitfish. The catch per unit effort (CPUE) of the bonefish and several important fishery species declined significantly from 1977 to the period 1992-1993. The bonefish not only decreased in abundance but became smaller in weight and size. The male to female ratio increased from 1.4: 1 (1977) to 6.8:1 (1993). It was suggested (Abbott, *et al*., 1995) that fishing has removed most of the older and larger female fish while the premature fish caught did not have a chance to spawn and contribute to the next generation's stock.

Other migratory species, goatfish and mullet, were found to have disappeared. Reef fish such as snappers or te morikoi, were more abundant in the western open side of the lagoon than the south eastern closed part but many were believed to be less abundant than the past. Several species of small baitfish such as the goldspot herring or te tarabuti, had become rare.

The Fisheries Authority (FAR, 1998) supported the fact that increase in fishing pressure mainly in the overpopulated South Tarawa was affecting the already depleted stocks including commercially important species of: bonefish, goatfish, mullet, paddletail (*Lutjanus gibbus*), spangled emperor (*Lethrinus nebulosus*), lobsters and sea cucumbers, mainly white teat (*Holothuriran fuscoglvia*).

9.2.1.4 Shellfish

Shellfish collected on the lagoon flat from 1992 to1994 during low tide showed (Abbott, *et al*., 1995) that the small conch (*Strombus luhuanus*) or te nouo (Fig. 9.1), appeared capable of withstanding intense collection without collapsing due to its rapid reproduction capacity, hence the fishery seemed sustainable.

The most popular bivalve or clam (*Anadara maculosa*) or te bun, which usually inhabits seagrass beds showed a less favourable fishery condition as it had not been able to keep up with the intense collection. During the course of the 1992-1993 period (Abbott, *et al*, 1995), the subsistence collectors were estimated to harvest 1,000 mt per annum, with a similar quantity in the commercial collection.


Figure 9.1 Shell of small conch or Te nouo (ECD, 2000)

There were few shellfish, except sea urchins at the south eastern corner of the lagoon. Giant clams (*Tridacna gigas*) seemed very sparse in the lagoon and could be endangered from overfishing.

9.2.1.5 Plankton

Plankton abundances were not excessive in Tarawa Lagoon but higher than the surrounding ocean. Oxygen and nutrient concentrations indicated good water quality. Phytoplankton (rate ~ 22gC m^{-2} y^{-1} from chlorophyll) and zooplankton (rate ~ 0.9 gC m^{-2} y^{-1}) biomasses, and particulate matter were high in the lagoon, the enclosed eastern part being the highest (Abbott, *et al*, 1995).

9.2.1.6 Mangroves

On Tarawa, mangroves cover an estimated 57 hectares (Metz, 1997). Aerial photographic comparison of the atoll in 1945 and 1988 showed an estimated >70 % of mangroves has been removed within 50 years.

In South Tarawa, approximately 14 ha of *R. stylosa* wetlands form a narrow fragmented fringe along the lagoon shoreline (Metz, 1995). The species was found in Ambo (1 ha), Eita 2.0 ha), Temaiku (8 ha), Bonriki (1 ha) and Tanaea (2 ha). The only remains of the aitoa swamp in Eita is a single tree (Figure 9.2).

Analysis (Metz, 1995) from aerial photographs in 1940, showed a mangrove wetland of 84 ha existed. An estimate of 70 ha or 83 % of mangrove area has been lost over 50 years. Probable causes include land reclamation, fishpond construction, causeways and natural coastal processes (Metz, 1995).

North Tarawa has approximately 43 ha of *R. stylosa* wetlands that generally forms a fragmented littoral fringe that parallels the lagoon shoreline for about 10 km and ranges from 3 m to 150 m in width. The species was found in Buota (4 ha), Abatao (2 ha), Tabiteuea (1 ha), Tabiang (2 ha), Nea (0.2 ha), Kainaba (0.2 ha), Kairiki (0.5 ha), Tabonibara (4 ha), Marenanuka (1 ha), Abaokoro (0.2 ha), Taratai (12 ha), Tebangaroi (7 ha), Nuatabu (5 ha), Tearinibai (1.5 ha), and Buariki (2.5 ha).

From aerial photographs, Mertz estimated (1995) that approximately 111 ha of mangrove wetland existed in 1940, suggesting a loss of 68 ha or 61 % of the wetland has been lost within 50 years. Loss could be attributed to land reclamation, causeway construction and natural processes (Metz, 1995).


Figure 9. 2 The only remnant of Lumnitzera littorea at Eita, South Tarawa (ECD, 2000)

It has been also known (pers.comm. Dr. Randy Thaman) that a single tree of **te aitoa** (*Lumnitzera littorea*) in Eita is the only remnant of the species on South Tarawa.

9.2.2 Chemical oceanography

Human inputs were also found (Abbott *et al*., 1995) contributing towards the phosphate concentrations through defecation, but are a minor contribution to the overall nutrient budget of the lagoon. Based on the 1993 data, phosphorus uptake rates in the lagoon can be both positive and negative. Concentrations of intestinal bacteria were highest on reef flats close to heavily populated islets but decreased with increasing distance from the shoreline.

A computer circulation model was calibrated against tidal stage, passage flow and salinity, and gave a mean residence time of 9.5 days for lagoon water of Tarawa (Abbott, *et al*., 1995). Water exchange between the ocean and lagoon is rapid because of the large opening on the western side of the atoll. This may contribute to good water quality and an excellent base of the food chain.

9.2.3 Coastal oceanography

Mean annual sea-surface temperature is 28.4^{0}C but water temperature in the Tarawa Lagoon has been reported to be in the range 28.3 to 29.3 ^{0}C and salinities between 35.06 and 35.82 ppt with corresponding values of 27.6 ^{0}C and 34.37 ppt in the ocean. In other parts of the lagoon, observed temperatures can range from 27 to 35 ^{0}C. Observed salinities in the main shipping channel of Betio range from 33.6 to 34.3 ppt (Forbes & Hosoi, 1995).

Tides are semidiurnal of 0.8 m at neaps and 1.9 m at springs. Mean high spring tide is approximately 1.8 m above chart datum (0.9 m above msl). Mean sea level annual variability can be up to 0.5 m, correlated with SOI. Mean sea level can remain high during the westerly wave activity associated with an El Nino episode (Forbes & Hosoi, 1995). Tidal motion dominates circulation in the lagoon, with maximum speed of about 0.4 m/s during spring tides

9.2.4 Waves

From limited satellite observations, deepwater wave data showed a mean annual significant wave height of <1.8 m during 1986 to 1989, spanning the 1987 El Nino. Waves give typical heights of <2 m with peak periods <6 s under easterly winds during 1978 to 1981. Significant wave heights of around 5 m with a minimum peak periods of 10 s occurred during El Nino episodes with strong westerlies in 1982 (Forbes & Hosoi, 1995).

Deepwater wave heights of not more than 3.5 m frequently occur 4 % from December to March and only 1 % from April to November (Burgess, 1987 in Forbes and Hosoi, 1995). Wave generation in the lagoon is limited by fetch and shallow water.

Satellite data also showed (SOPAC, 1997) that islands acts as brakes on transport of wave energy being semi-transparent to northerly waves, hence wave heights and energy levels tend to be lower to the west of island chain. Offshore wave power on west (10-15 kW/m) of the islands is significantly less than the east (14-16 kW/m) side. On the coasts, wave power levels will be lower than offshore. Highest wave heights registered by GEOSAT in these equatorial waters reached 5 m on 5 January 1988 during development of Cyclone Anne.

9.2.5 Coastal habitats/ecosystems of Kiritimati

This section discusses the terrestrial ecosystems identified by Thaman and his colleagues (Thaman *et al*, 1996) for their uniqueness in terms of ecological and economical importance for conservation and eco-tourism (Refer to Fig. 8.1).

9.2.5.1 Beaches

Most of the coastal beach fronts that stretch for many hundreds of kilometres are clean, unpolluted, coral sand beaches which are unlike the beaches of many islands in the Gilbert group. The white sand beaches extend along the following:

I. coastline of Ronton (London) to the north and along most of the north coast to Northeast Point;
II. coast extending south from Joe's Corner, south of the Bay of Wrecks, to Aeon Point;
III. entire south coast from southeast Point extending to Vaskess Bay and around Southwest Point to Benson Point at the south of the Lagoon mouth on the west of the island
IV. numerous white sand beaches on the lagoon-side of the island south of benson Point
V. encircling reef islets, eg Cook Islet, Motu Upua and Motu Tabu

Beaches are commonly bordered by limestone substrate in the intertidal zone and coastal vegetation strands. Common flora is **Te boi n tari** (*Sesuvium portalucastrum*) while the main fauna are ghost crabs (*Ocypode cerathopthalma*) and land hermit crabs or te makauro, (*Coenobita perlatus*) and surf clams (*Atactodea striata*).

9.2.5.2 Coral Rubble Ramparts

These cover extensive scenic and unique areas of large, slab-like, water worn and weathered hard coral pieces. These ramparts rise in some places up to 3 to 6 m above sea level. They are concentrated from the Northeast Point south along the Bay of Wrecks to just north of Artemia Corner and in scattered locations on the east and west facing coasts such as the 1 km of Captain

Cool Hotel and the northwest coast of Cook Islet. Common fauna are hermit crabs (*Coenobita perlatus*) and grapsid shore crabs, Te kamakama, (*Grapsus albolineatus*).

9.2.5.3 Sand Dunes

Concentrations of well-formed sand dunes have developed making the island relatively high in elevation as compared with other atolls. Known locally as sand ridges, these ecologically unique dunes include:

a. Joe's Hill Collimes, just to the south of the Bay of Wrecks, attaining an estimated elevation of 20 m above mean sea level;
b. Smaller, lower dunes just inland from the coast between Joe's Hill and Aeon Field;
c. Some extensive dunes near the west end of Aeon Field;
d. Sandhill inland from Southeast Point;
e. Lower dunes about 1 km east and also west of the Captain Cook Hotel; and
f. Small raised area of dunes on east coast of Cook Islet

9.2.5.4 Limestone Hardpans

Extensive areas form the matrix for countless hypersaline ponds. Areas are colonised by salt tolerant scrub vegetation (*Suriana maritima, Scaevola taccada, Tournefortia argentea, Heliotopium procumbens, Sida fallax, Portulaca, Cassytha filiformis*). These are seabird nesting areas, near Y-Site and the Frigatebird reserve (Ngaaon te Taake) contributing to scenic and scientific importance.

9.2.5.5 Lagoon Islets

A number of uninhabited islets, including the bigger Cook Islet, Motu Upua and Motu Tabu are important seabird nesting areas protected from the mainland due to isolation. Most are already declared as Reserve areas under the Wildlife Ordinance (1975). Historically, Cook Islet was the landing site of Captain Cook when he discovered it around Christmas Day in 1777.

9.2.6 Marine Habitats of Kiritimati

These sites were identified (Thaman *et al.*, 1996) prior to proposing Kiritimati atoll as a Conservation Area (CA) during the project preparatory phase under the South Pacific Biodiversity Conservation Programme (SPBCP).

9.2.6.1 Hypersaline Ponds

Hundreds of landlocked hypersaline algae-rich ponds are concentrated to the east of the central lagoon and southeast of the island. The milkfish or **te baneawa** (*Chanos chanos*) breed and are fished in these ponds. The introduced tilapia (*Oreochromis mossambica*) has been reported to be a predator of the milkfish, thus may cause a decline in the locally highly regarded (economically, culturally and nutritionally) **baneawa.**

9.2.6.2 Inner lagoon

This is the main fishing grounds of the world renowned bonefish or **te ikari** (*Albula glossodonta*). Catch-and-release, without killing, bonefishing is a very important seasonal economic activity of game fishing that attracts many fly fisher tourists to the island. Other species like milkfish are also present in the inner lagoon but such are not as tasteful as those found in the hypersaline ponds

9.2.6.3 Main lagoon

The main lagoon cover an estimated area of about 160 km^2. An opening is at the west with inlets, bays and interconnected saline ponds to the east and southeast. Cook Islet of about 1.2 km stretches across the opening. A passage to the lagoon from Paris Point to London Point in the north is almost 6 km wide, sufficient to allow adequate circulation of seawater and the migration of biota between the inner lagoon and the open ocean beyond Cook Islet.

Reconnaissance surveys (Thaman *et al.*, 1996) indicate that the fisheries resources are considerable, including the bonefish, range of trevally species (Carangidae) and many other finfish of considerable subsistence and economic importance.

9.2.6.4 Fringing Reefs, Reef flats and associated communities

The entire perimeter of the island is surrounded by coastal formations. Turbulent corals at places with surf and current conditions, are deeper and less exposed, for instance the Bay of Wrecks area towards the east of the atoll. Extensive fringing reef formations have substantial intertidal, sub-tidal, neritic and benthic communities

On the leeward coast of Poland, it was revealed from a 2-hour reef snorkel that these areas remained relatively unexploited, as judged by the population densities of:
Giant clam (*Tridacna maxima* and *T. squamosa*) ~ 15 per 1.5 m in diameter; and
Porites coral heads up to 100 per 5m X 5 m quadrant.

The reefs remain healthy and are rarely gleaned for food. The variety and number of fish, including two species of shark, showed that spear effort is not yet excessive. These sites could offer potential for controlled subsistence purposes.

9.2.7 Coral Reefs

Coral reefs are generally in a very good condition in Kiribati because they are subjected to low human impacts (Lovell & Kirata, 2000) in comparison with many areas worldwide. Habitat diversity is high on the atolls of Kiribati within the wet equatorial belt.

Coral islands in the arid zone south of the equator offer low habitat diversity because of their size, except Nikumaroro, Manra and Orona in the Phoenix group and Caroline, Flint and Vostok in the Line Islands (Lovell & Kirata, 2000). This could be due to the presence of human population in the Gilbert group that is lacking in the southern Line and Phoenix Islands.

The results of benthic surveys (Lovell *et al.*, 2000) of Tarawa and Abaiang using the line transect and manta tow methods are shown in Table 9.1. Benthic compositions of the various sites at the two atolls are covered extensively in Lovell *et al.* (2000). Some of these survey sites at 3m and 10 m are represented in Figures 9.3 and 9.4.

Table 9.1 The range of the Percentage of benthic forms for Tarawa and Abaiang

	Depth	
	3 m	10 m
Hard Coral	6.5 - 57.3 %	28.1 - 71.7 %
Algae	2 - 41.8 %	0 - 32.8 %
Abiotic	0.8 - 69.5 %	16.1 - 79 %
Acropora component	0.2 - 9.75 %	0 - 34.75 %
Non-Acropora	4.5 - 50.7 %	22.7 - 62 %
Macro algae	0	0
Turf algae	0	0
Coralline algae	0 - 33.3 %	0 - 39.8 %

(Source: Lovell & Kirata, 2000)

Fringing reefs of South Tarawa in the ocean from Betio to Bikenibeu that are periodically exposed at low and neap tides are depauperated with flora and fauna. *Acropora* component is minimal, extensively covered principally by *Porites rus*, with *Pocillopora eydouxi* and *Heliopora* in abundance. Large massive colonies of *Plerogyra sinuosa* carpeted the base of the ridges at >12 m depth. Water visibility can be <6 m (Lovell *et at.*, 2000).

South sites such as in Bikenibeu were the least luxuriant with more dead corals while the northern sites of the atoll having the most luxuriant with hard coral in Tarawa. Impacts of the dense populated urban South Tarawa could account for the lower percentage of coral cover in Bikenibeu, Ambo and Bairiki at 3 m. On the other hand, rural North Tarawa have higher coral coverage. The benthic composition comparison in the southern and northern reefs at 3 m depth is illustrated in Figure 9.4 and Figure 9.5 respectively.

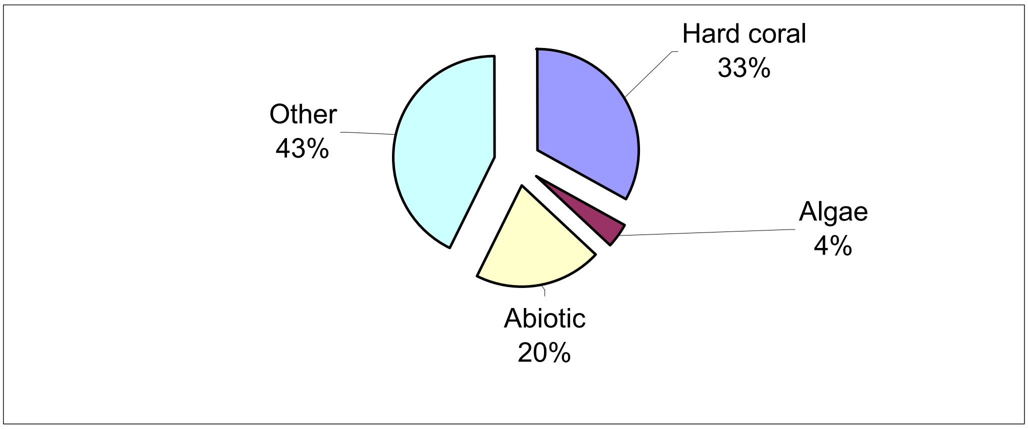

Figure 9.3 Benthic % composition at 3 m depth in Bairiki of South Tarawa
(Source: Lovell & Kirata, 2000)

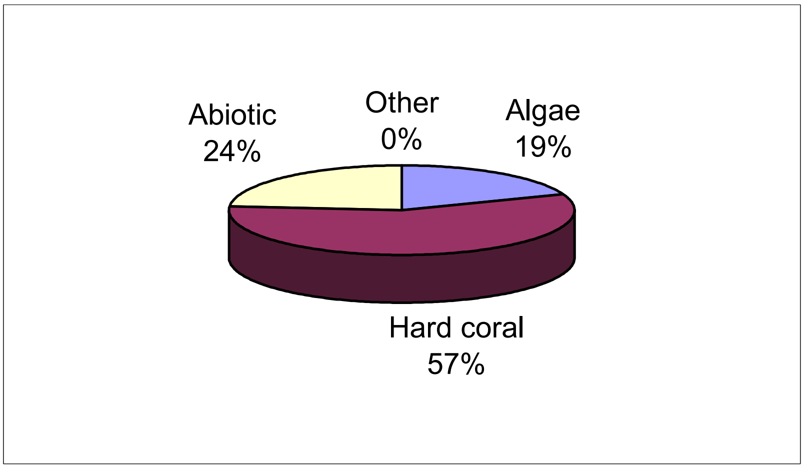

Figure 9.4 Benthic % composition at 3 m depth in the north reef of North Tarawa
(Source: Lovell & Kirata, 2000)

A collection and details of the coral diversity at Tarawa and Abaiang is housed at the Fisheries Division at Tanaea in Tarawa. The database contains 115 coral specimens from the two atolls, characteristic of the depauparate central Pacific, in comparison to the Marshall Islands (138 records) and Guam (159 records) further north of Kiribati (Lovell *et al.*, 2000).

The benthic compositions of the two atolls at different sites and depths are detailed in Lovell *et al.* (2000), and the statistics of the islands and coral reefs of Kiribati are provided in Lovell and Kirata (2000).

Other marine organisms have been covered in previous studies as sighted by Lovell & Kirata (2000), within the three groups of islands are listed below:

A. Gilbert Group

Coral reefs in Tarawa by Zann in 1982;

Intertidal fauna of Tarawa Lagoon by Bolton in 1982;
Coral reefs of Tarawa & Abaiang by Lovell *et al*. in 2000;
Marine biology of Onotoa Atoll by Banner and Randall in 1952;
Geology and marine environment of Onotoa Atoll by Cloud in 1952;
Marine algal review by Why and Reiti in 1987;
Algae on the atolls of Abemama, Marakei, Nonouti and Tamana by Tsuda in 1981;
Bibliography of the algae of Micronesia by Tsuda and Wray in 1977 and Tsuda in 1981;
Cultivation of Euchema seaweed by Why in 1985, 1986 and 1987
Status of giant clam stocks in atolls of Abaiang, Abemama and Maiana by Munro in 1986;
Marine turtles by Balazs in 1975, Onorio in 1979 and Anon in 1979.

B. Phoenix Group

Turtle breeding by Garnett in 1983 on Kanton, Enderbury, Rawaki, Orono, Caroline, Starbuck and Malden atolls;
Assemblage of reef building corals on McKean Island by Dana in 1979;
Ecosystem surveys by Dahl in 1980 focussing on fish, birds and coconut crabs;
Algae in Kanton by Dawson in 1956.

C. Line Group

Tabuaeran reef by Chave and Kay in 1974;
Reef development and sedimentation by Roy and Smith in 1971;
Community structure of coral communities by Maragos in 1974 compiling a species list of 71 hermatypic corals;
Biology and ecology of holothurians by Townsley and Townsley in 1974;
Molluscs of Flint and Caroline Islands by Pilsbry and Vanatta in 1905 when coconut crabs were abundant.

9.2.8 Near-pristine Phoenix islands

The first and comprehensive marine biological survey (Stone *et al*., 2001) of the Phoenix group, except Birnie Island, found that the islands are a diverse and healthy example of central Pacific atoll coral reef communities. The isolation and exclusion of the islands from human impacts (except Kanton with <50 people) showed them as excellent habitats in a near-pristine state thus providing the foundation for understanding the island ecosystems, and initiating an inventory of the fauna and flora of the region.

Coral reefs of the islands have moderate coral cover (20-40 %) and possess evidence of high physical breakage by wave energy on most of the shores. The bottom cover of all the survey sites is shown in Figure 9.5

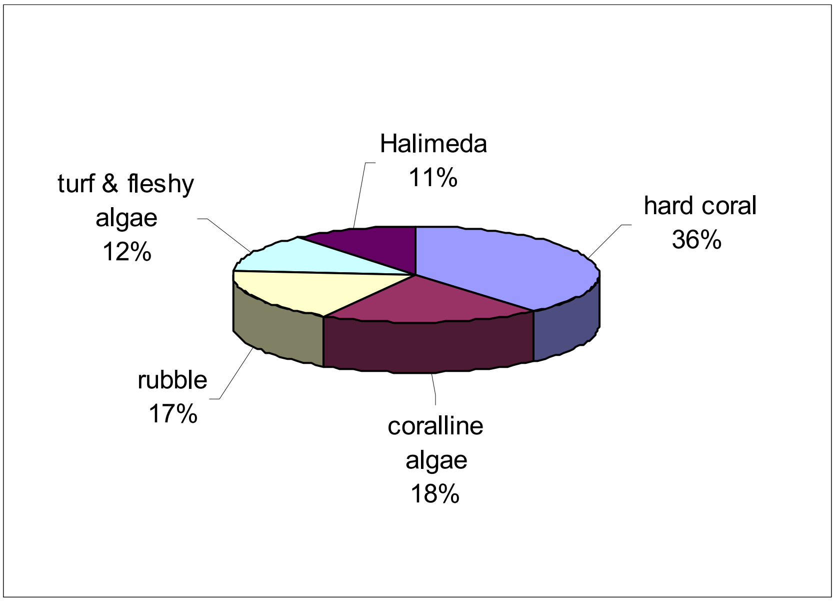

Figure 9.5 Percentage bottom cover of all the survey sites at the Phoenix Islands
(Source: Stone *et al.*, 2001)

The dominance of coral and coralline algae indicates healthy reef ecosystems that are dominated by calcifying organisms and active reef framework growth (Stone et al., 2001). High rubble composition shows the dramatic influence of wave energy.

The dominant growth form of corals throughout the islands was encrusting or submassive, followed by branching and massive (Figure 9.6).

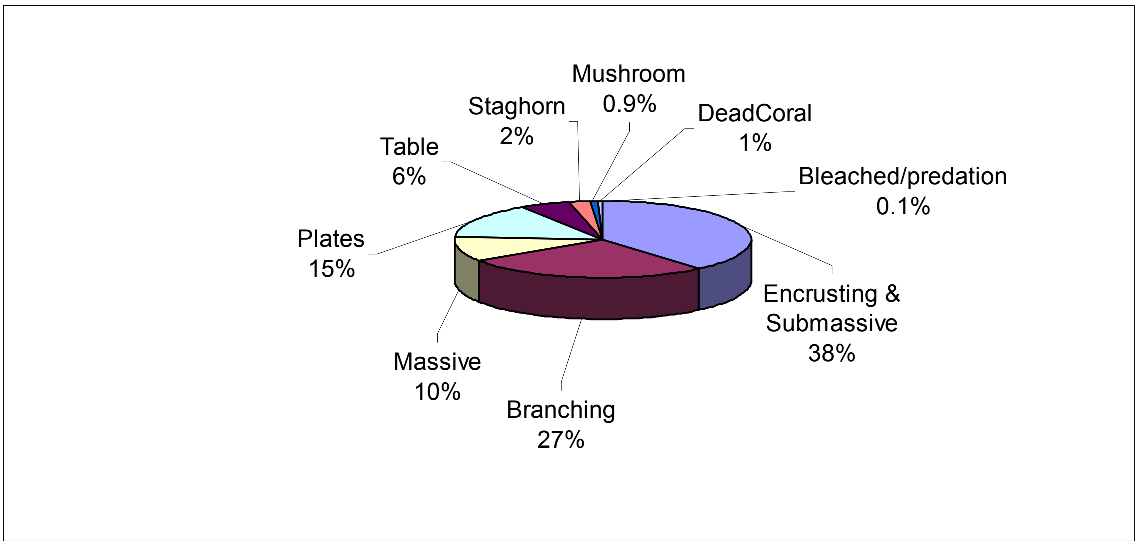

Figure 9.6 Percentage composition of growth form of corals (Source: Stone et al., 2001)

The dominance of the encrusting or submassive type followed by branching and massive further confirms the importance of physical disturbance in the islands. Coral diversity is higher at the larger islands of Nikumaroro, Canton and Orona in comparison to the lower diversity in the smaller islands. This indicates that larger islands can support greater species and functional guild diversity (Stone *et al.*, 2001).

