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Water in the Pacific Islands: Case Studies from Fiji and Kiribati

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INTRODUCTION

Water can be a scarce resource in the Pacific Islands. This statement seems to be rather contradictory considering that the Pacific Ocean is by far the single largest body of water on the globe, and most of the Pacific Islands are humid tropical islands, where precipitation is plentiful (Carpenter et al., 2002). Drought and water scarcity therefore is not easily recognized as a problem (Terry and Raj, 2002). Despite this a growing number of islands in the Pacific Ocean are reporting water scarcity, many of them even facing severe water problems. White et al., therefore, highlight that population centres in small islands of the Pacific have water supply problems that are amongst the most critical in the world (White et al.,1999, 2004).

Quite often islands in the Pacific Ocean are very small and without meaningful catchment areas. The harvesting and storage of freshwater is a constraint with a number of factors such as small land areas, atoll geology, pressures of human settlements, conflicts over traditional resource rights, capacity limitations, frequent droughts and inundation by the sea during storms (White et al., 2004). At the same time the Pacific Islands are experiencing the increasing demand for water from a fast growing population, the expanding tourism sector and sometimes also industries. In addition many countries in the Pacific Island region are threatened by a continued over-exploitation and pollution of limited surface and groundwater resources and the environmental degradation of coastal areas (including coral reefs) (Baisyet 1994).

Water scarcity cannot be seen isolated from the other threats that the small islands are facing. Natural hazards like cyclones and flash floods have caused severe damage to the island's water supply since long. Global climate change and the anticipated rise in sea-levels are especially threatening the low-lying atoll islands. These new risks, which will have an impact not only on freshwater resources on these islands, but also on the ability of island populations to cope with their changing environments. The danger that a growing number of islands will become uninhabitable and their residents environmental refugees (Dow et al., 2005) is thus rather real and urgent.

There are many issues regarding water in the Pacific Islands. As it is not possible to cover all—two major aspects therefore will be in the foreground in this chapter. First to describe the background under which water-related issues are dealt with in the Pacific. This means the physical, environmental, economic as well as the political and institutional sides of water supply and distribution. Such a perspective should serve the purpose of discussing whether the islands in the Pacific are different in their water-related problems from other regions in the world.

This general overview will then be developed by a number of case studies. These case studies will highlight the various topics involved in water- related issues in the Pacific. The first case study looks at the 1997-98 in Fiji. The vulnerability of Fiji's economy and the people to cope with such a lack of rainfall will be the centre of discussion. After that we will have a look at the situation in Suva, the capital of the Fiji Islands, and the biggest urban agglomeration in the Pacific Island region. Annual rainfall of more than 3,100 mm makes Suva one of the 'wettest' capitals on the globe, but nevertheless water scarcity has become a major problem for the 200,000 odd citizens. The episodes of 'urban droughts' are becoming more frequent in recent years and it seems that in the near future not much hope for an improvement can be expected. Another important issue on water will be taken up in the third case study on Fiji: conflicting property rights create economic, political and social instability in Fiji. The parallel existence of traditional and modern institutions create fields of uncertainty that also make water-related issues even more complex than they are already. Finally, the last case study is on South Tarawa, the capital of Kiribati. South Tarawa is one of the most densely populated areas within the Pacific Island region. Today almost half of Kiribati's population is concentrated on South Tarawa, and the population is rising at a very fast pace. Migration from the outer islands of Kiribati might reduce water-related problems there, but in South Tarawa the limits for a sustainable water supply have been reached since long.

WATER IN THE PACIFIC ISLANDS – AN OVERVIEW

The Pacific Ocean is the biggest in the world. It is 16,700 km wide at the equator and more than 19,000 km at its widest point from Singapore to Panama. The huge body of water, more than 150 million km^2, covers an area larger than the world's entire land mass combined.

The Pacific Islands region occupies a vast 30 million km^2 of the Pacific Ocean, which is an area more than three times larger than the United States of America or China. The region has a very small land mass. Geographically it extends from Pitcairn in the east to Papua New Guinea in the west. It has 7,500 islands of which less than 1000 are inhabited. The 22 countries and territories of the Pacific Islands region consist of approximately 550,000 km^2 of land with 7.5 million inhabitants. If Papua New Guinea is excluded, the figures drop to 87,587 km^2 of land and 2.7 million people.

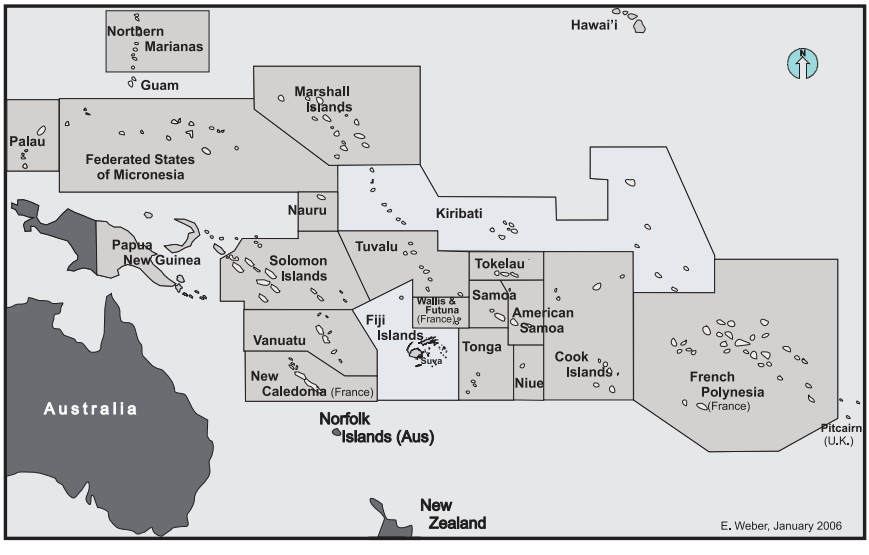

Fig. 1. The Pacific Islands

The countries in the South Pacific have large coast-to-land ratios. Their economies mainly depend on coastal resources, and large proportions of their populations are concentrated in coastal areas. The only exception in the region is Papua New Guinea, which has a more dispersed population and economic base (Bleakley, 1995).

