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ENVIRONMENTAL PLANNING, CLIMATE CHANGE AND POTENTIAL SEA LEVEL RISE: REPORT ON A MISSION TO KIRIBATI

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SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME

ENVIRONMENTAL PLANNING, CLIMATE CHANGE AND POTENTIAL SEA LEVEL RISE: REPORT ON A MISSION TO KIRIBATI

SPREP REPORTS AND STUDIES No. 50

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A report produced for the Association of South Pacific Environmental Institutions (ASPEI) to the Government of Kiribati and to the South Pacific Regional Environmental Programme (SPREP)

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CONTENTS

1. INTRODUCTION

1.1 Background

As a result of previous studies carried out through the support of UNEP to the South Pacific Regional Environmental Programme (SPREP) Regional Seas programme in the Pacific, a number of island States have been perceived as being under immediate threat of major environmental change should greenhouse-forced climatic warming and consequent sea level rise occur.

The problems identified have been set out in both summary and detail in the reports of the Association of South Pacific Environmental Institutions (ASPEI) Regional Task Team (Pernetta 1988, Pernetta and Hughes 1989). In these reports Kiribati has been identified as one of the Pacific Island nations most vulnerable to any sea level rise which would result from climatic warming.

It is apparent however that climatic warming and consequent sea level rise is simply one, and in many cases not the most urgent, of a number of environmental problems facing small island nations (Wyrtki 1990), and plans to deal with these climatic change problems can be most appropriately considered along with other environmental planning issues.

1.2 Mission brief

The brief for this mission was provided by UNEP and followed closely that provided for a study carried out in 1989 in the Maldive Islands (Pernetta and Sestini 1989). The specific brief presented to the Kiribati team by the Government of Kiribati had been modified slightly from that for the Maldives study. The terms of reference set out by the Government of Kiribati, and agreed upon by UNEP and SPREP, for this mission were:

1.2.1 Purpose of the visit

Prepare a proposal for an in-depth study of the potential impact of expected climatic changes on the natural environment and the socio-economic structures and activities of Kiribati, including identification of response options which may be suitable and available to avoid or mitigate the potential negative impact of the expected climatic changes.

1.2.2 Specifically the mission would

(i) examine and evaluate the available information concerning the physical and biological environment of the atolls of Kiribati;

(ii) examine and evaluate the available demographic, social and economic data;

(iii) present the results of relevant studies as to the applicability of each study to the case of Kiribati;

(iv) discuss consequences of the potential impact of climatic change with relevant authorities in Kiribati and seek their views on suitable response options;

(v) identify the appropriate national authority which may participate in the in-depth studies expected to follow the mission and determine the modalities of co-operation with the team which will be in change of the in-depth study.

1.2.3 On the basis of the activities in 1.2.2 above, prepare a joint report containing

(i) a general overview of the climatological, oceanological, biological and socio-economic factors which may be relevant to or affected by the potential impact of expected climatic changes;

(ii) a preliminary identification of the most vulnerable components and sites of the natural environment, as well as those socio-economic structures and activities which may be most critically affected by expected climatic changes;

(iii) a detailed proposal for an in-depth evaluation of the potential impact of expected climatic changes on the natural environment and the socio-economic structures of Kiribati, including the identification of policy or management options suitable to avoid or mitigate the impact of climatic changes. The proposal should identify the workplan, timetable and financial requirements of the in-depth evaluation as well as the possible institutional arrangements for carrying out the evaluation;

(iv) before leaving Kiribati, to present and discuss with the Ministry of Home Affairs and Decentralisation officials the line of the proposal for the in-depth evaluation;

(v) The final report of the visit will then be transmitted to the Kiribati Government within a reasonable time after the completion of the visit.

1.3 Programme of visit

The visit to Kiribati took place between 18th and 28th April 1990. This visit was organised, and the programme was planned, by the Ministry of Home Affairs and Decentralisation (MHAD). The outline of the programme followed is set out as Appendix II to this report.

2. KIRIBATI - THE ENVIRONMENTAL SETTING

2.1 Geographical setting

The Republic of Kiribati is made up of 33 islands in three distinct groups; the Gilbert Islands, the Phoenix Islands and the Line Islands. These groups straddle both the equator and the international date line (Fig. 1).

The Gilbert Islands, from which Kiribati took its name, comprise 17 islands spread over a latitudinal distance of almost 700 km, from approximately 2.5° or 450 km north of the equator to 1.6° or 250 km south, lying to the west of the international date line. Tarawa, the seat of government is within this group. All islands in this group are occupied, and all land except reclaimed land in the Gilbert Islands is customarily owned. In South Tarawa however much of the land is leased to the Kiribati Government and there is an increasing trend towards individual freehold sale of former family owned land.

The Phoenix Group comprises eight islands lying between 200 and 600 km south of the equator, and east of the international date line.

The easternmost group, the Line Islands are a widely spread group of eight islands distributed across 2,000 km of ocean between about 500 km north and 1,500 km south of the equator. Kiritimati (Christmas) Island, which makes up approximately half the land area of Kiribati, lies within this group. All land in the Phoenix and Line Islands is owned by the Kiribati Government.

Except for Barnaba (Ocean) Island, which is a raised coral island, all the islands of Kiribati are motu or cays developed on coral reefs at sea level. Nowhere in the atolls does elevation rise more than 5 m above sea level, and the average elevation of the land surface is about 3 m above sea level.

The vegetation of the atolls comprises a restricted range of trees and shrubs, most of which are used as food plants, or to supply the raw materials for house and canoe construction, or burnt as firewood. There has been little change in the vegetation of most of the Kiribati Islands since it was described by Sabatier (1934), although Talu (1985) noted over a 50 year interval diminished plant resources in densely populated areas such as South Tarawa, and the introduction of some food plants.

The main tree crops are coconut (*Cocos nucifera*), used as a source of food and building materials, *mai* or breadfruit (*Arctocarpus altilis and A. mariannsis*) and pandanus (*Pandanus tectorius)* which is eaten as nuts, or the fruit preserved.

Other tree species such as *uri* (*Guettardia speciosa*) *bariati* (*Barringtonia asiatica*), *ren* (*Turnifortia argentea*), *non* (*Morinda citrifolia*), bird-lime trees (*Pisonia grandis*), and shrubs such as *mao* (*Scaevola koenegini*) or *Hibiscus tiliaceus*, were used specifically for building canoes, for house posts, for furniture and for firewood. In densely populated areas such as South Tarawa coconut wood has mostly replaced the species formerly used for furniture or buildings, and canoe timber is imported. Mangroves (*Bruguiera* and *Avicennia* spp) are also used for building timber.

Everywhere in the islands the giant taro or *baibai* (*Cyrtosperma macchoriza*) is cultivated in pits dug to the watertable, and herbs such as *Ipomoea* and *Portulaca* spp, and other introduced crops, are eaten. In South Tarawa *baibai* pits are becoming less common, and Lawrence (1977) has suggested that even in the outer islands there is a slow decline in *baibai* cultivation.

2.2 The atolls

The coral foundations which form the bases of the islands of Kiribati are either intertidal atolls, or platform or table reefs, all of which rise steeply from the surrounding ocean floor (see Sullivan and Pernetta 1989, McLean 1989). Most of the atolls of Kiribati are elongated rather than circular, with their long axes aligned mainly north-south. The tabular reefs do not enclose lagoons, but like the atoll reefs support islands of sand and coral rubble.

2.3 Low islands: cays or motu

With the exception of Barnaba, all of the islands of Kiribati are examples of the low islands built up on a coral reef base, and known as cays in the Caribbean and motu in the Pacific. Such islands are common on atolls, where groups of three to five islands commonly indicate the underlying reef form. Islands comprising sediments accumulated on such reef flats rarely emerge more than a few metres above sea level - maximum elevations on such islands are normally about four metres, and this is the case for Kiribati.

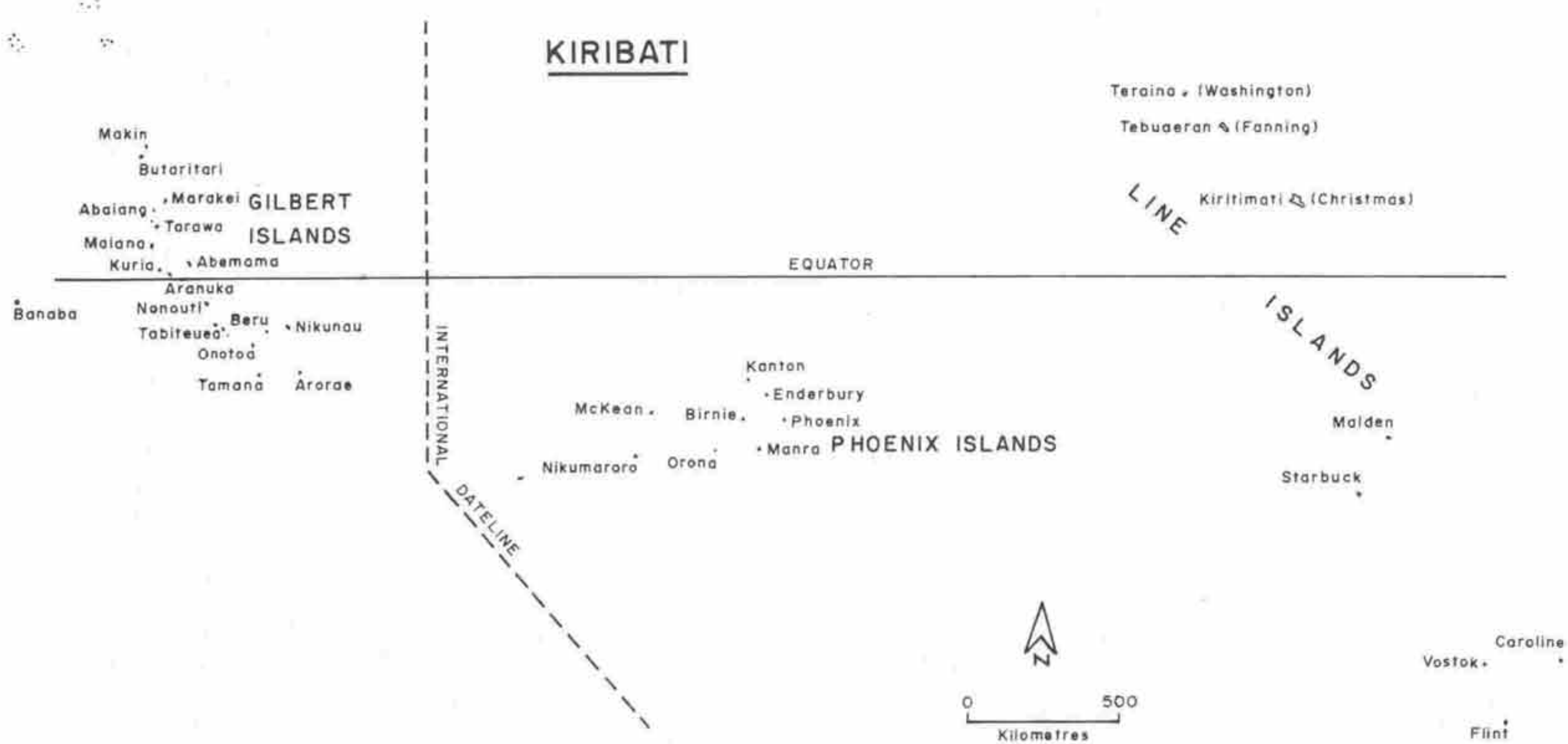
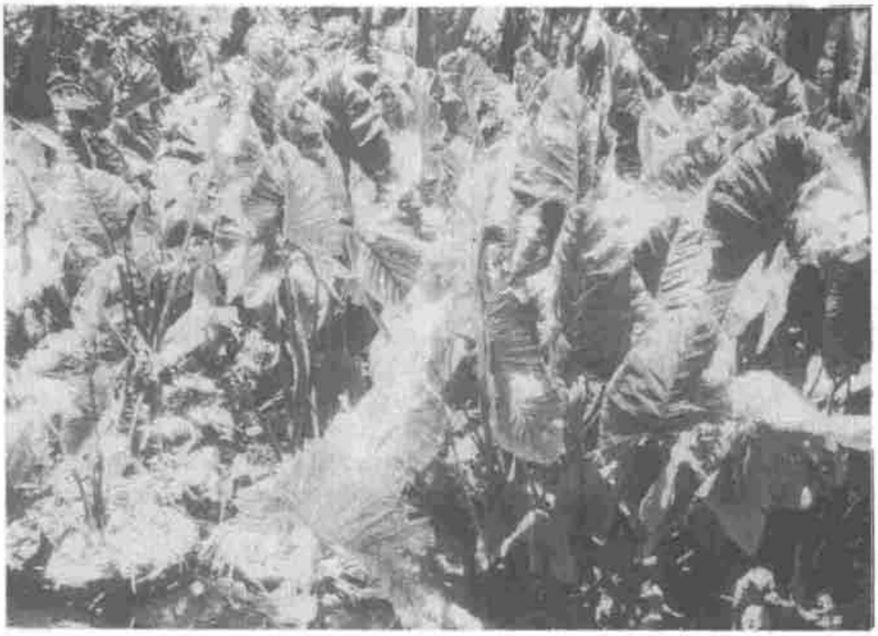


Fig. 1 : The islands of Kiribati



Baibai cultivation, North Tarawa.

2.3.1 Motu development

Motu are composed of sediments derived from the breakdown of reefs, and are characterised by a sequence of sediments of variable grain sizes (Wiens 1962:69, Bird 1984:275). Storm activity is important in depositing the coarse beachridge sediments which form the basis of motu development. Following debris deposition primary colonising plants become established, to form a stable motu. Beach rock cementation at the water table level assists the formation and enhances the stability of motu. The Kiribati islands show pronounced beachrock development.