Fish populations were abundant with high currents and topographic complexity locations, large schools of jacks, barracuda, snappers, surgeonfish, and parrotfish, and abundant sharks. Most survey sites had a diverse mix of reef and pelagic predatory fishes schooling in large numbers. Invertebrates were notably low including *Tridacna* clams, pearl oysters, holothurians and lobster.

The results of individual island surveys are provided with comprehensive details in Stone *et al* (2001).

The low human disturbance contributed to the overall appearance of near-pristine condition and several sites were identified (Stone *et al.*, 2001) as "significant" due to ecological parameters of uniqueness and sensitivity (Table 9.2)

Table 9.2 Significant Sites of the Phoenix Islands.

Dive Site/island	Significant pattern	Importance
Coral castles (Canton lagoon)	Maximum coral cover, dominance of table and staghorn Acropora	Delicate climax community of low-energy reefs. High vulnerability to disturbance
Satellite Beach (Canton), Deepwater, Stillwater (Phoenix)	High coral cover, diverse coral communities	Biodiversity and ecological complexity
Algae Corner (Orona)	Lowest coral cover, highest algal cover - evidence of chronic stress from low water quality	Impact of lagoon and land-based factors on coral communities, vulnerability
Nikumaroro, Canton, Orona islands	Highest coral diversity due to large area effect	May contain key source and refuge sites for corals and other reef species during the stressful events
Orona and Canton lagoons	Only true lagoons with coral and other communities	Rare habitats with extreme isolation from neighbouring island groups.
Canton lagoon mouth and adjacent sites	Super abundant fish populations aggregate in and beside channel mouth, for feeding, spawning, etc	Critical ecological role in feeding and reproduction, high vulnerability to destructive and over-exploitation
Windward Wing (Canton)	Largest barracuda aggregations seen in islands	High vulnerability to fishing
Rawaki	Largest aggregations of sharks, in particular grey reef sharks	Special circumstances enhancing shark populations
Phoenix	Green turtle nesting sites	First record of Green Turtles nesting on the island

(source: Stone, et al., 2001)

The coral reefs of the Phoenix islands are of national, regional and global importance. They provide a unique opportunity in the Pacific for conservation of biodiversity and a significant baseline database which is lacking for most of the atolls of the Gilbert group and other densely populated islands of Kiribati.

9.3 Pressures on the Environment

9.3.1 Continuing Population Growth

South Tarawa, being the capital island of the country, housed about 45 % of the total population (2000 census), which constantly fish and collect fishery resources of the lagoon. The over-exploitation of living resources of the Tarawa lagoon reflects the high population demand on South Tarawa.

9.3.2 Overly Efficient and Destructive Methods of Resource Harvesting

Decline in marine coastal resources is also a function of the techniques used for fishing and high population:

- Use of Scuba Diving for deeper water resources (beche-de-mer, clams, ornamental coral fish for export, etc)
- Splashing (Te Ororo) at sea during spawn runs

- Use of gill netting (~1 km long) in the lagoon by commercial fishermen
- Use of crowbars in catching ornamental coral fish, damaging the corals in the process.

9.3.3 Land-based sources of pollution

Overcrowding of population with lack of proper sanitation and poor enforcement of environmental regulations on South Tarawa has seen high levels of land based pollution sources and uncontrolled development affecting land and coastal environments.

- Poor Pig sty design and location: e.g along South Tarawa coastline (Fig. 9.7)
- Poor siting and management of waste dumps along the shoreline (See Section 14.2.5)
- Direct disposal of bulky/junky (organic or industrial) waste at sea
- Human defecating at sea, particularly in the lagoon (See Section 10.3.1).
- Infilling of seawalls/reclaimed land with general waste (See Section 14.2.5)
- Sewerage outfalls (refer to Section 15.2.2)
- Sedimentation due to development, port construction and increase in shipping activities

Figure 9. 7 Pig sty on South Tarawa

9.3.4 Causeway constructions along South Tarawa

Causeway construction has impacted severely by blocking fish migrations such as those of bonefish, goatfish and mullet. The fish need to travel to the ocean to spawn and their larvae must move back to the lagoon. Some years prior to 1994, bonefish disappeared for almost a decade. Although they came back in the mid-1990s, other species never came back. It was believed that the five causeways constructed along South Tarawa must have been the principal cause of these migratory fish disappearance.

Ananau Causeway at Temaiku was constructed for land reclamation for coconut plantation. Local families around the area in the 1940s used to collect abundant shellfish and the area was formerly intertidal, except land projecting into the lagoon with an area of about 200 hectares (Barnett & Jones, 1994 in Royds, 1996). The causeway construction has contributed to high contamination of lagoon water, as seen to be highest at the enclosed eastern tip (Abbott, 1994).

9.3.5. Natural threats to Coral Reefs

Crown-of-thorns starfish (*Acanthaster plancii*) influx on the reefs can kill corals as seen by local surveys by the Fisheries Division at Makin, Butaritari, Abaiang, Tarawa and Kiritimati. Coral bleaching due to various factors including temperature elevation can also impact corals, however, it is proven not to be a problem in Kiribati (Lovell & Kirata, 2000).

9.4 Responses to Environmental Pressures

9.4.1 Effective enforcement of pollution abatement regulations

Public awareness campaigns have been targeted against the traditional habit of using the lagoon as a toilet. Local Council Authorities have been discouraging the establishment of pig-sties along the shoreline that has contributed to the pollution of coastal waters.

The Environment Act 1999 empowers environmental inspectors to issue pollution abatement and stop notices for pollution control.

9.4.2. Re-opening of natural passages and causeways

Several feasibility studies have considered the re-opening of natural passages affected by causeways to imrprove water circulation in the Tarawa Lagoon (Kaly, 1996; Royds, 1996). Under an ADB technical assistance project a proposal to re-open a few natural passages along the South Tarawa portion of the capital were considered. Due to astronomical costs of these improvements on the existing causeways, many donors, including Government, have declined funding these projects. There is still political pressure from the three Local Council Authorities on Tarawa for these crucial rehabilitations.

9.4.3 Banning of destructive fishing methods and gears

The North Tarawa Conservation Area (NTCA) first initiated bans on a destructive fishing method of splashing or **te ororo** and imposed closed fishing seasons prior to spawn and aggregate runs to the ocean of migratory bonefish at Tarawa. This single approach by the North Tarawa Council was difficult to enforce because the commercial fishermen from South Tarawa are not under the ban and closed season regulation.

More recently the three local councils on Tarawa: Betio Town Council, Teinainano Urban Council and North Tarawa Council jointly submitted a bye-law to the Minister responsible for Local Government to approve fishing regulations covering the entire Tarawa atoll fishery limit, i.e., 3 miles of territorial ocean water and enclosed lagoon.

Other islands in the Gilbert group have different bye-laws governing fishery management. Arorae, for instance, prohibits the use of outboard motor boats (i.e., boats with engines) and pressure lamps to fish with on the reef at night. Abemama prohibits the harvesting of *Tridacna* clams by visitors. Tamana island banned fishing by visitors on inter-island boats.

9.4.4 Establishment of marine protected sites and conservation zones

Effort has been geared towards establishment of a marine protected site at the Tarawa Lagoon for endangered species like Giant clams. However, effective implementation requires cooperation of the public and commercial fishermen.

At Kiritimati (see Fig. 8.1), certain areas has been designated prohibited fishing zones where access has been restricted to protect the natural stock of milkfish from over-exploitation. In addition, new marine protected areas (MPAs) have been also declared where commercial activities like collection for pet fish and sea cucumber are commonly undertaken in order to conserve the inshore resources (Awira & Kirata, 2000).

9.4.5 Establishment of closed fishing seasons

A few days prior to spawn and aggregate runs of migratory bonefish, the local council in North Tarawa has prohibited fishing for the species.

9.5 Data Gap

- Base line data and status of corals for all islands in the Gilbert group, except Tarawa & Abaiang.

Chapter 10: Health and Nutrition

10.1 Introduction

10.1.1 General

Health services are provided solely by the Government in Kiribati. These services and drugs are provided free of charge, except for the private ward in the Central Hospital, Nawerewere in South Tarawa. Expensive dental services (e.g., dentures) and reading glasses are provided but at subsidised prices.

Health care facilities in Kiribati are shown in Table 10.1

Table10.1 Health care facilities in Kiribati, 2000

	South Tarawa	Outer islands	Linnix Group	Total
Main Hospital	1	0	0	1
District Hospitals	1	0	1	2
Health Centres	0	19	3	22
Dispensaries	5	44	6	55

(source: WHO, 2000)

10.1.2 Availability of Data

Health data and information available in-country are held by MHFP, but they are not easily accessible (in comparison to other national environmental data and documents). The chapter is based on WHO's reports, annual reports of the Nutrition Centre and morbidity records for the periods 1992-1996 and 1999-2000 prepared by the Health Information Centre (HIC).

10.2 Present State of the Environment

Health Indicators (Table 10.2) are generally poorer in comparison to other Pacific countries. The life expectancy at birth is 60.2 years, making Kiribati the third shortest after Papua New Guinea and Nauru. The infant mortality rate is the highest among Micronesian countries and second only to PNG among Pacific countries (WHO, 2000).

Major illnesses are closely related to poor sanitation and overcrowding. Influenza, pneumonia, diarrhoeal diseases, dysentery and worm infestations are the highest common diseases; all of which are related to poor environmental health (WHO, 2000).

Table 10.2 Health Indicators in Kiribati

	1990	1995
Crude Birth Rate (per 1,000 population)	32.2	33.2
Crude Death rate (per 1,000 population)	9.6	8.3
Infant Mortality Rate (per 1,000 live births)	65.0	62.0
Maternal Mortality rate (per 1,000 live births)	1.73	0.0 (1998)
Under Five Mortality rate (per 1,000 live births)	88.0	24.0
Life expectancy at birth: male	57.7	58.5
Female	62.8	64.7

% Urban population	35.1	36.5
% Access to adequate sanitation: Tarawa	N/a	70
Outer islands	N/a	80

(source: WHO, 2000)

10.2.1 Morbidity

Based on the number of reported cases from 1992 to 1996 and 1999 to 2000, priority health problems and disease has thirteen main groups of morbidity (IHC, 2001). Some of these are as follows:

1. Respiratory tract infection; influenza; sore throat; lower respiratory tract infection (LRTI); bronchitis; pneumonia
2. Wounds; wounds and sores; motor vehicle accidents
3. diarrhoeal diseases; diarrhoea; food poison; dysentery A/B; typhoid
4. Parasitic; worm infestation
5. Communicable diseases; tuberculosis; leprosy; dengue fever; chicken pox; meningitis.
6. Dental diseases: dental carries, periodontal
7. Fish poisoning:
8. Parasitic infestation.

The last three groups: 6th; 7th; 8th; are among the uncommon categories of diseases, having the lowest numbers. Figure 10.1 shows the categories of leading morbidity graphically for the periods 1992 -1996 and 1999-2000.

The trends of respiratory infection and diarrhoeal diseases (Fig. 10.1) that are environmentally related health problems, rank among the top three leading morbidity categories. This reflects how unhealthy the environmental media of air and water are, contributing to frequent occurrences of these diseases.

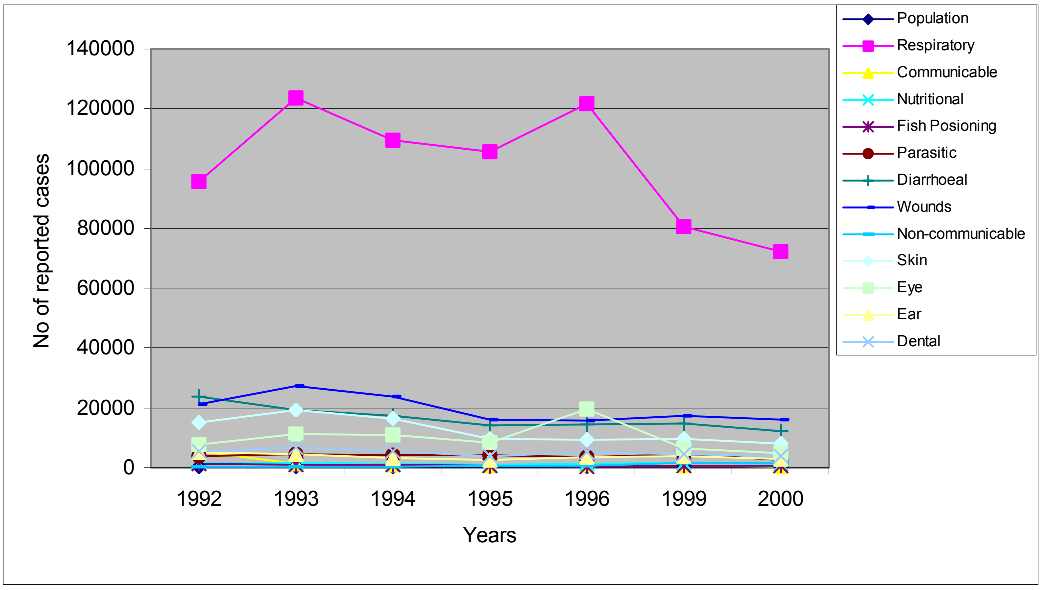

Figure 10.1 Priority health problems & disease records
(extracted from IHC, 1997 & IHC, 2001)

In terms of percentage contribution of each disease to the overall morbidity in 1992 (Figure 10.2), respiratory diseases were the main bulk (> 50 %) with diarrhoeal and wounds contributing more than 10 % each.

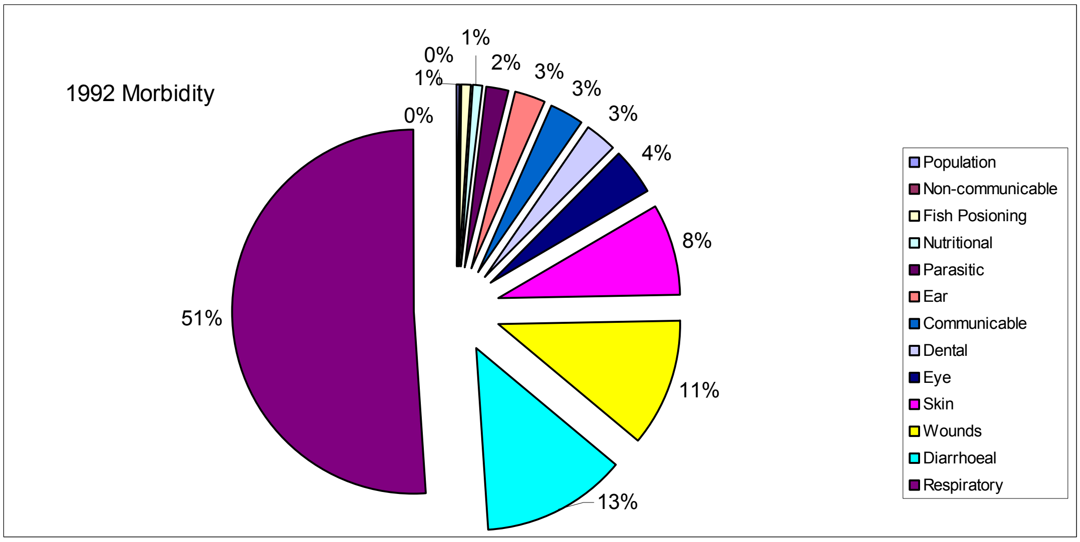

Figure 10.2 Morbidity in 1992

Morbidity for subsequent years are detailed in HIC (1997; 2000).

Non-communicable diseases associated with unhealthy lifestyles are becoming common. Heart diseases, cerebro-vascular diseases and complications of diabetes are the main cause of death (Table 10.3).

Table 10.3 Ten Leading Mortality in 1998

Mortality	Total Numbers	Rate per 100,000
Cardiovascular Diseases	72	92.5
Certain Perinatal Conditions	49	62.9
Liver Diseases	44	56.6
Intestinal Infectious Diseases	21	26.9
Disease of Respiratory System	21	26.9
Tuberculosis	21	26.9
Diabetes	20	25.7
Neoplasm	20	25.7
Meningitis	6	7.7
Malnutrition	12	15.4

(source: WHO, 2000)

10.2.2 Nutrition

According to the Health Centre and Dispensary Morbidity Data (1992-2000), nutritional related cases are grouped together with anaemia, malnutrition and vitamin A deficiency.

The trend (Figure 10.3) declined from the early 1990s to a minimum of about 1,000 reported cases to Health Centres in 1995. The trend however rose again in 1999 but the actual pattern was uncertain due to lack of data from 1997 to 1998. The final tail of the curve declined again from 1999 to 2000.

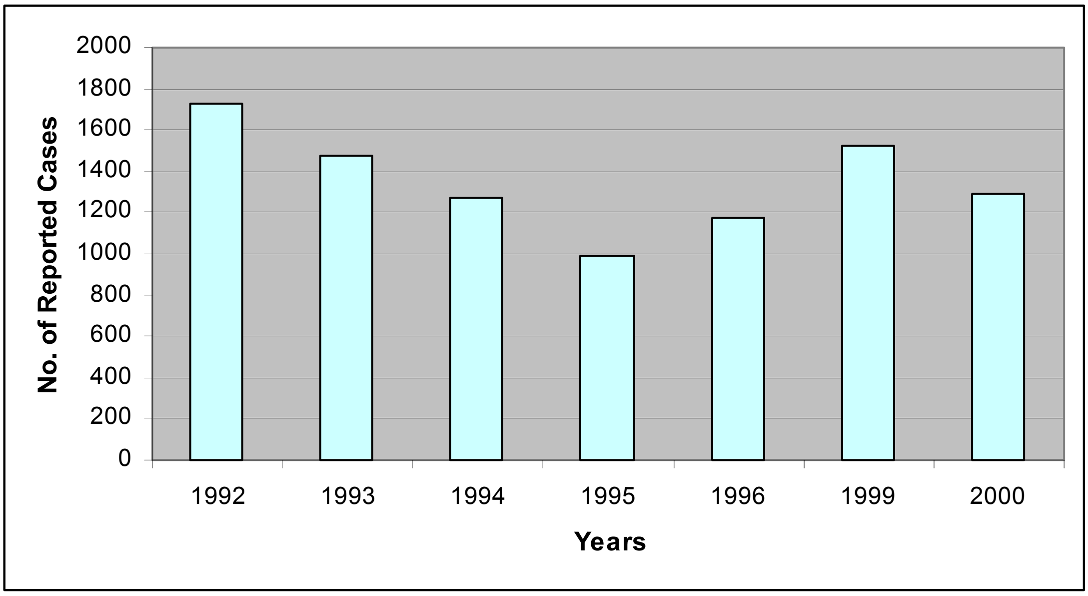

Figure 10.3 Anaemia and Nutritional Disorder

(source: HIC, 1997 & HIC, 2000)

Other nutritional issues include promotion of breast feeding, home gardening and intake of vitamin A capsule through public awareness programmes at the community level (NNC, 1998).

10.2.3 Sanitation

In 1995, almost 70 % of the South Tarawa population had access to adequate sanitation while about 35 % in the remaining Gilbert islands and 55 % in the Line and Phoenix (Linnix) have the same facilities (Table 10.4). In total, 46 % of the households in the entire country had adequate sanitation (WHO, 2000).

Table 10.4 Household Sanitation Kiribati, 1995

	South Tarawa	Outer Islands	Linnix Group	Kiribati
Toilet facilities (% households)				
Flush Toilet	48.2	4.6	30.7	19.4
Water-sealed latrine	20.8	30.2	24.3	27.0
Lagoon beach	31.7	64.5	23.9	51.8
Ocean beach	32.6	61.0	25.1	49.9
Elsewhere (bushes)	11.8	43.7	38.0	33.9
Note: Figures do not add up to 100 % because most households members surveyed use more than one option and do not necessarily stick to one habit. Adequate sanitation refers to flush toilet and water sealed latrine.				

(source: WHO, 2000)

The poor sanitation was exacerbated by unsafe disposal of sewage. About half the population used the beach as the lavatory. About one fifth of households used flush toilets and a third used water sealed latrines that are more hygienic systems (WHO, 2000).

By 2000, Kiribati's coverage for sanitation was still below 50 %, covering 54 % of its urban population (a decrease of 16 % from 1995) and 44 % of its rural population (a decrease also of 36 % from 1995) thus giving a 48 % of total sanitation coverage (WHO, 2001).

Poor sanitation must had been a major contributing factor to an outbreak of diarrhoeal diseases in South Tarawa in mid 2000, affecting more than 3,000 people, 74 % of whom were children below five years of age; this resulted in 14 deaths among the children (WHO, 2000).

10.2.4 Disease patterns

The morbidity pattern for some diseases over the last decade is incomplete, lacking data for the 1997-1998 period and thus the trends cannot be accurately shown. The fact that data is based on reported cases at different health facilities, makes a comprehensive assessment of disease patterns difficult as there may be cases of under reporting. However, a general trend is nevertheless shown graphically (Figures 10.4 – 10.6) as derived from the morbidity statistics of HIC. HIC is continually been fed with data from Health Centres and Dispensaries throughout Kiribati.

10.2.4.1 Population priority health problems.

Diseases considered in this category are those related to reproductive organs complications such as bleeding of and discharges from the female reproductive organs, toxaemia of pregnancy and purperial pyrexia, among others.

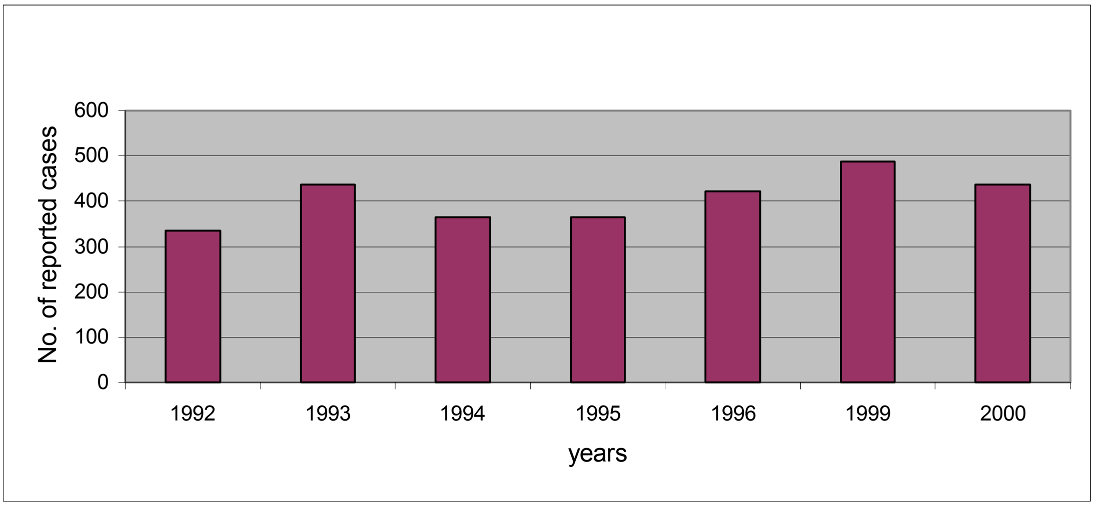

Figure 10.4 Population related diseases

10.2.4.2 Communicable Diseases:

This group of diseases comprises of tuberculosis, leprosy, dengue fever, chicken pox, meningitis, gonorrhoea, measles, Hepatitis, tetanus and whooping cough which spread through contact.

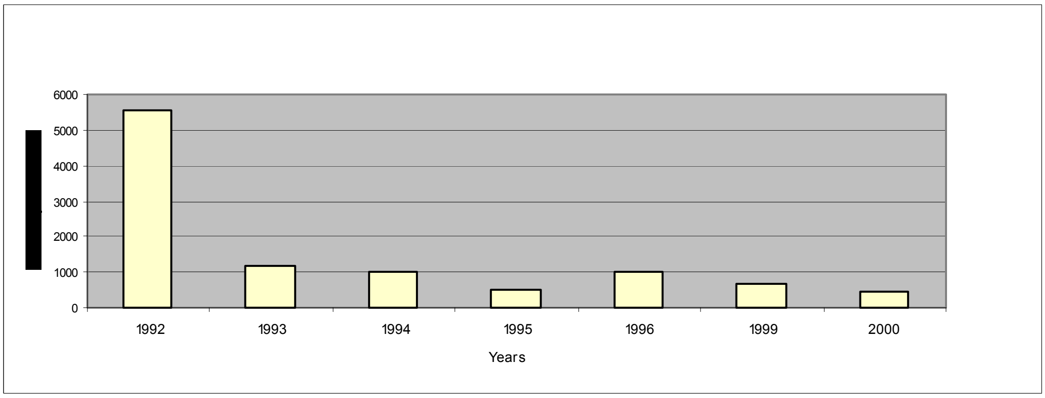

Figure 10.5 Communicable diseases trend

These diseases have been on the decline since 1993 and have stayed within 1,000 cases/yr. Either the diseases are slowly being eradicated through effective prevention measures such as vaccination and better hygiene thus has greatly improved, or patients are not visiting health clinics.

10.2.4.3 Non-Communicable Diseases

This category encompasses hypertension, diabetes and mental cases. Although, data for 1997 to 1998 are lacking, the trend seems to be increasing, as indicated in Section 10.2.1.