The Pacific Islands region is geographically extremely diverse. The largest state, Papua New Guinea, has a land area of 462,000 km^2, while the smallest islands states such as Nauru, Pitcairn, Tokelau and Tuvalu are smaller than 30 km^2 each. Some countries and territories, like Nauru and

Table 1. Summary data for Pacific Island countries and territories, Source: Falkland (2002)

Country or territory	Sub-region	Approx. population (in 2000)	Total land area (km^2)	Number of islands or atolls	Island type according to geology
Pacific Island countries					
Cook Islands	Polynesia	16,000	240	15	Volcanic, volcanic & limestone, atoll
Federated States of Micronesia	Micronesia	114,000	702	607	Volcanic, atoll, mixed
Fiji	Melanesia	785,000	18,300	300 (Approx.)	Volcanic, limestone, atoll, mixed
Kiribati	Micronesia	85,000	810	33	32 atolls or coral islands, 1 limestone island
Nauru	Micronesia	11,000	21	1	Limestone
Niue	Polynesia	1,700	260	1	Limestone
Palau	Micronesia	22,000	487	200 (approx.)	Volcanic, some with limestone
Papua New Guinea	Melanesia	4,400,000	462,000	?	Volcanic, limestone, coral islands and atolls
Republic of Marshall Islands	Micronesia	60,000	181	29	Atolls and coral islands
Samoa	Polynesia	175,000	2,930	9	Volcanic
Solomon Islands	Melanesia	417,000	28,000	347	Volcanic, limestone, atolls
Tonga	Polynesia	99,000	747	171	Volcanic, limestone, limestone & sand, mixed
Tuvalu	Polynesia	11,000	26	9	Atoll
Vanuatu	Melanesia	182,000	12,190	80	Predominantly volcanic with coastal sands and limestone
Other Pacific islands (Territories of USA and France)					
American Samoa	Polynesia	67,000	199	7	5 volcanic and 2 atolls
French Polynesia	Polynesia	254,000	3,660	130	Volcanic, volcanic & limestone, atolls
Guam (USA)	Micronesia	158,000	549	1	Volcanic (south) and limestone (north)
New Caledonia (France)	Melanesia	205,000	18,600	7	Volcanic, limestone
Island countries in other regions					
East Timor	SE Asia	800,000	24,000	1 main island	Volcanic
Maldives	Indian Ocean	270,100	300	26 atolls	Approx. 1,900 islands

Niue, consist of one single small island while others such as French Polynesia and the Federated States of Micronesia have more than a hundred islands each (Table 1), which are in some cases spread out over enormous

distances of several thousands of kilometers like Kiribati. This state has a land territory of just 810 km^2 scattered over an Exclusive Economic Zone of more than 3.5 million km^2. The country stretches almost 5,000 kilometers from East to West and more than 2000 kilometers from North to South. To fly from South Tarawa, the country's capital, to Kiritimati Island, the biggest island, one has to cross over in two other countries, Fiji and the USA (Hawaii).

Small islands are often classified according to their topography, which is mainly a result of their geological structure (Fig. 2). We roughly differentiate between 'high' and 'low' islands, and somehow in the middle 'raised' islands. Geographical factors play a major role in development problems of the islands in the Pacific. Many of them belong to the group of the least developed countries, but differences in resource endowment and living standards of the population are vast. High islands have fertile soils for agriculture and generally good water resources, both surface water as well as groundwater, however there are usually much bigger problems in low islands.

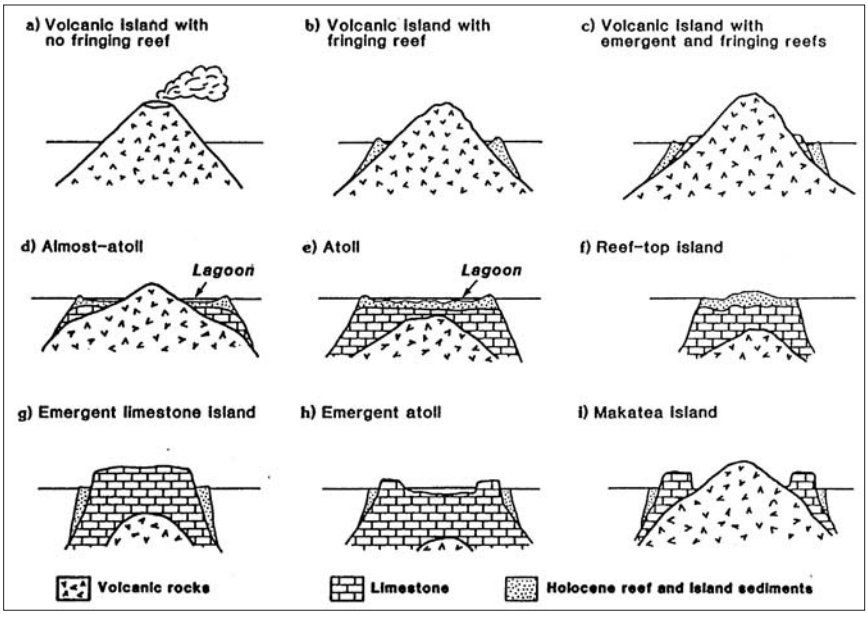

Fig. 2. Main types of mid-oceanic islands in the Pacific
Source: Scott et al. (2003)

The Melanesian countries are relatively big, mountainous and of volcanic origin. Rich soils that provide a good base for agriculture, exploitable mineral resources and plentiful marine resources are found here. Many of the Polynesian and Micronesian island nations however are much smaller

and disadvantaged by a number of physical features. Kiribati, the Marshall Islands, Tokelau and Tuvalu consist mainly of low-lying atolls, many less than 100 km^2 in size and not more than five meters above sea level.

Atolls are often described as one of the earth's harshest environments. In most cases they are extremely isolated like oases amidst an oceanic desert. Tiny long stretches of land, only a few hundred metres broad, and hundreds, if not thousands of kilometers away from larger landmasses create unique ecosystems, but also unique conditions for human existence. Here people do not have the safety margin available in continental and large insular regions. Considerable effort is needed to exploit poor atoll soils. Atoll production systems include a limited selection of tree crops, root crops, fisheries and cottage industry (Rapaport, 1990). Some atoll states such as the Maldives Islands in the Indian Ocean have managed to set up commercial fishing and are also rather successful in the tourism sector.

Smaller volcanic islands such as the Cook Islands, parts of the Federated States of Micronesia, Tonga and Samoa have some fertile land, but their small size and the lack of natural resources are enormous obstacles to economic development.

High islands of volcanic origin usually have good potential for the development of surface water resources as well as groundwater resources. They often have perennial rivers (e.g. many islands in Fiji, Papua New Guinea, Samoa, Solomon Islands and Vanuatu). Volcanic islands frequently have springs, both in elevated and coastal areas that are used as important sources for water supply schemes, especially on the rural community level.