The island configuration may change due to gradual climatic changes (Bird 1984:275), or during exceptional storms whole motu may be swept away, or the configuration changed abruptly. Kiribati follows the normal Pacific pattern where motu are mainly found on windward reef flats (see McLean 1977). The sequence of landforms and sediments which are typical of motu are a shingle ridge on the windward side, and a sandy flat on the leeward side of the reef flat (Bird 1984:275). On the lee side of reef patches refracted waves converge, preventing debris being swept over the lee side of reef islands, and maintaining the existence of the low sand islands.

On many atoll motu in the Pacific, it has been noted that severe storms have completely altered the position and configuration of the motu - commonly exposing beachrock which is an indication of the location and extent of former motu (see e.g. Baines and McLean 1976). Beachrock can be destroyed by the impact effects of wave-carried debris, but can also be re-lithified and solidified, enhancing the island's stability. Recovery time of an island's form and biological communities from a hurricane or tropical cyclone was estimated by Stoddart (1965) at 20-30 years. He also noted that motu are in general built up by cyclones rather than destroyed by them.

2.4 Climatic and oceanographic setting

The climate of Kiribati is determined by its oceanic equatorial setting, and is controlled by the presence of warm humid airmasses, the meridional or north-south movements across the equator, of the Hadley Circulations, which converge in the Inter Tropical Convergence Zone (ITCZ), and the zonal east-west moving Walker Circulation. The controls on climate have been discussed by McLean (1989:45), who produced a map of mean annual rainfall over the central Pacific Ocean and described the variability of rainfall for Kiribati, and by McGregor (1989), who summarised climatic determinants for the Pacific Ocean.

Predominant winds throughout the year are easterlies, with seasonal variations between northerly and southerly components related to the movement north and south of the equator of the ITCZ. When the ITCZ lies at its maximum southerly position in December-January northeasterly trade winds prevail on Kiribati, and in June-July, when the ITCZ lies to the north, Kiribati experiences easterly and southeasterly winds.

The islands of Kiribati lie within and adjacent to the western extremity of the equatorial dry zone such that there is a rainfall gradient through the island chains, with the northwestern islands being wetter and the southeastern-most islands drier. South of the equator this zone is normally characterised by upwelling of cold ocean water, airmass divergence, low cloud cover and low rainfalls. The northwestern islands lie at the eastern margin of the western Pacific zone of high sea surface temperatures, convective air movements, high cloud cover and higher total rainfalls.

Variations in these weather patterns occur when the zonal Walker Circulation, which brings cold easterly air towards Kiribati, weakens. At such times the surface easterlies weaken and moist equatorial westerlies penetrate into the region. The centre of maximum convective activity and convergence, normally positioned west of 165°E, moves into the Kiribati region, associated with rising sea surface temperatures. This phenomenon, known as El Nino, causes associated variations in the Southern Oscillation Index (SOI) and has a dramatic impact on the climate of Kiribati. Positive index values bring dry easterly winds to Kiribati. When index values are negative (as during El Nino events), moisture bearing winds blow from the west causing increased rainfalls, and rises in local sea levels of up to 40 cm. Such El Nino-Southern Oscillation (ENSO) phenomena have been well recorded in the Pacific over the last two decades and related to higher tidal stands in the western Pacific.

The trends and cycles of oceanographic phenomena for Kiribati are reviewed by McLean (1989:39). He also summarised existing information on tropical cyclones for Kiribati (1989:48) and has demonstrated that such severe disturbances are rare. Severe westerly winds associated with storms do however generate high energy storm waves on the island coastlines. The main influence on ocean conditions is a dominant ocean current which runs west to east, and a subsidiary return or countercurrent which runs east to west along the equator. Both currents pass through Kiribati, and their patterns are well known to tuna fishermen.

Sea levels vary markedly in response to the movements of these currents, and are highest between October and December, and lowest during April to June.

2.5 Water lenses

The islands of Kiribati, like other low islands, are characterised by the absence of surface water sources. The high porosity of their sand or shingle sedimentary cover, and of the underlying reef limestones generally results in rapid percolation of precipitated water from the ground surface (Wiens 1962:317). Water is held by capillary action in the soil layers, and basal groundwater is stored in unconsolidated sediments and in the porous limestone. A lens of freshwater fed from the overlying sediments, and roughly proportional to the size of the island, occurs in motu or low islands of about 1.4 or more hectares (Wiens 1962, McArthur and Wilson 1967:32). Groundwater is fresher towards the lagoon and brackish seaward. While fresh water enters the groundwater storage through infiltration and percolation, sea water enters through cracks and crevices in the reef structure, and infiltrates through the porous seaward boulder ridges (Wiens 1962:69, 323).

There is a density separation of fresh and saline water within the water lens, and fresh water floats on a sea water base. The position and volume of the lens varies with tidal changes and with local hydrological conditions. The lens shrinks during periods of low rainfall, and swells following rainy periods. The fresh water lens is thickest near the centre of the islands and thins towards the coastal margins.

Limestone solution or karst development occurred during Pleistocene glacial or low sea level phases in many atoll bases (Guilcher 1971:73, Wiens 1962:18, Stoddart and Taylor 1971). The voids or spaces so formed are important in funnelling and storing fresh water. Marshall and Jacobsen (1985) observed karst water sources on Tarawa Atoll and described a repetitive sequence from bores of a cemented top layer (beachrock), which forms a partial aquiclude, unconsolidated sediment, which provides a perched aquifer, and corals and leached limestone of last interglacial age with solution cavities. It is likely that a similar pattern occurs on other Kiribati atolls.

Groundwater occurrence is controlled by reef geology, tidal fluctuations, precipitation and island and reef geometry, and these variables have been used in models to predict the occurrence of freshwater lenses and their behaviour under conditions of rising sea level. Oberdorfer and Buddemeier (1986) and Buddemeier and Oberdorfer (1989) noted that island and reef hydrology are heterogeneous. They have provided models for assessing fresh groundwater resources on low islands and have discussed the likely impacts of potential climatic change and sea level rise on such fresh water lenses.

2.6 Land use

Traditional culture was based on a household and village system of organisation where groups were involved in subsistence production. Coconuts, *baibai* (taro, *Cyrtosperma macchoriza*), pandanus and breadfruit were the major crops grown, and a variety of foods was produced from them. Prominent among these foods was *karewe* or toddy, a sweet liquid prepared from coconut spathes. This was either reduced to a sweet syrup (*kamaimai*) or was further fermented to an alcoholic beverage, sour toddy. Pandanus was similarly used for fresh nuts, ground to flour, or the fruit preserved. Tree crops such as breadfruit, banana and paw paw, and some vegetables were also grown. Many of these plants were also used to provide roofing or house building materials, matting, canoes or firewood and fishing implements. Fishing and marine foods remain important elements of both the subsistence and, more recently, the commercial economy (Sabatier 1934, Luomava 1953, Catala 1957, Small 1972, Watters and Banibati 1977, Lawrence 1977, Bate *et al.* 1979, Iobi 1985, Kirion 1985, Tofiga 1985, Koch 1986, Teiwaki 1988). The traditional pattern of subsistence agriculture persists in all the outer islands, but on South Tarawa there is an increasing emphasis on the importance of imported food as the local population grows and gardening land becomes more scarce.

Kiribati has an unusual descent system which, combined with its colonial settlement history and the influence of Christian missions has produced a mixed land tenure system. Kiribati society is ambilateral in that people can attach themselves to descent groups through either or both of their parents. It is also ambilineal, in that capital can be passed on to both male and female offspring (Watters and Banibati 1977:13-14). Traditionally land was customarily owned and rights to land were passed on to male and female descendants and their families.

This system of customary tenure has largely continued although in the Line and Phoenix Islands the Kiribati Government is the sole owner of land. In the Gilberts the government leases tracts of land from communal landowners (Namai 1987). Churches - both Catholic and Protestant - are also now major land owners. Since 1956 land ownership in the Gilbert group has been registered. More recently the land tenure systems throughout the country have become formalised under the terms of the Native Lands Commission Ordinance (1952), and with the introduction of lands courts. In the post-independence period, since 1979, land tenure patterns have changed markedly with an increased frequency of land sales (Namai 1987). The result of this has been a reduction in the size of family landholdings and a consequent increase in pressure on remaining communally owned land. Because of land pressure on South Tarawa and some outer islands in the Gilbert group, government sponsored resettlement to Fanning and Washington Islands in the northern Line group is continuing.

2.7 Cultural or traditional sites

A number of traditional cultural sites, mostly relating to creation stories, mythological sites, graves of important figures or other notable locations are known (Kirata 1985). Some of these are recorded by the Department of Culture. Additional records will undoubtedly be collated in the future.

Prehistoric archaeological sites in Kiribati are not well known or recorded. In several parts of South and North Tarawa the walls of pits dug for various purposes reveal layers of shell and other cultural debris. It is possible that many present village locations and other areas on the islands have been used sporadically for much of the time that the islands have been occupied. Press reports during 1989 indicated that more than ten radiocarbon dates from archaeological sites in the northern Marshall Islands and on Majuro indicated that these islands had been occupied for 3,000 to 4,000 years. Similar histories of occupation exist for eastern and central Polynesia (see e.g. Bellwood 1975). It is therefore likely that Kiribati may similarly have been settled for more than 3,000 years, and that the remains of early settlements occur within archaeological sites which have yet to be investigated on Kiribati.

Many historical sites are also known, but not fully recorded. Kiribati was the site of numerous battles fought during World War II on Barnaba, Butaritari and Tarawa (see Mamara and Kaiuea 1979). Some war relics, including guns, and memorials at the sites of historical battles are preserved in Betio and Bairiki, and it is likely that additional restoration or protection work will be carried out on other decaying war relics at their present sites. Such sites will warrant protection from future environmental changes.

2.8 Socio-economic setting

2.8.1 Administration

The total land area of Kiribati is slightly more than 800 km^2, within an ocean area of about 1,000,000 km^2. Communications between the islands have always been limited, but are constantly improving. The history of such communications has been documented by Kirion (1985). Radio contact between the islands exists and telephone links are currently improving with the installation of a satellite linked telephone system. The outer islands in the Gilberts group are serviced by once or twice weekly air services, and boat services between the islands are constant but irregular. Access between the Gilbert Islands and the Phoenix and Line Islands is via the Marshall Islands and Hawaii, and is difficult, time-consuming and expensive.

The islands' administration is based on a policy of decentralisation of power and decision-making (Kiribati National Planning Office 1988) which follows the traditional *Maneaba* or local council initiation of projects (see Talu 1985, Teiwaki 1985), with planning decisions now proceeding upwards through Island Councils to the National Government.

2.8.2 Demography

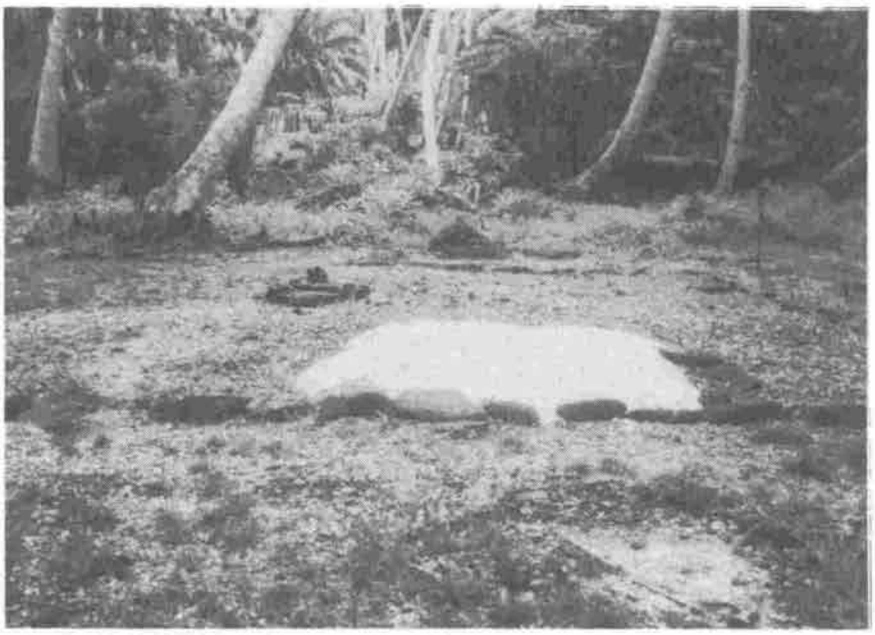
According to the latest estimates Kiribati has a population of slightly more than 68,200. The population has more than doubled during the past-war period and the current rate of growth stands at about 2% per annum. If the present rate of increase continues, the country's population can be expected to double in the next 35 years or so (Kiribati Statistics Office 1989:3).

A population increase of this magnitude will place increasingly severe strains on both the physical and human environments, particularly when both the delicate nature of the Kiribati environment and the concentrating of population on South Tarawa are considered. The capital's share of total population has risen sharply from only 5% in 1917 to the present, where more than one third of the people now living in the country reside in South Tarawa, resulting in a very high population density of 1,357 per square kilometre for the capital (Kiribati Statistics Office 1989:7).

Migration from the outer islands to the capital has been the primary reason for the rapid increase in South Tarawa's population. In 1985, for instance, 6,181 of South Tarawa's 21,393 residents (28.9% of the population) had lived outside the capital at independence in 1979. The age-selectivity of the migration process has contributed to a situation where South Tarawa now has a very young population with 61% (13,042 people) being less than 25 years of age. Without active measures to reduce the birth rate it can be expected that South Tarawa's population will experience substantial internally-generated growth through natural increase in the future.

Given this rapid concentration of population on South Tarawa the Government has attempted to decentralise the population through resettlement in Fanning and Washington islands. It should be noted that the Ministry of Health and Family Planning has been successful in encouraging a general decline in the fertility rate in Kiribati. Particularly important is the marked decline in the number of annual births for South Tarawa from a peak in 1980 of 1,122 to 656 in 1988 (Kiribati Statistics Office 1989:13).