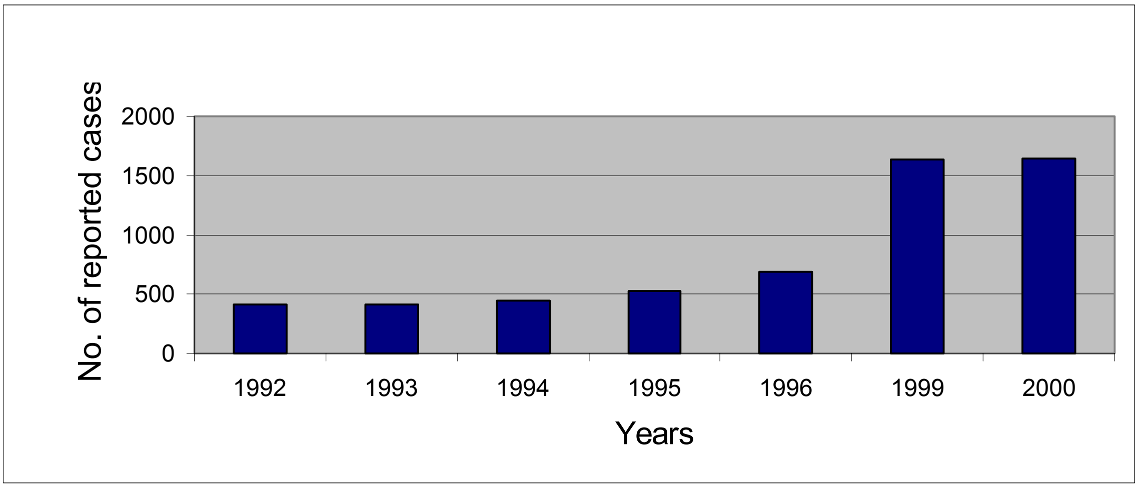

Figure 10.6 Non-communicable diseases

10.3 Pressures on State of Environment

10.3.1 Traditional sanitation

Many I-Kiribati, particularly the older generations and those who grew up on the other islands would never be comfortable to use in-house toilet and latrines since the traditional place for defecation is on the beach. Even if there are adequate sanitation facilities throughout Kiribati the present generation will continue to use the beach or the bush for defecation. It may take another generation or two for most people to accept and use hygienic sanitation facilities.

10.3.2 Overcrowding

Many households in Kiribati have large memberships (>6) because of the traditional system of living in extended families. The 1990 household survey (Statistics, 1990) shows it is common for households to have between 4 to 10 people on South Tarawa, while the rest of Kiribati commonly have between 3 to 7 people.

Population density for the entire country remains at less than 20 people/km^2 since 1931. In contrast, the South Tarawa population density alone rose from slightly over 500/km^2 in 1968 to >2000/km^2 in 2000. Betio, a small town in South Tarawa has the highest density of 6,200 people/km^2 (Statistics, 2001)

Large household members and high population densities enhance rapid spread of communicable diseases, adding pressure to the limited sanitation facilities and safe water supply. Chapters 13 and 14 will cover this topic in more depth.

10.3.3 Shortage of trained human resource

In 2000, Kiribati has 22 doctors, 4 dentists, 192 registered nurses, 4 phamarcists, 32 Medical Assistants (MAs) and 11 Health Inspectors. Kiribati has to depend on foreign doctors (10) to serve its population in a ratio of 1: 3,862 (doctors to population), however this ratio is meaningless because of the uneven distribution of population. The 43 % of the total population (~85, 000) on South Tarawa have most of these trained health staff at their disposal, except the MAs. Trained health planners are lacking, such as epidemiologists. Each health sections with limited technical skills make individual divisional plans with little coordination with the rest of MHFP (WHO, 2000).

10.3.5 In-adequate access to primary and secondary care

Due to the shortage of trained staff (Section 10.3.3), primary health care in rural and remote areas is provided by Medical Assistants (MAs) who were originally registered nurses that have undergone another 14 months of further in-country training. Health clinics manned by registered nurses could be closed when staff is away on leave. Secondary care is provided through referral from MAs. Because of high costs of transportation from the outer islands, only serious cases are being sent to the Central Hospital on South Tarawa. A limited number of cases were sent overseas for further care due to high costs.

The limited capacity of Kiribati to provide services in more specialised field like ophthalmology and orthopaedic, access to secondary and tertiary health care is in turn limited.

10.4 Responses to Pressure on Environment

10.4.1 Recognition of local traditional healers group

The Federation of local traditional healers have been given recognition by Government to work alongside modern medicine practioners to complement curative and preventive measures undertaken by the Ministry of Health. This has been covered in Section 7.4.1.2

10.4.2 Intense public awareness activities

The health education unit of MHFP regularly raise the awareness of the general public on various health issues through the media. At the community level, Public Health Nurses and Medical Assistants make regular consultations on various health programme like child care and compulsory vaccinations.

10.43 Improvement of water and sanitation facilities

Through the SAPHE loan project, the water and sanitation facilities on South Tarawa only will be improved. More details of this improvement development is covered in Chapters 6, 13 and 14. MFPH continues to provide subsidies for water sealed latrines for the general public.

10.5 Data gap

- Data on morbidity for 1997/8 were still in print during preparation of this report. Other relevant documentation were not easily accessible during the 4 weeks long (August, 2001) data collection exercise.
- Household sanitation in Kiribati prior to 1995.
- Mortality data, including disease causes, birth rates during the last decade, based on health records, are not accessible, if available.

Chapter 11. Demography

11.1 Introduction

11.1.1 General

The Kiribati population has been steadily increasing notably from 1931, and has an uneven distribution mainly due to rapid urbanisation since the 1960s in the capital South Tarawa, where population density is among the highest in the Pacific region. Although the general population growth has slightly decreased in the 1990s, the bulk of the population structure is young, between the ages of 15-59 years old. Consequently, the population will continue to increase as the majority of the population are constantly fertile for at least another decade.

11.1.2 Availability of Data

All statistics data of Kiribati, including census data are available at the Statistics Office of the Ministry of Finance and Economic Planning (MFEP). However, comprehensive analysis of the data is provided by the Secretariat of the Pacific Community (SPC).

Preliminary results of the latest census in 2000 are available at the Statistics Office upon request, but the full report is yet to be produced. Hence most of the analysed information of this section has been obtained from the SPC's publication on Kiribati's population profile based on the second last census in 1995.

11.2 Present State of the Environment

Some basic statistics of Kiribati are shown in Table 11.1

Table 11.1 Population estimate and projection

Last census	1995
Population as counted at last census	77,658
Mid-year population estimate 2000 (c)	90,700
Mid-year population estimate 2010 (c)	112,400
Projected annual population growth rate circa 2000 (%) (d)	2.5
Projected population dounbling time (years)	28
Land area (Km^2)	811
Population Density (people/km^2) circa 2000 (e)	112
Urban population (%) (f)	37
Annual intercensal urban growth rate (%) (f)	2.2
Annual intercensal rural growth rate (%) (f)	1.0
Average household size	6.5
Sex ratio (males/100 females (h)	97
Median age (i)	19.8
Crude birth rate (per 000) (j)	33.1
Crude death rate (per 000) (j)	8.4
Crude net migration rate (per 000) (j)	0.0
Total fertility rate (TFR) (k)	4.5
Reference period for TFR and teenage fertility	(1995)
Teenage fertility (15-19) (m)	61
Infant mortality rate (IMR) (n)	62
Reference period for IMR	(1992-1993)
Life Expectancy at birth (p)	
Males	58.5
Female	64.7
Both	61.5
Reference period	(1990-1995)

Notes: (c) population projection for 2000 & 2010 and projected age-sex pyramids are based on the latest available demographic data.
(d) average annual growth rates are derived from the projections
(e) population densities are based on 2000 population estimates
(f) urban population (%) is derived from the latest, urban and rural growth rates are based on the last two censuses (inter-censal growth)
(h) sex ratio is the number of males per 100 females, based on 2000 total population estimate
(i) median age is the age that divides a population into two numerically equal groups; that is half the population is younger than this age, and half is older. Calculations are based on the 2000 total population estimate
(j) number of births/deaths/migrants per 1000 population per year
(k) average number of children a woman would give birth to during her lifetime, if she were to pass through her childbearing years conforming to the fertility patters of a given year
(m) refers to the number of births per 1000 females aged 15 –19
IMR is the number of deaths before one year per 1000 live births.
(p) average number of years that would be lived if current survival rates were constant

(Source: SPC, 2001)

11.2.1 Population size

The population of Kiribati, as numerated in 2000, was 84,494 people. There was an increase of 6, 836 people compared to the 1995 census (77,658) with an annual growth rate of 1.69 per cent (see section 11.2.2). The annual growth rate before 1995, based on the 1990 and 1995 censuses was much lower: 1.4 per cent.

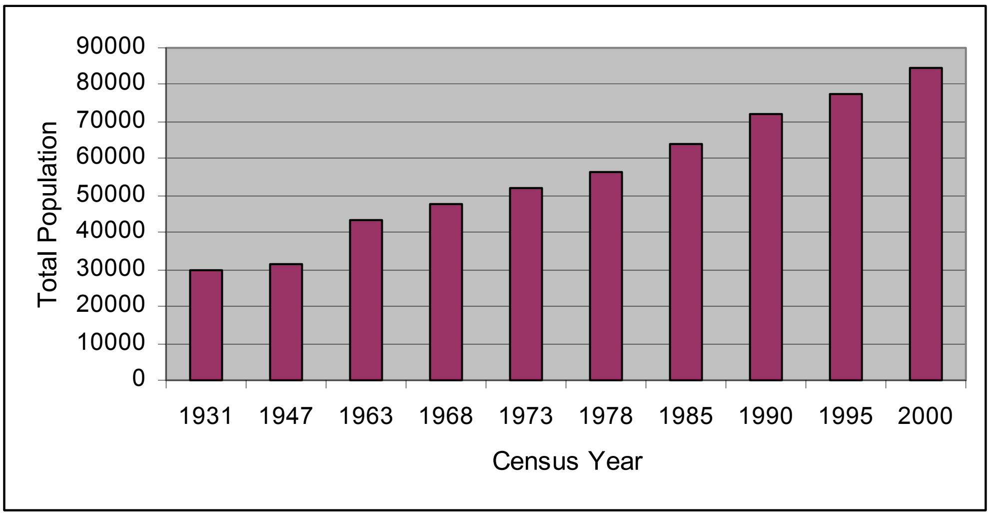

Figure 11.1 Kiribati Population from 1931 to 2000 (source: Statistics, 2001)

The population has steadily increased since 1931 (Fig. 11.1). According to population estimates by SPC (1998), the Kiribati population will have tripled in 70 years based on the 1995 data. The 2000 mid-year population estimate (90,700) was close to the actual population count (84,400) in 2000

11.2.2 Population Growth

Population growth varies by island and group of islands (Table 11.2). Generally Kiribati has an overall growth rate of 1.4 % annually, the Gilbert group grew at 1.2 % while the Line and Phoenix grew at 4 % per annum in 1995. South Tarawa's growth rate of 2.2 % accounted for the positive growth rate of the Gilbert group, otherwise many islands of the Gilbert group would either have zero or negative growth (SPC, 1998).

Table 11.2 Population Inter-Censal Growth Rate 1931 – 2000 per island

Islands	1931/47	1947/63	1963/68	1968/73	1973/78	1978/85	1985/90	1990/95	1995/2000
	15.2 yrs	15.8 yrs	5.6 yrs	5 yrs	5 yrs	6.4 yrs	5.5 yrs	5 yrs	5 yrs
Banaba	1.55	1.73	-4.48	1.08	-1.00	n.a	33.1	3.54	-4.11
Makin	1.92	1.82	1.51	0.82	-0.36	3.52	-0.2	0.76	-1.58
Butaritari	0.57	2.27	0.82	1.81	1.16	2.19	0.75	0.70	-2.42
Marakei	0.59	1.3	-0.32	0.29	1.08	2.23	1.11	-1.00	-1.37
Abaiang	0.56	1.12	-0.63	0.15	0.9	3.76	3.21	2.8	-0.77
N.Tarawa	1.14	-0.33	2.36	2.26	-0.36	5.69	2.35	1.86	2.23
S.Tarawa		**8.2**	**11.79**	**6.73**	**3.74**	**2.77**	**3.11**	**2.21**	**5.17**
Maiana	0.09	1.07	0.28	-3.82	3.56	3.72	0.33	0.04	-1.29
Abemama	1.8	3.56	0.67	1.57	0.94	3.24	1.48	1.35	-1.82
Kuria	2.27	5.31	5.81	-3.09	-0.44	4.22	-1.1	-0.39	-0.21
Aranuka	1.49	2.38	6.92	1.13	1.69	2.29	0.33	0.26	-0.99
Nonouti	-0.78	0.67	1.64	-1.6	0.54	3.89	-0.73	1.56	0.86
N.Tabiteuea	0.14	0.25	1.89	-2.95	0.86	1.0	0.17	1.11	-0.11
S.Tabiteuea		1.18	1.1	-0.43	1.58	1.75	0.12	1.07	-2.86
Beru	-0.03	0.29	0.67	-0.80	-0.94	3.13	1.34	-0.88	-0.38
Nikunau	-0.33	1.15	1.31	-1.90	0.17	1.87	-0.60	0.15	-2.96
Onotoa	-0.62	1.84	-0.36	0.37	0.37	-0.84	1.56	-1.81	-2.79
Tamana	-0.75	2.22	2.68	0.43	-0.37	0.33	0.09	-3.19	-4.10
Arorae	0.47	0.77	0.83	-2.36	-1.26	-0.59	-0.37	-2.86	-0.37
Tot. Gilbert	**0.19**	**1.95**	**2.35**	**1.51**	**1.47**	**2.0**	**1.78**	**1.22**	
Washington	0.75	5.44	2.83	0.94	-1.92	1.26	13.28	0.88	2.11
Fanning		4.42	-5.82	-2.01	4.88	0.39	19.62	4.2	1.69
Kiritimati	2.06	14.03	-4.68	12.16	12.59	4.95	6.89	4.8	1.24
Kanton	22.75	21.2	-	-	-	-	11.43	12.24	-6.16
Tot.Line & Phoenix	**-0.49**	**6.79**	**-2.68**	**4.42**	**7.25**	**3.42**	**10.36**	**4.02**	
Other nes	-0.57	2.66	-9.55	21.1	-10.4				
Total Kiribati	**0.38**	**2.02**	**1.73**	**1.68**	**1.59**	**2**	**2.26**	**1.42**	**1.69**

(source: Statistics, 2001)

More recently, the negative growth rate in 2000 of many islands of the Gilbert group and high growth rate in the Line islands reflected the Government's resettlement scheme of moving people from the Gilbert group to Fanning (Tabuaeran) and Washington (Teraina). The overall growth rate for the entire nation (1.69) is about a third of the increasing growth rate of urbanisation in South Tarawa (5.17).

11.2.3 Age and sex structure

The distribution of the population by age and sex ratio (Table 11.3) showed that the working ages (15-59) formed the bulk (>50%) of the population during the census years of 1985, 1990 and 1995. The young (0-14) constituted a considerable portion (39-41 %) of the total population while the elderly made up a small fraction (5-6 %).

Table 11.3 Distribution of population by age, median age and dependency ratio from 1985 to 1995

Age-group (yrs)	**1985 (%)**	**1990 (%)**	**1995 (%)**
0-14	39	40	41
15-59	55	54	53
60+	6	6	5
Median Age	19.7	20.4	19.6
Dependency ratio	81	85	87
Sex ratio	98	98	98

(source: SPC, 1998)

Generally, the sex structure of Kiribati is roughly a 1:1 male to female ratio though each census year may vary slightly (Fig. 11.2)

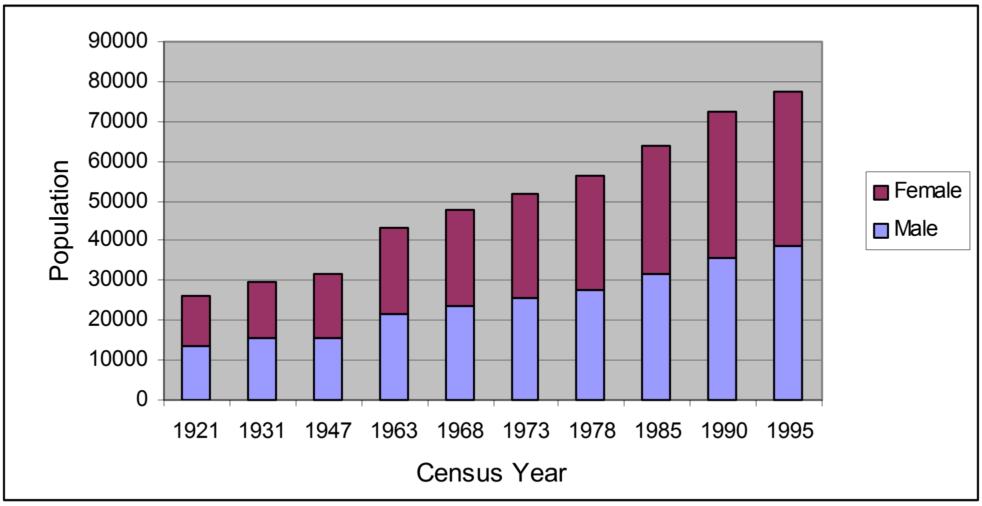

Figure 11.2 Sex Structure from 1921 - 1995

However, the female population may be slightly higher than male at times due to the slight higher life expectancy of women than men (Table 11.3)

11.2.4 Spatial distribution

The spatial distribution of the population in 2000 is best illustrated in Figure 11.3. The population is unevenly distributed throughout Kiribati. The Capital, South Tarawa has almost half (43%) the nation's population, and the remaining population is sparsely distributed in the rural areas of the Gilbert Group (48 %) and Kiritimati (4 %) in the Line Islands. Banaba and Kanton have the lowest of < 1 % each.

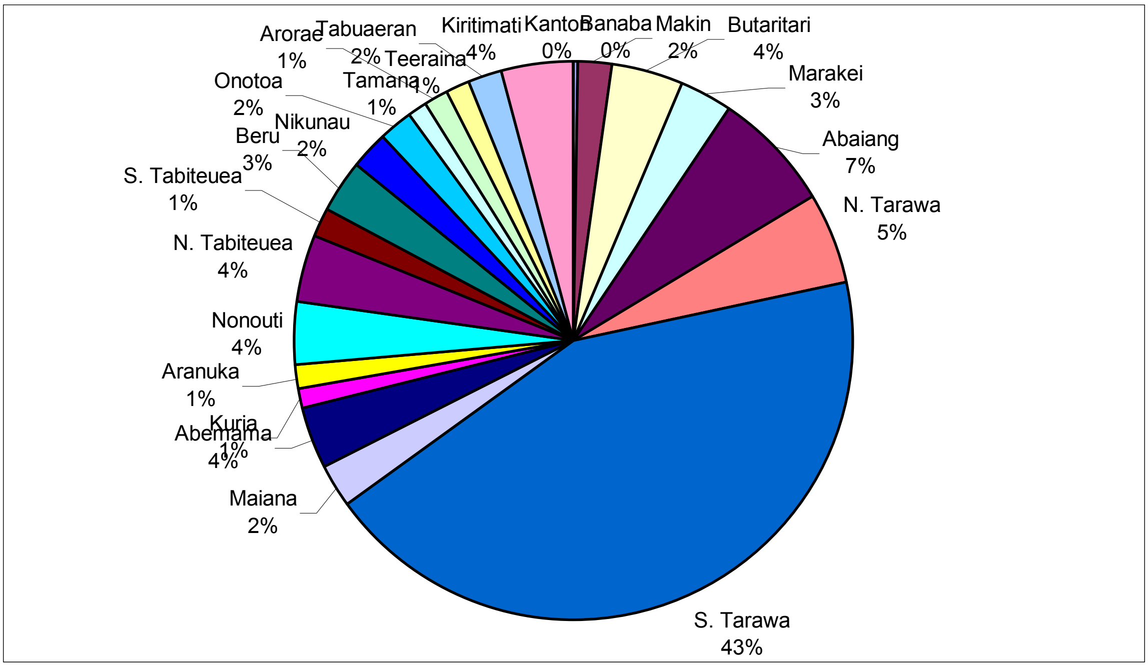

Figure 11.3 Population (%) distribution in Kiribati, 2000 (source: Statistics, 2001)

A comparison (Fig. 11.4) of the population density over the years between the entire nation and South Tarawa showed a marked difference of sharp increase in the capital while the overview of Kiribati is a gradual increase.

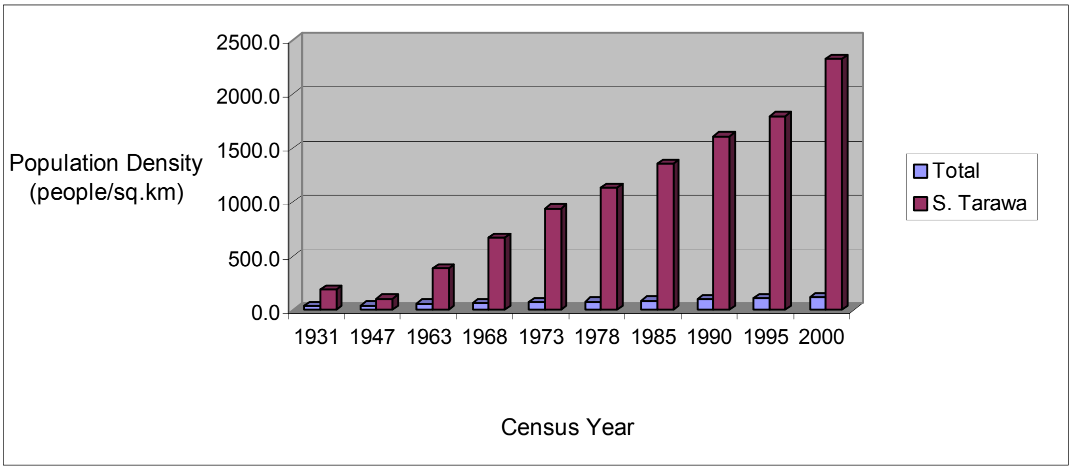

Figure11.4 Population Density Comparison of South Tarawa and Kiribati (source: Statistics, 2001)

11. 2. 5 Birth and Death rates

The incidence of death shows the population's standard of living and the general state of health, depending on many factors including environmental conditions. Indicators such as infant mortality and life expectancy at birth are commonly used to describe the overall development status of a country (SPC, 1998).

Since data is incomplete for registration of birth and death in Kiribati, estimates (SPC, 1998) for life expectancies at birth for males and females (Table 11.5) and indirect estimation of early-age mortality (Table 11.4) has been used.

Table 11.4 Summary results of indirect estimations of early-age mortality.

Mortality indices	**Males**		**Females**	
	1990	**1995**	**1990**	**1995**
Infant mortality rate, (IMR)	68.3	67.5	66.5	56.3
Child Mortality rate, between ages 1and 5	28.3	27.8	26.8	20.8
Probability of surviving to age 1	0.93170	0.93250	0.93350	0.94370
Probability of surviving to age 5	0.90533	0.90658	0.90848	0.92407
Note: reference date of estimated mortality rates of 1990 census data refer to period 1987-1988, and 1995 census data refer to period 1992-1993				

(Source: Table 17 in SPC, 1998)

A decrease of mortality levels from 1990 to 1995, especially for young girls, indicated an improving general health situation. However, the general mortality situation for males has a slight change. During the inter-censal period, the IMR for males has decreased slightly by about 1 % while females has decreased by more than15 %. The same trend is seen in child mortality where males have decreased slightly from 28.3 to 27.8 while females has decreased significantly from 26.8 to 20.8.

Table 11.5 Estimated life expectancies at birth for males and females in Kiribati 1985, 1990 and 1995.

Sex	**Census year**		
	1985	**1990**	**1995**
Males	51	57.7	58.5
Females	56	62.8	64.7

(Source: Table 19 in SPC, 1998)

Mortality levels have improved greatly from 1985 to 1990 by >6 years for both males and females since the 1980s. However, a comparison of the same during the inter-censal period 1990 – 1995, the estimated life expectancy for males has a marginal improvement whereas the female life expectancy seems better by two years. There may be unfavourable health situations for men (SPC, 1998).

Due to incomplete data on births, and deaths and the causes, indirect estimation has been employed by SPC (1998) for the population life expectancy and infant mortality rate. Thus improvement in life expectancy may not actually have occurred in Kiribati.

11.2.6 Population and Environmental Sustainability

The 2000 Census indicated that the population on South Tarawa was 36717. It comprises approximately 43% of the National Population which live on South Tarawa. Its annual growth was 5.17% while annual growth for Kiribati was 1.6%. The forecast in the population projection was very low in comparison to the 2000 Census result. It is likely that South Tarawa population will be more than 50,000 persons by the year 2010. There were 2330 persons per square kilometre. It is alarming to note that the population density for the islet of Betio have gone over the projection of 8,700 persons per km^2 for the Islet of Betio (Statistics Office, 2000).

The high fertility rate in Kiribati is leading to a rapidly growing population that will increase the number of people in poverty which lack opportunities to utilise natural resources. The population of South Tarawa has continued to grow both through natural increase and in-migration from the outer islands. Urbanization growth rate is accelerating by the so-called "internal migration or rural to urban drift" which most contributes to high figures of South Tarawa population since independence. Most islands in the Gilbert Group have negative annual growth. The population growth between 1995 and 2000 for Abaiang dropped from 2.8% to -0.77%, for instance. North Tarawa grew from 1.86% to 2.23% and Maiana with -1.29%. The continuous drift in population is expected to be worsened exacerbating the already serious problems of waste disposal, sanitation and environmental pollution and biodiversity deterioration in the future.