Depending on their location many of the high islands also receive a lot of precipitation, most as orographic rain. The availability of water is therefore not the major problem, but the storage and distribution of water alongwith the very high capital costs for the water supply of fast growing urban centres are areas of concern. Low coral islands as well as (raised) limestone islands have little surface water resources and largely depend on groundwater resources that are often complemented by the collection of rainwater (and unconventional sources of freshwater such as desalination). Raised limestone islands generally have little or no surface water owing to the high permeability of the rock. On smaller islands and small catchments of larger islands, stream flows may become very low or cease during extended droughts. Surface water on low islands, if present, is likely to be in the form of shallow, brackish lakes unless the rainfall is very high when it may be fresh. Nauru, for example, is a limestone island which has an interior brackish lake near sea level (Falkland, 2002). Freshwater on atolls is the most limiting factor for human settlements. The island soil and underground is usually so porous that water seeps down to a lens of freshwater saturating rocks and sand almost instantaneously.

Rapaport (1990) highlights that many Pacific atolls once supported larger populations than they do today. Early accounts indicate a "miserable existence for the inhabitants of many atolls visited" (Wiens, 1962). Starvation, emigration, and war were very much the reality on many atolls (Alkire, 1978, Pollock, 1970).

Freshwater resources of small island states are often classified as either 'conventional' or 'non-conventional'. Falkland (2002) differentiates between "naturally occurring water resources" that require a relatively low level of technology to develop them and "water resources involving a higher level of technology" (Falkland, 2002). Naturally occurring or conventional resources include rainwater collected and stored, groundwater and surface water. Non-conventional resources include the use of seawater or brackish groundwater, desalination, water importation by ships or pipelines, treated wastewater, and substitution of water (such as the use of coconuts during droughts).

The collection of rainwater is rather common on the Pacific Islands. Sometimes entire collection systems are developed, especially where other sources of freshwater are limited and where sufficient precipitation can be expected during longer periods of a year. Rainwater collection systems are found on the roofs of individual houses, administrative buildings or even especially paved runways. On some very small low-lying countries, such as Tuvalu, the northern atolls of the Cook Islands, and some of the raised coral islands of Tonga, rainwater collection on roofs of community buildings is the sole source of fresh water.

For small, low-lying islands groundwater is often the most reliable and important water resource. Groundwater occurs either as perched or as basal aquifers. Perched aquifers develop above an impermeable layer, or when groundwater is retained in compartments by a series of vertical volcanic dikes (Falkland and Custodio, 1991). They are similar to the aquifers found on large islands or continents. Basal aquifers occur on high as well as low islands in the form of coastal aquifers or rainwater that percolates through an island and floats on the denser salt or brackish water in what is called a Ghyben-Herzberg lens (Whittaker, 1998, see Figure 3).

The size of such a freshwater lens is more or less proportional to the width and surface area of an island. It is also influenced by factors such as rainfall levels, the permeability of the rock beneath the island, and salt mixing due to storm- or tide-induced pressure (Roy and Connell, 1991). In some cases such lenses may be as thick as 20 metres providing secure and long-lasting water supply. On raised coral atolls, such as Nauru and many of the islands of Tonga the freshwater lens may be no more than 10–20 centimetres thick, and is thus very vulnerable to over-exploitation (Falkland and Custodio, 1991).

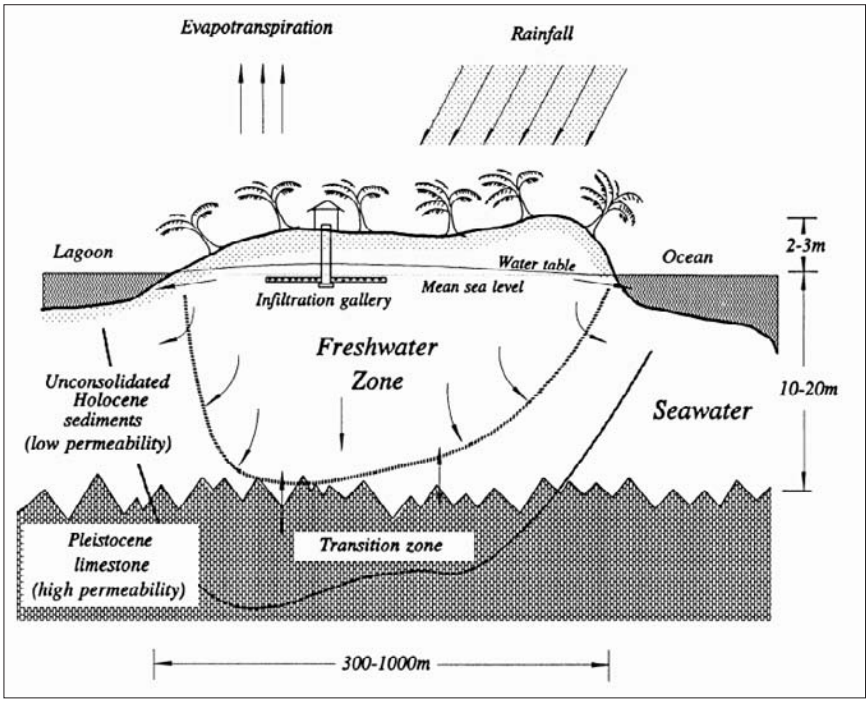

Fig. 3. Freshwater lens of a coral atoll
Source: White et al. (2002)

Surface water in bigger quantities and potable qualities is mainly restricted to high islands. It occurs here in the form of ephemeral and perennial streams, springs, lakes, and swamps (Falkland, 1999). On coral atolls and limestone islands surface water is rarely found because of the high infiltration capacity of the soils and rocks (Falkland and Custodio, 1991). The usual small size and altitude of these islands also restrict the size of potential catchment areas. In those rare cases where surface water is found on low islands, it is likely to be in the form of shallow, often brackish lakes that easily get polluted especially in places with a high population density.

A number of high islands in the Pacific use mainly surface water as their major source of freshwater supply because gravity-fed water systems are more cost-effective than the development and maintenance of systems based on groundwater sources. For example, surface water provides more than 95% of the water requirements in French Polynesia. Surface water also contributes to the freshwater supply in Samoa, Fiji, Nauru, Palau, and on the high islands of the Cook Islands (Falkland and Custodio, 1991).