There is pressure on available land due to competing needs for housing, community buildings, churches, schools, graves, *baibai* pits, other gardening needs, public utilities and government and commercial office space. There is similarly pressure on the groundwater sources, especially of the smaller islands.



A marked site of traditional cultural significance on North Tarawa.

Milkfish caught in the lagoon for immediate local sale in South Tarawa.

Drying copra for export, North Tarawa.

2.8.3 Economy

The Kiribati economy may be described as a MIRAB economy with migration, remittances, aid and bureaucracy playing particularly important roles in the country's economic structures and processes (Bertram and Watters 1985).

Migration and remittances

On the most recent census night 2,227 people were registered as I-Kiribati residents overseas. Of this number 1938 were either seamen (665) or in Nauru (1,273) (Kiribati Statistics Office 1986:17). Although this migrant group represents a small proportion of the country's total population, it plays a very important part in strengthening the Kiribati economy's balance of payments.

A large percentage of households relies on the remittances in cash and kind from these migrants. For example, in 1985, of a total of 10,093 households in Kiribati, 630 received cash remittances from I-Kiribati working in Nauru, 1,060 households were sent cash from seamen working on South Pacific Marine Services (SPMS) vessels and 2,446 household units received remittances-in-kind from all sources (Kiribati Statistics Office 1986:211).

As well as supporting a large number of family groups in Kiribati, the money and goods sent home by the temporary migrants forms a substantial external source of cash for the economy. Figures calculated by the Bank of Kiribati for 1989 show that in that year A$5.9 million (on average about A$6,000 per migrant) was remitted through the SPMS account by seamen (Communication from Bank of Kiribati). As well as this, each year I-Kiribati workers in Nauru remit approximately A$200,000 through the Bank of Kiribati (Kiribati Statistics Office 1989:126). When it is also considered that migrants on returning home bring gifts as well as leave payments, the magnitude of this group's contribution to the economy becomes clear.

It should be noted however that as phosphate mining comes to an end, remittances from Nauru can be expected to decline in the near future and to cease in the medium to long term. Figures calculated for 1989 depict this fall with only A$65,000 being remitted in that year through the Bank of Kiribati. In response to this decline and because these external cash sources are environmentally 'friendly', it may be sound economic and environmental policy to direct resources into the Maritime School to increase recruitment and so ensure continued remittance flows.

Aid

Although the Government of Kiribati is concerned to 'work towards economic self-sufficiency ... in the long run' (Kiribati National Planning Office 1988:16), Official Development Assistance (ODA) plays a very important role in the development process.

Virtually all of the funding for the current Development Budget is to come from aid donors (Kiribati Ministry of Finance 1990), whilst in the years since independence (excluding 1979) ODA has roughly been equivalent to between 60% and 70% of Gross Domestic Product (Fig. 2).

In real terms the annual aid figure has risen from about A$9.5 million at independence to an estimate of just under A$24 million for this year (Fig. 3). If the supplementation costs, which are substantial, are added to the aid figure, actual ODA for the years 1988 and 1989 would measure A$34.3 million and A$34.2 million respectively (Kiribati Ministry of Finance 1990:4).

Remittances and aid are therefore vital in balancing the Kiribati economy's current account. This is particularly true when trade is considered. Since phosphate ceased to contribute to export earnings, the country's trade situation has steadily worsened (Fig. 4). For instance in 1979 the country enjoyed a trade surplus of A$6.3 million, but by 1988 the trade deficit measured A$21.5 million.

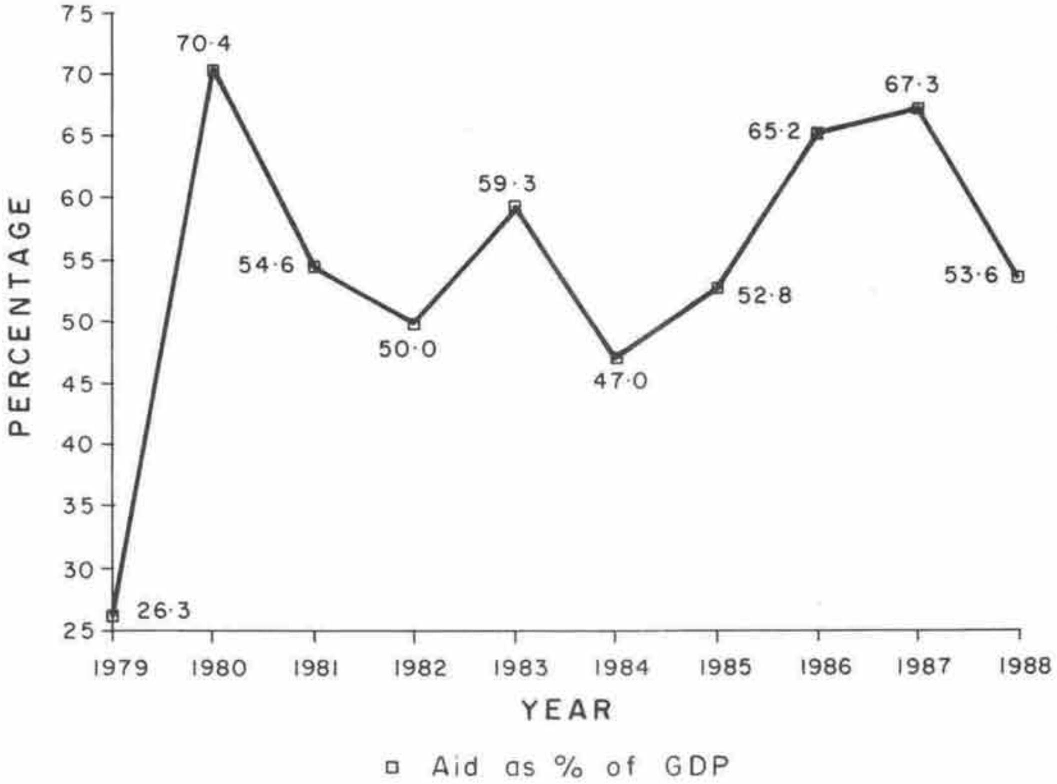


Fig. 2 : Aid as a percentage of GDP. (Kiribati Statistics Office 1989: 43).

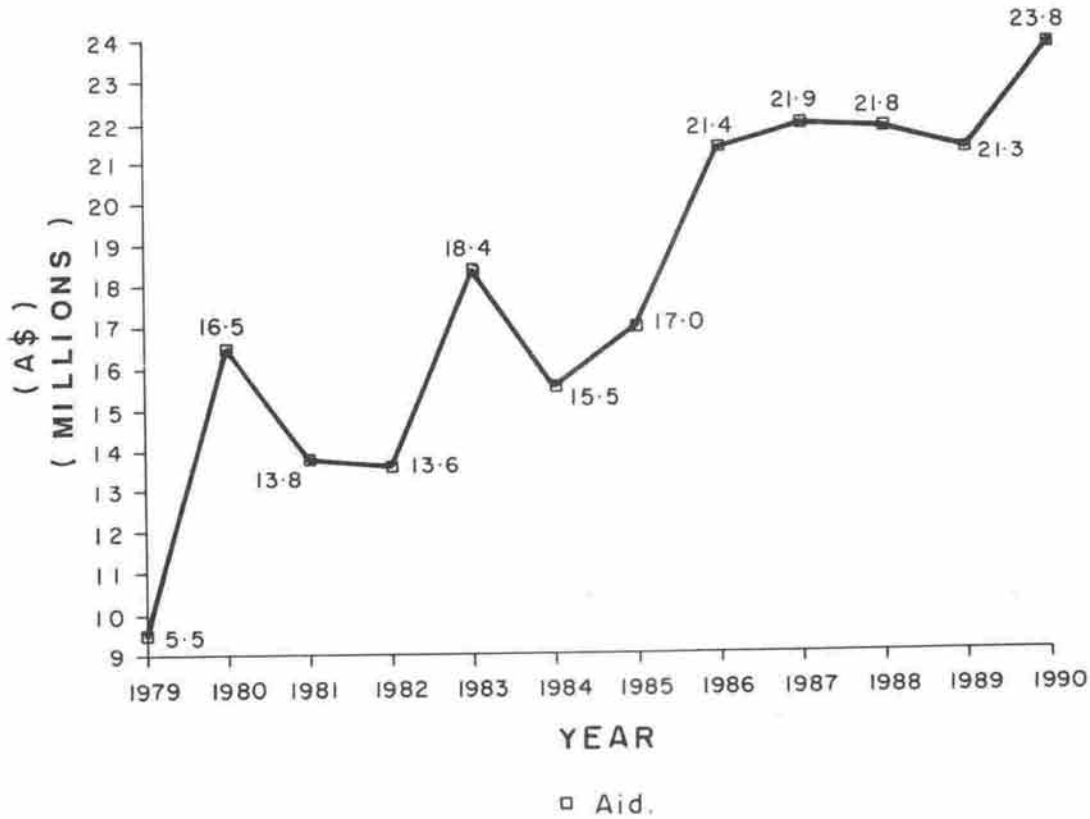


Fig. 3 : ODA to Kiribati 1979 - 1989. (Kiribati Ministry of Finance 1990:4 , Statistics Office 1989:43)

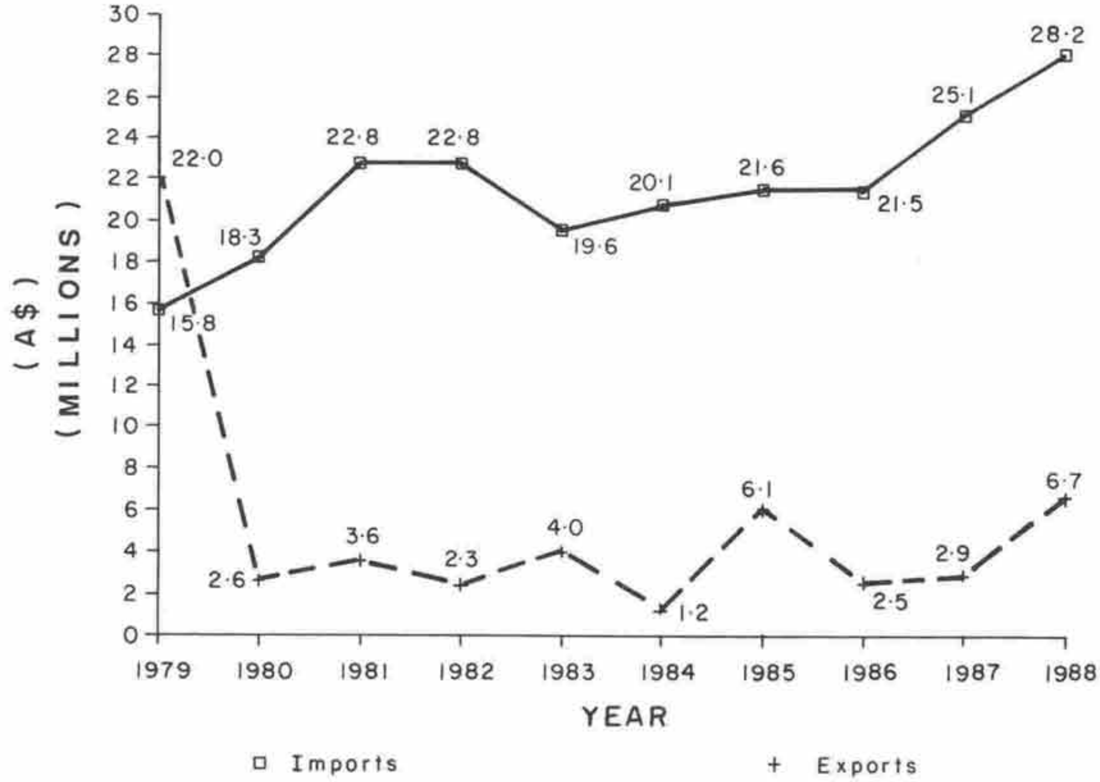


Fig. 4 : Kiribati imports and exports. (Kiribati Statistics Office 1989: 20 - 24).

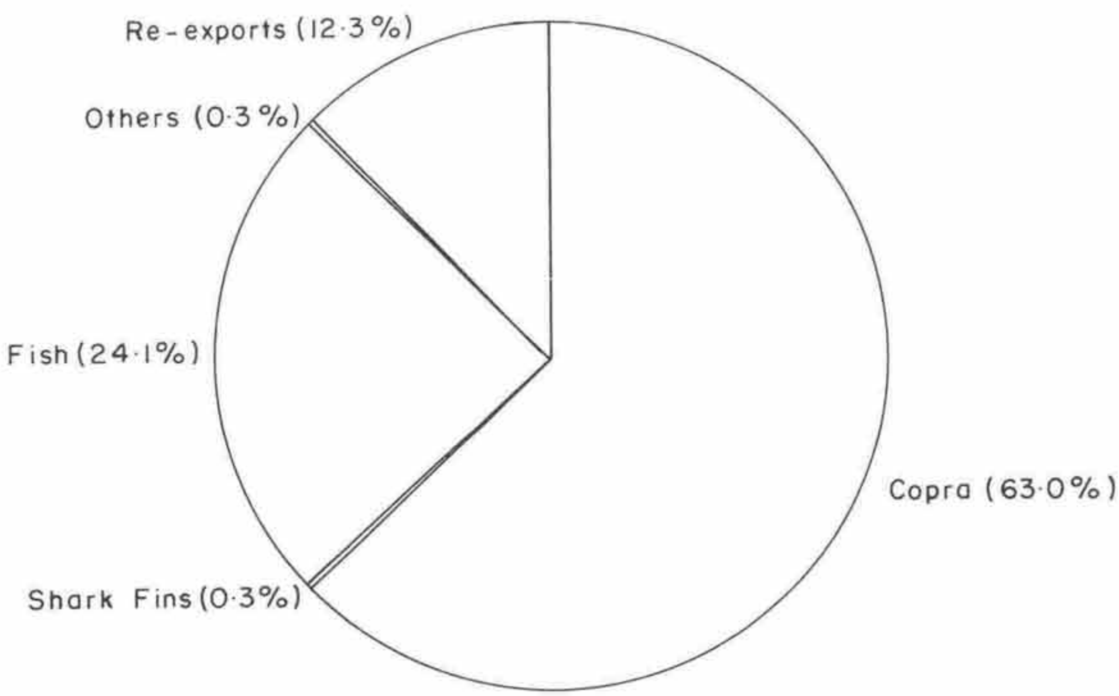


Fig. 5: Kiribati 1988 exports (Kiribati Statistics Office 1989 : 24).