Since Independence the growing numbers of people and rising of level consumption per capita are depleting natural resources and degrading the environment. Especially on South Tarawa the capital shortages of land, increasing of land subdivision, chronic water shortages, loss of arable land, destruction of natural habitats, and widespread pollution undermine public health and threaten economic, social and traditional progress.

In Kiribati every year, more and more overseas products are imported to accommodate the consumption needs of the people and initiate developments, but waste production and disposal is always the final outcome which is maybe beyond the government control and requires external assistance in terms of technical expertise. Population increase outpaced the economic growth and so is pollution control. With a fragile atoll environment, population growth has also contributed to the disturbance and degradation of the marine ecology and environment, "the backbone of the Kiribati national economy".

Much of the concern over population has been raised by ecologists and environmentalists alike, who are mindful of the adverse impact of high population pressures on environmental sustainability. South Tarawa demonstrates a classic example of population growth, causing ecological stress. Many of the pressing environmental and health problems in Kiribati resulted from congested living conditions on the single atoll of Tarawa, that are compounded by increased population, urbanization, infrastructural development, changes in technology and increased resources consumption, not to mention poorly managed sewage system and waste disposal which are collectively stretching the carrying capacity of South Tarawa to its limit.

Chung (2000) stressed that over-crowding, unsanitary conditions contribute negatively to both human and natural resources health. She also stated that while water supplies are safe, demand for clean water far exceeds supply, a situation made worse by wastage from deteriorating distribution mains and illegal connections. Many households use water from unprotected and unclean wells, settlements encroaching onto water reserves threaten further pollution of ground water. Squatters were uncooperative with Government's plans for relocation.

If Kiribati manages to slow down its population growth and manage to resolve an uneven distribution of population, the government can invest more in environmental and ecological protection and conservation, education, heath care and other improvements that help boost living standards. As individual investments rise, more resources become available that can boost productivity and environmental sustainability (Population and Environment, 2000??). Chung (2000) also recommends that lowing the increase in the population, especially in the face of rising per capita demand for natural resources, can take pressure off the environment and buy time to improve development on a sustainable basis.

11.3 Government Responses to Environmental pressures

If over population and environmental degradation persist, the challenges of accommodating population increase on South Tarawa requires a collective response from all sectors of government to formulate an effective policy framework in alleviating the social and economic pressures on South Tarawa.

However since over population have already been a concern to the government, policy measures have been placed properly that includes; outer island development; resettlement on less densely populated islands; decentralization of educational systems; family planning programs.

11.4 Data Gap

- Registration of vitals (birth and death), including data by age and sex.
- Systematic inter-survey cohort in any community or contrasting environmental areas.

Chapter 12. Coastal Erosion

12.1 Introduction

Coastal erosion continues to be a severe environmental problem throughout the Gilbert Islands, but worst on South Tarawa where high population densities and limited land resources have resulted in many infrastucture developments, overcrowding and over exploitation of the physical resources of the coastal zone. This has resulted in loss of houses, roads, food trees and highly valued land. In many instances, man-made foreshore protection structures have been constructed, but failed to serve their purposes and sometimes exacerbate coastal erosion.

Severe coastal erosion has drawn political attention because people have been demanding assistance to curb the destruction by erosion of their shoreline and villages. This prompted Government to request external assistance from SOPAC and other donor agencies and simultaneously spend local resources to combat the problem. Extensive surveys (Gillie, 1992; Gillie 1993) and coastal management planning have been undertaken but, to date, coastal erosion has not been arrested

12.2 State of the Environment.

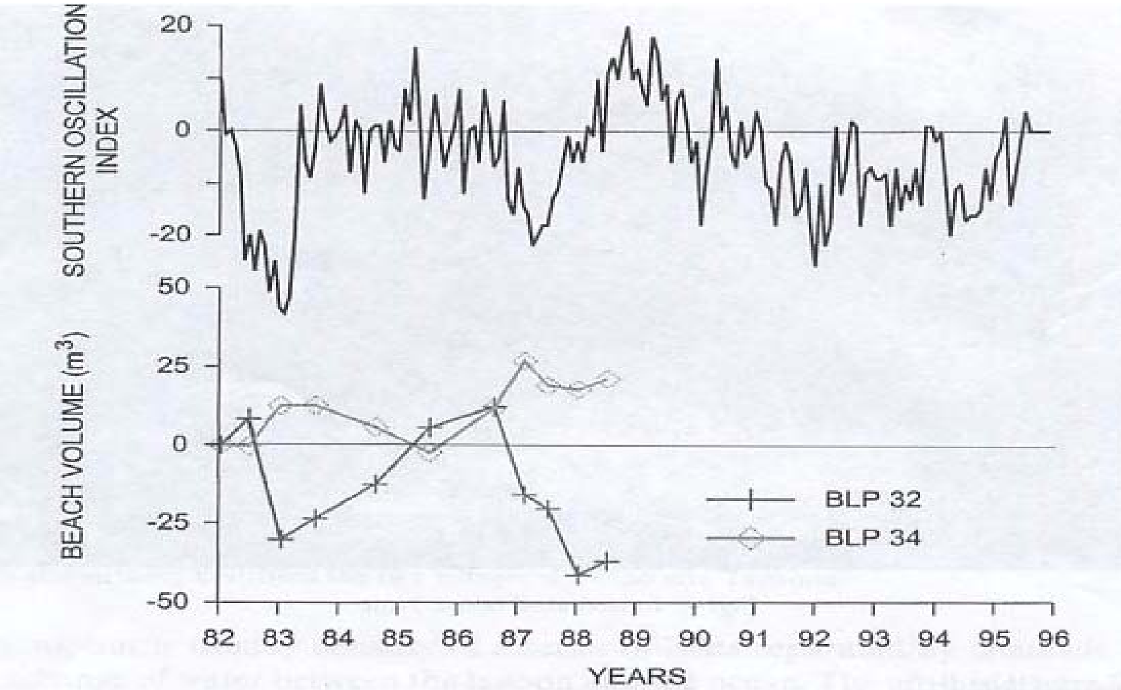

Figure 12.1 SOI is a measure of the strength of ENSO (after Solomon & Forbes, (1999)

Coastal erosion has both natural and man-made causes (Gillie, 1993a). The former is associated with locations with high variability of shoreline position, exposure to winds and waves from western sides, higher than average sea levels, strong to gale force westerly winds and ENSO (Fig.12.1) events that contribute to episodes of saltwater incursion or inundation. The latter includes causeway constructions, boat channels, removal of beach sediments and beach rock and impact of seawall and revetment constructions.

Figure 12.1 above shows the upper graph (negative excursion represents El Nino events) representing monthly and low-pass filtered values of SOI from 1982 to 1996. Bottom graph illustrates changes in beach volume at 2 sites in Bairiki, South Tarawa. The profile changes are out-of-phase with each other and related to changes in wind direction, which occur during El Nino events (Solomon & Forbes, 1999).

12.2.1 South Tarawa

Due to severe coastal erosion problems on South Tarawa, SOPAC initially established in 1982 a beach monitoring program at Betio and Bairiki with twenty six profiles to evaluate the possible impact of a causeway between Betio and Bairiki, the Dai Nippon Causeway. There was concern that causeway construction may alter sediment transport patterns within its vicinity and indirectly affect the stability of the surrounding shores (Harper, 1989).

An initial analysis of the first 26 profiles (Carter, 1983) after one year showed that four beaches on Betio lost a total of 17.5 m of beach sand, eight beaches gained a total of 36

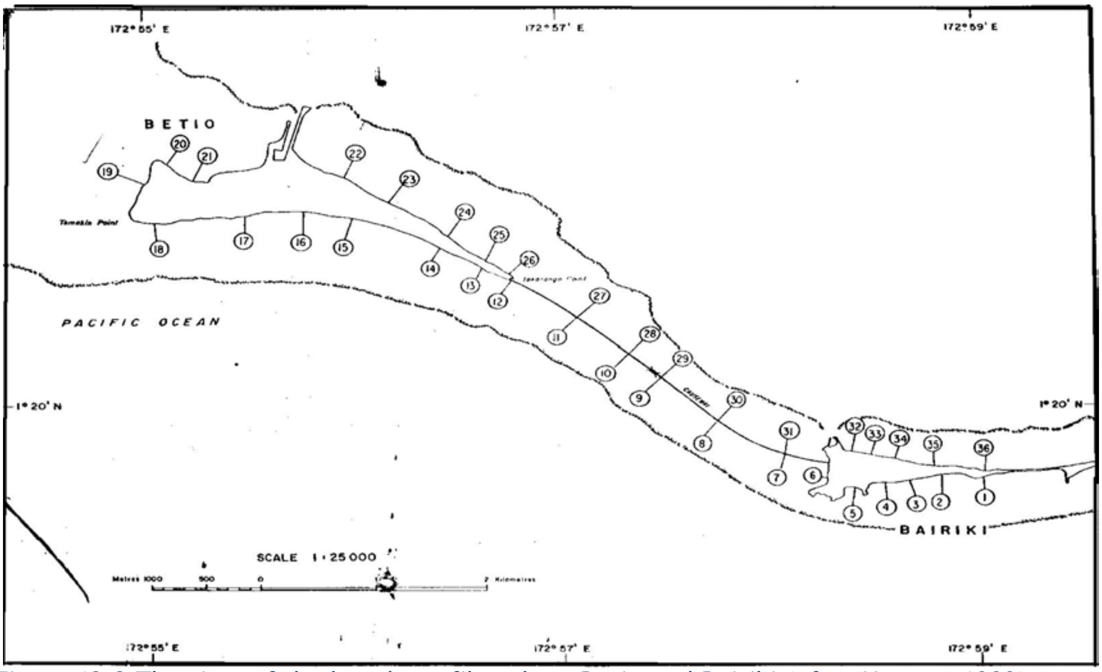

Figure 12.2 The sites of the beach profiles along Betio and Bairiki (after Harper, 1989)

m of beach, and three beaches were unchanged. There was also scouring of 0.4 m at one sand flat, nine flats shoaled a total of 1.1 m, and five were stable. Of the Bairiki profiles, three beaches lost a total of 11 m, seven gained a total of 22 m and one was unchanged. The flats had no net loss of sand; some shoaling in 6 sites and stablisation in four.

Later in 1987, another ten sites were established along the lagoonal sides of the Nippon Causeway and Bairiki.

Another analysis of the then 36 sites was made by Harper (1989). Several trends were evident within the dataset around Betio and Bairiki. First, the effects of an increased percentage of westerlies in 1982 and 1987 associated with the ENSO were evident as shown in Table 12.1 causing the most significant shoreline changes at lagoon-shore beaches. Secondly, beach changes were significantly more variable and with greater magnitude on the lagoon shore than on the ocean shore. Thirdly, there appeared to have been an overall balance or erosion and accretion on the two islets. Lastly, it appeared then that there was no shoreline changes that could be definitely attributed to the Nippon Causeway.

Table 12.1 Relative beach Changes during the 1982 & 1987 Southern Oscillation

	No. of Profiles in 1982		No. of Profiles in 1987	
Type of Change	Ocean Side	Lagoon Side	Ocean Side	Lagoon Side
Accretion	6	7	7	5
Erosion	3	2	1	4
No Change	4	2	5	2
Based on relative change	Between mid-1982 & early 1983 surveys		Between mid-1986 & mid-1987	

(source: Harper, 1989)

In February 1988, there was a substantial accretion along the Nippon Causeway (Forbes & Hosoi, 1995) of a total sediment > 108, 000 m^3 accumulated along the causeway. Accretion of sand created extensive beaches on both sides of the west end and on the lagoon at the east end of the causeway, developing into natural woodland above the berm, just like other accreted land on the other causeways of South Tarawa. These woodlands have been declared new National Parks, adding significant public recreational land.

Ten beach profile sites were later established at Bikenibeu in 1994 (Howorth & Woodward, 1995). From 1986, the Lands and Survey Department of MHARD undertook the collection of the beach profiles data (Harper, 1989) and was later assisted by the Mineral section of MNRD. These monitoring activities are still ongoing under the control of both departments.

There were a number of other severe coastal erosion problems experienced, such as the Government Secondary school, KGV & EBS at Bikenibeu and the main hospital at Nawerewere. SOPAC undertook to assess (Forbes & Hosoi, 1995) some of these incidencies in response to Japan's request for its major project sites on South Tarawa.

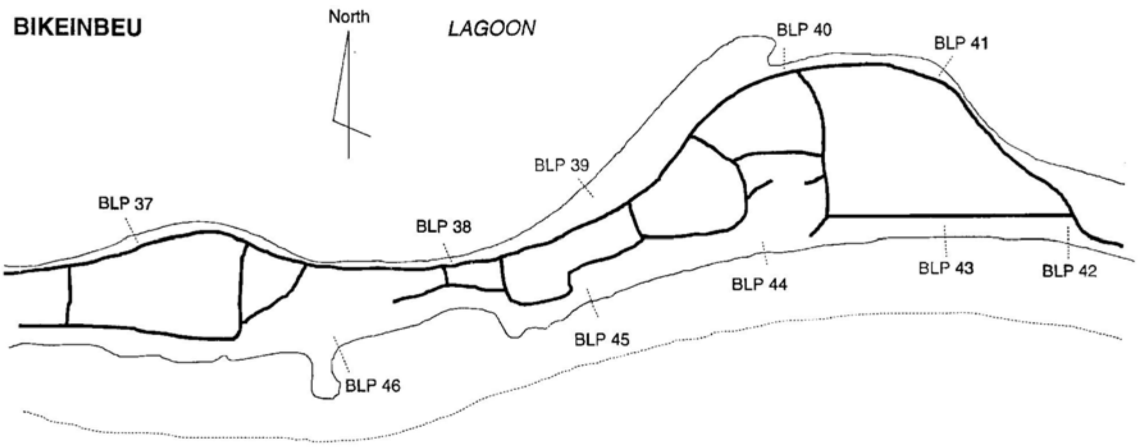

Figure 12.3 Bikenibeu Beach Profiles (BLP37 – BLP 42 after Howorth & Woodward, 1995)

Figure 12.4 Coastal Erosion at Betio (ECD, 2000)

The hospital site had:

- a medium term rate of coastal recession during 1969 to 1992, approximated at 0.2 m to 0.4 m annually;
- rate of erosion at the backshore scarp increased to about 1.2 m annually over the years from 1992 to 1995 but most of the erosion may had occurred during an extreme event between May 1992 and April 1993;
- the eroding backshore scarp was at 0.8 m from the emergency access road and about 9 m from the nearest hospital ward;
- evidence suggested cyclic variations in sand volume on the beach, associated with ENSO-driven changes in prevailing winds (Forbes & Hosoi, 1995).

The government school had:

- a medium term rate of coastal erosion up to 0.3 m annually at the west end of the school compound between 1969 to 1992, where erosion has reached about 4 m of the classroom block in May 1992;
- efforts to protect the site with sandbag in July 1992 resulted in severe damage five months later. Reconstruction began at the following year, only to be damaged again later in November 1994. Repair was made again in early 1995;
- recession rate of the backshore scarp in the 150 m immediately east of the seawall accelerated from an average of 0.11 (+/- 0.14) m annually during 1969 to 1992 to 0.93 (-/+0.20) m annually from 1992 to 1995, with a maximum of 1.2 to 1.3 m/a;
- farther east along the shore, the backshore disappeared and the shore had been stable in recent years. However, the beach showed evidence of longterm recession from exposed beachrock and conglomerate. Localised washover suggested potential erosion in severe storms (Forbes & Hosoi, 1995), refer to Fig. 12.1.

Extensive sections of the shorelines of South Tarawa have been modified by construction of seawalls, revetments, groynes and other structures for either responding to coastal erosion or for land reclamation. The outer islands have fewer coastal protection structures. These coastal structures were classified (SOPAC, 1996) into 5 categories (Table 12.2)

Table 12.2 Problems with current coastal protection systems used in Kiribati

Structure	Cost (AUD$)	Problems and Comments
Vertical face coral rock wall stacked over the other	$100-200/m	Size of rocks used for constructing walls are too small or not big enough, poor quality of some rocks, foundation not deep enough to withstand scour problems
Cemented vertical face coral rock wall	$200-400/m	Poor quality of rock, Shallow foundations to with stand scour problem, lack of maintenance caused by shortage of funds
Gabion baskets filled with coral	$200-400/m	Plastic coating on wire netting damage which causes corrosion to wire netting. Rock in basket not stacked properly and allows rock movement inside the basket
Sandbag filled with sand cement front wall	$200-400/m	Lack of maintenance and foundations not deep enough to withstand scour problem
Sloping face coral rock wall with rock and vertically and interlock one another, sand cement mortar used when rocks are not big enough	$300-500/m	Type of seawall is more successful when heavy flat rock are used instead of rounded ones. Less problem with this type of seawall

(Source: SOPAC, 1996)

The beach has been the traditional source of construction material. The growing demand for building aggregate on South Tarawa is resulting in major coastal erosion problems because demand is outstripping supply (See Section 4.3.2). Apart from the beach, resources are also obtained from the reef flats and dredged from the lagoon (See Section 4.3.1).

The Public Works Division (PWD) of Government has standardised (Biribo & Smith, 1994) aggregates according to sizes:

Cobble size	75-100 mm
Coarse gravel	20-74 mm
Fine gravel	10-19 mm
Coarse sand	5 - 9 mm
Medium coarse sand	1- 4 mm
Fine sand	0.1 – 0.9 mm

From 1989 to 1993, sand and gravel usage (Biribo & Smith, 1994) on South Tarawa included cement blocks (69%), reclamation (5 %), coastal protection (2 %) and road maintenance (18 %). It was found that building requirements for aggregate had increased from 515 m^3 in 1989 to 39,028 m^3 in 1993. This implies that demand has continually increased as more developmental infrastructures are constructed by Government, the private sector and the public.
.
Mining of reef carbonates that replenish beaches and sediments, has caused many coastal problems such as coastal erosion and land loss due to removal of natural coral barrier protection. Dredging results in deepening of nearshore bathymetry, altering hydrodynamics and causing the propagation of larger waves along the shorelines, resulting in scouring and coastal land loss thus threatening coastal infrastructure and increasing erosion risks to coastal communities (Maharaj, 2001).

12.2.2 Outer-islands in the Gilbert Chains

During an El Nino event in the early 1990s, Government was very concerned with coastal erosion affecting all islands in the Gilbert group and requested SOPAC in 1993 to assist in identifying the causes of erosion and recommend actions to remedy the problem. A reconnaissance survey (Gillie, 1993a) of known coastal erosion sites was undertaken that later became useful in determining the nature and extent of coastal erosion where it was a problem at that time. Full details of the survey were provided in Gillie (1993b) and a brief summary of the survey is reproduced in Table 12.3

Table 12.3 List of islands, site locations of some of the islands surveyed and summary of problems

Island	Site/Village	Summary of Coastal Erosion Problem
Abaiang	Tabontebike	Moderate erosion of 5-10 m along 200-300 m of sheltered ocean shoreline. Amenities affected include loss of coconut trees and salt water intrusion into agricultural crop (babai) bits. Erosion appears due to natural causes
	Koinawa	Moderate erosion of 5-10 m along 150 m of lagoon shoreline. Potential effects on road if erosion continues
	Tebunginako	Severe erosion of greater than 10 along > 5000 m of lagoon shoreline. Site previously surveyed (Harper, 1989; Holden, 1992). Southern or old meeting hall (maneaba) now inundated by sand overwash. Many traditional buildings have been removed or are threatened by further erosion. Erosion due to natural causes of spit migration along lagoon shoreline
Marakei	Rawannawi	Severe erosion of ocean shoreline along village fronted by natural pass in reef which has been modified (boat channel near shore). Erosion extends 400 m north and south of reef pass. Cause of erosion appears to be loss of beach sands to boat channel, reef pass and beyond reef
	Buota	Moderate erosion along ocean shoreline for 0.5 kn north and 1-2 km south of Buota village. Affected amenities includes village, coconut trees and road. Shoreline subject to storm overwash
	Baretoa Passage	Natural inter-islet channel closed by accretion of large sand ridge on ocean side entrance approximately 10 years ago. Channel closure probably related to causeway construction across channel some 15 years ago. Severe local impact on lagoon fisheries since channel is one of only two channels on Marakei allowing flow between ocean and lagoon waters
Makin	Naka Primary School	Moderate erosion along ocean shoreline for about 0.5 km north & south of school located on point. Besides school, other amenities affected include village houses. Erosion occurs with strong westerly winds and waves
Butaritari	Ukiangang	Moderate erosion 5-10 m of ocean shoreline adjacent to road threatens babai growing areas. Saltwater inundation occurs with. Main concern is security of food supply. Saltwater inundation difficult to prevent with coastal protection alone
	Keuea village	Minor coastal erosion (<5m) with some erosion scarps along ocean shoreline away from village on lagoon shoreline. Approximately 3-4 years storm driven saltwater overtops coastal ridge and flows inlandabout 40 m to babai pits causing young crops to die off
	Keuea/ Tanimainiku	Moderate erosion 5-10 m along lagoon shoreline north of causeway under construction for 9 years (1975-1983). School built in 1980 now some 30 m from shoreline. Erosion beside road to north of school as well.
Tamana	Barebuka	Erosion at west end of runway with vertical scarp changing to cobble beach and then sand beach accretion on extreme north end of island. Erosion associated with westerly winds, esp. storms surge in early Jan.1993
	Bakarawa	Shoreline approx. 300 m north of shipwreck comprises of altenating beach rock and sand with some erosion and evidence of wave overwash into backshore. Progressive erosion over 10 years of about 5-10 m. shoreline still at least 20 m from settlements
	Bakaka	Shoreline protection includes existing and destroyed seawalls, however all building are set back
Arorae	Taribo	Erosion site approx. 100 m south of boat channel. Storm surge in early Jan. 1993 caused overtopping of beach ridge and destruction of seawalls. Overwash deposits up to 0.5 m thick and 4-50 m back of beach

	Tamaroa	Minor erosion at large church north of village. Beach accreting seaward in front of erosion scarp from Jan. storm.
	Batitotai	Erosion of west side of southern end of island > 50 years period. Site comprises abandoned village site.
	Babaroroa	Erosion
Beru	Taboiaki	Moderate erosion predominantly south of village. Erosion extends over 1.5 km along shore. Extensive length of existing seawall construction
Nikunau	Tabomatang	Extensive length of shoreline with seawalls north of church. Longer term erosion in order of 10-20 m according to local sources
Aranuka	Takaeang	Minor erosion near school on point along south coast of island. Strong tidal currents flow past this pointing both directions (flood to east and ebb to west). Initial gabion basket seawall placed in 1985 and came apart 2-3 years later. School presently 30 m back of beach and not in immediate danger.
	Buariki South	Erosion of low lagoon shoreline over 500 m along Buariki south village area. Moderate erosion of 10 m over approx. 50 years. Beach rock exposed along shoreline and broken pieces have been used extensively for seawall construction

(source: Gillie, 1993a)

From the survey, a few sites with serious problems on selected outer-islands were protected with seawalls but not all islands and sites were protected due to cost. Environmentally sound recommendations were included in the report (Gillie, 1993b).

Severity of coastal erosion did not abate, so Government called for another round of reconnaissance surveys of the outer islands in 1996-1997 that was undertaken by Government officials from the Local Government, Mineral Section, Public Works Division and the Environment Unit. Government later prioritised all the sites according to coastal erosion severity, among others, for funding of seawall protection. Despite construction of coastal protection structures, erosion still continues at these sites.

It seems that the islands with long records of erosion are the inhabited islands of the Gilberts group where human settlements has long been established for centuries. The remaining islands of Line and Phoenix, which are mostly uninhabited, including the inhabited Kiritimati, Fanning, Washington and Canton, have not recorded incidences of coastal erosion. There may have been severe coastal erosion like the rest of the Gilbert chain but this has probably gone unnoticed due to their sparse and uneven populations.

12.3 Pressure on the Environment

Continued pressures driving coastal erosion are expected to continue. The following threats and barriers need to be addressed:

- Current coastal protection systems used have various problems that in many ways are ineffective and exacerbate the erosion problem.
- Loss of beach may be accelerated in future due to the practice of intensive shoreline occupation and development.
- Continual mining of sand and gravel from the foreshore as material for infrastructure construction and infill for land reclamation.
- Technical know-how is generally lacking and technical guidelines and codes of professional practice are lacking.
- Clearing of mangrove forests and other coastal vegetation which act as coastal defence and provide buffer zone for land against storms and high waves, wind breakers and barriers to dissipate high energy waves and currents.

12.4 Responses to the Pressure

There have been a number of studies and actions over the last decade aimed at addressing critical coastal erosion and resource management. Many have been at the investigation and planning stage, however discreet and long term action has not been taken up in many instances:

- Documentation of sand and gravel production by the private, commercial and government sectors by Government with assistance of SOPAC (Biribo and Smith, 1994)
- Identification of an alternative and sustainable resource of sand and gravel aggregate for South Tarawa by Government with assistance of SOPAC (Smith and Biribo, 1995)
- Training workshop on understanding of beaches, beach dynamics and nearshore processes, erosion and erosion processes and hydrodynamics aspects of nearshore environments by Government with assistance of SOPAC (Maharaj, 2000)
- On-going public awareness on sedimentation and coastal erosion related issues
- Formation of the Foreshore Committee by relevant Government departments and Stakeholders led by Land Management Division.

12.5 Data gaps

- Regular beach profile data of the outer-islands.