Almost 98% of global water resources is saltwater. It therefore seems logical when countries in the middle of the ocean start to use saltwater to generate freshwater. There are several technologies at hand (distillation, reverse osmosis and electrodialysis) and some countries in the Pacific region started to use this unconventional source for their regular water supply. On Nauru about 60% of the island's water supply is from desalinisation. The heat from the power station is used for saltwater distillation. Experience with desalination on South Tarawa, Kiribati, has however shown the problems and limitations of desalinisation. A number of reverse osmosis units have been installed (Metutera, 2002), but some had been non-functional for long periods as it took months to get spare parts. The plants installed on Tarawa supply only a small proportion of the total water supply requirements. It would be rather risky to depend entirely on a technology that obviously cannot be well maintained. In addition water produced in desalinisation plants is much more expensive than 'conventional' sources of freshwater due to the high energy costs and other operating expenses. Desalinisation is therefore an option where the high costs can be recovered easily, or where due to the lack of other freshwater sources no alternatives to this rather expensive solution are available. In a number of tourist islands reverse osmosis is used to supply water to hotels and beach resorts (e.g. Mana Island, Fiji and Akitua island, Aitutaki atoll, Cook Islands).

Another non-conventional source of freshwater is the transportation of water from one island to another through ships or pipelines. Before Nauru started to produce freshwater through distillation, ships supplied water to the people of this tiny island nation. Also some of the small islands of Fiji and Tonga regularly receive water from nearby islands by barge or boat. During severe droughts or natural disasters small islands of Fiji, Kiribati, and the Marshall Islands have relied on coconuts for drinking water. Finally, non-potable sources, including sea water, brackish groundwater and wastewater, are used to flush toilets and fire fighting on a number of Pacific Islands such as Kiribati and the Marshall Islands (Falkland, 1999).

In the Pacific region there are a growing number of people, who do not have as much water as is required. A survey by the Asian Development Bank (ADB) found that only 50–75% of the residents of Samoa and only 44% of the residents in Kiribati had access to safe water (Burns, 2002). In the Federated States of Micronesia only 30% of the population has access to safe water, and in the Marshall Islands not more than 50%. (UNEP, 1999). In Papua New Guinea just 10% of the rural population has access to safe drinking water (Burns, 2002). Rapid growth in population , and an increasing demand from the tourism sector and industry are placing a lot of strain on the limited water resources of many Pacific Island Developing Countries (PIDCs) (Falkland and Custodio, 1991). In the major centres

that are growing at alarming rates the existing supply and distribution systems are no longer capable of satisfying demand. Very often capital is not available to make necessary expansions or even to safeguard that the existing system is well maintained. Water leakages have let large quantities of this already scarce resource go waste. In extreme cases up to 70% of water is lost through leaks in the system. (SOPAC, 2001).

Burns (2002) highlights that many islands in the Pacific rely on a single source of water. This makes them rather vulnerable to all sorts of risks. Here vulnerability is different from the risk of water scarcity elsewhere. Sometimes the next freshwater source is thousands of kilometers away; at times there are no frequent transport links to many of the islands, so that it can take many days, if not weeks to provide supply. The ability to sustain a particular level of freshwater supply thus decides whether an island is permanently suitable for human settlement or whether people have to move elsewhere. In the years to come many islands might get deserted by people because water scarcity makes them uninhabitable. Environmentally induced migration will aggravate the concentration of population on major islands and increase environmental problems even further.

Problems with water are caused not only by population growth and migration to the major cities in the region. Cyclones with heavy winds and torrential rain are causing floods in many areas, destroying crops in the fields and people's homes. Flooding also often leads to water pollution, making water unsafe for human consumption. This occurs especially where no adequate sewage disposal infrastructure exists (UNEP, 1999).

Last but not the least, El Niño/Southern Oscillation (ENSO) episodes have reduced the amount of rainfall considerably in many parts of the western Pacific. Droughts caused by El Niño were reported in 1978, 1983, 1987, 1992, 1997-98, 2001 and 2003. Some stations recorded a decline in precipitation by as much as 87% in the western Pacific while resulting in unusually high rainfall in the central Pacific (Burns, 2002; Terry and Raj, 2002).

Droughts caused by El Niño have a severe impact on both high as well as low islands. They put a lot of strain on agricultural production, and have also depleted rainfall collection supplies and the freshwater lenses and perched aquifers on many atoll islands in the Pacific. For example, in 1998, 40 atolls of Micronesia ran out of water during an ENSO event, resulting in the declaration of a national emergency (Field, 1998a, b). In the same year, rainwater tanks in substantial parts of Kiribati dried up and shallow groundwater reserves became brackish (World Bank, 2000). The main island of the Marshall Islands only had access to drinking water for seven hours every fourteen days, and rationing occurred on all islands in the North Pacific (East-West Center 2001). In 1998 Fiji had one of the severest droughts in history. In the seven months from September 1997 to

March 1998, rainfall recorded was 60% lower than the average – the lowest ever recorded in the country since 1942 (Bolataki, 1998; Lightfood, 1999).

Water and Vulnerability of Small Island Developing States

Although small island states are not at all homogeneous they share many common features that lead to an increase of their vulnerability. They are small in size and in most cases surrounded by larges expanses of ocean; they usually have limited resources, are prone to natural disasters and extreme events. Geographically they are often rather isolated and their economies are extremely open and vulnerable to external shocks. These and other characteristics limit the capacity of small island states to mitigate risks and stress and to adapt to changing natural and cultural environments (IPCC, 2001a).

Freshwater resources and their management have many aspects not only in the Pacific. Severe drought conditions in Fiji, Kiribati, Samoa and many other countries in the Pacific Island region highlighted the urgency to develop more efficient ways of water use, and better and safer ways of water supply and distribution. Restrictions are not only due to natural reasons, but very often because financial commitment Pacific Island nations can contribute is much less than it would be necessary. Capital costs are very high especially for urban water supply systems.

Small Island Developing States (SIDS) in the Pacific attract the highest per capita aid in the developing world. A justification of this could be that due to their very special situation, SIDS are more vulnerable to natural hazards, and to economic recession than 'normal' developing countries. The vulnerability of the SIDS is also often mentioned, as regards to water-related problems.

Many of the Pacific Islands are amongst the Small Island Developing States. SIDS are small islands and low-lying coastal countries that have a small population, lack of resources, are remote, and are especially vulnerable to natural disasters. They largely depend on international trade. They suffer from lack of economies of scale, high transportation and communication costs, and costly public administration and infrastructure.