The continued dominance of copra as an export and the increase in capital equipment, fuel, and food imports suggest that in the short term the conditions of trade for Kiribati will not improve (Figs. 5 and 6). In the long term, if the developments now being undertaken by government and aid donors are successful, it is hoped that this will improve.

Bureaucracy

Government plays a key role in the Kiribati economy. Apart from its important part in formulating and administering policy, the national government is crucial to the economy in two other ways.

Firstly the government is by far the largest employer; about 70% of the people in cash employment work in the civil service (Kiribati Statistics Office 1989:117). The public sector's second major role is in its contribution to gross domestic product (GDP). Since independence government economic activity has accounted for one quarter to one third of GDP at factor cost (Fig. 7) (Kiribati Statistics Office 1989:56).

Urbanisation

Urbanisation is here defined as the increase in the proportion of total population living in urban areas. In Kiribati this process has taken a special form in that urban growth and concentration has been focussed solely on South Tarawa, the capital, which accounts for 33.5% of the country's total population, 57.4% of those in cash employment and 95.4% of the registered unemployed (Kiribati Statistics Office 1989:4, 119).

As well as involving these economic and demographic factors urbanisation necessarily brings important social and cultural changes. Officers in the Lands and Survey Department mentioned the existence of a squatter problem, for example, resulting from increasing land pressure in South Tarawa.

Officers in the Social Welfare Department also spoke of important socio-cultural changes that have stemmed from the urbanisation process. Growing urban poverty, increasing signs of stress and a decline in cultural attachment to land were three such changes mentioned.

Data collected at the last census depict changes in the nature of living in urban Kiribati that underscore important social and cultural alterations. The picture that emerges is one of a fundamental movement away from traditional lifestyles. These changes will have important impacts on both the physical and human environments. For South Tarawa the average number of persons per household is 7.4 while for the rest of the country the average is less than 5. Further, while the proportion of households with 15 or more persons is almost 5% in the capital, this proportion in the rest of Kiribati is only just over 1%. (Kiribati Statistics Office 1986:204-206).

Looking at two of the major traditional activities, fishing and *baibai* cultivation, significant differences between rural and urban Kiribati emerge. Only 14.4% of the households in South Tarawa have *baibai* pits while in the rural areas 89.4% of all family units still cultivate taro. For fishing a similar pattern of movement away from traditional practices can be seen. Only 5.9% of rural households do not fish while 13.7% of households in the capital are not involved in fishing (Kiribati Statistics Office 1986:204-206).

2.8.4 Health and nutrition

Standards of health and nutrition in Kiribati have fallen over recent years in both urban and rural areas, although the rate of decline has been greatest in urban Tarawa. A diabetes and cardiovascular diseases survey (Zimmer *et al.*. 1984:18) concluded that urbanisation had been 'associated with an increased prevalence of non-insulent-dependent diabetes mellitus and impaired glucose tolerance, marked obesity, reduced physical activity, and increased consumption of refined imported foods'.

2.8.5 Tourism

Kiritimati Island is the only major tourist destination in Kiribati, serving mainly tourists from the United States and some from Japan, who are primarily interested in game fishing. Between 1980 and 1985 the numbers of such tourists rose from 400 to about 1,000, where they have stabilised (Kiribati, Ministry of Finance 1988:221).

2.9 Current environmental problems

Kiribati, and in particular South Tarawa, is already suffering a number of environmental problems which are summarised below:

1. Recent increases in population in South Tarawa have led to overcrowding, problems of disposal of rubbish, and pollution of the groundwater lens through infiltration of sewerage or effluents from domestic animal production.

2. Problems related to the disposal of toxic or non-biodegradable household and minor industrial wastes are now being increasingly recognised, and in areas of dense settlement the natural environmental value of the islands is diminishing.

3. Coastal erosion is widely perceived to be an increasing problem and shifts in sediment deposition in lagoon channels, on coral knolls within lagoons, and on the outer reef flats, are thought to be related to the construction of causeways linking the atoll islands.

4. Shortages of fresh water in the drier, southern islands are exacerbated by increasing populations, as are the similar problems associated with intermittent drought periods in the Tarawa islands.

3. GLOBAL CLIMATIC CHANGE

3.1 Previous work

It is probably noteworthy that the question which, on the 'Arrivals' card to be completed by incoming visitors to Kiribati, heads the list of reasons for visiting Kiribati is 'working with the government'. There is no shortage of consultants' reports and advice to the Kiribati Government, and some of these reports were written specifically with relevance to the question of the consequences of global climatic change and sea level rise for Kiribati.

Other reports which were written for other purposes, such as the proposal to construct causeways linking the islands of Tarawa Atoll, contain much information which is relevant to the consideration of likely greenhouse-generated environmental changes.

A report by McLean (1989) which specifically addressed the consequences of climatic change is the most relevant. This report has been (we consider unduly) criticised by some later visitors to Kiribati (F. Ngalu pers. comm.) because of McLean's cautious approach to the issue, and his clear and considered recommendation that there is time to monitor changes before setting in train a panic response to the problem.

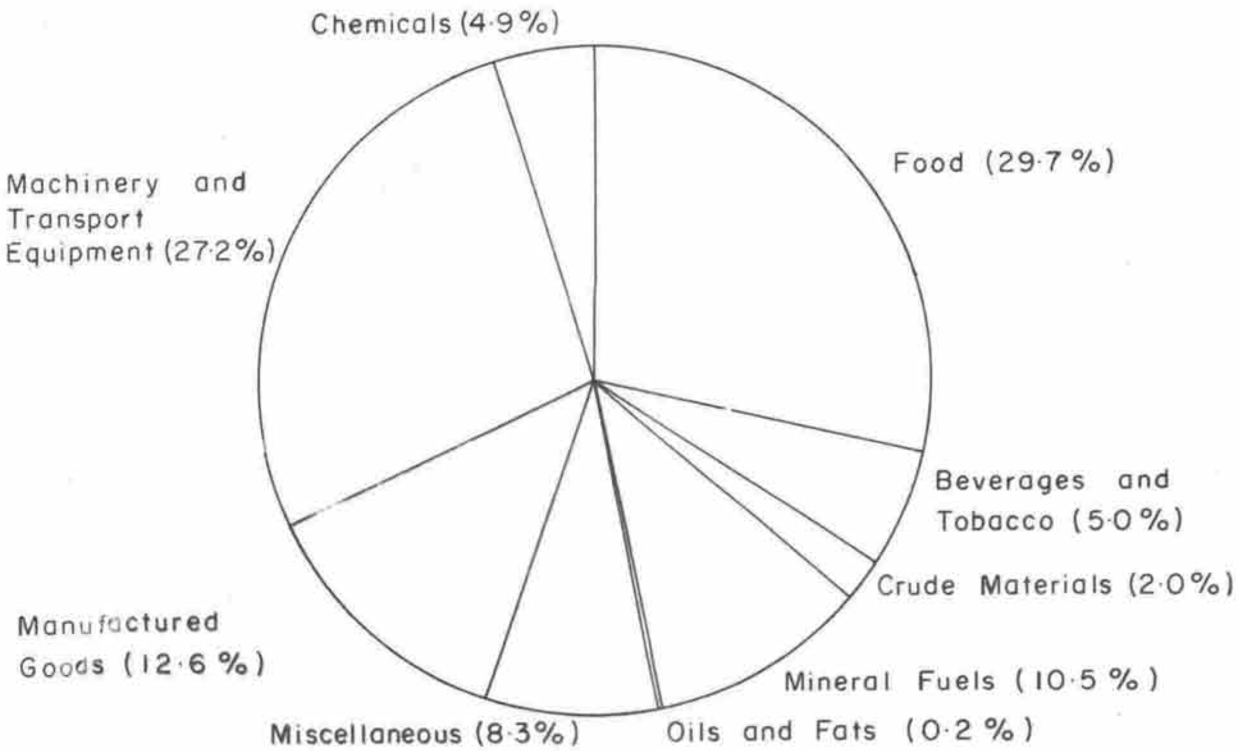


Fig. 6: Kiribati 1988 imports (Kiribati Statistics Office 1989 : 20).

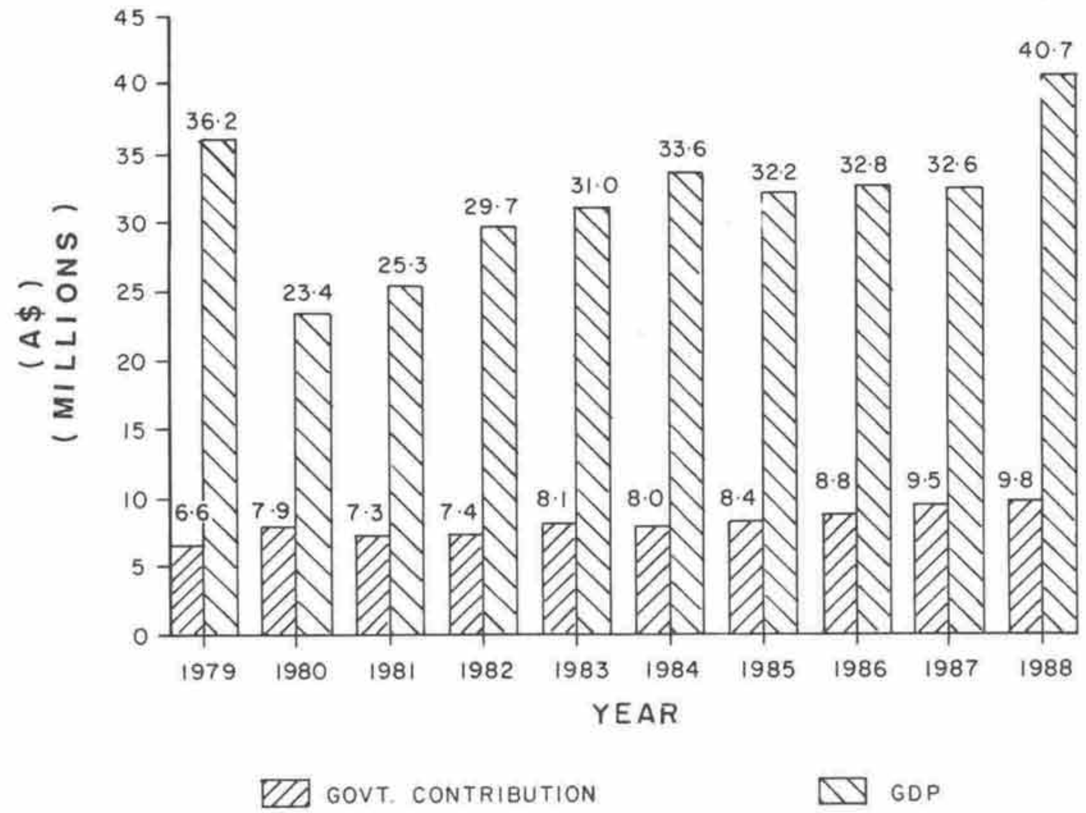


Fig. 7: Kiribati government contribution to GDP 1979 - 1988 (Kiribati Statistics Office 1989:56)

McLean used Hoffman's (1984) middle-range projection of likely rates of sea level rise, and assumed that the average overall rise by the year 2020 would be of the order of 40 cm. He also demonstrated from a preliminary evaluation of *Porites* microatoll sections, that at times in the recent past, local sea level in Kiribati has stood up to 40 cm higher than it does at present, and that the Kiribati islands will therefore certainly survive such a sea level rise.

In the light of more recent evidence on world-wide sea level rise presented at the International Panel on Climatic Change (IPCC) Management Strategy Options Conference in Perth, February 1990 (IPCC 1990), the projection used by McLean (1989) appears to be an appropriate basis for planning. Current measured average world wide sea level rise is about 1.4 mm annually. This rate could be expected to rise gradually but slightly in future, suggesting a likely sea level rise of about 25 to 40 cm by the year 2020. As pointed out by McLean (1989:11) however, this projection is merely a 'time slice', and sea level rise is likely to continue for an indefinite period beyond that time.

Other relevant studies have been carried out by Lewis (1988) for Kiribati and Tuvalu, and useful comparative studies of the likely environmental effects of sea level rise on the Maldives have been carried out by Pernetta and Sestini (1989) and Woodroffe (1989).

A programme of mapping and monitoring changes in the surface and mixing layers of groundwater lenses on the outer islands was recommended by McLean. Such a programme is already underway, as a by-product of a UNDP-UNCRD project to provide accessible freshwater from wells on the outer islands, and the results can be used to monitor sea level changes.

3.2 Projections of global climatic change

A great deal has now been written on the projected changes in climate which are likely to develop from greenhouse-induced global warming (see e.g. Hoffman 1984, Barth and Titus 1984). McGregor (1988) has summarised the likely climatic changes for the South Pacific, based on world-wide general circulation models, and has discussed various scenarios of likely climate change. Such scenarios project a likely pattern of global warming over the next 30 years which ranges from 17°C in sub-Arctic regions to about 2°C near the equator (Pearman 1988). Consequent upon this warming will be a rise in world ocean levels, brought about by both thermal expansion of the surface layers of the oceans and some melting of glacial ice (Thom 1989).