Chapter 13 Energy

13.1 Introduction

Kiribati relies mainly on imported fuel for electricity power generation and transport. In the two main urban centres of Tarawa and Kiritimati, electricity is provided publicly by the only government owned utility company, PUB. Some households, institutions and community centres on the outer islands use fossil fuelled generators to provide electricity while others use solar photo voltaics for generating electricity for light and entertainment.

Other energy related issues like transport, air and noise pollution are other components of this chapter.

13.2 State of the Environment

The energy balance in Kiribati is presented schematically (Fig.13.1) to illustrate a basic structure of energy sources and uses (SOPAC, 1999).

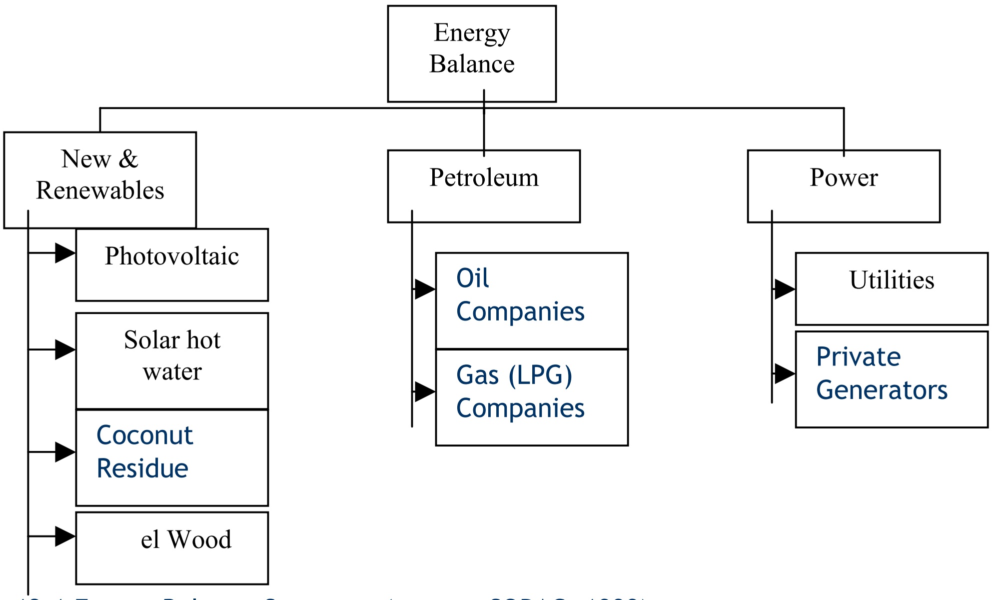

Figure 13.1 Energy Balance Structure (source: SOPAC, 1999)

The New and Renewable class contains a summary of consumption by the four sectors (units = GJ), that is the solar hot water systems total energy (units in MWh & GJ), the PV's energy (MWh and GJ), the calculation of energy obtained from coconut wood and residue (GJ and te) and the total consumption of fuel wood and waste wood (GJ and te).

The Petroleum sector contains the total petroleum products data from the 3 companies: Burns Phillip (BP); Kiribati Oil Company (KOil); and Kirigas. The last class, Power generation, covers the outer islands which have private/utility power stations that are generally small generators.

The database for this energy balance should be available at SOPAC and the Energy Planning Unit (EPU) of the Ministry of Works and Energy (MWE).

13.2.1 Imported Energy

Table 13.1 A comparative figures for imports of the different fuel types for the years 1990, 1994 and 1999/2000.

Fuel Imports for 1990, 1994 and 1999/2000			
Fuel Types	Quantity (ton)		
	1990	1994	1999/2000
Secondary Fuels			
Gasoline	1755	2148	Na
Jet Kerosene	1027	1260	Na
Other Kerosene	496	995	Na
Diesel Oil	5700	5656	Na
Residual Fuel Oil	0	12	3.3
LPG	25	39	Na
Ethane	0	Na	Na
Naptha	0	Na	Na
Bitumen	61	Na	na
Lubricants		190	124.5 kg
Note: Na means not available during search for data because of incompleteness in some companies			

(Modified Table 4 p23 in GOK, 1999 & Statistics, 1998)

The main sectors as users of this fossil fuel are generally electricity generation on South Tarawa and transport at land, sea and air. Fuel utilisation for electricity used to be higher than transport purposes however, the trend has been reversed (GOK, 1999).

13.2.2 Renewable Sources of Energy

In spite of the abundance of solar energy in Kiribati, its present usage is limited to a few areas. Under Government funding through various development agencies from JICA, EU, UNDP, WB and SOPAC, an estimated 500 to 1000 solar systems have been installed. These include other institutional solar systems on the outer islands for school lighting, water pumps (Fig.13.2), cooling and telecommunication sets for clinics, private home systems and solar hot water systems installed in hotels (Tannang, 2001).

The Solar Energy Company (SEC), a government owned corporation, is directly controlling about 314 solar photovoltaic systems of private homes on the outer islands of Nonouti, Marakei and North Tarawa. These systems provide radio, cassette players and lighting for domestic and community activities in the evenings, refrigeration of health vaccines and clean water as long as their energy demand does not exceed 1 kilowatt (Gillet & Wilkins, 1998; Akura, 1998). More recently water pumps powered by solar energy are now also controlled by SEC (Eita Metai per.comm).

Figure 13.2 Solar-powered water pump (ECD, 2000)

Renewable sources of energy like solar systems, are environmental friendly, for being pollution free when compared to imported fuel. Hence solar usage must be fully provided and extended to more homes and institutions on the outer islands where fossil fuel powered generation is minimal. The expansion programme will depend largely on the continually support of Government and donors to assist and facilitate the SEC in installing and maintaining these systems, before SEC can operate sustainably.

13.2.3 Transport

Traffic on urban South Tarawa is made up of pedestrians, bicycles, motorcycles, cars, vans, buses and trucks. Table 13.2 shows the number of motor vehicles registered from 1982 to 2000.

Table 13.2 Motor Vehicle Registration in South Tarawa

	1982	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Motorcycle	1236	948	959	826	786	772	571	416	577	538	699
Cars	312	282	292	280	250	264	2222	168	268	205	307
Trucks	62	74	45	40	42	49	35	39	57	41	68
Buses	34	27	32	41	39	73	80	54	106	50	46
MiniBuses	0	0	0	0	0	0	0	0	0	43	70
Tractors	9	17	6	6	11	6	1	7	17	9	27
Others	31	19	14	22	12	13	8	12	19	20	21
Total	1684	1367	1349	1215	1140	1177	917	696	1044	906	1208

(source: Statistics, 2001)

Table 13.2 (contd)

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Motorcycle	764	548	450	799	687	764	793	702
Cars	373	257	202	353	408	438	480	477
Trucks	88	74	59	107	136	141	202	287
Buses	47	24	17	22	15	14	11	10
Mini-Buses	80	64	68	124	171	203	238	392
Tractors	23	9	5	13	5	13	4	1
Others	9	20	15	21	19	46	10	12
Total	1384	996	814	1439	1441	1619	1738	1861

Road vehicle numbers have continued to increase and so overall levels of noise and air pollution from motor vehicle use has continued to rise in South Tarawa. Adverse environmental effects from motor vehicles, with related health problems, such as respiratory complaints, are becoming increasingly obvious in urban centres. No previous study has been undertaken to determine a correlation between motor vehicle numbers and respiratory problems in Kiribati.

13.2.3.1 Road Congestion

While vehicle use has increased, no new roads are being built, hence road congestion will continue to escalate. With increasing population and economic growth particularly on South Tarawa, there is a need for a better public transport system to minimize use of private motor vehicles.

A traffic survey (Redfern, 2001) excluding motorcycles, bicycles and pedestrians in 1994 at the 3 main centres of the capital showed the following:

Betio Ring Road (3 locations) 1180-2190 vehicles/day
Bairiki Access Roads (2 locations) 1630-1824 vehicles/day
Bikenibeu Access road (3 locations) 1299-1550 vehicles/day

For such small centres on conjested South Tarawa which has only one main road, a range of 1000-2000 vehicles per day is considered very busy. The lack of comparative data for subsequent months or years means the traffic trend over time cannot be shown.

13.2.3.2 Air pollution

Increasing numbers of vehicles have given rise to numerous forms of air pollution including carbon monoxide (CO), nitrous oxides (NOx), and airborne lead. Road vehicles are a major source of air pollution on South Tarawa. The major source of airborne lead pollution is anti-knocking compounds which are used in some automobile fuels. Imports of second hand vehicles from Japan (Statistics, 1998), particularly minibuses which frequently use an incompletely tarsealed road daily as well as trucks and saloon cars, have contributed more to the air pollution level. Until 2000, no authority was monitoring or regulating air pollution. The enactment of the new Environment Act (1999), has mandated the Environment Conservation Division of MESD to regulate such pollution. Environmental audits and pollution control procedures are now in place.

13.2.3.3 Noise Pollution

Noise pollution is a problem from traffic, apart from powerhouse generators and other heavy machinery works. Research shows that motors and exhaust systems of large trucks contribute the largest component of traffic noise. Like air pollution, there has been no ground monitoring of noise pollution at the national level yet, but ECD has been legally mandated under the new EA to control noise pollution. However, institutional strengthening is required for effective enforcement.

Figure: 13.3 Betio Power House in Royds, 1996 Vol 2

13.3 Pressure on the Environment

13.3.1 Pollution of the air through vehicles exhaust pipes and powerhouse stack chimneys

Road congestion with vehicles, particularly during busy hours of weekdays, resulted in concentration of vehicles exhaust emissions near roadsides. Electricity powerhouses also contribute to the air pollution level on South Tarawa.

13.3.2 Traffic increase

Traffic problems are arising from a single main road running along the length of South Tarawa from east to west with a width of less than 5 m. there is an increasing number of vehicles but the road stays the same

13.3.3 Groundwater pollution

Pollution of underground water lenses occurring at many sites in Betio and Bikenibeu due to ground spillage of used oil (Fig. 13.4).

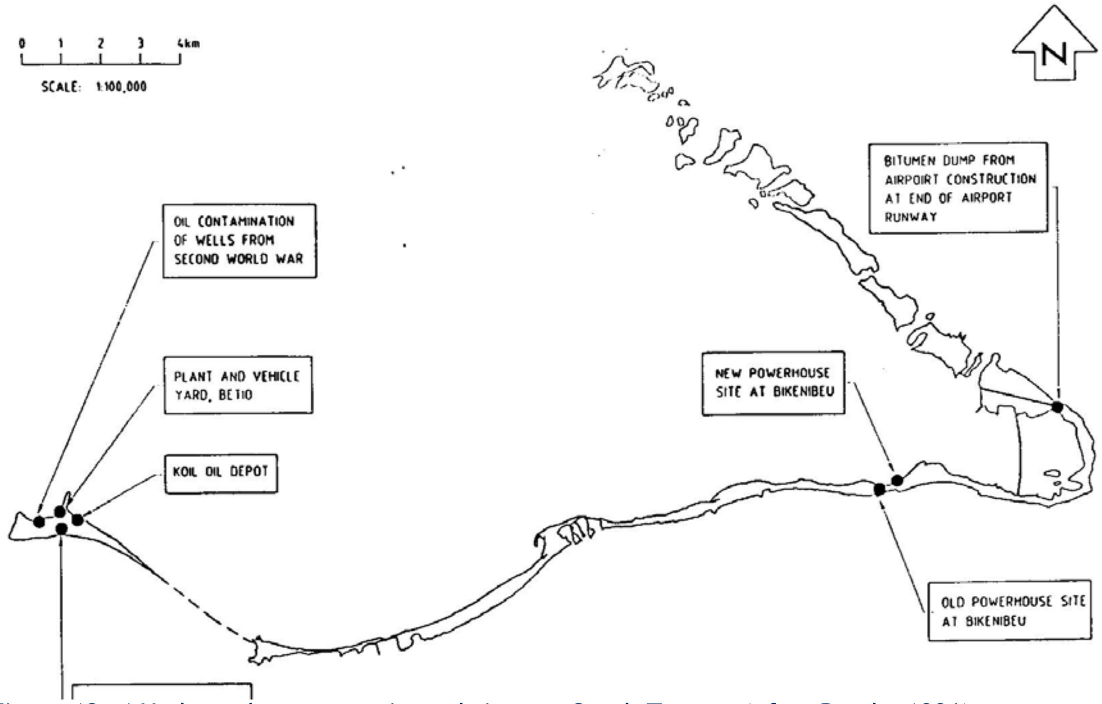

Figure 13. 4 Hydrocarbon contaminated sites on South Tarawa (after Royds, 1996)

13.4 Responses to the Pressure

13.4.1 Other alternative sources of energy

The following are continually being explored by the EPU:

- Cardboard solar cooker
- Biogas production
- Wind turbine project
- Solar parabolic cooker

13.4.2 Extension of the rural electrification

The pilot program on the 3 outer islands will be expanded to other islands which have not been serviced by solar energy. The Solar Energy Company (SEC) has already prepared and submitted to Government project proposals for the extension program for interested donors such as EU and JICA.

13.4.3. Energy Conservation Program (ECP)

The ECP will be initiated by EPU with the assistance of SOPAC to monitor electricity consumption within Government bodies. Commencement will depend on availability of funds

13. 5 Data Gap

- incomplete imported fossil fuel
- percentage usage of fossil fuel by various sectors (transport, electricity, etc)
- data to show road usage, ie busiest roads, of number of vehicles per day.
- Level of air and noise pollution in conjested South Tarawa.

Chapter 14. Waste

14.1 Introduction

Waste problem has an increased alarming rate in Kiribati. There is a great need for better management and coordination to improve the current waste situation in Kiribati. Increased urbanization and growing populations have accelerated problems with the collection and disposal of both solid and liquid wastes. Limitation in land seize on South Tarawa is insufficient for storing wastes, alternatively land reclamations out offshore have constructed for possible waste landfills. Facilities for waste transportation are also deficient, there are no actual designed waste trucks used to transport collected waste.

Waste collection is managed by Local Councils. The present waste collection system which is operated on South Tarawa, by Tarawa Urban Council (TUC) and Betio Town Council (BTC), is uniform to all sections of the community, that is residential, institutions and industrial as well as commercial premises. Tractors and trailers are used by both Councils to collect general waste that is piled up on the road side. Depending on the pace of work of operators, collection can be twice or more per week for the three main centres of Betio by BTC while Bairiki , Nanikai and Bikenibeu are serviced by TUC. Apart from those most urbanised villages, the rest of South Tarawa and Kiribati dispose of waste either at sea or compost for gardening by burying or burning

14.2 Present State of the Environment

14.2.1 Waste generation

It was estimated (SPREP/Sinclair Knight Mertz, 2000 & OEC, 2000) that waste volume generated domestically and commercially from households and others in South Tarawa was approximately 3,500 tons per annum; domestic waste generation rate is 0.33 kg/capita/day and bulk density was estimated as 130 kg/m^3. The characteristics of domestic waste are shown in Table 14.1. The Pie chart below (figure 14.1) shows the perenctage compostion of year 2000 domestic waste.

Table 14.1 Summary of Domestic Waste Composition Surveys (Wt %)

Classification	1994	1996	1997	2000
All organics	80	62	76	51.3
Papers	2	14	5	7
Plastics	2	12	5	7.2
Glass/Ceramics	3	-	3	13.6
All Metals	7	7	10	9.4
Textile/Rubber	<1	3	<1	3
Miscellaneous	6	2	-	8.5
Total	100	100	100	100

Notes:
1. 1994 and 2000 are based on household surveys done by Gangaiya (1994) and Sinclair Knight Mertz (2000) respectively.
2. 1996 is based on Waste Dumpsite survey at Red Beach Dump, done by PPTA (2000)
3. 1997 was undertaken by ISEU for ADB
4. The general trend for usage for plastics, paper and metal (aluminium cans) indicated an increase (SPREP/Sinclair, 2000).

(*adapted fromTable 2.1, page 3 of OEC, 2000*)

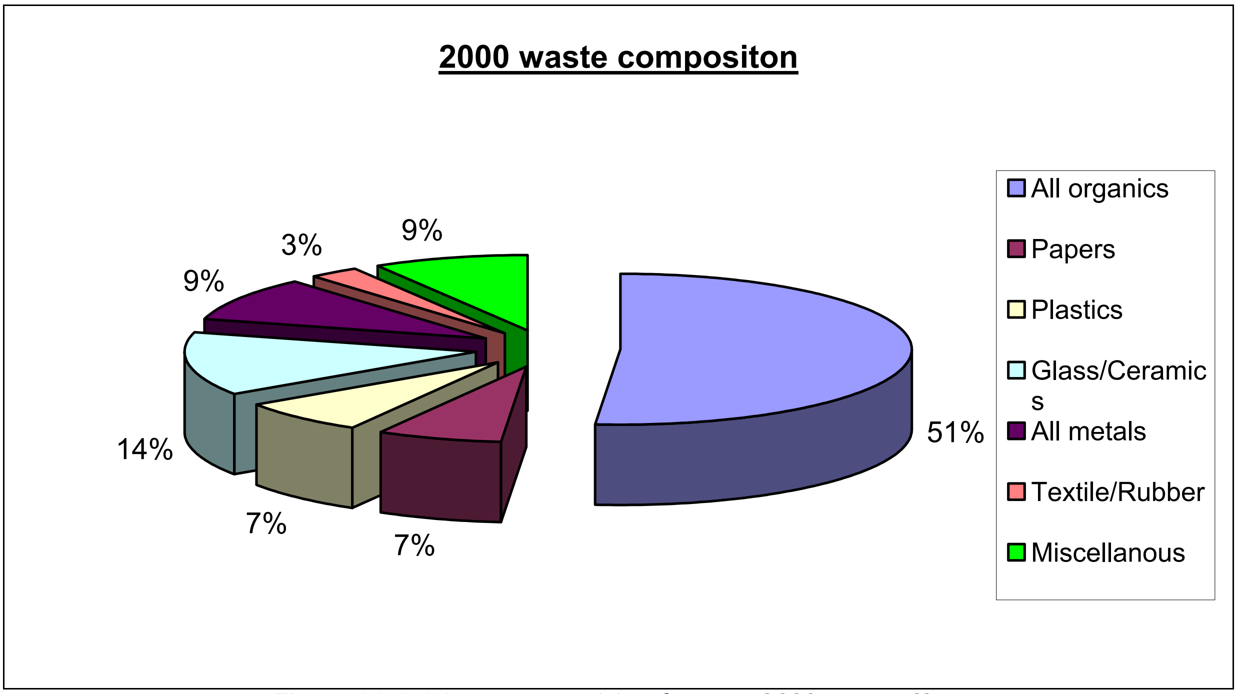

Figure 14.1: Waste composition for year 2000 (source??)

14.2.2 Solid Waste

Solid waste disposal is a serious and increasing concern in Kiribati, particularly the capital, South Tarawa. Although regulations forbid littering, lack of enforcement and inability of responsible authorities to ensure proper waste disposal has caused the capital to be generally littered visually and degraded environmentally.

The limited resources allocated to relevant authorities coupled with the lack of both concern and sense of responsibility by the general public to manage waste appropriately in communal or public areas, had resulted in poor management of waste. However, at individual private properties, waste is better managed because both daily sweeping of compounds and composting are commonly practised.

In the capital, urbanisation, overcrowding and increased dependence on imported goods with non-biodegradeable packaging, make South Tarawa an unsightly place. Disposal of solid wastes is a common problem that both harms the aesthetic tourism value of the islands, endangering the biodiversity, ecosystems, creates odor environment and breeding sites for disease bearing mosquitoes also directly harm the people. In comparison, rural areas where responsibilities for managing waste at public places and private property rest on caretakers and landowners respectively, are better managed.

Hazardous materials are substances that can cause adverse impacts on the environment and human health. Such can be in the form of a gas, solid, liquid, sludge or organism but are categorised according to their major properties of biological; radiation; explosive; toxicity; chemical; and corrosiveness (SPREP, 2001).

Using the Rapid Hazard Assessment Scheme (New Zealand Ministry for the Environment, 1993), risk ratings were determined for hazardous materials specific to Kiribati (Table 14.2) These contaminated sites were identified during an in-country survey of POPs in Kiribati (Burns *et al*, 2000). It was based on the: extent of contamination; toxicity and mobility of contaminants; contamination potential (food/water); and ease of public access.

Individual ratings of sites for the above factors were combined to give an overall hazard rating for the site, ranging from 0 for non-hazardous to 100 for extremely hazardous (SPREP, 2001).

Figure 14.2 Unused bitumen close to Bonriki airport (Koin, 2001)

14.2.3 Hazardous Material

Table 14.2 Risk rating, priority and treatment options of contaminate sites in Kiribati

Location	Site Activity	Risk Rating	Priority	Treatment Option
Pesticide Contaminated Sites				
Canton Island	Quarantine former Store	30	18	Collect spillage and decontaminate, then off-island disposal
Hydrocarbon Contaminated Sites				
Bonriki airport	Asphalt dump	100	1	Local use or solidify and bury
Bonriki airport	Aspault dump on beach	100	2	Local use or solidify and bury
Betio	Power station	64	5	Landfarming and oil management programme
Betio PVU	Vehicle workshop	58	11	Landfarming and oil management programme
Bikenibeu	Power station	51	16	Landfarming and oil management programme
Kiritimati	Bulk fuel depot	50	20	Landfarming and oil management programme
Kiritimati	Linnix (Banana PWD) asphault	30	37	Local use or solidify and bury
Miscellaneous Contaminated Sites				
Bikenibeu	Landfill	30	22	No remediation but need to upgrade site management
Betio	Landfill	30	23	No remediation bbut need to upgrade site management
Kiritimati	General waste disposal	30	24	No remediation but need to upgrade site management

(extracted from Burns *et al*, 2000)

An inventory of Waste and Obsolete Chemicals and Chemical Contaminated Sites is provided in Appendix 5.1

Very limited infrastructure and human resources exist for the control and management of hazardous chemicals. Responsibility rests with many Government and NGOs, but many materials are left unattended.

Since it lacks industries, Kiribati does not produce great amounts of chemicals or any hazardous materials and chemical waste. However there are still pollution problems with waste petroleum products from power plants, automobile shops, school laboratories, printeries and other chemicals.

14.2.4 Management of Special waste

14.2.4.1 Medical/clinical waste

Medical wastes such as sharps and syringes are put in small containers or boxes with dressings, clothes, etc., which need incineration. These materials are burned using kerosene at the hospital. The remaining is disposed at dumpsites by Council staff.

14.2.4.2 Sludges/septage

Most are channelled through the present sewerage system and dumped at outfalls that extend into the deep ocean. The main central hospital has its own sewer outfall to the ocean (refer to Section 15.2.2).

14.2.4.3 Waste oil

Waste oil generated from the powerhouse, garages and bowsers generally lack an appropriate collection system. However, used oil is stored in drums, particularly at the Kiribati Oil Company (KOil) and sometimes at the Powerhouse (Fig.14.2), awaiting shipment to Fiji or other oil recycling/reuse facilities in the Pacific region. This is done through the Fiji-based Mobil company. The system faces problems due to lack of both empty drums and the financial costs of handling.

14.2.4.4 Quarantine waste

Quarantine waste received from ships is burned by an incinerator that requires firewood. The incinerator is a donation from the South Pacific Commission (SPC). Airport facilities lack an incinerator so waste is burned with kerosene and firewood by the Agricultural Authority. A hole is simply dug in the ground and waste is manually burned.

SPC will be providing another three incinerators of the same brand that require firewood, one for the airport at the capital and the rest for the Kiritimati port and airport quarantine site (per. comm. Teuriaria).

14.2.4.5 Other Waste

Scrap metals from derelict vehicles, mechanical equipment and World War II relics are causing problems of occupying limited land and aesthetic issues.

Used batteries are another environmental hazard. Although NGOs had made efforts to collect used batteries, this has ceased because concentration of these toxic waste could cause more environmental harm and there is no off-island disposal mechanism. There is no current scheme for recycling or exporting to external facilities. Currently used batteries are treated with other general waste, of dumping at waste tips. Gangaiya (1994) estimated that battery use in Kiribati at up to 1 million batteries per year. According to the Statistics Office (1999) there were 1,788,162 batteries imported to the country. There is a concern over the disposal of these batteries and potentially toxic metal contained therein into the marine environment.

14.2.5 Waste Disposal

14.2.5.1 Location

Waste collected are dumped by both Councils at about ten dump sites along the coast of South Tarawa, mostly on the lagoon side of the atoll. At most of these sites, the rubbish is reached by seawater at high tides and so lots of rubbish gets swept into the sea but most eventually comes back to shore away from the dumpsites. This causes further pollution of coastal waters and leaves beaches covered with trash.

Figure 14.4 Waste dump at Red beach, Betio (Royds, 1996)

Rubbish dumping is uncontrolled at sites authorised by Councils and also by private landowners who wish to reclaim their property along the coast with sea wall. The public would know a dumpsite whenever they see Council staff empty their trailers of waste.

14.2.5.2 Site access and Condition of road

The dumpsites are accessible by tractors and trailers, through feeder roads which are unsealed, that usually detour from the main and only tarsealled road on the island.

14.2.5.3 Site gate house/office/amenties

All dump sites lack gates or fences, offices and amenities, and thus management. Site services like water, power and sewer are not available. The sites are unmanaged, due to absence of on-site staff and supervisors, and thus recording of waste type and vehicles is not practised.

14.2.5.4 Types of waste disposed of at the site

All types of waste collected from residential, institutions and commercial entities are dumped together, without sorting or recycling at the dumpsites. There is no covering of these sites creating unpleasant sights, possible human health risks associated with toxic material, glass, sharp objects, and breeding of disease vector insects (Fig. 14.6).