Fifty one states and territories work together in the Alliance of Small Island States (AOSIS). In April 1994, at their first Global Conference on Sustainable Development of SIDS in Barbados, they adopted the Barbados Programme of Action that at various levels would promote sustainable development of SIDS. Since then the United Nations confirmed the special situation of the SIDS at various meetings and conferences.The special status of SIDS was also confirmed at the World Summit on Sustainable Development in 2002.

Undoubtedly life on a tiny island, in the middle of a huge ocean, with a small population and hardly any resources would be difficult. Cyclones or hurricanes frequently destroy crops and bring floods. However the per capita income of many of these SIDS is higher than in many other developing countries. Countries that have their own problems that might be different from those of the SIDS, but not necessarily less severe and easier to solve.

Pacific Islands are not homogenous at all. There are vast differences in the physical, economic, historical and cultural backgrounds of island nations, and also among the individual islands themselves. Drought on a low-lying atoll island that largely depends on its groundwater is very different from drought on a big, mountainous high island where the water supply is mainly dependent on rivers. Both types of islands are very vulnerable to internal processes such as a high population growth and also to external pressure of no rainfall due to El Niño events. But both types of islands are vulnerable in a different way, and their vulnerability requires different coping strategies and adaptations.

One could get the impression that due to the (small) scale of cities and a low population on the Pacific Islands problems related to water are better and easier manageable than elsewhere. The cities of the Pacific Islands are not huge settlements with millions of inhabitants such as many cities in Asia. In the Pacific the cities are tiny. The solutions should be within the financial means of the municipalities and the Governments of these islands. However we should not forget that the budget outlay of all these nations is also very small. Investments in water supply systems are costly, and thus the size of a population is not really a good indicator on the affordability of modern technology especially in case where the majority of the people is rather poor and not able to pay much for their water needs.

In a recent report on Urbanization in the Pacific Islands the World Bank remarked:

> "The problems associated with delivering satisfactory water supply in Pacific island towns are primarily political and institutional rather than technical. They reflect inappropriate policies, undue government interference, and the lack of appropriate incentives for consumers to reduce demand to sustainable levels, all of which undermine the ability to operate and maintain water supply systems properly" (World Bank, 2002).

In the case of Suva, the capital of the Fiji Islands, a lack in rainfall can hardly be seen as a major reason for water scarcity. Also an unequal distribution of rainfall during the year does not explain the situation. As in many other places in the Pacific Islands, Suva has high rainfall throughout the year, without a real distinct dry season. Nevertheless there are tremendous problems with water and its supply.

The three case studies from Fiji and one from South Tarawa, the capital of Kiribati, will give insights in the very complex causes of water-related problems. The case studies show that scarcity created by nature is only marginally the reason, why human societies face problems regarding water. The case studies also clearly demonstrate that even in individual countries like Fiji and Kiribati, regional variations play a very important role as far as supply of water is concerned.

CASE STUDY 1: EL NIÑO AND AGRICULTURAL DROUGHT IN FIJI

The Fiji Islands are located between 12°-21°S latitude and 176°E-178°W longitude. Fiji consists of more than 300 islands of which about 1/3 are inhabited. With a land mass of 18,272 km^2 Fiji is the third largest state in the region next to Papua New Guinea and the Solomon Islands. The Exclusive Economic Zone (EEZ) of the country covers 1.3 million km^2. The two biggest islands, Viti Levu and Vanua Levu, have the majority of the total population of about 900,000, with about 50% living in urban centres such as Suva (177,000), Lautoka (45,000), Labasa (25,000) and Nadi (33,000). The two largest islands account for 87% of the land area and 90% of the population.

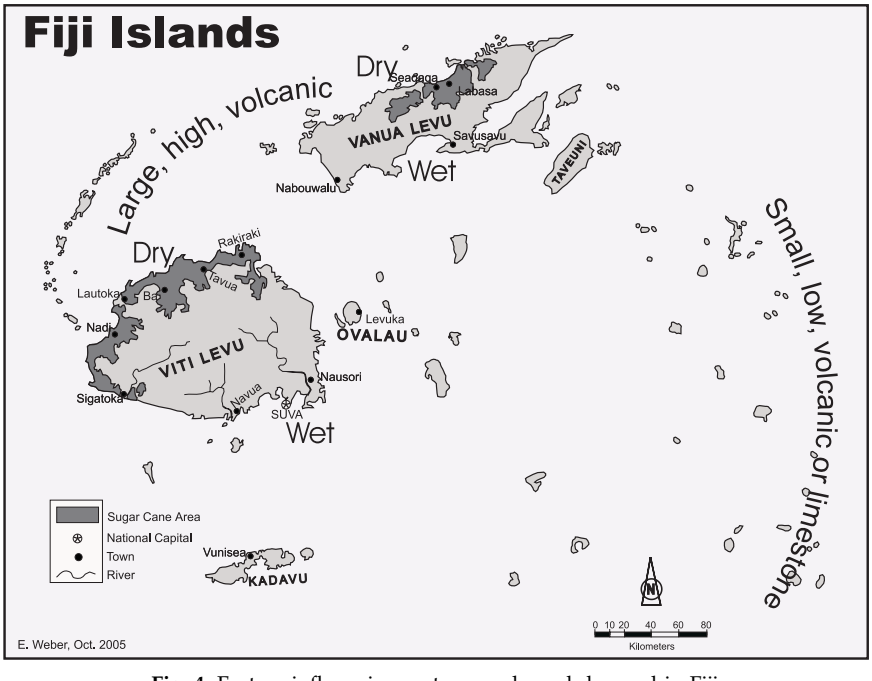

Fig. 4. Factors influencing water supply and demand in Fiji

The larger islands such as Viti Levu, Vanua Levu, Taveuni, Kadavu and the islands of the Lomaiviti group are rather mountainous and of volcanic origin. They are rising more or less abruptly from the shore to impressive heights. The southeast or windward sides of the islands record the highest rainfall of up to 5,000 mm per year. The western and northern parts of the major islands are in the rain shadow of the volcanic mountain ranges. They are therefore much drier and frequently threatened by droughts (Terry and Raj, 2002).

The climate in Fiji is dominated by the southeast trade winds. Exposure and topography control the distribution of rainfall on the islands. Average annual precipitation over the Fiji Group ranges from 1500 mm on smaller islands to over 4000 mm on the larger islands. Topographic effects mean however that much of this falls within the windward side of the islands.