The Villach (Austria) Conference on the Greenhouse Effect in 1985 predicted a rise in sea level in the next 50 years of between 20 and 140 cm, this range being based on a number of scenarios or projections (Fig. 8) for ocean thermal expansion and the melting of mountain glaciers and polar ice (Thom 1989). Recent evidence from world-wide monitoring, has led to the general opinion amongst climatologists that the middle scenarios proposed at the Villach conference are the most likely, and many countries are now basing their physical planning decisions on the presumption of such sea level rises (see e.g. Fig. 9).

Associated with climatic warming will be changes in the general atmospheric circulation patterns. For the equatorial tropics this is likely to result in a weakening of pressure differences, and a subsequent weakening of the trade wind patterns which prevail in the near-equatorial zones. Weakening in the El Nino pattern which could accompany global warming would result in lower rainfalls throughout Kiribati, especially in the southeastern islands. At present the interactions between ocean and atmospheric circulation patterns are not well understood, but future research should enable better predictions of the likely changes in atmospheric circulation patterns.

While there is also expected to be an increase in the intensity, and possibly the frequency of tropical cyclones or hurricanes as sea surface temperatures rise, it will continue to be unlikely that cyclones will occur within 5° of the equator. The effect of increased cyclonic activity at slightly higher latitudes may affect Kiribati through increased storm surges or marginal climatic instability.

3.3 The likely impacts of climate change on Kiribati

The direct changes in climate in Kiribati are likely to be slight. Temperatures in the islands are already uniformly hot and show very little seasonal variation. That pattern would not be expected to change with global warming.

Some direct changes are however likely:

1. In his regional prediction of direct greenhouse induced climatic changes, McGregor (1990) projected that by the year 2060 for all equatorial and sub-equatorial locations in the Pacific there will be year-round conditions of severe discomfort and thermal stress.

2. Such decreases in thermal comfort, with the associated increase in heat stress while working outdoors, especially during the middle part of the day, will mean that the patterns of work, especially for outdoor workers will need to change, so that people can avoid being outdoors during the hottest three hours around mid-day. There are economic implications in this unless plans are made to gradually change outdoor working hours.

3. Another direct implication of increasing thermal discomfort is the associated increasing need for atmospheric management in urban areas. McGregor (1990) noted that some changes could be made in commercial or office building design to encourage air circulation and avoid the need for expensive and energy-consuming air-conditioning. This also requires advanced planning.

4. An increase in storm surges and higher energy wave climates generated by intensified cyclonic activity in higher latitude areas to the north and south of Kiribati.

5. A change in the pattern of temporary high sea level stands as the ENSO pattern changes. Reduction in El Nino events would decrease temporary higher sea level stands around Kiribati, and partially offset the impacts of world-wide rise in sea level.

6. A direct change in local ocean water temperatures of 1 to 2°, which may cause coral die-back. Bleaching and death of coral colonies was noted for instance in the Maldives by Brown and Dunne (1986) during a period in which the local sea surface temperature was 1 to 1.5°C higher than average, and in Hawaii (Jokiel and Coles 1990) and Indonesia (Brown and Suharsono 1990) with similar temperature rises. This suggests that Indo-Pacific coral communities are currently living near their upper levels of thermal tolerance. Such coral dieback has other implications, notably an expectable increase in the energy of coastal wave climates.

7. An expectable change in the agricultural potential for many food crops, and a consequent change in crop varieties which may be able to be grown, given a 2°C average rise in ambient air temperature (See Jacobs 1990).

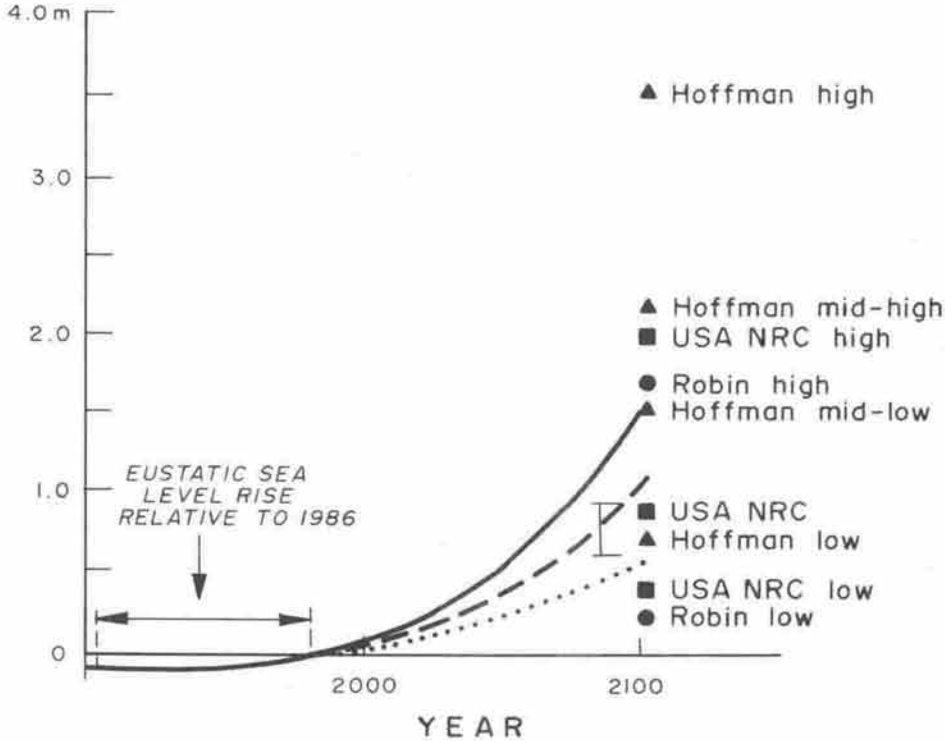


Fig. 8 : Sea level rise scenarios compiled by the USA National Research Council. (after Thom 1989)

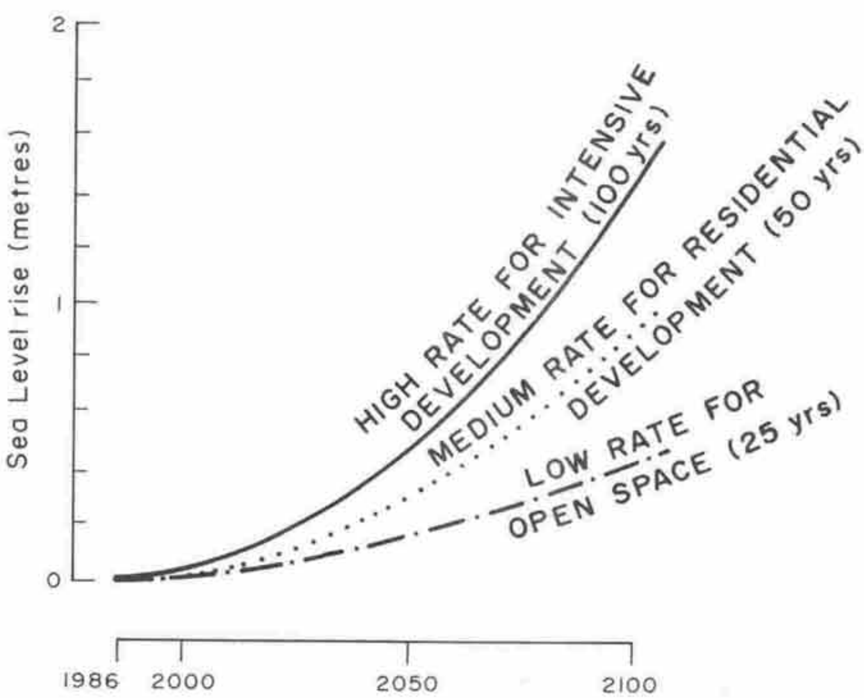


Fig. 9 : Examples of considering projected sea level rise in long-term planning. (after Thom 1989)

One of several *Porites* coral microatolls on the Buota-Tanaea reef flat. Such microatolls are suitable for use in monitoring regional sea level change.

3.4 The likely impacts of sea level rise on Kiribati

The potential impacts of sea level rise on Kiribati are far more dramatic than the direct climatic changes. Many of these impacts have been described fully by McLean (1989) and discussed briefly by Lewis (1988). Where such discussions are considered adequate only a brief summary is included here. Longer discussions are presented only where it is considered these are essential for the present report or there is some doubt or disagreement with those interpretations.

It is now clear that world wide average temperatures are gradually increasing, and world wide evidence indicates that sea level is currently rising at 1.4 to 1.5 mm annually (IPCC 1990). As pointed out by McLean (1989) however, the meteorological and ocean circulation patterns along the equator mean that sea level in this low latitude region has shown no consistent trend towards an overall rise, and that during El Nino phenomena in the recent past, sea level near Kiribati has stood as much as 40 cm higher than its current average level.

Currently equatorial sea levels do not show any evidence of a uniform rise in sea level (McLean 1989). If overall world sea levels are rising however, despite the delayed effect which is expected in equatorial latitudes, there will nevertheless be a consequent rise in sea level in the equatorial region.

As noted above, several scenarios have been advanced to project the likely rate of rise in sea level (Barth and Titus 1984, Hoffman 1984, Thom 1989). The indication from current trends is that the middle to low scenarios are the most likely, and that sea level will continue to rise at a rate of about 1.5 mm annually, or slightly faster, for the next 50 years or so. It should be stressed however that unless global greenhouse gas emissions are considerably reduced, the trend to an increasing rate of sea level rise will persist, and by a little more than 100 years from now sea level could well stand as much as 2 metres above its present level.

In view of this it would be advisable for Kiribati to take into account in all future physical planning decisions, the likelihood that sea level will be about 40 cm higher than its present level in about 30 years time. Longer term policy planning can be based on better global data than are now available, and on assessments of the results of local monitoring of the immediate Kiribati environment, but may need to take into account the possibility of continuing rises in sea level.

A number of direct consequences follow from these assumptions of short term (30 years) and possible longer term sea level rise:

3.4.1 Impact on coral reefs

The general impacts of sea level rise on reef bases and atolls have been outlined by Sullivan and Pernetta (1989). Much has also been written on rates of individual coral colonies and of coral reef growth. Many reefs in the Pacific grew upward to their present level following the rapid postglacial rise in sea level in late Pleistocene and early Holocene times, between about 15,000 and 6,000 years ago, i.e. they are 'catch up reefs' as described by Buddemeier and Smith (1988).

Growth Rates of Coral Atolls and Other Reefs

McLean (1989:15, 62) presented evidence to show that reef growth in the Kiribati atolls is similar to that in other parts of the Pacific, at about 5 to 8 mm annually. This is comparable with rates of coral reef growth summarised from a variety of locations (Sullivan and Pernetta 1989:10). Coral reef growth is primarily a response to light availability (Sato 1985) and is highest just below the surface water layers. Marshall and Jacobsen (1985) noted that coral growth kept pace with sea level rise during the most rapid rises in the early Holocene when rates of accretion were measured at 5-8 metres/1,000 years. Should sea level rise at a rate faster than 8 mm per year, then that rate slow down, or should sea level stabilise as it did about 6,000 years ago, it could be expected that reef growth would initially lag behind the rising sea level then 'catch up'.

There have been a variety of estimates of average and maximum rates of both coral growth and vertical reef accretion, and the question of maximum rate of accretion is vital to any projection of coastal process and morphological changes which occur in response to rising sea levels. Wiens (1962:90) noted that on average individual coral colonies grow upwards and outwards at about 1 metre/40 years or 2.5 metres/100 years. Reefs grow more slowly due to the compounded effects of storm damage and recovery, the interaction between the growth of coral and algal mantles and the rate of clastic sediment production to fill the interstices of the reef platform. He noted normal rates of reef growth of 0.5 to 2 metres/100 years (consistent with those later recorded by Marshall and Jacobsen 1985), but quoted extreme growth rates (1962:91) of 30 metres/100 years.

Buddemeier and Hopley (1988) pointed out that predictions of reef growth rates must take into account the structure of the reef community, and the likely occurrence of local events such as cyclones or predator attacks, which would temporarily inhibit reef growth. They noted that although rising sea levels generally favour reef growth, this growth may not keep up with predicted sea level rises due to global warming (1988:4). Buddemeier and Smith (1988) cited extremely high projections of sea level rises of 15 ± 3 mm annually over the next century, and commented that this is several times greater than the modal rates of vertical accretion on reef flats (about 1 metre/100 years), and 50% greater than currently measured maximum rates, although they acknowledged that Holocene data indicate that vertical reef growth rates of 14 metres/100 years are possible in favourable circumstances.

3.4.2 Impact on low islands

Clearly the impact of sea level rise on motu is closely related to the impact on their reef bases. As early as 1962, Wiens (1962:134) expressed concern about the fate of atolls, and low islands developed on atolls, should sea levels continue to rise at the rate then recognised. He described a likely sequence of landform changes which could be expected to occur on small atolls, and which still remain valid in the light of more recent observations. Continually rising sea levels would produce gradually rising beach ridges when sediments on the seaward side of atolls piled up, as they were pushed inwards towards the lagoon. This would result in a slope from the top of the beach ridge towards the central lagoonal depression, down which sediment could move, gradually filling the central depression, and forming new islands with swampy interiors. He noted that this effect would be exacerbated on occupied atolls by the digging of taro pits in the swampy depressions.

Wiens (1962:134) also estimated that at then recognised long-term average rates of Holocene sea level rise, most present land on atolls would be inundated, and most present reef islands destroyed within the next 5,000 to 6,000 years. He noted however that during the first half of this century the rise in sea level was higher than the long-term average, and went on to comment 'Were the earth's temperatures to increase and the sea level rise at the same rate, most atolls would be awash or at least largely comprised of saline swamps within a thousand years.' In commenting on the fate of atoll islands, he noted "... the migration of the land area lagoonward ... will probably end with their (atoll islands) being pushed back across the reef into the depths of the lagoon ...". Present projections of the rate of sea level rise are higher than those estimated by Wiens.