Figure 14.5 All kinds of waste dumped (ECD, 2000a)

However, at some sites burning is done to lessen the impact of odour and economise space, but this creates air pollution from fumes of burnt items like plastics.

These dumping sites lack: any stormwater or leachate management; other environmental control measures (e.g. dust, noise, odour); fire controls; public health controls, e.g., insects and vermin; environmental monitoring program; and public health inspections. Although there are no existing Landfill Management Plans, a few landfill sites and their management plans are currently being considered under the Sanitation, Public Health and Environment (SAPHE) loan project from ADB. Suitable potential sites are few and all lie along the shoreline (Table 14.4)

Reporting on waste streams is also lacking; but existing data are made available only from aid-funded short term studies. There are neither recycling facilities nor separate management of garden waste on site.

Since almost 50 % of the solid waste stream on Tarawa is biodegradable waste, composting is an advisable strategy. Composting will not only minimise imports of fertilisers but improve the quality of the soil for gardening. Traditionally, I-Kiribati people use composting for gardening, but most of the population on South Tarawa living at the main urban centres, rarely compost biodegradable waste because of underground cables for utilities, fearing compensation claims from telecommunication and utility companies for damaging their wires and pipes running underground. Food scraps are rarely thrown away but kept as poultry (domestic chickens and pigs) feed.

Handling and disposal of special wastes or proposals for closure and rehabilitation of present waste sites are lacking at present. Currently the Councils rubbish collection authority determines when to leave, most probably due to space limitation. A dump site is usually left as it is, with hardly any rehabilitation process, allowing nature to take its course. Sites with seawalls encompassing them are normally covered with reef mud and left for few years, before Council or landowners can regard it as reclaimed land Fig. 14.6).


Figure 14.6 Waste tip to be reclaimed with seawall at Teaoraeke (Royds, 1996)

Reclamation of old dumpsites on the foreshore usually results in creating more space for residential and or commercial ventures.

14.3 Pressures on the Environment

14.3.1 Waste Storage

Waste is hardly stored at any residential, institutional, commercial and industrial premises. All solid wastes are dumped, without containers, beside the road site waiting for collection by the Council staff. Liquid wastes, like chemicals and used oil, may be stored temporarily in drums. Since there are no facilities for treatment of such wastes, most just sit in drums for years until the drums rust. The liquid wastes eventually seep into the ground if nothing is done to avoid spillage.

However, some scrap metals are most dangerous to health that consisted of lead, mercury, copper, zinc, etc. Such metals are found naturally in the soil in trace amounts, but most presented in many abandoned scrap metals which pose few problems. As seen today some scrap metals are concentrated in some particular areas especially in the Public Vechile Unit compounds, though, they may cater serious danger to soil and ground water quality. At Nanikaai, for example, a PVU former designated site for scrap metal dumping area aggregated mainly all public used and unwanted mechanical scrap metals. Some of these dangerous metals like copper and lead may be presented in these areas that can cause brain and bone damage. The marine animals and plants at ocean side of this dumping land are most susceptible to these metals.

14.3.2 Waste Collection

The Council collection system from residential, institutional (e.g. school and hospitals), commercial and industrial premises is labour intensive, slow and inefficient. Infrequent collection, such as once or twice a week, could result in unsightly waste scattering widely as a result of wind and animal scavenging. Related health problems happen frequently, particularly at households which are close to these waste piles. Heavy trash that cannot be lifted manually, is left uncollected.

Hospital waste is supposed to be incinerated separately on site but due to constant breakdown of its exclusive incinerator, some waste has to be burned with kerosene. More recently in mid 2001, the hospital has purchased another incinerator. Operation has been delayed due to environmental requirements that are yet to be fulfilled by MHFP, the owner and operator of the machine (per comm., Dr Kabwea Tiban).

14.3.3 Lack of adequate resources at national level

Implementation and enforcement of existing measures to combat pollution control from hazardous material, chemical waste and other wastes stem from lack of the following (NON, 2001):

- Understanding of effects of hazardous waste materials;
- Effective legislation to control importation of toxic materials;
- Trained personnel in Hazardous Waste Management;
- Protective/safety equipment;
- Appropriate technical expertise;
- National capacity and infrastructure;
- Specific legislation to chemical management and occupational and health safety.

These are coupled with uncertainty of which institution is responsible for each issue, unavailability of data for chemicals management, and absence of methods for sound disposal of hazardous materials (NON, 2001).

14.4 Responses to Pressure

14.4.1 Awareness Raising Programmes

Weekly radio programs and other means of public awareness raising are continually being run by both government and environmental organizations, such as workshops on waste management. Workshops for all sectors of communities like religious groups, councils, women and youth groups have been held on various waste and related issues including training on effective management of hazardous materials, hazardous wastes and contaminated sites. Annual environmental days with various competitions, clean-up weekends such as World Clean-up Days, are also run to raise environmental awareness throughout South Tarawa. Community participation and engagement in all environmental issues and activities will enhance the community appreciation and ownership of their natural environment.

14.4.2 Waste Minimisation Activities

Reusing plastic bags and bottles and other usable containers and items had already been practised by the local people in many ways, much beyond the expectations of waste management authorities. A visit to any household to make an inventory of what is reused would result in an amazingly long list. The following is a short list of just a few waste reuse options:

i. Battery chemicals as soil fertiliser, dyes for mat weaving leaves, kids' toys, etc. Local farmers have found that battery contents improved the soil fertility yet no scientific research has been cited;
ii. Car tires: used as coastal protection/walls, washing and bathing tubs, hammocks, roof weights against strong winds, children's toys, domestic animal's feeding troughs, etc.;
iii. Bottles: used for liquid (traditional juice and body oil, kerosene, etc) storage containers, dug-in decorations on ground around compound;
iv. Plastic bags: rewashed and used more than once as shopping bags. Re-used as rubbish bags;
v. Aluminium roof sheets: garden walls, domestic animals enclosures, roofing extensions of traditional cooking huts (separate from main living house).

Metal recycling of aluminium cans only is currently running on Tarawa by two private enterprises. It is likely to expand in future as imports of beer and soft drinks increase. However, continual break-downs of the balers may discontinue this recycling process in future. Paper, plastic and other recyclable items are still considered for recycling, but feasibility studies to confirm their viability need to be undertaken.

In a study by Sinclair Consultants (2000), opportunities and obstacles for waste minimisation in Tarawa are highlighted (Table 14.3):
Table 14.3 Opportunities and Obstacles for Waste Minimisation in Tarawa.

OPPORTUNITIES	OBSTACLES
Home composting (ideal for geology and island environment) has already been done and will continue as community schemes	Lack of funds for waste management initiatives (eg. Procurement of appropriate machineries such as baler and shredder, start up cost of any recycling scheme, etc)
Kiribati has been recognised, by several aid agencies, as in need of waste management assitance	Require constant public awareness on waste minimisation and management issues
Considerable studies had been undertaken on feasibility of scrap metal recycling	Current waste collection scheme is poorly managed
	Lack of expertise in waste management
	Public unable to pay for services
	Lack of public "perception of waste"
	No financial incentive to sort waste at source and dumpsite
	Cost of shipping material to external recycling facilities
	Small volume of recyclable material volume

[modified from Table 4.2 Opportunities and Obstacles for Waste Minimisation in Tarawa, of Sinclair (2000), p38]

14.4.3 Legal Mandate to Control Pollution

The Environment Act 1999 has MESD as an implementing body under the Act, through the ECD, to develop regulations. With the assistance provided by Consultants under the SAPHE project, regulations are currently underway to control pollution. However, some difficulties are now encountered with implementation and enforcement of the Act due to lack of financial, technological and personnel resources available locally. In addition, some polluters especially shops and mechanical businesses are even unwilling to remove their unwanted wastes from current sites which affect aesthetic view as removal and transportation of these wastes will incur them costs.

14.4.4 SAPHE Project

The Government of Kiribati had initiated a loan project known as SAPHE from ADB that began in 2000 and will span for five or more years, depending on achieving its objectives. The project aims, inter alia, to improve and promote efficient solid waste management and hence promote better hygiene and sanitary circumstances for the people of South Tarawa which houses roughly 43 % of the national population. This includes composting household sorting of rubbish, collection of non-organic waste, recycling, identifying suitable landfills and the associated regulations, policies and programmes.

Assessments (Table 14.4) for other suitable landfill have been made. Implementation is still uncertain.

Table 14.4 Results of assessment for Location of Recommended Landfills

Name of Landfills	**Location**	**Assess from View of**	
		Physical perspective	**Environmental perspective**
Betio Red Beach	- Northwest of Betio Town, close to shipyard, - Facing Red Beach	**Acceptable:** - Convenient Access to site - Capacity 5-7 more years	**Acceptable:** - Some improvement required to prevent leachate
Bairiki Landfills	- Lagoon side of Nippon causeway - included in National Park - close to private households	**Acceptable, however:** - access to site is inconvenient - Require large extensive & restructure works to accept waste sanitary - dumping period limited to 2-5 years.	**Unlikely to Acceptable:** - large restructure work will demolish landscape - seawall may cause new sand accretion - site included in National Park
Nanikai Landfills	- Lagoon side of Anderson Causeway	**Acceptable:** - Convenient Access from	**Acceptable:** - Require rehabilitation to set

	- Site of sand mining - earmarked for National Park	collection sites - Adequate capacity for 15 years dumping with sanitary - Require improvement for sanitary dumpsite	up sanitary landfills.
Taborio Landfills	- Lagoon side of Stewart Causeway - Old sand mining area - Earmarked for National Park	**Not acceptable:** - Too narrow to make up sanitary landfills & limited capacity to store waste - Poor access from eastern Districts - Ready back filled by sand and created as a Park/Green Belt	**Unlikely to be Acceptable:** - Spoil scenic spot - Seawall may induce coastal erosion

(modified Table 3.4.1 in OEC & PPK, 2000: p3-17)

14.4.5 Current status on Betio Landfill.

The management of disposing wastes at Betio Landfill requires more efficient coordination and monitoring. BTC mandates the filling of this landfill, however disposing measures of waste into this landfill is inadequate and mismanaged. Wastes dumped inside the landfill by BTC are accumulated in an area which is proximity close to the main road. This accumulation merely increasing in height blocking accessibility for dumping inside the middle of the landfill. The accumulation would exceed its capacity and pushing toward into the main road (Fig.14.7) As it very hard for BTC waste dumpers to get through to the inside of the landfill for dumping, wastes collected start to be disposed offshore outside the landfill (Fig. 14.8).

(Fig, 14.7) Wastes increasing in height toward the road outside landfill. (K. Tonganibeia, 2003)

(Fig, 14.8) Wastes dumped offshore

14.5 Data Gaps

Inventory of hazardous chemical imports and usage
Annual inventory of waste stream

Chapter 15. Sewerage

15.1 Introduction

The only reticulated sewerage system in Kiribati is the Tarawa Sewerage Project (TSP) that was introduced through external aid (AusAID) in response to a major cholera epidemic in 1977. Sewerage currently services about 40 % of the population at Betio, Bairiki and Bikenibeu.

TSP, operated since 1979 by the PUB, relies on seawater flushing that is serviced by a separate saltwater reticulation with discharge to the ocean. Currently, the system is in a run down condition and badly in need of maintenance (Royds, 1996).

It has been noted (Forsyth, in Royds, 1996) that the TSP system could both be beneficial and harmful as follows:

Beneficial effects:

- Reduce risk of groundwater contamination;
- Seawater flushing could eliminate further exploitation of freshwater;
- Elimination of septic tank effluent could improve quality of groundwater;
- Limit concentration of harmful bacteria and viruses in bivalve shellfish;
- Reduce risk of worm infections, transmission of shigellas, amoebae and viruses from use of beach and bush for defecation;
- Reduce fly borne spread of disease;
- Introduce both health education programme for promotion concurrently with sewerage scheme.

Potential harmful effects:

- Concentration of heavily polluted sea water adjacent to raw sewage outfalls;
- Local alteration of reef biota near sewage outfalls;
- Failure of sewerage project either by design problems or more likely failure of maintenance would be catastrophic and might set back implementation of hygienic principles for considerable period.

15.2 Present State of the Environment

15.2.1 Physical system

The current sewerage reticulated systems in Betio, Bairiki and Bikenibeu use saltwater for flushing and disposal of raw sewage by pipelines to the deep ocean off the edge of the reef. There are a number of pumping stations with rising mains but all lack primary sedimentation tanks. Plants are also lacking for composting primary sewage sludge with household and other refuse. An estimated 1350 households in South Tarawa, which is 38 % of households, are being serviced by a waterborne sewerage system (Royds, 1996).

Sewers are lifted to within one metre of the ground surface at pump stations, when depth of sewer inlet exceeds 3 to 4 m. The water table generally lies 1 to 2 m below surface, hence sewerage system lies at least 1 m below water table. The system consists of 225 mm and 300 mm diameter spine lines laid at very flat gradients (0.20 %) between pump stations. Smaller 100 mm and 150 mm diameter sewer lines feed into spine lines laid at steeper gradients of 1.5 % and 1 % respectively (Royds, 1996).

In length, sea outfalls are 804 m in Betio and 236 m in both Bairiki and Bikenibeu. Outfall pipes were laid at flat gradient in trenches about 1.5 m deep excavated into the coral platform and bedded on selected bedding with backfilling of selected coral sands and concrete capping slab 200 mm thick over most of their length. Near the end of outfall, the final 30 m of pipe was provided with a 200 mm concrete surround (Royds, 1996).


Figure 15.1 Central (Nawerewere) Hospital Outfall at low tide (Royds, 1996)

Pump stations are generally in an untidy condition, overgrown with insecure wire enclosures, gates open, pump station lids missing or makeshift ones in place and missing or absent pumps.

Sewer pipes are severely blocked (90 %) upstream with sand, sediment and solids. Sewers lower downstream and connecting functioning pump stations appear less blocked
but capacity appears reduced (50 %), with sewers blocked with sand and sewage solids.

Manholes were evidently corroded on the underside of concrete lids with many having being replaced by PUB. Some lids were notably cracked with missing pieces and some were concreted to prevent foul odour. A summary of the present conditions of the sewage conveyance, pumping and outfall system has been provided by Royds (1996).

15.2.2 Sewage system impacts on marine environment

Prior to the development of the sewerage system in 1979, no baseline study was undertaken to gauge the present situation of the receiving ocean-side marine environment of South Tarawa.

In 1996, an impact assessment from the existing sewage system on South Tarawa was undertaken (Kaly, 1996) by comparing community structure of corals, algae, fishes, toxic dinoflagellates and inter-tidal organisms at outfall areas and secondary impacts sites to examine the abundance, species richness and total numbers of organisms and physical characters in impacted areas and control using the "after-only" and before after control impact (BACI) assessments methods. Figure 15.2 shows the location of sewer outfalls, secondary impact areas and controls surveyed in the assessment of impacts of the existing system on South Tarawa.

On land, open pits containing sewerage pipes have become illegal solid waste dumps and source of sewage smell. The outfalls were unsightly, with discoloured and odorous surrounding water. People continue however to fish, collect seafoods and swim at outfalls (Fig.15.3). This poses a health risk from potential chemical contamination and biohazards, particularly at the hospital outfall. Fish have been observed to aggregate and feed at outfalls. When eaten raw, fish could possibly be contaminated by the pathogens that survive in their gut (Kaly, 1996).

Some of the most obvious effects on subtidal and intertidal communities were the general appearance of the habitat found (Kaly, 1996). Overall, there was lower substratum diversity with a decline in total hard corals and algal turf and an increase in cover by sand and soft corals at the impacted sites. Coral species which declined included *Pocillopora edyouxi. P. verrucosa and Montipora sp.* An approximate 50 % of the impacts detected for the species/measures were limited to the outfall site while the rest (50 %) were detected at secondary impact areas, at least 100 m west from the outfalls. Full analysis can be located in Kaly (1996).

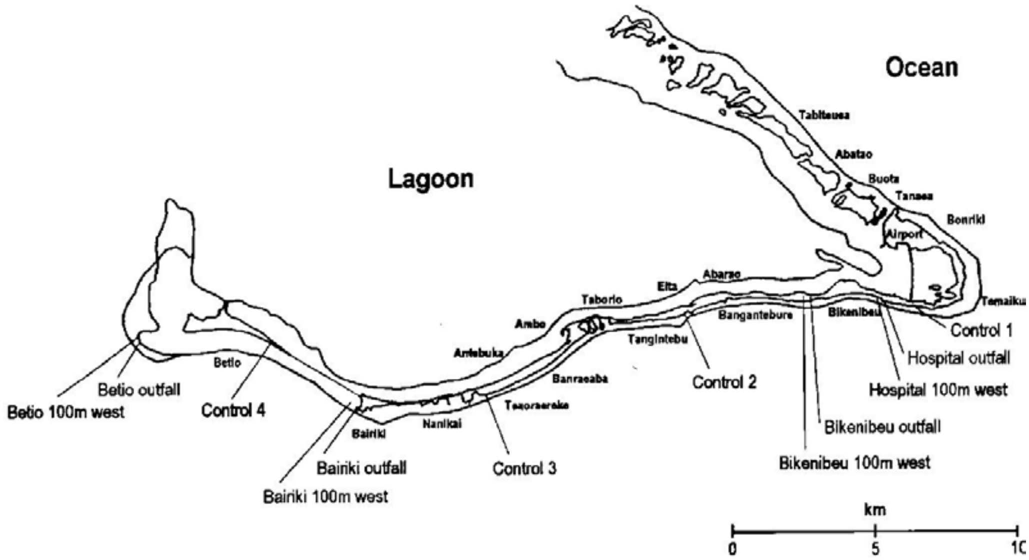

Figure 15.2 Location of assessment sites along South Tarawa (after Kaly, 1996)

Six species of toxin producing dinoflagellates were found (Kaly, 1996) in the shallow subtidal of South Tarawa. These were: *Prorocentrum lima; Ostreopsis siamensis; Ostreopsis lenticularis; Ostreopsis ovata; Dinophyssis sp.; Gambierdiscus toxicus.*
The last is commonly known to be capable of causing ciguatera outbreaks but the rest produce mainly water-soluble toxins incapable of bioaccumulation to dangerous levels in fish tissues. *G. toxicus* was found (Kaly, 1996) to be maximum in density at a control site which is 100 m east of the central hospital outfall (upstream) at the ocean-side of Temaiku. The most abundant dinoflagellate present were the *Ostreopsis* species, dominated by *O. siamensis*, recorded at a maximum at 100 m west of the central hospital outfall or downstream.

It was concluded (Kaly, 1996) that organisms and physical characteristics of the sub-tidal and intertidal habitats at and downstream of the sewage outfalls in South Tarawa were apparently affected more than other types of disturbances in other parts of Kiribati (Kaly & Jones, 1993). A significant impact of outfalls on dinoflagellates communities in South Tarawa result largely on lowering the population of G. toxicus at outfall sites as compared with controls.

It was found (Kaly, 1996) that sewage impacts are generally greater than seen for dredging, blasting and causeways developments. The overall results of the study for corals, algae, fishes and intertidal organisms totalling 150 species and measures of diversity, total abundances and physical characteristics of the habitats showed that:

- 57 % of measures showed no change or no impacts;
- 18 % of organisms increased; and
- 26 % decreased in sewage outfall areas as compared with controls
- 50 % of these impacts were limited to the outfall site itself, while 50 % extended downstream (100 m) of the outfall as compared to controls.

15.3 Pressure on the Environment

The sewerage system lacks primary sedimentation tanks associated with composting plants for composting primary sewage sludge with household and other refuse, adding more waste to the outfall marine environment.

Continual break down of the system and irregular maintenance lead to land contamination including groundwater lenses, destruction of vegetation and food trees due to saltwater usage, and pollution of air by foul odour to local residents resulting in public complaints.

Figure 15. 3 Fishmen and children using the sewerage outfall site as recreation area (Royds, 1996)

15.3.4 Outfalls end inappropriately at the edge (Fig.15.3) of reef platform where spur and groove and intertidal habitats exist (strong currents, onshore winds could trap effluents in surf zone and transport it along shore over the reef) instead of extending right to the reef slope where currents could bring significant amount of sewage over reef, discharging effluents below surface (> 5 m) to minimise effects of on-shore surface currents and wave action (Kaly, 1996).

Toxic substances, particularly hospital waste and chemicals, are unselectively disposed along with general household wastewater.

15.4 Responses to Pressure

The SAPHE project proposes to improve the existing outfall in extending its pipes to a further 100 m and discharges of effluent at least 15 m below the surface. The hospital sewerage system will also be rehabilitated. Additional maintenance work on the sewerage piping on land will also be addressed (OEC & PPK, 2000).

15.5 Data Gap

- Baseline ecological studies and regular monitoring of the sewerage outfalls on South Tarawa.
- Populations of *G. toxicus* and other associated dinoflagellates during severe outbreaks of ciguatera.

Chapter 16 Climate Change

16.1 Introduction:

Kiribati is seriously concerned about global climate change and its associated impacts, especially sea level rise, because of its low lying islands, most of which are less than 1 m above mean sea level (Figure 16.1) while some barely reach 3 or 4 m, with the exception of uninhabited Banaba. Except Kiritimati, most of the islands are very narrow, hardly exceeding 450 m in width.

Figure 16.1 Aerial view of Abatao Islet in North Tarawa (Source: Morrison & Seru, 1986)

Most of the islands lie outside the main cyclone belt and hence are unlikely to be impacted by major natural disasters such as tropical cyclones, but they are only susceptible to storm surges during El Nino and droughts within the La Nina events. Events similar to the predicted impacts of climate change have already being felt such as inundation of coastal areas and frequent extreme weather events are becoming stronger and more severe.

According to the International Panel on Climate Change (IPCC) Assessment Reports (IPCC, 1995 in GOK, 1999), global sea level rise were predicted to be in the range 15 to 95 cm by the end of the 21st century. Although there is global agreement to reduce emissions of greenhouse gases (GHG) that cause global warming to trigger climate change, the implementation of international commitment under the global climate change agreements (UNFCCC & Kyoto Protocol) is inadequate to stabilise atmospheric concentrations of GHGs, particularly from the developed nations (GOK, 1999).

Studies by Solomons (1997), Woodroffe & McLean (1992 *unpublished*), Taeuea *et al* (2000) and World Bank (2000), have considered Kiribati's vulnerability to climate change including adaptation and mitigation options.

From installed tide gauges in Kiribati and through out the Pacific, together with general observations by the local inhabitants of the region, there is general cause for alarm by the Government and people of Kiribati because like its neighbours (Marshall islands and Tuvalu), Kiribati has no capacity to mitigate nor adapt to climate change and its associated impacts.

16.2 Predicted Impacts of Climate Change

Kiribati is expecting growing and emerging pressures on its natural resource base from Climate Change, Variability and Sea Level Rise:

- Decline in coral health due to elevated sea surface temperatures;
  As global mean temperatures rise, the ocean will gradually absorb most of this heat from the atmosphere. The top 100m of the ocean will be the first affected in the gradual exchange resulting in the ultimate rise in temperature of this region of the ocean. Corals are highly sensitive to temperature fluctuations and will undergo bleaching if exposed long enough to temperatures exceeding 29^{0}C, which is currently the normal recorded temperature of our coastal waters.
- Increased coastal erosion increasing the threat to the already limited land area and vital infrastructure:
  Mean climate projected from models indicate a more El Nino state for the pacific region. For Kiribati this means a general change in wind in both direction and intensity. Under this scenario, coastal erosion can be expected to be more severe than is currently experienced.
- Possible introduction of otherwise not common diseases especially vector borne diseases.
  A rise in ambient air temperatures would mean that vectors for diseases not known to occur in the past may find the new environment to be more conducive to their survival. This would open the way for the introduction of new and more severe illnesses that have not been able to establish in the past. A typical example would be dengue fever and malaria – diseases of rare incidence in our country though very deadly.
- Inundation of land, hence loss of valuable land (Figure 16.2);
  As sea levels rise, storm surge would take on a new meaning to our atolls as swells of similar magnitude would reach further inland affecting more of the coastal environment than ever before. The already limited land would be further affected as more of the tenable land area would be rendered worthless from the damage. Contamination of the water aquifers would already be a concern especially in the urban areas where water availability is intermittent.
- Saltwater intrusion, hence decrease in quantity and quality of water resources;
  During long periods of drought, crops and plants continue to draw on the freshwater aquifers without any replenishment throughout the period. Coupled with the intense evaporation, the aquifers become increasingly brackish as salt water is drawn into the aquifers. With the prospect of rising sea levels, some state that the volume of potable water held in these aquifers would not change given no other parameters change. This would hardly hold true as the dynamic nature of both the weather under a changing climate and of the atolls themselves, all parameters governing the amount of water in the aquifers will change leading most likely to a decrease in the volume of these aquifers.
- Loss of terrestrial food crops:
  Kiribati is comprised of narrow strips of lands usually surrounding lagoons. The soil is not conducive to extensive agricultural activites (Tianeti Ioane, WSSD report 2003) limiting production to domestic scale only. The few food crops such as breadfruit and the giant swamp taro are highly valued and require extensive cultivation in the case of the taro. The combined impact of the above would further stress these crops in a way that would

Figure 16.2 Overwash at Steward Causeway, Tarawa (ECD, 2000)

All these would add to the already increasing problems experienced on the islands, especially in the urban areas of South Tarawa. In the long term, the atoll nature of the islands would mean that they would no longer be viable for inhabitance thus leading to the possible dispacement of the population.