The wet season from November to April is also the season of tropical cyclones. In the western parts of the bigger islands up to 80% of the annual total rainfall falls during this period. The western and northern parts of the major islands receive only 60-70% of the rainfall recorded in the eastern parts (Fig. 5). Here drought conditions are more likely to occur, especially during El-Niño episodes. These drier parts of Viti Levu and Vanua Levu are the centre of Fiji's sugar cane production. Drought therefore frequently affects the livelihood of a huge number of people and also cause a lot of harm to Fiji's export earnings (Lightfood, 1999).

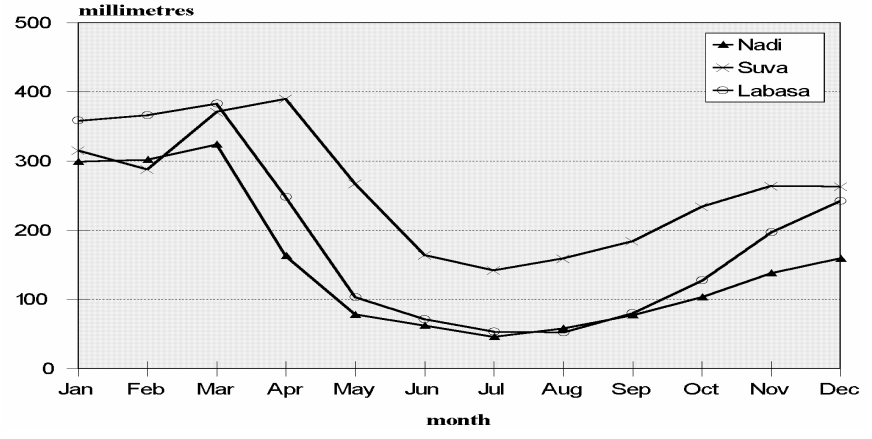

Fig. 5. Monthly total rainfall averages (1961–1998) for selected places
Source: Fiji Meteorological Service

Decline in agricultural production threatens food security, and poses severe health problems, whilst errant rainfall patterns disrupt hydroelectric power generation on Viti Levu. These are some of the more visible impacts of water shortages over these periods.

Table 2. Rainfall during Nov-April and May–Oct. in major centres of Fiji

	Nadi		Suva		Labasa	
	mm	%	mm	%	mm	%
Nov-April	1385	76.6	1991	63.4	1794	78.7
May-Oct	424	23.4	1150	36.6	486	21.3
Total	1809	100.0	3141	100.0	2280	100.0

Source: Fiji Meteorological Service

Drought in the western and northern parts of Fiji's major islands were recorded in 1983 and 1987. Both were connected to El Niño events. The latter one caused severe water shortages all over Fiji, including the usually wet areas of Suva/Nausori. The shortages were so severe that water supply needed to be restricted in most urban centres. Agriculture, especially Fiji's sugar industry, was badly affected.

The drought of 1987 was considered the worst drought in more than 100 years – until ten years later when an even more severe one afflicted the country. The 1997/98 drought affected most of the Pacific Island countries. The impact on water supply and agriculture created a number of economic, social and health problems. A direct consequence of the drought was Fiji's economic recession of 1998, when GDP was 8% lower than in 1996 (Lightfoot, 1999). In the western and northern provinces of the two main islands, Viti Levu and Vanua Levu, agricultural activities and production suffered a lot. These provinces are the centre of Fiji's sugar cane cultivation, and until recently the most important economic sector of the country.

There are more than 22,000 sugar cane farmers in Fiji. The vast majority of them have holdings that are not larger than 3–4 hectares. They rarely produce more than 200 tons of sugar cane a year. They earn around F$3,000 not enough to be above the poverty line. Another 20,000 low paid harvesting workers earn their livelihood directly through sugar cane production. A few thousands work as lorry drivers to bring the sugar cane to the mills or are employed in the sugar mills. Altogether some 50,000 people find employment in the sugar sector. This is about a quarter of Fiji's economically active population. Drought and income loss in sugar cane thus have severe consequences for the wellbeing of hundreds of thousands of people. In addition to that sugar cane is also one of the major export sectors that provide Fiji with foreign exchange. In a good year more than F$300 million is earned through the export of sugar mainly to the European Union.

During the drought of 1997-98 Fiji's sugar cane production declined by more than half. Instead of about four million tons not even two million tons of sugar cane were harvested. Officials from the Fiji Sugar Corporation estimated that the country lost about US$ 50 million in export earnings. For the first time in history, Fiji had been forced to import its domestic sugar requirement. About 35,000 tons of sugar was bought from Thailand,

Guatemala and Australia. The country was also forced to cancel export commitment of more than 100,000 tons of sugar to Japan, Malaysia and other Pacific Island countries (Radio Australia, July 13, 1998). The price of shares of the Fiji Sugar Corporation dropped to a record low of US$ 0.18 (Radio Australia, June 5, 1998).

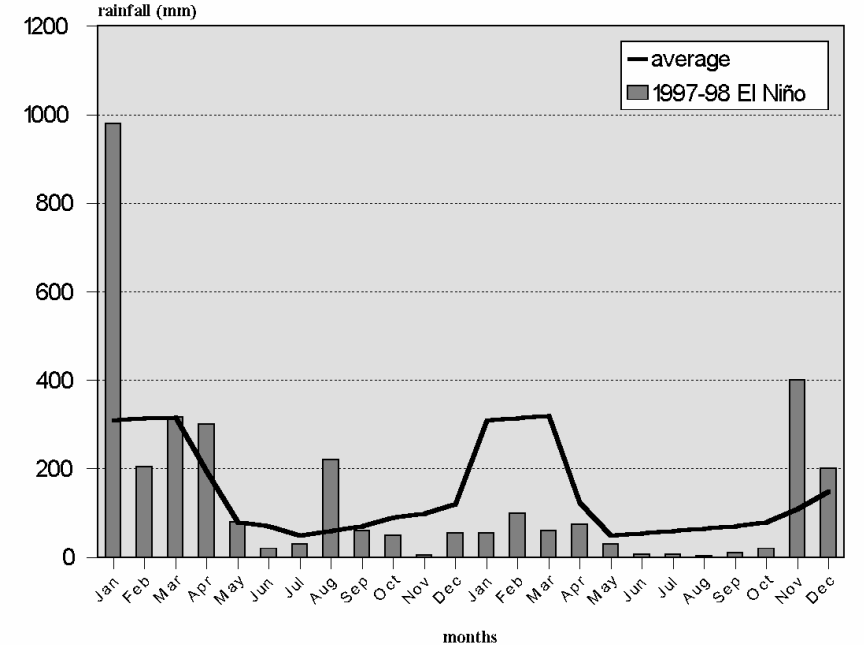

Fig. 6. Average rainfall in Lautoka and during the 1997-98 drought
Source: Fiji Meteorological Service