Such predictions appear to be based on an assumption that coral growth will not keep pace with sea level rise. It is however likely, depending on a number of biological factors, that coral growth will be able to keep pace with even rapidly rising sea levels, perhaps with changed reef composition and form, if such rises occur no more rapidly than 3 metres per 100 years.

It is possible to model the likely effects of prolonged sea level rise on low islands, based on various assumptions of coral growth rates.

Sea level rise - models of change in atolls and motu

Based on the present state of knowledge of the formation and subsequent changes in atolls and low islands, Sullivan and Pernetta (1989) presented two simple models of changes which are likely to occur on Pacific atoll motu should sea level continuously rise, or rise as much as two metres, then stabilise.

These models are based on the alternative assumptions that coral reef growth either will or will not keep up with rising sea level. This and the problem of reef dieback in water which exceeds the maximum temperature for coral growth (see e.g. Brown and Dunne 1986, Jokiel and Coles 1990), require careful monitoring to make the models useful for planning purposes. The negative effects on coral growth of increasing surface water temperature may be sufficient, in either 'keep up' or 'catch up' reefs, to maintain reef platform growth somewhat below the average tidal level. Slightly below the ocean surface, water temperatures should remain near the optimum range for coral growth, but hotter surface layers may inhibit such growth. This would ensure that reef surfaces would remain submerged below mean low water level, which would in turn mean that sediments would no longer be deposited on the reef surfaces, and island building could not continue.

Model 1. Assuming coral growth keeps pace with sea level rise

(i) Low island sediments will be swept either into atoll lagoons, where the sediment will be stored in the central depression, or off the leeward margins of platform reefs. In the case of platform reefs on a shallow shelf zone, this sediment will be stored on the leeward side of the reefs, but in deeper water conditions it will be lost to the ocean sediment sink.

(ii) Coral growth will be re-established on newly submerged reef flats, and there will be an upward and outward growth, resulting in the extension of atoll rings, and possibly the enlargement of knoll, patch and ribbon reef flats.

(iii) These reef flats may bear ephemeral low islands, but such islands are unlikely to establish stable vegetation communities or to maintain a lens of fresh groundwater.

(iv) If the sea level rise slows or stabilises, there will be a re-establishment of motu on atolls, possibly including the establishment of motu on the leeward side of lagoons due to the supply of stored sediment.

(v) There will be island growth on the leeward side of platform and ribbon reefs and a possible rapid development of motu on the windward side of such reefs if they lie downwind of reefs currently bearing motu.

(vi) The end result will be of a gain in low island land area, but in other than the current locations of low islands, and with the subsequent slow development of freshwater lenses. Biological communities, which may take 20-30 years to re-establish, will regain stability only when the rate of sea level rise falls below the rate of sediment production.

Model 2. Assuming coral growth does not keep pace with sea level rise

(i) Low islands will (a) become saline swampy islands, then (b) undergo submergence, and their sediments will be swept into atolls lagoons or to the leeward side of platform reefs.

(ii) There will be a lagging upward and outward growth of atolls and platform reefs, but at a rate insufficient to support motu development.

(iii) Island coastlines which are presently protected from storm waves by offshore atolls and motu or by wide reef flats will become subject to storm wave erosion as the protective barriers are removed.

(iv) The overall effect of this will be a significant loss of land.

For either model, should sea level continue to rise, reefs would probably 'keep up' or 'catch up', but the sandy islands on their surfaces would be severely disturbed and displaced. In situations described by such models the removal of surface sediments may be followed by the upward growth of coral, the development of submerged atoll structures, and the re-establishment of new islands. Temporary removal or displacement of the low island land is inevitable, even if a later result is the formation of a new island land mass. The social implications of this for populations resident on the motu are considerable.

McLean (1989:21, 73) proposed the development and implementation of a vulnerability index to determine the relative risk factor for small atoll islands. It is essential that further work be carried out to refine such an index, particularly for the physical attributes of the islands, to allow rational planning which might incorporate resettling populations from small highly vulnerable islands. Additional work has been carried out to develop such an index (Holthus, SPREP, pers. comm.), and this index could very well be applied to Kiribati.

3.4.3 Impact on coastlines

Increased wave height and increased storminess are both likely to cause erosion of unstable coastlines. On many islands in the Kiribati atolls coastline stability is greater than on other atoll islands because of the extensive fringe of sandy or conglomeratic beachrock, and the existence of natural beachrock accumulations (McLean 1989:31, 74). These deposits will offer temporary resistance to the erosion likely to be caused by rising sea level, but in time will themselves succumb to this erosion.

On parts of the North Tarawa coastline there appears to be an association between areas of mangrove clearance and increasing coastal erosion. This possible association requires further investigation, and if such an association is demonstrated, mangrove clearance and subsequent coastline changes require monitoring, and possibly control.

3.4.4 Impact on watertables

The complex interaction between the groundwater lens of an atoll, recharge by rainwater and tidal mixing in the layers below the freshwater cap of that lens has been described by Oberdorfer and Buddemeier (1989) and Buddemeier and Oberdorfer (1986, 1988).

In the southernmost islands of the Gilbert group in Kiribati the groundwater lens commonly becomes saline following drought periods. In the more northerly islands, including the Tarawa Atoll islands, adequate rainfall prevents this from occurring.

At present, as noted by McGregor (1989:32) and McLean (1989:49), warmer periods in the tropical Pacific are associated with positive Southern Oscillation Index values or anti-El Nino movements, and drier climatic conditions. Should this association of lower rainfall with higher temperatures persist with climatic warming, the groundwater sources of these atolls would decrease, with less rain-fed recharge, increased evaporation and increased water demand.

Should sea level rise however, the freshwater lens which floats above a mixed and saltwater base will be elevated, and its slope and head increased. This is likely to result in increased lateral saline mixing, increased evaporation through *baibai* pits and wells, increased loss of freshwater by coastal leakage, saline water being brought within the reach of coconut and other tree crop roots, or of pump intakes, and generally a loss of the freshwater resource.

Island size and elevation are also important in the development and maintenance of the freshwater lens. McLean (1989:58-60) suggested that as sea level rises island size is likely to be maintained or to increase, and with that the groundwater lens is likely to be conserved or enlarged. One conclusion of McLean's report that warrants further investigation is whether fresh groundwater lenses will in fact withstand such a sea level rise. Should such a rise be accompanied by increased storm surges, which will favour island building, such wash processes will render groundwater saline until a state of stability returns. Such stability is possible only if sea level rise ceases.

Atoll island growth however involves the deposition of coral rubble onto the existing base through storm wave activity. Should such islands grow it is likely therefore that saline stormy waves will in fact deposit sediments onto the islands, but in doing so will exacerbate salt water intrusion into the aquifers from above. Should such island building reach a level of stability then cease, the layered groundwater lens would be expected to resume its normal form, however in the intervening period, or while sea levels continue to rise, it is likely that groundwater lenses will be rendered saline.

Monitoring of lens surface and mixing layer levels will be necessary to ascertain whether sea level rise is occurring, and whether it is affecting the groundwater lenses on the Kiribati islands.

3.4.5 Impact on land use

Agriculture, including the subsistence production of *baibai*, coconuts, breadfruit, paw paw, and the commercial production of copra are highly dependent on fresh groundwater supplies. Similarly, water for domestic purposes is mainly taken from groundwater aquifers. Any change in groundwater resources would have a profound impact on land use in Kiribati.

Many of the settlements in Kiribati are located on or near the coast. Increased coastal erosion may make re-location of houses necessary. This would be most difficult in the densely populated areas of South Tarawa such as Betio and Bairiki. In addition any removal of subsistence land or garden areas by increased coastal erosion would be of vital importance here.

3.4.6 Impact on engineered structures

Sea walls, wharves, slipways and causeways are all threatened by rising sea level, as are associated port facilities, roads and other infrastructure.

In addition possible changes in current patterns which may occur with ocean surface warming could weaken or even reverse present nearshore circulation. These changes could have the effect of re-circulating sewage from ocean outfalls back towards the coastline, or changing the patterns of sediment movements. Such potential impacts also require monitoring.

3.4.7 Impact on fishing zones

Very little has been done to model the complex current systems which circulate at ocean-wide and local scales in the Pacific. Fishing areas are closely tied to ocean circulations, zones of upwelling and tidal change areas.

It is important that the Kiribati government authorities remain informed on the modelling being carried out in Hawaii, Australia, New Zealand and through the GEMS programme.

4. FUTURE ENVIRONMENTAL PLANNING IN KIRIBATI

There is currently no active policy or initiative for environmental planning or environmental management in Kiribati. Two government departments (Home Affairs and Decentralisation and Natural Resource Development) currently carry out functions which incorporate aspects of environmental management, but there is no single authority responsible for environmental management. There is similarly no stated policy of environmental protection, although this may be implied by the stated policy of sustainable resource use (Kiribati 6th National Development Plan, 1988). There is a stated policy of conservation of biodiversity, and the schedule of laws which relate to pollution and conservation, and would affect implementation of this policy, are set out in Appendix III.

The Ministry of Home Affairs and Decentralisation has taken the lead role in concern over possible climatic change and future sea level rise, and as such has demonstrated an active interest in that aspect of environmental planning. A decision has recently been taken to broaden these concerns, and to include other co-ordinating functions of environmental planning and management within this Ministry. The Ministry is also responsible for the co-ordination of projects on the outer islands, and with welfare issues, and encompasses the Lands and Survey (i.e. physical planning) branch of government. This Ministry could therefore be considered to be the appropriate one to co-ordinate all future environmental planning and management.

As all resources are however part of the environment, and as management of resource development is one aspect of environmental management, it is clear that the Department of Natural Resource Development is already involved with environmental management. This is particularly the case in view of that Department's current involvement with the Tarawa-based Atolls Research and Development Unit of the University of the South Pacific (USP), other USP Departments, and the US Government, in a planned resource management and environmental planning programme for Tarawa (Kiribati 1990). It will therefore be necessary for the Ministry of Home Affairs and Decentralisation, in dealing with environmental management on a national scale, to work in close co-operation with the Ministry of Natural Resource Development on that and other specific projects.

In this respect the Atolls Research and Development Unit would be an appropriate place to locate laboratory-based monitoring studies, and consultants working on environmental planning programmes. If an environmental planning unit is set up in the near future within a Kiribati Government Ministry, that unit would not only develop policies and strategies, but would require research and monitoring to be carried out within the programmes it designed. Such research would probably be commenced or carried out entirely by overseas scientific consultants or advisers. These people would require a research base, laboratory and computer facilities, secretarial assistance, and access to technical assistance. It is clear that the USP's Atolls Research and Development Unit would be the most appropriate base for such scientists to work. Discussions with the Unit's Director revealed that appropriate facilities are available and that the Unit would be very happy to have such consultants and researchers based there.

Close co-operation by people engaged in a range of environmental studies, the focussing of aid-funded equipment into this Atolls Research and Development Unit, and close interaction between Kiribati government departments and the Atolls Research and Development Unit could strengthen that institution, and make Kiribati the centre of worthwhile atolls research in a number of fields. This would be of mutual benefit to Kiribati and to other Pacific atoll nations. It would be helpful to have the Project Officer responsible for the environmental planning unit on the advisory board of the Atolls Research and Development Unit.

5. RECOMMENDATIONS

5.1 The in-depth study

During our discussions with the Minister of Home Affairs and Decentralisation, and with senior administrators from this and other Ministries, all I-Kiribati participants made it clear that they did not believe an in-depth study carried out entirely as a consultancy by a team of overseas experts would be particularly useful to Kiribati. Instead they suggested that such a team of experts should be advisers to an I-Kiribati co-ordinator within a government unit.

What is proposed here is therefore an 'action plan' to set up an environmental planning and/or management unit within the government administration, with responsibility for all environmental planning, including the impact of likely sea level rise. On this basis we make the following recommendations:

1. That an Environmental Planning Unit be set up immediately within the Ministry/Department of Home Affairs and Decentralisation. This Unit would be responsible for formulating and implementing a programme of environmental planning and management as set out below.

   As the Unit would both contribute to productive land use decision-making, and save expenditure by discouraging unwise or poorly planned development, it would therefore fit within the Kiribati Government's stated first planning priority.

   Steps should therefore be taken by the Ministry of Home Affairs and Decentralisation to have the establishment of this Unit, and its work programme of environmental planning and management, included in the next (7th) National Development Plan.

2. That this Unit be staffed initially by:

   (a) One I-Kiribati Project Officer, this position to be funded by the Government of Kiribati. The Project Officer will need to have, or to undergo, training to at least Bachelors Degree level in an environmentally oriented programme.

   (b) One expatriate contract officer, a Scientific Adviser, to be funded externally for a total of 12 months over a 3 year period, who will initially take responsibility for advising on environmental planning, and who will simultaneously assist in training the I-Kiribati Project Officer to take over this role.

3. That the policy, strategy development, and other functions of this Unit include:

   (a) To determine environmental planning policy.

   (b) To determine (if necessary using expert advice) short term (up to 5 years) and long term (30 to 50 years) strategies for implementing such policies, including strategies which will take into account the likely impacts of predicted global climatic changes and associated sea level rise.

   (c) To develop, in consultation with other departments concerned with the collation of natural resources data, with sustainable resource use planning, and with the locations of sites of cultural significance, a National Conservation Strategy, and hence to identify both land and marine areas (particularly in the Phoenix or Line groups) requiring special conservation status or management planning, because of their natural or cultural values.

   (d) To develop regulations for development planning which require private developers and government agencies to take into account environmental concerns in their proposals for new developments and in ongoing works proposals.

   (e) To liaise with other relevant departments on the possible development of eco-tourism in Kiribati, and hence the potential for environmental conservation to contribute directly to the cash economy of Kiribati, as well as ensuring the controlled use of conserved areas.