The World Bank (2000) study considered likely impacts (Table 16.1) on the coastal areas and water resources of Tarawa with varying levels of uncertainty. The rise in sea level by 2100 is projected to be in the range of 0.5 m to 1.0 m, an impact that is very critical to the low-lying atolls. As mentioned above, an increase in atmospheric temperature of more than 1.0 (^{0}C) by 2050 could be detrimental to the sensitive and fragile coral ecosystems which support the livelihood and economy of the people of Kiribati.

Impact	**2025**	**2050**	**2100**	**Level of Uncertainty**
Sea level rise (cm)	11 - 21	23 – 43	50 - 103	High
Air temperature increase (^{0}C)	0.5 – 0.6	0.9 – 1.3	1.6 – 3.4	Low
Change in rainfall (%)	-4.8 - +3.2	-10.7 - +7.1	-26.9 – +17.7	High
Cyclones				
Frequency	Models produce conflicting results			Very high
Intensity (% increase in wind speed)	0 - 20			Moderate
Region of formation	No change			High
Region of occurrence	No change or increase to north and south			High
El Nino Southern Oscillation (ENSO)	A more El Nino-like mean state			Moderate
Note: ranges given reflect a best-guest scenario (lower value) and a worse-case scenario (higher value) derived from global projections for sea level and rest use global circulation models.				

Table 16.1 Climate change and variability scenarios for Kiribati (Source: Table 1 in WB, 2000)

Changes in rainfall, e.g., more intense droughts would place more pressure on the already scarce and limited water supply or floods would increase the occurrence or more virulent disease-causing bacteria and viruses. A rise in sea surface temperature and shift to El Nino conditions could expand the cyclone path and occurrence. The combination of more intense cyclones and higher sea level may lead to higher storm surges (Jones *et al.*, 1999 in WB, 2000). These predictions are more certain at the global level but decrease in certainty on moving to the regional and to the local levels. Though this may be the case, it is critical that these issues are well known at all levels throughout the community.

16.3 Sea level rise

Two tide gauges have been installed in Betio, Tarawa by the University of Hawaii (UOH) in 1974 and later the Australian National Tidal Facility (NTF) in 1992.

From the UOH dataset, it was observed by Etuati (1994 in GOK, 1999) that sea level has risen by 4 mm per year. Later a vulnerability and adaptation study of Kiribati by Solomon (1997 in GOK, 1999) concluded that sea levels were generally higher than the original mean sea level, indicating a rise of up to 78 mm over 23 years using the same dataset.

Based on the NTF dataset, Mitchell *et al* (2000) stated that the average sea-level trend for all stations in the Pacific is 0.77 mm per year, against the expected sea level rise in the order of 1.5 mm per year (Turner, 2000). However, in quantifing the approximation changes in sea level in Kiribati, Mitchell *et al* (2000) predicted a sea level lowering of 11.74 cm over 6.8 years as effects of El Nino and La Nina events in the Pacific region. This analysis caused discontent among local experts because an analysis of the maxima of sea level indicated an increasing trend over the same period for which the trend in mean sea level has been decreasing (GOK, 1999).

At the local level, particularly the grassroots level in Kiribati, there is a general experience of an increase in sea level, in support of the UOH tide gauge dataset of a faster sea level rise rate than the global rate over the last century (GOK, 1999).

16.4 Climate Change Policy

Kiribati is recognised as one of the most vulnerable small island least developed states, because of its nature and its inability to afford the necessary response measures required to deal with the adverse impacts of climate change. Rising populations with inadequate measures in place to properly manage the increasing pressures on the environment, mean that the state of the environment in the country especially in urban areas is steadily degrading and the impacts of climates change will certainly exacerbate the situation.

Due to its vulnerability to climate change, Kiribati is keen to participate at international and regional forums on climate change and associated activities in order to voice its grave concern and to keep abreast of the latest developments on global and regional climate change.

Although Kiribati's contribution to global GHG is insignificant of 18.566 Gg of carbon dioxide (CO_2) and 0.425 Gg of methane (CH_4) in 1994 (GOK, 1999), there are apparent interests at various levels that have mitigation potential such as using solar power in rural communities and evaluation of the electricity generation system in South Tarawa. However, these interests are hampered by the low diversity of the economy, low level of specialisation and trained manpower and inaccessibility of appropriate technology.

At the national level, institutional capacity building within the cross-sectoral disciplines of climate change (energy, water, fisheries, etc.) is being gradually considered as an integral part of national development to deal with any predicted adverse impacts. Training of local officials at external institutions, is more readily accepted by national authorities.

A number of externally funded projects on climate change from USAID, AusAID and the Global Environment Facility have assisted Kiribati to be better informed of the ramifications of climate change and its associated impacts, for instance the regional Pacific Islands Climate Change Programme (PICCAP). Public awareness activities and consultation with various and interested sectors of the community are still on-going to plan implementation strategies. Studies and research are still on-going, while more are in the 'pipeline'.

At the time of writing, a World Bank funded project has started which will address adaptation to climate change and variability. The project involves extensive consultation with all relevant stakeholders including representatives from the community as well as Non – Government Organisations. All this is intended to be included into the next issue of the National Development Strategy for the period 2004 – 2007. Also the Kiribati National Adaptation Program of Action will soon start which is funded under the Least Developed Countries Fund made available from the Conference of the Parties to the United Nations Framework Convention on Climate Change. This will identify all immediate and urgent adaptation options for the country.

16.5 Adaptation in response to climate change

A number of adaptation and mitigation strategies have been identified (GOK, 1999; WB, 2000) in various sectors, but implementation may prove difficult due to lack of relevant and appropriate resources, at the technical, technological and financial levels.

16.5.1 Agriculture

The agriculture sector can promote a balance between the relative roles of food imports and subsistence food production (WB, 2000). This includes promotion of reliance on imported foods in order to counteract negative effects of a decline in rainfall as well as promoting and strengthening traditional agricultural systems such as drought and salt tolerant species or rainfall resistant varieties. The former option is costly to Kiribati and could lead to long-term nutritional impacts.

16.5.2 Water resources

The water resources options for adaptation have been summarised (Table 16.2) with rankings in technical and economic feasibility, cultural and social acceptability and finally environmental acceptability in South Tarawa with wide application to the rest of Kiribati.

Adaptation Option	Technical & Economic feasibility	Cultural & Social Acceptabilit y	Environment al Acceptability	Rankin g
Leakage control	H	H	H	H
Consumer education & awareness	H	M	H	H
Pricing control	H	M	H	H
Water conservation plumbing measures	M	M	H	M
Expansion of rainwater collection schemes	H	H	H	H
Groundwater protection measures:				
• land use planning and water reserves	H	M	H	H
• non-polluting sanitation systems	H	M	H	H
Desalination	M	M	H	M
Land reclamation for increased pumping	M	M	M	M
Importation of water	L	L	H	L
Emigration	L	L	?	L
Note: H = high (good), M = medium and L = low (poor) score				

Table 16.2 Summary of Adaptation Options for Water Resources (source: Table 5 in WB, 2000)

The overall best options are leakage control, raising the awareness of consumers through various campaigns, pricing control that discourages water wastage, expansion of rainwater collection schemes and groundwater protection measures.

16.5.3 Coastal Areas

Specific adaptation options for the coastal areas (Table 16.3) can avoid development in areas that are vulnerable to inundation (Fig.16.3) and 'over-wash'; ensure that critical natural systems continue to function; and protect human lives, essential properties and economic activities against the ravage of the sea (WB, 2000).

Type of Protection	Advantages	Disadvantages	Suitability
Preservation of reef environment	Minimum disruption to environment. Low cost.	Not appropriate in highly developed areas. Needs community cooperation. Requires regulation & enforcement. Long-term strategy.	Highly desirable since Kiribati coastal are still under-developed
Setback/Relocation	Preserves natural beach. Offset future erosion problems. Costless compared to engineering structures.	Requires Gov't regulation. Requires compensation for land. Offers no protection for existing shoreline.	Implementable only with enforcement of regulations. Recommended where possible.
Revegetation	Low cost. Re-establishes natural coastline. Does not disrupt coastal processes.	May hinder access to coast. Only effective in sheltered areas.	Recommended where possible.
Beach replenishment	Preserves/restores natural beach. Does not disrupt natural processes.	Requires periodic replenishment. Requires heavy equipment and a supply of sand.	Not feasible for small projects.
Seawalls	Protects land and infrastructure only. With local labour & material, some designs are possible.	Can cause erosion. Require proper design & construction. expensive	Suitable where threatened property and buildings are valuable and relocation is impossible.
Gabion basket	Portable, can be imported and transferred to outer islands. Can be removed if not effective.	Deteriorate rapidly. Expensive. Require suitable size and shape of rock	Unsuitable due to cost and non-durability.
Proprietary protection structures Breakwaters	Can be designed for specific wave conditions. Effective for erosion with shore parallel breakwaters.	Expensive Require heavy machinery. Requires heavy equipment Expensive.	Required to protect expensive infrastructure on exposed coasts. Not generally required due to protective nature of reefs. Large boulders and heavy equipment not often available.
Groynes	Sand build-up on up-drift side. Some designs can be constructed from local materials.	Erosion on down-drift side. Unnatural beach obstruction. Can promote offshore sand transport.	Generally not recommended because of detrimental effects on coastline.

Table 16.3 Possible adaptations on coastal areas (source: modified from Kaly *et al.*, 1999)

Although it is difficult to make precise predictions in advance, the possible adaptation strategies (Table 16.3) are "no-regret" because they are justifiable in the absence of climate change and sea level rise.

Figure 16.3 Fragmented Low-lying islets vulnerable to storm surges (ECD, 2000)

16.6 Data Gap

- Land use change and agricultural practices for GHG
- Lack or incomplete environmental data limits use of appropriate models on impacts and vulnerability.

Chapter 17: Recommendations

17.1 Introduction

The baseline information on environment quality present in the SoER also needs updating in future to show trends in environmental changes. It is also vital to develop environmental indicators so that when reporting on these indicators in future, assessment of different stakeholders' performance will be possible as well as the identification of measures that need to be adopted to improve the quality of the environment.

17.2 Indicators

Indicators are key parameters (physical, chemical, biological, economic, social) that provide useful information about a whole system. These enable users to evaluate changes in the environment without having to present the whole complexity of a system. They are based on best scientific understanding of how the environment works, and this indicates trends (ELN, 2001).

17.2.1 Types of Indicators

There are general indicators that show the health and resilience of the ecosystem such as species diversity. Other indicators show threats to the ecosystem integrity; like rising trends in population, water use, waste production and transport. In contrast, some indicators reveal reduced threats to the ecosystem integrity, for instance declining use of hazardous materials and increasing outputs per unit resources used, recycling or conservation of scarce resources and community involvement in environmental management (ELN, 2001).

Indicators of sustainability show environmental conditions in water, air, biota and land as well as international environmental agreements reporting requirements, for instance, wetlands, migratory birds and special breeding sanctuaries and climate change (UNFCCC), etc.

17.2.2 Criteria for Selecting SoER Indicators

In selecting indicators for the SoER, the following criteria (ELN, 2001b) need consideration:

1. Data must show measurable trends aspects of environment that are components of ecosystem (non-living, living – animals & plants) or necessities and vitals for ecosystem to function (water).
2. Impacts environment adversely or improve environment due to less impact.
3. Measurable units/quantities – affordable equipments to collect & measure reasonably.
4. Reflects what local communities feel is vital: very important as it is something where community (because of their interests) involvement where possible - neither Government's nor private sectors' interests.
5. Consistent with other countries, local areas for comparison purposes.
6. Scientifically credible.
7. Be easy to understand.
8. Provide an early warning of potential problems.
9. Be capable of being monitored to provide statistically verifiable and reproducible data that shows trends over time.
10. Be monitored regularly with relative ease.
11. Be cost effective.
12. Serves as a robust indicator of environmental change.

A checklist (Table 17.1) for certain indicators according to the aforementioned criteria is useful in the consideration of selecting an indicator for the next SoER, by giving a total score for priority rating.

Table 17.1 Ranking of each indicator according to certain criteria

Indicator	Criteria 1	2	3	4	5	6	7	8	9	10	11	12	Score
Population:													
• Total population M/F	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	10
• Birth/death & growth rates	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	10
• Density/migration	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	10
• # of permanent residents	Y	N	Y	Y	Y	Y	Y	N	Y	N	Y	Y	9
• # of households	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	11
• # of people per household	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	11
Climate Variability:													
• Rainfall per year	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
• Sea surface temperature	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
• Relative sea levels	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	9
• Wind speed	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Humidity	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	10
Water resources (drinking water):													
• Volume extracted from lenses	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	Y	9
• Salinity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• pH	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Contaminated water incidences	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Complaints	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Water quality (surface water):													
• Faecal coliform in lagoon	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y	9
• Colour	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	9
• Turbidity	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	8
• Monitoring of sewage outfalls	N	N	N	?	Y	Y	N	Y	Y	N	N	Y	7
• BOD	Y	N	Y	?	Y	Y	N	Y	Y	Y	Y	Y	9
• Complaints	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	10
Biodiversity:													
• Total Number of species	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	9
• Number of Invasive species	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Number of Endemic species	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	9
• Status of Species:													
# of Extinct species	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	11
# of endangered species	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	11
# of vulnerable species	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	11
• Key Ecosystems:													
Reefs	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	8
Mangroves	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	8
Mudflats	N	Y	N	Y	Y	Y	N	N	Y	N	N	Y	6
Terrestrial	N	Y	N	Y	Y	Y	N	N	Y	N	N	Y	6
• Protected Areas (Level of Protection /disturbances)	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	10
Fisheries:													
• Annual catches	Y	Y	N	Y	Y	Y	Y	N	Y	N	N	Y	8
Local	Y	Y	N	Y	Y	Y	Y	N	Y	N	N	Y	8
Commercial	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	9
• Annual consumption	N	N	N	Y	Y	Y	Y	N	Y	N	N	Y	6
(kg/head)	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	11
• # of Aquarium fish exported per annum	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	10

• By-catches (fraction)													
Waste (type):													
• Volumes/Mass generated	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	9
• Volume/ Mass disposed to:													
Landfill	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	9
Recycled	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	Y	8
Other	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	Y	8
• Complaints	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Land :													
• Land based pollution	N	Y	N	Y	Y	Y	N	Y	N	N	Y	Y	7
(sources)	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	10
• Affected/contaminated	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
sites cleaned	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	9
• Affected/contaminated													
sites remaining	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	10
• Vegetation cover	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
• Area of parks & recreation space per urban region.													
• Complaints													
Air quality:													
• Total fuel imports	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	11
• Emission estimates of	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	9
pollutants													
• Population subject to air	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
pollution													
• Complaints	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Energy:													
• Generation rates	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	10
• Consumption	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	10
• Total per capita domestic	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	9
use													
• Total per capita industry	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	8
production	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	10
• Renewable resources													
Transport:													
• trends	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Number of cars, buses,	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
lorries	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
• Motorbikes	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	11
• Density of road use	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
• Complaints													
Noise:													
• Levels at various sites	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	10
• Population subject to noise	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
pollution													
• Complaints	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Regulations:													
• # of Pollution Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Licenses issued	Y	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	9
• # of EIAs/IEERs completed	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	8
• Number of offences, court	N	N	Y	Y	Y	N	N	N	Y	Y	N	Y	6
cases, etc													
• Changes to regulations													
Note: Y = yes; N = no; High score 10-12 (high priority); Medium score 7-9 (medium priority); Low score 1-6 (low priority); ? = unknown													

The total score gives a preliminary indication and hence recommendation of indicators which are easier to collect having 10-12 scores and most likely 7 –9 that are worth working on in preparation for the next SoER.

17.3 How to go about the next SoER

Since the task of compiling a SoER involves cross-sectoral disciplines at the national level, a committee with working sub-committees should be established consisting of relevant experts from Government, private sector, NGOs and some community representatives. Regular meetings of these subcommittees, at least once every six months or as seen necessary, should be maintained to establish the collection of relevant data and identify lacking information so collection could be initiated whenever possible. Working workshops and surveys could be held to bring in data and experts in relevant fields to develop each chapter. The environment authority (ECD of MESD) should be coordinator and Secretariat of the process.

17.3.1 Costs and timeframe for next SoER

The next SoER should be aimed for production within five years, preferably after every census year, or after each government election, to gauge on-going changes in the environment. If possible, a supplementary report could be produced after 2 to 3 years. The sequence of SoER production shall feed into the overall environmental planning since good planning require supporting information on the present state of the environment. Since most meetings and workshops require financing, an estimate of at least AUD3,000 per annum (AUD400 per subworking group) should cover these activities (transport, refreshments, tea/coffee, stationery etc). However an extra AUD 5,000 or more may be required for initiating data collection that is currently lacking or have ceased due to shortage of fund. The final fifth year will require more funding for the finalisation and the actual publication and circulation of the SoER of at least AUD 5,000. Hence the minimum budget of the SoER for the first 5 years can be summarised as follows:

Year 1	AUD 6,000
Year 2	AUD 4,000
Year 3	AUD 5,000
Year 4	AUD 4,000
Year 5	AUD 8,000

17.4.2 Process (procedures/methods/analysis)

Compiling the SoER depends entirely on work and research already done in relation to the environment. Each working subcommittee should know what data is available and how to access it. Data gaps should be identified early in the first year so data collection can begin immediately. Because Kiribati has become a Contracting Party of various international environment treaties, it is obliged to do regular reporting to the various treaty secretariats as specified in each agreement. Some possible sources of information and data will be many UN agencies and regional organisations in the Pacific.

Many problems would be encountered in producing a SoER, some of which are political in nature, limitation in resources and cooperation with data owners to release data. The latter has been bridged by the ECD through written agreements, however many data owners are still reluctant to release their data freely. Collating and analysing available data is an even more difficult problem, because methods of data collection which may not be scientifically credible could provide unsound and contradictory information in terms of quality control of data or reliability.

A useful preliminary exercise in the first year is to review all existing environmentally related data collection or monitoring programmes from all institutions along the questions of purpose, method, analysis, interpretation and fulfilment as well as cost and time required. Many programmes would prove to be reliable but those which needs readjustments shall be improved within the constraints of money, manpower and time so that objectives could be realistically met (ELN, 2001b). For instance, some programmes that may be over ambitious but poorly done, could be lessened in scope in order to do a better job of covering fewer but more important parameters.

Another important aspect of the SoER process is analysis of information. Most data collection are left in their raw form without analysis being done, maybe due to lack of expertise or time constraint by the owners. Coordination of protocols for collection, handling, storage, preparation and analysis will be streamlined as well to ensure that all parties interested in the data shall comply with all requirements stipulated by law or data owner (ELN, 2001b). In the case of absence of analysis due to lack of local expertise, mechanisms could be established to ensure appropriate assistance is obtained from external organisations.

Should resources are made available, the ECD shall endeavour to establish a national environmental monitoring program (project proposal of >AUD50,000) in order to compliment existing monitoring programmes of other institutions and initiate the collection of data which are currently lacking.

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Appendix 2: Hazardous Wastes

This appendixl lists the waste and obsolete chemicals and chemical contaminated sites of Kiribati. It contains risk rating (using Rapid Hazard Assessment Scheme – New Zealand , 1993) as follows:

1. extent of contamination
2. toxicity and mobility of contaminants
3. contamination potential (food/water)
4. ease of public access

Range from 0 (non-hazardous) to 100 (extremely hazardous).Source: SPREP, 2000 POPs in PICs, Kiribati Report.

Location	Site owner	Site Activity:	Risk rating	Priority	Proposed treatment
Tanaea	Animal Health Unit	Chemical Storage Shed/CCA sludge	low	Low	Off-island disposal
Bonriki airport	Private land	Asphalt dump	100	1	Local use or solidify and bury
Bonriki airport	Beach	Asphault dump	100	2	Local use or solidify and bury
Bikenibeu	Private/TUC	Landfill	30	22	No remediation but need to upgrade site management
Betio	Private/ BTC	Landfill	30	23	No remediation but need to upgrade site management
Betio	Public Utilities Board	Power Station	64	5	Landfarming and oil management
Bikenibeu	Kiribati Teachers College	Chemical Store room	low	low	
Bikenibeu	Agricultural Unit	Chemical Storage Shed	low	Low	Not potentially contaminated
Betio	Plants and Vehicle Unit	Depot	58	11	Landfarming and oil management
Bikenibeu	Old Central Hospital	Laboratory	low	Low	Not potentially contaminated
Bikenibeu	Handicraft centre	Former agriculture store	low	Low	Possibly contaminated
Bikenibeu	PUB	Power Station	51	16	Landfarming and oil management
Abemama		Former timber treatment site	low	Low	Minor contamination
Aranuka		Former timber treatment site			Minor contamination
Nonouti	Former timber treatment site		low	Low	Minor contamination
Canton island	Agriculture division	Former quarantine station			Potential contamination
Banana, Kiritimati	Linnex PUB	Asphalt disposal	30	37	Local use or solidify & bury
Kiritimati	Agriculture division	Fertilizer storage			Not contaminated
Kiritimati island	Former US Defence camp	General waste disposal	30	24	No remediation but need to upgrade site management
Kiritimati		Former British Bulk Fuel Store	50	20	Landfarming and oil management
Kiritimati		Transformer oil storage			Not contaminated
Tanaea	Animal Health Unit	CCA sludge Medicines	1000.0kg 2000.0kg	- poor	Off-island disposal
Bonriki airport	Private land	Waste bitumen	40000	Poor	Landfill
Bonriki airport	Beach	Waste bitumen	60000	Poor	Landfill
Betio	Public Utilities Board (PUB)	Waste oil	7000	OK	Waste oil disposal programme
Betio	PUB	PCB's	22000	OK	Off-island disposal
Bikenibeu	Kiribati Teachers College	Photographic chemicals	150.0 kg	OK	Local use or disposal
Bikenibeu	Agricultural Unit	Fertilizer	12000	OK	Land application
Bikenibeu	Handicraft centre	Unlabelled liquids	400 litres	Poor	Off-island disposal
Bikenibeu	Handicraft centre	Zinc Phosphide	200 kg	Poor	Off-island disposal
Canton island	Agriculture division	Diazinon	Not yet available	Poor	Off-island disposal
Canton island	Agriculture division	Unlabelled	Not yet available	Poor	Ditto

Canton island	Agriculture division	Carbaryl	Not yet available	Poor	Ditto
Canton island	Agriculture division	Malathion	Not yet available	Poor	Ditto
Canton island	Agriculture division	Bromacil	Not yet available	Poor	Ditto
Banana, Kiritimati	Linnex PUB	Bitumen	100000	Poor	Landfill
Kiritimati	Agriculture division	unlabelled	1400.0 kg	OK	Land use or disposal
Kiritimati	Power Station	PCB's	800	OK	Off-island disposal

Appendix 3: Development Control

1. Ornamental fish collection-private	2.dredge reef mud 20-30 m3-private
3.construction of four fuel tanks (500,000 litres) at reclaimed land-public	4. sand mining- private
5. school (infrastructure) construction-public	6. workshop (infrastructure) construction-private: pollution issue
7. long line tuna (fishing) - private	8. brick making - private: sand (coastal material) extraction
9. sand mining - private:	10. seawall - private
11. seawall - church	12. seawall - private
13. infrastructure - private	14. wharf repair - public
15. seawall - private	16. seawall - private
17. infrastructure construction - private	18. Fruit juice - private
19. sand mining - private	20. land reclamation - private
21. seawall - private	22. Dredging (infrastructure construction) - private
23. seawall - private	24. seawall - private
25. brick making (mining of aggregates)- private	26. Infrastructure construction - private
27. Marine resources (lobster, etc) exploitation - private	28. infrastructure (maneaba) construction - private
29. sand mining - private	30. seawall - private
31. Infrastructure (church) construction - private	32. Fuel tank (550 KL) construction - public
33. Live fish export - private	34 Infrastructure (seawall) - private
35. reef mud extraction/mining - 21mx21mx3m	

Appendix4: Lists of IEE/EIA/EA and DC completed

IEE:
Private:
1. Small Scale Cement Brick Manufacturing Project ➔ Environmental Planning Consultant, (EPC)
2. Small Basin and Channel Project at Banraeaba, Tarawa,➔ EPC
3.