In some districts small farmers lost their entire sugar cane crop. In the Ba province, almost all of 43,000 people needed government assistance. In all drought – affected provinces about 80,000 people – 10% of Fiji's population – depended on government support to avert starvation and destitution (Daily Post, June 5, 1998). A year later sugar cane production had fully recovered and a production of 4 million tons was realized (Fiji Times, March 22, 1999). This time Fiji also benefited from a severe drought in Mauritius. As this island nation in the Indian Ocean was not able to supply its sugar quota to the European Union, Fiji was asked to make up Mauritius' deficit (Radio Australia, August 12, 1999).

As sugar cane production declined the demand for cane cutters, mill workers and other workers dependent on sugar production dropped. In total there was 50% less work available for sugar cane cutters. The burden of this reduction fell mainly on casual workers (Lightfood, 1999).

The drought of 1997-98 demonstrated how vulnerable Fiji's economy and society is to water scarcity. The losses in the sugar industry were surely the most profound and led to severe consequences. In 2004-05 dry conditions again seriously affected the cane farming belt in Viti Levu. The Save the Children Fund Fiji estimated that 5,000 to 8,000 children dropped out of school during the year. Parents had no money to pay for school fees, lunches, bus fares and school books (Fiji Times, February 2, 2005). Water scarcity however is not only connected to insufficient rainfall. The case study of Suva shows that people can suffer from a drought even when plenty of freshwater is around them.

CASE STUDY 2: PROBLEMS OF WATER SUPPLY IN SUVA

The urban agglomeration that comprises Fiji's capital Suva and two smaller independent towns, Lami to the west of Suva peninsula and Nausori to the east at the Rewa River is at the south-eastern side of the main island of Fiji, Viti Levu. Between Suva and Nausori a number of larger settlements have come up during recent decades. Quite often the area therefore is called the Suva-Nausori-Corridor. Today more than 270,000 people live in this greater Suva urban area, almost a third of Fiji's population. One water supply system serves the entire area, but Suva, Nausori and Lami have their own sewerage systems. The water for the present system is mainly supplied by the Waimanu and Tamavua rivers and the Savura creek.

The central piece of the greater Suva water supply system is the clear water reservoir at Tamavua. It is located at an elevation of 124 m, and water from here is fed into the distribution network and distributed by gravity. The Tamavua plant is supplied by three gravity sources located in the headwaters of the Tamavua river catchment, and two pumped sources on Savura Creek and the upper Waimanu River. In addition water from the Waila water treatment plant is pumped to the Wainibuku Reservoir at 81 m and to the Raralevu Reservoir at 55 m. Also from these two reservoirs water is fed by gravity into the distribution network. The Waila water treatment plant is supplied by water pumped from the lower Waimanu River.

The water supply in the Lami-Suva-Nausori area is often disrupted, and the quality of the water is often rather poor as streams and the coastal waters are more and more polluted. The existing water supply system has reached the limit of its capacity, and has already placed restrictions on housing development.

In the year 2002, many of Suva's citizens often went to work without a shower. Or they got up an hour earlier to visit a friend or relative who

lived in a part of the town where no water disruption occurred. In the same year, more rain fell on Fiji's capital than in an average year: 3,627 mm in Suva, and even 1,000 mm more on the township of Lami, eight kilometres away from Suva, and a notorious area as far as water scarcity is concerned. Whoever has lived in Suva for a while wonders how water scarcity could occur here, as Suva is one of the 'wettest' capitals on earth. People living in the west of Viti Levu always felt sorry for the residents of Suva: as so much rain is not easy to tolerate.

During the early 1990s water disruptions occurred during 'drought' years. By the mid-1990s disruptions became frequent during the drier periods of each year. Disruptions now occur during all periods of the year. Provision of water by tank trucks, with storage in plastic tanks, which is expensive, is becoming increasingly common.

Water scarcity is a real problem for a larger part of Suva's population. It happens and those who are not affected by it would not even recognize the suffering of people living just in the next suburb: It occurs on days when there is a heavy downpour; during the rainy season, and it happens not because there is no rain. Sometimes areas in Suva, Lami or the small town of Nausori people must arrange their lives without water for days, weeks and sometimes even months (Keith-Reid, 2003). They get used to waking up in the middle of the night to see if the pressure is strong enough for some water in their taps. At the roadside they wait with buckets and cans for the lorries and trucks of the Public Works Department – quite often in vain. Employers send their workers home as the low water pressure does not reach higher levels in multiple-floor buildings. Schools have to close and the University of the South Pacific has sent thousands of students home as there was no water available on campus.

There are many reasons for the water scarcity in Suva, and a lack in rainfall is not one of them.

According to the Suva-Nausori Water and Sewerage Masterplan more than 50% of the water provided through Suva's distribution system gets lost before it reaches consumers. Leakages, illegal connections and other errors cost the water supply authorities a lot.

The population of greater Suva will increase from 248,000 in 1999 to 371,000 by the year 2019 (Fiji Times, December 27, 2001). The present distribution system is already too small to cater for the existing population, not to speak of the annual population increase of 2.1% over the next 20 years. In addition to shortages in water supply not even 40% of Suva's population is connected to the sewerage reticulation system. More than 60% use septic tanks and pit latrines, which perform poorly in Suva's low permeability soils. These large numbers of unconnected households, overflows from the sewerage system as well as industrial discharges to

drains, creeks and the bay are causing environmental damage and pose a potential risk to public health (Fiji Times, December 27, 2001).

People living in one of the many squatter settlements in and around Suva are not connected to the water supply and sewerage system. It is estimated that by the year 2006 the Suva-Nausori corridor will be home to 90,000 squatters. 50 to 60% of these squatters live below poverty line and do have not enough money for even basic needs (Fiji Sun, August 18, 2004). Between 1996 and 2003 there had been a 73% increase in squatter settlements in Suva (Fiji Times, Feb. 9, 2005).