   (f) To liaise with other relevant Departments and Institutions on all aspects of environmental planning and monitoring, including: meteorological and tidal level data which are collected by external agencies operating networks of recording stations (TOGA, Hawaii; Governments of Australia and New Zealand), locational information on sites of traditional cultural significance, and of archaeological sites.

   (g) To liaise with curriculum advisers on the design of an 'environmental change' module which could be introduced into the primary school curriculum's environmental studies course.

   (h) To act as the focal point for regional environmental institutions or organisations e.g. SPREP, SOPAC, and participate in meetings and appropriate training courses as offered by such institutions and organisations.

4. That where possible associated essential environmental research and monitoring be carried out by researchers seconded from South Pacific universities or other research institutions, and their projects be co-ordinated through the Environmental Planning Unit. Such researchers could be based at the Atolls Research and Development Unit, where they can work in close collaboration with people engaged in projects identified by that Unit (see Appendix IV) and in a South Tarawa environmental monitoring project.

   Projects which require immediate consideration include:

   (a) Establishment of sea level monitoring stations specifically for Kiribati locations. McLean (1989:65, 72) suggested the use of *Porites* microatolls as the basis for such monitoring, and the methodology for such monitoring has been described by Woodroffe and McLean (1990).

   Such microatolls record changes in mean sea level, and are therefore excellent recorders of sea level change. The use of such corals rather than of calibrated tidal gauges means that tidal height at the time of measuring is not important, and that no particular or fixed interval of recording is necessary. Sites should be chosen, and such monitoring should be put in place as rapidly as possible. Numerous *Porites* microatolls were observed on South Tarawa, and there should be no difficulty in choosing appropriate monitoring sites throughout the country.

   In addition, tidal gauges should be set up within atoll lagoons, to observe changes in relative water levels inside, and outside the lagoons, especially on atolls where causeways are being constructed, which may encourage banking up of water inside the lagoons.

   (b) Monitoring the change in the extent of mangroves. This could be done using air photos to establish recent changes due to clearing of mangroves, and by ground surveys to establish the rate of present clearing. Associated areas of coastal erosion should be mapped at the same time.

   (c) Coastal erosion monitoring. This can be done using air photos, and repeated ground transects. Data for South Tarawa can be correlated with those collected by SOPAC in the Bairiki-Betio areas.

   (d) Establishing an index of vulnerability to sea level rise, based on physical environmental factors. Although there are socio-economic implications for loss of land, in the first instance it is important to focus attention on areas likely to respond early to any sea level rise.

   (e) Water lens monitoring, for level and salinity changes.

It is apparent that many Government Departments and Statutory Authorities have a direct interest in environmental planning and management issues, and that others will inevitably be involved in assisting with monitoring studies, with surveying, with physical planning decisions and in liaison with researchers and advisers.

We also therefore recommend:

5. That the Environmental Planning Unit have an Advisory Board, chaired by a representative from the Ministry of Home Affairs and Decentralisation, with members from other Government Departments or Branches and Statutory Authorities e.g. Finance and Economic Planning, Lands and Survey Branch, Works and Energy (Engineering, Water Management, Public Utilities Branch), Department of Natural Resource Development (Agriculture, Fisheries, Management), Meteorological Office, Atolls Research and Development Unit.

Protective walls of coral rubble constructed on the seaward shoreline of North Tarawa as protection against coastal erosion. Cemented beachrock can be seen on the beach in the upper photograph.

Protective walls of coral rubble constructed on the lagoon shoreline of North Tarawa as protection against coastal erosion, commonly in areas of mangrove clearance.

5.2 Remarks on the role of the environmental project officer

5.2.1 The institutional setting

The Kiribati civil service is characterised by a small number of ministries each with a large number of functions or portfolios. The Ministry of Home Affairs and Decentralisation, for example, has no less than 15 functions within its area of responsibility. What this means in effect is that government officers are called upon to perform a wide range of often quite different tasks. The difficulty of giving adequate attention to particular issues in such a situation is exacerbated by staff shortages within the bureaucracy.

It was recommended above that the Environmental Planning Unit be a discrete body whose staff concentrate as much as possible on the functions of the Unit and not on other more general concerns of the Ministry. It is particularly important that the efforts of the staff be focussed during the setting-up phase of the project because it is during this period that the success or otherwise of an environmental programme will be determined.

It is clear that any unit set up within a Government Ministry to deal specifically with environmental planning and management issues will involve extensive liaison with other Ministries on wider issues of concern, and such liaison functions are set out in the recommendations above. It should however be stressed that all authority for the Unit will rest with the Ministry of Home Affairs and Decentralisation. The functions of the Environmental Project Officer will need to take account of the following:

5.2.2 Environmental planning

Much sound environmental planning has implications for dealing with existing problems which are likely to be exacerbated by any rise in sea level. These include short to medium term planning for the sustainable use of fresh groundwater supplies, and plans to deal with increasing coastal erosion. Steps taken now to protect fresh groundwater sources by moving wells from the coastal fringes of the islands to locations further inland will ameliorate the effects of rising saline watertables should sea level rise. Similarly, well-planned coastal protection works, such as the use of sloping deposits of loosely packed uncemented rubble rather than vertical gabion baskets or solid vertical sea walls, and plantings of protective coastal shrubs such as *Hibiscus*, and *Scaevola* and trees such as *Casuarina*, *Pandanus*, *Barringtonia* and *Terminalia* (Thaman 1987, 1989b, 1990a&b, in press) behind the backbeach or along beachridges, will later assist in combatting the expected increased shoreline erosion which would accompany any rise in sea level or change in meteorological patterns.

5.2.3 Environmental monitoring

McLean (1989) has set out a simple and logical monitoring programme to assess local sea level changes, using coral micro-atolls. This monitoring should be set up as soon as practicable under the co-ordination of the Environmental Project Officer, in close co-operation with officers from the Ministries of Natural Resource Development and Works and Energy.

Relevant information on the impact of intermittent climatic phenomena such as El Nino-Southern Oscillation (ENSO) events in Kiribati is provided by Howorth (1983), who has also demonstrated (n.d., 1985) that marked shoreline oscillations have occurred on Kiribati over the last 50 years, and that these can be mapped using sequential air photographs from 1945 and 1980s, as well as by using anecdotal evidence.

In order to understand the direction of future changes in coastline erosion, it is necessary to record historical changes. A programme of interviewing older village residents could enable dates to be assigned to changes identified from air photos. Byrne, Riedel and Byrne (n.d.) also present useful data, albeit with unlikely explanations.

Near the equator, where the projected temperature rise for the next 30 years is unlikely to exceed 1 to 2°C, only extremely sophisticated climatic monitoring procedures would be capable of identifying average temperature increases which might be taking place within the pattern of normal daily and seasonal temperature variations. Humidity may change more noticeably than temperature, but it is also likely that this will also be difficult to detect over the short term. Coastal wave climates which may change in response to changes in global atmospheric and ocean circulation patterns are likely to be a better indicator of impending global climatic changes.

Monitoring of fish catches in the zones customarily fished - the lagoon, the reef zone, the deeper ocean off the reef (see Teiwaki 1988) - will help to indicate changes in these environments with respect to both water depths, and the ability of coral reef growth to keep up with any rise in sea level. Such monitoring will also provide useful information on over-exploitation of target fish species.

5.2.4 A national conservation strategy

Developing such a strategy would be a long term aim of the Environmental Planning Unit. Production of such a strategy would require a comprehensive data base on the country's natural and socio-economic resources, and an established environmental planning policy. Although no systematic work has been carried out for this purpose there is an extensive literature on which to base further research. Work by Luomaua (1953) and Catala (1957) provide details on the human ecology and ethnobotany of the Gilbert Islands. Small (1972) has summarised the agriculture of the Gilbert Islands, and Thaman (1987), Overy *et al.* (1982) and the Nature Conservancy (USAID 1988) have compiled detailed lists of the plant resources and the threats to the maintenance of biological diversity in Kiribati. In addition, the Applied Atoll Research for Development Consultation held in Tarawa in 1989 outlined a number of areas for resource management research and management strategy planning for Kiribati which would be important in the development of such a conservation strategy, and these are listed in Appendix IV.

5.2.5 Contingency planning for most vulnerable areas

One early task in the work of the Project Officer will be to complete a vulnerability assessment for whole islands, or for particular sectors of the coastline on larger islands. Should there be indications of increased climatic instability, whether or not this can be definitely related to global warming or sea level rise, early contingency planning for effective coastal protection of such areas on islands supporting major infrastructure, or on large (refuge) islands will be necessary, and sources of funds identified.

5.2.6 Education

All rational evaluations of the present evidence for global climatic change and sea level rise conclude that the projected changes will become noticeable over a period of approximately 30 years from now. An implication of this is that there is no cause for panic, or for immediate widespread advertisement of impending sea level rise which could cause obliteration of the Kiribati island groups. Broad scale environmental planning, which can encompass consideration of the likely effects of a sea level rise of about 50 cm in the next 30 years, is however essential.

This should be coupled with an educational programme on environmental change and human impact on the environment, aimed at primary school children. Such a topic would fit into the environmental studies courses already taught at this level (Tautua 1985), and could introduce the concept of the greenhouse phenomenon and its likely impacts, along with other problems such as land degradation and waste pollution to the children who will later have to take the steps being planned now. This concept was discussed with Mr Nakibae Mera and Mr Tiaoti Itaia of the Tarawa Teachers' College, and we were shown the Teachers' Guides for this course, prepared by a group of Tarawa teachers, and a USP-SPREP-UNEP adviser. The climatic change and sea level rise concepts could be introduced into this syllabus in the existing units on climate, plant physiology, waste disposal and pollution, the water cycle, and in various sections which deal specifically with Kiribati and world land uses. Considerable relevant resource material can be made available through SPREP-UNEP, and if necessary, slight modifications made to the next issues of the Teachers' Guides. Advice on updating all aspects of this curriculum should also come from the Environmental Planning Project Officer.

5.3 Personnel for in-depth study

5.3.1 Kiribati Government personnel and services

The establishment of an Environmental Planning Unit would involve a commitment to the creation and maintenance of initially one, and perhaps after three years a second position for a Project Officer. Ideally the initial appointee would be a graduate with training in an earth science or in general environmental science as well as some socio-economic training, and the second appointee would either be a graduate in an ecological discipline or in a socio-economic discipline.

It would also involve the compilation and maintenance of computerised registers of areas of natural or cultural significance and of the results of monitoring programmes, facilitation of monitoring programmes, and access to vehicles, maps, air photos and cartographic services.

5.3.2 Proposed UNEP consultants

It is envisaged that this consultancy would commence as soon as the Kiribati Government established the position of Environmental Project Officer, who would co-ordinate the programme. Consultant Personnel:

1. Scientific Adviser. An expatriate consultant selected by the Ministry of Home Affairs and Decentralisation and UNEP, and formally recruited by UNEP.

2. Technical Experts. Expatriate consultants, selected jointly by the Ministry, Scientific Adviser and UNEP, and formally recruited by UNEP.

3. Technical Trainee. An I-Kiribati trainee, selected by the Ministry, Scientific Adviser and UNEP, and formally recruited by UNEP to assist with monitoring and mapping projects. This trainee should undertake relevant undergraduate studies, and would hopefully become the second Project Officer in the Environmental Planning Unit after the completion of these studies.

Other support staff or trainees may be locally recruited to the project, as considered appropriate by the Kiribati Government.

Duties of the Scientific Adviser

- To advise on the framework and methodology for developing both a programme of national environmental planning and management, and a National Conservation Strategy.

- To advise on setting up a framework for recording sites, areas or features of biological or natural area significance.

- To advise on setting up a system of recording sites or areas of cultural or traditional significance.

- To advise on a programme of monitoring environmental change, and on the recruitment of appropriate expatriate technical experts.

Duties of the Technical Experts

Specific expertise has been nominated for the Technical Experts described below. It should be noted however that the skills required for these shorter-term consultancies will be dependent on the special expertise of the Scientific Adviser. Should that Adviser have skills for instance in coral reef geomorphology or biology, one Technical Expert may then need to be a bio-climatologist or meteorologist. While the framework set out below is a likely one, this element of variability should be kept in mind.

1. Coral reef expert

This specialist should be available for two periods during 1991 and 1992 to:

(a) Initially set up, and later evaluate, and if necessary modify, a project for monitoring microatoll response to sea level change, and to train the Technical Trainee in this monitoring procedure.

(b) Set up a shallow water mapping programme, using low level air photography or satellite imagery, to establish a baseline which could be used by the Environmental Project Officer in ongoing studies of changes in reef height and morphology.

2. Physical Geographer or Environmental Scientist

This specialist should be available for two periods during 1992 and 1993 to:

(a) Carry out analyses of past air photographs, to consult appropriate reports (including SOPAC reports for South Tarawa) held by PWD, and to map coastline changes since 1945.

(b) Work with the Technical Trainee and Project Officer in setting up an index of biophysical vulnerability for individual islands, and train these people in applying the index in Kiribati.

(c) On the basis of this index, on a second visit to Kiribati, work with the Environmental Project Officer to plan protection strategies for the most vulnerable coastal locations, initially on the more developed islands of South and North Tarawa and Kiritimati.

3. Geohydrologist

This specialist, who would hopefully have worked either on the hydrology of Kiribati, or on the hydrology of similar atoll based islands, should be available in 1992 to:

(a) Collate information derived from the current UNDP study on groundwater lens surfaces and estimated volumes.

(b) Extend that study as necessary, to define mixing levels, to establish a monitoring system for groundwater bodies, and to train the Technical Trainee and Environmental Project Officer in its application.

5.4 Workplan

1990

Establishment of the Environmental Planning Unit in the selected Government Department, and recruitment of a Project Officer. Selection of Scientific Adviser.

1991

January to June Scientific Adviser to work with Environmental Project Officer on setting up and defining the initial tasks to be undertaken within the Environmental Planning Unit. Selection of UNEP Technical Experts 1 and 2, and the I-Kiribati Technical Trainee.