Public:
1. Fishbait/Tuna Longlining Project, Betio, Tarawa, EU for TML
2. Maneaba ni Maungatabu (House of Parliament) EU for Government
3. Betio Rubbish Landfill/Landfill Reclamation Project, EU for MHARD
4. Reef Blasting for Boat Channel at Teaoraereke, EU for Government

Environmental Appraisal
1. Composting toilet provision under SAPHE Project: EU
2. Non-Communicable Disease and Food Security Project - FSP/Kiribati: EU
3. Seawall Construction and Reclamation, KPC Theological College, Tangintebu, Tarawa: EU for KPC
4. Sand and Gravel Mining: Red Cross Dwelling to Catholic Cemetery, Mackenzie Point: ECD for Foreshore management Committee
5. Capacity Building for Women in Kiribati, ECD for FSP/Government

Appendix 5: Plants of Kiribati

Botanical name	Family	Kiribati name	English name
Asytasia nemorum	Acanthacae		
Pseuderanthemum carruthersi	Acanthaceae	Teiaro	
Pseuderanthemum laxiflorum	Acanthaceae	Teiaro	
Agave americana	agavaceae	Te robu	Sisal
Cordyline fruticose	Agavaceae	Te rauti	Palm lily
*Amaranthus dubius**	Amaranthaceae	Te mota	
Crinium asiaticum	Amaryllidaceae	Te kiebu	Crinum lily
Crinium augustium	Amaryllidaceae	Te kiebu	Crinum lily
Hymennocallis littorialis	Amaryllidaceae	Te ruru ni mane	Spider lily
Zephyranthes rosea	Amatyllidaeceae	Te roti	
Cerbera magnas	Apocynaceae		Poision apple
Nerium oleander	Apocynaceae	Te orian	Oleanda
Plumeria obtuse	Apocynaceae	Te meria	Frangipani
Catharanthus roseus	Apocynaeae	Te buraroti	Pink periwinkle
Caladium bicolour	Araceae		
*Colocasia esculenta**	Araceae	Taororo	Taro
*Cyrtosperma chamissonis**	Araceae	Te babai	Swamp taro
Plyscias fruticose	Araliaceae	Te kaimamara	
Polyscias grandifloria	Araliaceae	Te toara	
Calotropis gigantean	Asclepiadaceae	Te bumorimori	Giant milk weed
Asciepias curasavica	Aslepiadaceae	Te kaibuaka	Milk weed
Biden pilosa	Asteraceae		
Pluchea adorata	Asteraceae	Te karei	Curry plant
Sigesbeckia orientalis	Asteraceae		
Synedrella nodiflora	Asteraceae		
Tridax procumbens	Asteraceae		
Veronia cinerea	Asteraceae		
Wedelia biflora	Asteraceae	Te kaura ni Banaba	
Cordia subcordata	Boraginaceae	Te kanawa	Sea trumpet
Tornefortia argentea	Boraginaceae	Te ren	
Cassia occicdentalis	Caesalpiiaceae	Te katia	
Delovix regia	Caesalpiiaceae	Te tua	Poinciana
Canna indica	Cannaceae	Te riti	Canna lily
*Carica papaya**	Caricaceae	Te babaia	Pawpaw
Casurina equisetifolia	Casuarinaceae	Te burukam	Casurianas
Calophyllum inophyllum	Clusiaceae	Te itai	
Lumnitzera littorea	Combretaceae	Te aitoa	
Terminalia catappa	Combretaceae	Te kunikuni	Pacific almond
Terminalia samoensis	Combretaceae	Te ukin	
Rhoeao doscolor	Commelinaceae	Te ruru ni Buranti	Oyster lily
*Ipomia aquatica**	Convolvulaceae	Te kangkong	Water spinach
*Ipomia batatas**	Convolvulaceae	Te kumura	Sweet potato
Ipomia pes-caprae	Convolvulaceae	Te ruku	
Ipomia tuba	Convolvulaceae	Te ruku	
Bryophyllum pinnatum	Crassulaceae	Te ang	Life plant
*Cucurbita pepo**	Cucurbitaceae	Te baukin	Pumpkin
Cycas circunalis	Cycadaceae	Te bam	Cycad
Cyperus javanicus	Cyperaceae	Te titania	Giant sedge
Cyperus rotundus	Cyperaceae	Te uteute	Nut grass
Fimbristylis cymosa	Cyperaceae	Te uteute	Sedge
Fimbristylis dichotoma	Cyperaceae	Te uteute ni mane	Sedge
Pycreus polysmchyos	Cyperaceae	Te maunei	Sedge
Nephrolepis biserrate	Davalliaceae	Te keang ni Makin	Fish bone fern
Acalypha amentacea	Euphorbiaceae	Te aronga	Acalypha
Acalypha wilkesiana	Euphorbiaceae	Te aronga	Acalypha
Codiaeum varigatum	Euphorbiaceae		Croton
Euphorbia atoto	Euphorbiaceae	Te tarai	Spurge
Euphorbia hirta	Euphorbiaceae	Te tarai	Asthma plant
Euphorbia hysopifolia	Euphorbiaceae	Te tarai	Spurge
Euphorbia prostrata	Euphorbiaceae	Te tarai	Prostrate spurge
Macaranga caroliniensis	Euphorbiaceae	Te nimatore	
Phyllanthus amarus	Euphorbiaceae	Te kaimatu	Sleeping plant
Ricinis communis	Euphorbiaceae		Castor oil plant
Pedilanthus tithymaloides	Euphorbiceae		Cactus
Crotalaria retusa	Fabaceae		
Desmodium	Fabaceae		
Glirincidia sepium	Fabaceae		Mexican lily
Pueraria phaseoloides	Fabaceae	Te kitoko	
Sophora tomentose	Fabaceae	Te nikamatutu	Sophora

Vigna marina	Fabaceae	Te kitoko	Beach bean
Sesuvium portulacastrum	Ficoidaceae	Te boi	Seaside pursiane
Scaevola taccada	Goodeniaceae	Te mao	Salt bush
Hermandia ovigera	Hernandiaceae	Te nimareburebu	
Coleus atropurpureus	Labiatae		
Ocimum sanctum	Labiatae	Te marou	Sweet basil
Cassytha filiformis	Lauraceae	Te ntanini	Dodder
Barringtonia asatica	Lecythidaceae	Te baireati	Fish poison tree
Gloriosa superba	Liliaceae		Climbing lily
Pemphis acidula	Lythraceae	Te ngea	Ironwood
Gossypium tomentosum	Malvaceae	Te baubau	Island cotton
Hibiscus rosa-sinesis	Malvaceae	Te roti	Hibiscus
Hibiscus tiliaceus	Malvaceae	Te rau	Native hibiscus
Sida fallax	Malvaceae	Te kaura	
Sida rhombifolia	Malvaceae		
Acacia famesiana	Mimosaceae	Te kaibakoa	Acacia
Leucaena leucocephala	Mimosaceae	Rutinia	Leucaena
Artocarpus altilis	Moraceae	Mai kora	Breadfruit (seeded)
*Artocarpus sp (mariannensis)**	Moraceae	Bukiraro/bokeke	Breadfruit (seedless)
*Ficus canica **	Moraceae	Te biku	Fig
*Ficus tinctorial**	Moraceae	Te bero	Native fig
*Musa paradisiacal**	Musaceae	Te banana	Banana
Boevhavia diffusa	Nyctaginaceae	Te wao	Pigweed
Boevhavia tetrandra	Nyctaginaceae	Te wao n anti	
Bougainvillea spectabilis	Nyctaginaceae	Te akanta	Bougainvillea
Pisonia grandis	Nyctaginaceae	Te buka	
Mirabilis jalapa	Nyctaginaceaea	Te auaua	Four o'clock
Jussiacea suffruticosa	Onagraceae	Te mam	Yellow willow herb
*Cocos nucifera**	Palmae	Te ni	Coconut
Pritchardia pacifica	Palmae	Te bam	Fan palm
*Pandanus tectorus**	Pandanaceae	Te kaina	Pandanus/screw
Passiflora hispida	Passifloraceae		Wild passionfruit
Cenchrus echinatus	Poaceae	Te anti	Bindi/burr grass
Dectyloctenium aegyptium	Poaceae	Te uteute	
Eleusine indica	Poaceae	Te uteute	Crowsfoot grass
Eragrostis tenelaa	Poaceae	Te uteute	
Lepturus repens	Poaceae	Te uteute	
Paspalum vaginatum	Poaceae	Te uteute	
Thuarea involuta	Poaceae	Te uteute	
Polygala paniculata	Polygalaceae		
Coccoloba uvifera	Polygonaceae		Seaside grape
Microsorium scolopendria	Polypodiaceae	Te keang	Coconut fern
Portulaca lutea	Portulaceae	Te boi	Purslane
Portulaca quadrifida	Portulaceae	Te mtea	Purslane
Portulaca tuberosa	Portulaceae	Te boi	Purslane
Pteris tripartite	Pteridaceae		
Rhizophora mucronata	Rhizophoraceae	Te tongo	Mangrove
Ixora casei	Ribiaceae	Te katiu	Ixora
Borreria laevis	Rubiaceae		
Guettarda speciosa	Rubiaceae	Te uri	
*Morinda citrifolia**	Rubiaceae	Te non	Indian mulberry
Spermacoce assurgens	Rubiaceae		
Dodonaea viscose	Sapindaceae	Te kaiboia	
Russelia equisetiformis	Scrophulariaceae	Te kaibaun	
Suriana maritime	Simaroubiaceae	Te anoua	
*Nicotiana tabacum**	Solianaceae	Te kaibake	Tobacco
*Capsicum frutescens**	Solinaceae	Te beneka	Chilly pepper
Datura metel	Solinaceae	Te urintiana	Thornapple
*Physalis minima**	Solinaceae	Te bin	Wild gooseberry
Sonneratia alba	Sonneratiaceae	Te nikabubuti	
Tacca leontopetaloides	Taccaceae	Te makemake	arrowroot
Triumfetta procumbens	Tiliaceae	Te kiaou	
Laportea ruderalis	Urticaceae	Te uekeueke	
Pilea microphylla	Urticaceae		Artillery plant
Pipturus aggenteus	Urticaceae	Te aroma	
Clerodendrum inerme	Verbenaceae	Te inato	"Privet"
Lantana camara	Verbenaceae	Te kaibuaka	Lantana
Premma serratifolia	Verbenaceae	Te ango	
Stachytarpheta jamaicensis`	Verbenaceae	Te uti	
Tribulua cistoides	Zygophyllaceae	Te maukinkin	

Appendix 6: Endangered and cultural important plants

(from Thaman et al., 1995)

Local name	Common name	Scientific name
Endangered or of particular cultural importance		
Te aitoa		*Lumnitzera littorea*
Te aroa		*Suriana maritima*
Te babai		*Cytosperma chamissonis* (all cultivars)
Te baireati		*Barringtonia asiatica*
Te banana		*Musa* Baana and plaintain cultivars
Te bararuku		*Ximenia Americana*
Te baubau		*Gossypium barbadense*
Te bero		*Ficus tinctorial* (all cultivars)
Te biku		*Ficus carica*
Te bingibing, te nimareburebu		*Hernandia nymphaeifolia*
Te buka		*Pisonia grandis*
Te itai		*Calophyllum inophyllum*
Te kaibaba		*Bambusa vulgaris*
Te kaibakoa		*Acacia farnesiana*
Te kai boia		*Dodonaea viscose*
Te kaina	Pandanus	*Pandanus tectrius*
Te kaitioka,	Sugar cane	*Saccharum officinarum*
Te kaitu		*Vitex trifolia*
Te kanawa		*Cordia subcordata*
Te kaura		*Sida fallax*
Te keang, te keany ni Makin		*Phymatosorus scolopendria*
Te kiaiai, te rau		*Hibiscus tiliaceus*
Te kiaiai		*Thespesia populnea*
Te kiebutinang		*Neisosperma oppositifolium*
Te kunikun		*Terminalia catappa*
Te mai		*Artocarpus altilis/mariannensis* (all cultivars)
Te makemake		*Tacca leontopetaloides*
Te mangko	Mango	*Mangifera indica*
Te mwemweara, te babaia	Pawpaw	*Carica papaya* (all cultivars)
Te nii	Coconut	*Cocos nucifera (all cultivars, esp. toddy cultivars)*
Te nimatore		*Macaranga carolinensis*
Te nikabubuti		*Sonneratia alba*
Te nikamatutu		*Sophora tomentose*
Te reiango		Cerbera manghas
Te tiare		*Gardenia taitensis*
Te tongo buangi		*Bruguiera gymnorrhiza*
Te ukin		*Terminalia samoensis*
Te uri		*Guettarda speciosa*

Appendix 7: Marine algae of Kanton

(source: Deneger and Deneger, 1959 & Dawson, 1959)

Chroococcaceae
Anacystis aeruginosa; Anacystis dimidiata; Anacystis montana
Johannesbaptistia pellucida

Chamaesiphonaeae
Entophysalis deusta

Oscillatoriaceae
Hydrocoleum comoides; Hydrocoleum confluens; Hydrocoleum glutinosum; Hydrocoleum lyngbyaceum
Lyngbya aestuarii; Lyngbya confervoides; Lyngbya infixa; Lyngbya semiplena
Microcolues acutissima; Microcolues chthonoplastes; Microcolues paludosus; Microcolues tenerrimus
Phormidium gardnerianum; Phorimidium papyraceum
Porphyrosiphon fuscus
Schizothrix creswelli; Schizothrix heufleri; Schizothrix lamy; Schizothrix longarticulata; Schizothrix taylorii
Spirulina subsalsa; Spirulina tenerrima
Sumploca hydnoides

Nostocaceaea
Nodularia sphaerocarpa
Nostoc calcicola
Scytonemataceae

Plectonema nostocorum; *Plectonema terebrans*
Scytonema hofmannii

Rivulariaceae
Calothrix crustaceae
Chlorophyta:

Enteromorpha clathrate; Enteromorpha sp (E. clathrate var. pumila); *Enteromorpha kylinii*
Ulvella lens
Cladophora fascicularis; Cladophora flexuosa
Dictyosphaeria cavernosa
Boodlea composita
Cladophoropsis gracillimum; Cladophoropsis sundanensis
Derbesia attenuata
Caulerpa racemosa var. peltate; Caulerpa racemosa var. turbinate; Caulerpa serrulata;
Caulerpa urvilleana
Bryopsis pennata
Codium ovale; Codium geppi
Halimeda fragilis; Halimeda micronesica; Halimeda opuntia

Phaeophyta
Ectocarpus indicus
Sphacelaria furcigera; Sphacelaria spp
Dictyota friabilis
Pocockiella papenfussi; Pocockiella variegata
Turbinaria ornate; Turbinaria trialata

Rhodophyta
Gelidium pusillum
Pterocladia sp
Gelidiella rigidiuscula; Gelidiopsis intricate
Jania capillacea; Jania micrarthrodia; Jania tenella
Hypnea esperi
Gracilaria sp
Lomentaria sp
Ceramium clarionensis; Ceramium gracillimum var. byssoideum; Ceramium equisetoides; Ceramium vagabunde; Ceramium sp
Griffithsia
Herposiphonia secunda; Heterosiphonia wurdemannii
Polysiphonia ferulacea; Polysiphonia flaccidissima; Polysiphonia mollis
Laurencia nana

Appendix 8: Indigenous bird species of Kiritimati

(Source: Pratt *et al.*, 1987 & Perry and Garnett n.d. in Thaman *et al.*, 1996)

Common name	Latin Name	Kiritibati Name	Status
Line Islands reed warbler	Acrocephalus aequinoctialis	Te bokikokiko	Resident all year
Northern pintail	*Anas acuta*		Passage migrants & vagrants
Northern shoveler	*Anas clypeata*		Passage migrants & vagrants
? green-winged teal	*Anas crecca*		Passage migrants & vagrants
Mallard	*Anas platyrhynchos*		Passage migrants & vagrants
?gadwall	*Anas strepera*		Extinct
Black/Hawaiian noddy tern	*Anous minutus*	Te mangkiri	Resident all year
Brown/common noddy tern	*Anous stolidus*	Te io	Resident all year
Ruddy turnstone	*Arenaria interpres*	Te kitiba	Winter resident
Greater scaup	*Aythya marila*		Passage migrants & vagrants
Cattle egret	*Bubulcus ibis*		Passage migrants & vagrants
Sharp-tailed sandpiper	*Calidris acuminata*		Passage migrants & vagrants
Sanderling	*Calidris alba*		Winter resident
Willet	*Catoptophorus semipalmatus*		Passage migrants & vagrants
Pacific reef heron	*Egretta sacra*	Te kaai	Migratory breeder
Lesser frigate bird	*Fregatta ariel*	Te eitei	Resident all year
Great frigate bird	*Fregatta minor*	Te eitei	Resident all year
White/fairy tern	*Gygis alba*	Te matawa	Resident all year
Wandering tattler	*Heteroscelus incanus*	Te kiriri	Winter resident
Laughing gull	*Larus atricilla*		Passage migrants & vagrants
Ring-billed gull	*Larus delawarensis*		Passage migrants & vagrants
Franklin's gull	*Larus pipixcan*		Passage migrants & vagrants
White throated storm petrel	*Nesofregatta albigularis*	Tebwebwe ni marawa	Resident all year
Bristle-thighed curlew	*Numenius tahitiensis*	Te kewe	Winter resident
White-tailed tropic bird	*Phaethon lepturus*		Resident all year
Red tailed tropic bird	*Phaethon rubricauda*	Te take	Resident all year
Bluegrey noddy tern	*Procelsterna cerulea*	Te raurau	Resident all year
Phoenix petrel	*Pterodroma alba*	Te ru ru	Resident all year
?white-naped petrel	*Pterodroma cervicalis*		Passage migrants & vagrants
Audonbon's shearwater	*Puffinus lherminieri*	Te nna	Migratory breeder
Christmas shearwater	*Puffinus nativitatus*	Te tinebu	Resident all year
Wedgetailed shearwater	*Puffinus pacificus*	Te tangiuoua	Migratory breeder
Great crested tern	*Sterna bergii*	Te karakara	Resident all year
Sooty tern	*Sterna fuscata*	Te keeu	Resident all year
Grey backed tern	*Sterna lunata*	Te tarangongo	Resident all year
Black-naped tern	*Sterna sumatrana*	Te kiakia	Passage migrants & vagrants
Red footed booby	*Sula sula*	Te kota	Resident all year
Blue faced booby	*Sula dactylatra*	Te mouakena	Resident all year
Brown booby	*Sula leucogaster*	Te kibui	Resident all year
Scarlet breasted lorikeet	*Vini kuhlii*	Te kura	Passage migrants & vagrants

Notes:
? = unconfirmed record
Resident all year: but not necessarily breeding
Migratory breeder: breeds at locality, but departs for the rest of the year
Winter resident: resident during the non-breeding season, from the bird's perspective, eg some species visit during the austral winter and some during the northern hemisphere winter

Appendix 9: Non-finfish Resources of Kiribati

(Sources: Fishing Department, 2000; Thaman et al, 1996 & Awira, 2000)

Grouping	Scientific Name	Common Name	Kiribati Name	Reference
Crustacea	*Panuliris spp.*	Rock lobster	Te nnewe	
	P.versicolor			
	Parribacus caledonicus			
	Lysiosquilla maculata	Mantis shrimp	Te waro	
	Heterocarpus laevigatus	Deepwater shrimp		
	Heterocarpus			
	Carpilius maculatus	Three spot reef crab		
	Eriphia sebana	Red eye crab		
	Birgus latro	Coconut crab (land)	Te aii	
	Cardisoma carnifex	Land crab		
	Panaeus monodon	Freshwater prawn		
Shellfish	*Anadara maculosa*	Ark shell	Te bun	
	Gafrarium pectinatum	Venus shellfish	Te koumara	
	Asaphis violascens	Sanguin clam/sunset	Te koikoi	
	Atactodea striata	Striate beach clam	Te katura	
	Spirula spirula	Ram's-horn shell	Te katura	
	Turbo chrysostamus	Turban shellfish		
	Trochus pyramis	Top shell		
	Tridacna gigas	Giant clam		
	T. maxima			
	T. squamosa			
	Hippopus hippopus			
	Trachycardium orbita	Cockle shellfish		
Gastropods	*Strombus luhuanus*	Red lipped stromb	Te nouo	
	Trochus			
	Lambis lambis	Spider shell		
Sipunculids	*Siphonosoma australe*	Peanut worm	Te ibo	
	S. indicus	Sipunculid worm	Te ibo	Kaly & Jones, 1993
Eel	*Anguilla marmorata*	Freshwater eel	Tetuna	C. Mees
	Dorabella spp.	Black & green seahare		
	Conger cinereus	Moustache conger Or Conger eel	Manninnaba	Myers, R. F.
	Myrichthys colubrinus	Banded snake eel	Teimone	Myers, R. F.
	M. maculosus	Spotted snake eel	Teimone	Myers, R. F.
Turtle	C. mydas			
	Eretmochely imbricata	Hawksbill turtle		
	Lepidochely skempii	Kemp's Ridley turtle		
	L. solivacea	Olive Ridley turtle		
	Dermochely scoriacea	Leatherback		
	Caretta caretta	Loggerhead		
Holothurians	Holothurian fuscogilva	White teatfish		
	H. nobilis	Black teatfish		
	H. atra	Lolly fish		
	Theolenota ananas	Prickly Redfish		
	Actinopyga mauritiana	Red Surf		
	A. miliaris	Blackfish		
	Bohadchia argus	Tiger Leopard		
	B. vitiensis	Brown sandfish		
	Stichopus chloronotus	Green fish		

Appendix 10: Marine protected areas of Kiribati

(source: WCMC Protected Areas Database)

	IUCN Category	Latitutde	Longitude	Size (ha)	Year
Closed Area					
Cook Islet (Kiritimati WS)	Ia	2^0 00' N	157^0 20' W	3	1975
Motu Tabu Islet (Kiritimati WS)	Ia	2^0 00' N	157^0 20' W	1	1975
Motu Upua	Ia	2^0 00' N	157^0 20' W	4	1975
Ngaon te take islet (Kiritimati WS)	Ia	2^0 00' N	157^0 20' W	2	1979
North-west Point (Kiritimati WS)	DE	2^0 00' N	157^0 20' W	13	1975
Wildlife Sanctuary					
Birnie Island	IV	3^0 35' S	171^0 33' W	20	1975
Kiritimati	UA	2^0 00' N	157^0 20' W	32100	1960
Malden Island (Closed Area)	Ia	4^0 03' S	155^0 01' W	3930	1975
McKean island	IV	3^0 35' S	174^0 02' W	57	1975
Phoenix Island (Rawaki)	IV	3^0 42' S	170^0 43' W	6500	1975
Starbuck (Closed Area)	Ia	5^0 37' S	155^0 56' W	16200	1975
Vostock Island	IV	10^0 06' S	152^0 23' W	24	1979

Note: Sites have been based on the IUCN definition of marine protected areas:
"any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (resolution GA 17.38. 17th General Assembly, IUCN).

Definition includes sites with only a very small subtidal or intertidal territory which might otherwise be regarded as wholly terrestrial and described as recommended and proposed with no current legal protection status.

Appendix 11: People Consulted

Chapter	People Consulted
Chapter 2	Tebutonga Ereata, Senior Lands Surveyor, Lands Management Division Tiaontin Enari, Cartographer, LMD, MHARD GIS User Group Naomi Atauea, Mineral Development Officer, MNRD Various Officers of SOPAC Mark Kunzer, Environment Scientist, SAPHE Project
Chapter 3	Professor Ian White, Australian National University (ANU), Anthony Falkland, Eita Metai
Chapter 4	Harry Redfern, Land Planning Officer
Chapter 5	Koin Etuati & Farran Redfern: Environmental Inspectors, ECD, MESD Kautu Temakei, Environmental Impact Assessment Officer, ECD, MESD Ritia Kamautu, Assistant Secretary, MHARD Teata & Manikaoti, Rural Planning Unit, MHARD Harry Redfern, Senior Land Planning Officer, LMD, MHARD Taebo Teuatabo, Development Enforcement Officer, LMD, MHARD Mautaake, Acting Energy Planner, MWE Moarieta, Senoir Industry Officer, MCIT Motiti Koae, Foreign Investment Commission, MCIT
Chapter 6	Eita Metai: Water Engineer, Water Engineering Unit, Ministry of Works and Energy (MWE), Government of Kiribati Professor Ian White, Water Research Foundation of Australia, Centre for Resource and Environmental Studies, Institute of Advanced Studies, Australian National University, Canberra, ACT 0200, Australia Anthony Falkland, Ecowise Environmental, ACTEW Corporation, PO Box 1834, Fyshwick, Canberra, ACT 2609, Australia Taboia Metutera, Water Engineer, Public Utilities Board (PUB), MWE
Chapter 7	Dr Alolae Cati: Advisor to the Traditional Healers Association, MHFP Kinaai Ioane, Information Officer, Agricultural Division, MNRD Nakabuta Teuriaria, Plant Protection Officer, Agricultural Division, MNRD Bwere Eritaia, Conservation Area Support Officer, Environment and Conservation Division, MESD Nenenteiti Ruatu, Biodiversity Conservation Officer Designate, Environment and Conservation Division, MESD
Chapter 8	Maruia Kamatie, Chief Fisheries Officer, Fisheries Division, MNRD Tooti Tekinaiti, Senior Fisheries Officer,

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Chapter 10	Tinai Iuta Eita: Nutritionist, National Nutrition Centre, MHFP, Bikenibeu Ioeru, Medical Statistician, MHPF, Nawerewere Dr. Kabwea Tibwan, Public Health Consultant, MHPF, Bikenibeu
Chapter 11	Iete Rouatu, Republic Statistician, Statistics Office, MFEP Tekena Tiroa, Senior Statistician, Statistics Office, MFEP Gilda Manuel de Condinguy, SPC
Chapter 12	Naomi Atauea, Mineral Officer, MNRD
Chapter 13	Johnny Kulene: Manager, Air British Petroleum Mautaake Tannang: Acting Energy Planner, Energy Planning Unit, Ministry of Works and Energy, Harry Redfern; Physical Urban Planner, LMD, MHARD Terubentau Akura; General Manager of Solar Energy Company (SEC)
Chapter 14	Mr Taulehia Pulefou, Pollution Control Officer, Environment and Conservation Division, MESD Ms Buretau Kaureata, Clerk to the Betio Town Council (BTC), MHARD Mr Nakabuta Nakabuta, Quarantine Officer, Agricultural Division, Ministry of Natural Resources Development, (MNRD) Dr. Kabwea Tiban, Public Health Consultant, MFHP.
Chapter 15	Ursula Kaly, Environmental Specialist
Chapter 16	Nakibae Teuatabo, PICCAP Project Coordinator, ECD, MESD
Chapter 17	Professor John Morrison, Head of Environmental Science, University of Wollongong Michael Phillips, Former EIA Trainer at ECD (1998-2001).