October to November Technical Expert 1 to work with Environmental Project Officer and Technical Trainee to establish the sea level change and reef monitoring networks.

1992

February to April Technical Expert 2 to work with the Environmental Project Officer and Technical Trainee on the commencement of coastline mapping, selection of the coastal erosion monitoring localities and the design or modification of the vulnerability index.

April to July Scientific Adviser to return to Kiribati to evaluate the Unit's work to this time, and to continue to work with the Environmental Project Officer on the Unit's ongoing programme.

September to October Technical Expert 3 to work with the Environmental Project Officer and Technical Trainee on establishing groundwater surfaces, estimating lens volumes and establishing hydrological monitoring programmes.

November Follow-up visit by Technical Expert 1 to evaluate, and if necessary modify, the sea level and reef flat monitoring programmes.

1993

February and March Follow-up visit by Scientific Adviser to continue working with the Environmental Project Officer on the general functions of the Environmental Planning Unit.

February Follow-up visit by Technical Expert 2, to advise on and commence application of the vulnerability index.

Technical Trainee to leave Kiribati to commence an appropriate undergraduate university programme.

5.5 Budget

There has been no attempt to design an actual budget for this programme, but the items of expenditure being requested from UNEP are listed below, with general cost estimates [in Aus $]:

Trainee salary and field costs over 2 years (to be followed by further university training costs not included in this estimate). $20,000

Consultants fees, 20 to 24 person-months total time, and in addition fares for eight individual visits to Kiribati, and subsistence/fieldwork costs for the 20 to 24 months total person-time. $200,000

Costs of computerising both monitoring and data storage systems, provision of an appropriate vehicle, monitoring equipment and air photography. Housing and transport costs, including outer island travel. $80,000

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APPENDIX I

PROPOSED ACTION PLAN

ACTIVITIES TO BE COMPLETED BY END OF 1990

1. Establishment of an Environmental Planning Unit in the Ministry of Home Affairs and Decentralisation.
2. Identification of Environmental Project Officer.
3. Identification, and appointment by UNEP, of Scientific Adviser for Environmental Planning Unit.

ACTIVITIES TO BE COMPLETED WITHIN THREE YEARS

1. Outlining of a broad framework of Environmental Planning Policy.
2. Setting in place monitoring programmes for sea level changes, and changes to the reef platforms.
3. Setting in place monitoring programmes for coastal erosion and shoreline change.
4. Completing a vulnerability assessment for all the islands of Kiribati.
5. Setting in place monitoring programmes for groundwater resources on all outer islands, and for obtaining similar data for South Tarawa.
6. Liaison with Meteorological Officers on the collation of information on the meteorological patterns which directly affect Kiribati, on any trends or changes in those patterns, and on establishing a system for maintaining and updating this information.
7. Commencing a resource evaluation and data collation for both the terrestrial ecosystems and coral reef ecosystems of Kiribati. This would involve liaison with Ministries of Natural Resource Development, and Line and Phoenix Group, and with the Atolls Research and Development Unit, as well as scientists from several overseas institutions.
8. Liaison with Department of Culture to establish a geographically-based system of collating information on the location and significance of sites of traditional, cultural and archaeological value.
9. Liaison with Department of Education curriculum developers and interested people from other Government Departments to set up an environmental education programme which would include aspects of human-induced environmental change, including greenhouse-induced changes.
10. Outlining a framework for development control of both private and government projects, by drafting requirements for appropriate environmental assessment of any major development in its planning stage. This would eventually result in requiring Environmental Impact Assessments for all major construction and resettlement projects prior to their implementation.

11. On the basis of the vulnerability survey and the preliminary resource assessments, identify areas of terrestrial and marine ecosystems worthy of conservation area status, and draft management plans for their protection.

12. Commence preliminary planning and the development of strategies to cope with projected long-term environmental changes, including climate changes and changes in sea level.

ACTIVITIES TO CONTINUE BEYOND THREE-YEAR PROJECT PERIOD

1. Production of a Draft Environmental Policy to be forwarded to the Government in the form of a (Draft) Environmental Planning Act.

2. Production of a (Draft) National Conservation Strategy for Kiribati, for Government approval.

3. Production of a (Draft) Environmental Planning Policy and associated Regulations, to be forwarded to Government for enactment.

4. Ongoing monitoring of environmental parameters which would indicate climatic change or changes in sea levels

5. Development of long-term plans and strategy options to deal with irreversible environmental changes occurring as a result of global climatic change and associated sea level rise.

6. Management of regulations set in place which concern environmental management, conservation site or area management and development controls.

APPENDIX II

PROGRAMMES OF THE VISIT TO KIRIBATI

Tuesday 17.4.90. The two team members met at the University of the South Pacific, Suva, for discussions, and to collate relevant background information on Kiribati.

Wednesday 18.4.90. After a delayed start caused by a leaking fuel line, the two consultants travelled from Nadi to Tarawa via Funafuti, on Air Marshall Islands, arriving at 4.30 pm. Met by Mr Francis Ngalu (MHAD) and taken to the Otintaai Hotel, Bikenibekeu.

Thursday 19.4.90. Visits were arranged as follows:

10.00 Courtesy call and discussions with Hon. Mr Babera Kirata, Minister of Home Affairs and Decentralisation.

11.00 Discussions with Rural Planner, MHAD, Mr Geoff Habgood.

14.00 Discussions with Chief Engineer, Public Works Department (PWD), Mr Paul Schutz, and UN Volunteer Hydrogeologist, Mr Dan Jenkins.

15.00 Discussions with Meteorological Officer, Mr Uarai Konetiti.

Friday 20.4.90. Visits were arranged as follows:

09.00 Discussions with Chief Agricultural Officer, Department of Natural Resource Development (DNRD), Mr Roti Teaotai.

10.00 Discussions with Fisheries Officer, Mr Tukabu Teroroko, DNRD.

11.00 Discussions with Project Planning Officer, Ms Reina Timau, and Economic Planner, Ms Rose Sinclair, Department of Finance and Economic Planning (DFEP).

14.00 Discussions with the Head, South Pacific Marine Services (SPMS).

15.30 Visit to Statistics Office (DFEP) to obtain published census and other statistical data.

Saturday 24.4.90. Visit to North Tarawa, by boat. Visit Government Station, Travel along the island by motor-cycle, visiting selected shoreline areas.

Sunday 26.4.90. Inspection of reef flats and coastal landforms near Bikenibeu (Sullivan).

Monday 23.4.90. Visits, accompanied by Mr Beniamina Kiboboua, were arranged as follows:

09.30 Discussions with Secretary for Works and Energy, Mr Marae Irata.

10.30 Discussions with Manager, Public Utilities Branch, Mr Natara Biribo and AIDAB Water and Sewerage Adviser, Mr Peter Newhouse.

11.30 Discussions with A/Chief Lands Officer, Mr Tiriata Betero and A/Chief Land Surveyor, Mr Erene Nikora.

14.00 Discussions with the Principal, Tarawa Teachers' College, Mr Nakibae Mera and Environmental Studies Curriculum Planner, Mr Tiaoti Itaia.

Tuesday 24.4.90. Visits, accompanied by Ms Kamwea Atauea, were arranged as follows:

09.00 Discussions with Second Secretary, Transport and Communication, Mr Rubetaake Taburuea.

11.00 Discussions with the Manager, Mautari Company.

14.00 Discussions with Director, Atolls Research and Development Unit, Mr Anote Tong.

Wednesday 25.4.90.

09.00 Discussions with Permanent Secretary, Nakibae Teuatabo, and Senior Assistant Secretary, MHAD, Mr Francis Ngalu.

14.00 Discussions with Social Worker, Mr Paul Coulson (Gibson).

Visit to reef flats near Buota and Tanaea (Sullivan).

Preparation of draft discussion document.

Thursday 26.4.90.

Discussions were held with Hon. Mr Babera Kirata, Mr Nakibae Teuatabo and Mr Francis Ngalu, about the report to the Kiribati Government.

Friday 27.4.90. Depart Tarawa for Nadi.

APPENDIX III

KIRIBATI LAWS RELATING TO BIODIVERSITY CONSERVATION

Harbours Ordinance 1957

Prohibits the discharge of any sewage or other filth into a harbour. Regulations prohibit the discharge of any oil into a harbour from either shore installation or ship.

Fisheries Ordinance 1959

This ordinance provides for the regulation and conservation of fisheries resources. Foreign vessels may not fish in territorial waters without a licence. Explosives and poisons are prohibited, and customary fishing grounds are protected from poaching.

Local Government Ordinance 1966

Island councils are authorised to regulate fishing and to restrict any activities resulting in land erosion or degradation.

Prohibited Areas Ordinance 1971

This ordinance provides that any island in Kiribati and its territorial waters may be designated a prohibited area. Article 14(1) of the Constitution states that I-Kiribati shall have freedom of movement within the country, except as restricted for the purposes of environmental conservation.

Wildlife Conservation Ordinance 1971

This ordinance provides the designation of 'Protected Bird' for any bird species. Any bird so designated cannot be hunted or killed. Hunting of wild turtles is prohibited. Wildlife Sanctuaries are authorised, as are Prohibited Areas within such sanctuaries.

Land Planning Ordinance 1973

This ordinance provides for land-use planning, zoning, and the establishment of regulations for, among other things, the conservation of natural beauty in the landscape.

Public Utilities Ordinance 1977

This ordinance establishes a Public Utilities Board and makes it an offence for any person to cause the contamination of any water supply or reserve.

APPENDIX IV

POTENTIAL AREAS, SUB-AREAS AND SPECIFIC TOPICS FOR RESOURCE DEVELOPMENT AND MANAGEMENT RESEARCH IN KIRIBATI (AFTER THAMAN 1989A)

TERRESTRIAL RESOURCES

Land resources

Area, distribution, tenure status, carrying capacity. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Mineral resources

Extent/distribution. Sand and aggregate resources, phosphate deposits. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Soil resources

Extent/distribution. Structure, fertility, drainage. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Water resources

Extent/distribution. Surface water, groundwater, water quality. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Energy resources

Extent/distribution. Fuelwood, sunlight, wind, OTEC. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Plant resources

Extent/distribution. Inventory/identification. Abundance/endangerment status. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Animal resources

Distribution. Inventory/identification. Abundance/endangerment status. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Agricultural resources

Extent/distribution. Plantation agriculture, rural subsistence agriculture, urban subsistence agriculture. Inventory/identification of: food species and cultivars, medicinal species and cultivars, fragrant and sacred plants, other plant species of subsistence importance. Animal species/strains, traditional knowledge, abundance/endangerment status, current utilisation. Appropriate traditional technologies, appropriate introduced technologies. Analysis of local food resource use, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

MARINE RESOURCES

Lagoonal and nearshore resources

Extent/distribution. Water quality, turbidity, contaminants/degree of pollution. Productivity of shellfish, crustacea, finfish, other marine animal food species, plant species. Sand/aggregate resources, lagoonal phosphate resources. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Fringing reef resources

Extent/distribution. Water quality, turbidity, contaminants/degree of pollution. Productivity of shellfish, crustacea, finfish, other marine animal food species, plant species, baitfish availability. Sand/aggregate resources. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Reef slope resources

Extent/distribution. Water quality, turbidity, contaminants/degree of pollution. Productivity of shellfish, crustacea, finfish, other marine animal food species, plant species, baitfish availability. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Oceanic/Pelagic resources

Pelagic fisheries extent/distribution. Productivity of shellfish, crustacea, finfish, other marine animal food species, plant species, deepwater pink coral. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

Oceanic mineral resources

Extent/Distribution. Polymetallic manganese nodules, cobalt-rich crusts. Economic potential, mineability. Current utilisation, potential utilisation/improvement. Identification of conservation strategies and of appropriate development.

POTENTIAL STRATEGIES FOR THE MANAGEMENT OF SPECIFIED NATURAL RESOURCES IN KIRIBATI, THE DEVELOPMENT OF WHICH COULD DEPEND ON ASSISTANCE FROM APPROPRIATE LOCAL AND OUTSIDE ORGANISATIONS IN THE AREAS OF RESEARCH AND TRAINING

TERRESTRIAL RESOURCES

Land resources

National parks, local microparks. Reclamation, coastal erosion control.

Mineral resources

Rotational utilisation, restricted exploitation.

Soil resources

Soil improvement.

Water resources

Water conservation, water quality improvement, water catchment system improvement.

Energy resources

Fuelwood development, wood stove development, solar energy development.

Plant resources

Protection of endangered species, reforestation. Conservation areas/restricted zones, national parks, microparks.

Animal resources

Protection of endangered species, reaffaunation. Conservation areas/restricted zones, national parks, microparks.

Agricultural resources

Germ plasm collections, plant multiplication and distribution areas/stations. Reintensification of diversified multistory mixed cropping. Agricultural reserves.

MARINE RESOURCES

Lagoonal and Nearshore Resources

Lagoon:

Protected areas/lagoon parks or reserves. Protection of endangered species. Fishing regulations/laws, anti-pollution legislation.

Fringing Reef:

Protected areas/reef parks or reserves.

Reef Slope:

Protection of endangered species, resources. Fishing regulations/laws, anti-pollution legislation. Technology transfer.

Oceanic/Pelagic Resources

Pelagic fisheries joint-venture development. Maximisation of rental of fishing rights

Patrolling EEZ areas. Technology transfer.

Oceanic mineral joint-venture development. Leasing of exploration rights.

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We are also grateful to officers from other Ministries and Departments and people from private companies who gave their time and talked with us about their perceptions of the problems of climatic change and sea level rise in Kiribati.

We appreciate the frankness and humour with which our questions were answered, and we hope we have done justice to all their points of view which were expressed to us during our visit.

We also acknowledge the assistance of the SPREP secretariat, especially Dr Vili Fuavao in organising and managing to synchronise our visits, from Suva and Port Moresby, to Kiribati.