But not only the very poor suffer from water scarcity. In December 2002 one of Suva's most popular hotels had its own experience: within less than a day the hotel lost all its 105 guests. From full occupancy to empty, and to make matters worse most of the guests refused to pay their bills. The hotel had not received a single drop of water for more than 20 hours (Fiji Times, December 14, 2002). Tradewinds Hotel was not the only prominent victim of the water crisis. At Lautoka hospital major surgical operations were cancelled as the hospital had no water. In many parts of Viti Levu people had to improvise their water supply, in most cases without support from government authorities who just did not have the resources to deal with a crisis of such a dimension. In the first week of December 2002 a key pumping station in Suva broke down three times, one reservoir was empty, and a second one close to empty. Two lines between the reservoir burst, and aging pipes were leaking all over Suva. To ease the problem the Public Works Department employed 12 water trucks to bring water to residents in Suva's suburbs. Most of them however newer saw such a truck.

There are many reasons for Suva's ailing water distribution system. They range from chronic governmental neglect over years, insufficient budget allocations for the Public Works Department, lack of skilled and experienced engineers and administrators, and chronic corruption at various levels within the system. However the major reason is that over decades little had been done to maintain the water distribution system and adjust it to the fast growing population. Now as the collapse of the system is highly visible the costs to get out of the mess are just too high.

Suva is Fiji's capital. The government is located here and also the headquarters of most of the government agency. Suva beyond any doubt gets the highest government allocations as far as infrastructure development is concerned. The problems are even larger in other places in Fiji.

In June 2002 a state of emergency was declared in Kadavu, Fiji's fourth largest island about 80 kilometres south of Suva. Six hundred people live in the government station Vunisea, Kadavu's 'capital'. It consists of a government hospital, the only one in Kadavu, a government primary and secondary school, a police station and a post office and a few shops. Some

280 students from the government schools as well as 10 of the 12 patients from the hospital were sent home because of lack of water. Only two bedridden patients were allowed to stay in the hospital. The water for these patients had to be brought from a creek half a kilometre away. The Public Works Minister explained the collapse of the water supply system because of old and faulty pipes. "We need to replace the pipes for up to five kilometres. We need to find the money for that" (Fiji Times, June 11, 2002). What elsewhere is not really a big problem – To replace five kilometre water pipes—can become a major problem on an island, where water pipes are not available nor the workers who could do the work. It also can become a big problem when Governments are more concerned with the major islands, and just do not care much about the infrastructure of the islands in the periphery.

History and Background of the Present Water Supply System

In its present form Suva's urban water supply and sewerage system was developed in the 1970s and 1980s. Since then it could not keep pace with the ever increasing demand and has suffered from deferred maintenance and upgrading.

The need for a reliable water supply system became evident with the establishment of Suva as the capital of Fiji in 1882. The first piped supply was installed in 1890 from an intake in the Tamavua hills. With the growth of the city an appraisal of the existing supply became necessary and a number of improvements were recommended in 1911. Population and economic activities increased and thus water demand continued to become bigger and was met by piecemeal improvements in treatment and storage.

In 1961 the Tamavua water treatment plant was established, which needed urgent upgradation by 1970. Ten years later a new treatment plant was required – with support from the Australian Government – the Waila treatment plant was constructed in 1982. This, however, should have been the last major investment in Suva's water supply system for long.

Officials from the Public Works Department and representatives of the Government frequently blame each other for the neglect. The Director of Water and Sewerage (DWS) in the Public Works Department has the overall responsibility for Fiji's water supply and sewerage treatment and disposal. The PWD falls under the Ministry of Works and Energy and operates and maintains 13 regional, city or town water supply systems that produce and distribute about 170,000 cubic metres water daily serving some 610,000 people, or more than 80% of Fiji's population. Most of the freshwater distributed comes from surface water. At the moment the exploitation of groundwater does not play a big role in urban supply systems.

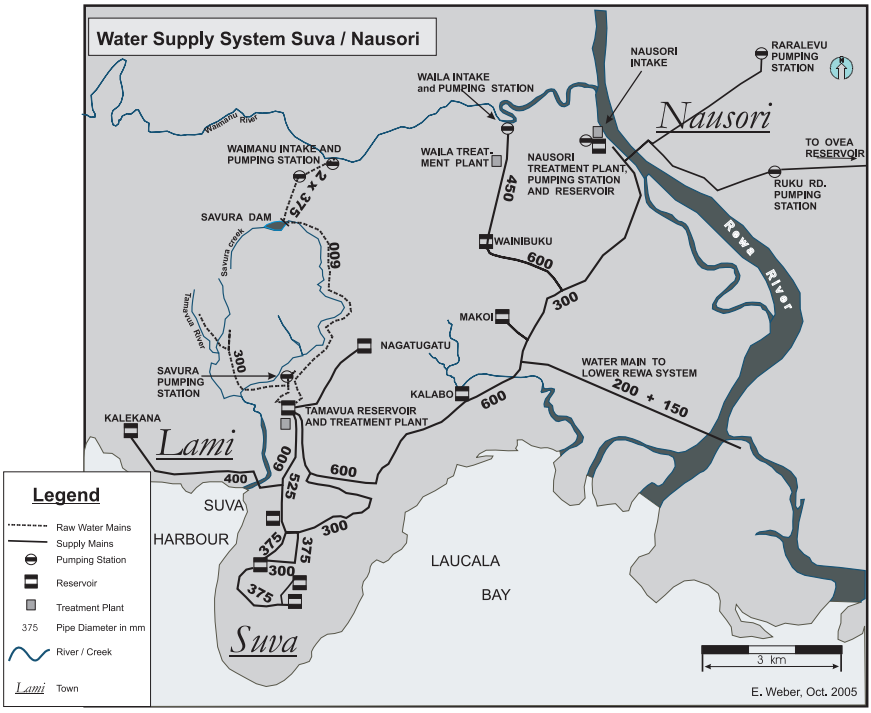

Fig. 7. Suva – Nausori Water Supply

To secure water supply to the residents of Suva, the PWD often complains of low budgetary support for the maintenance and improvement of its water and sanitation system. According to the PWD engineers it is technically not much of a problem to ensure that the residents of greater Suva have secure water supply 24 hours a day. The problems with delivering satisfactory water supply rather in financial and institutional bottlenecks. Like many other departments in Fiji with a more technical orientation the PWD has a shortage of personnel with appropriate managerial, financial, and technical qualifications and experience. The drafting of new projects, their technical and financial feasibility thus requires in most of the cases experts from overseas.

The Government on the other side often blames PWD for the insufficient system, but also highlights that it is not able to bear the high investment and operational costs of the existing system. It needs to be seen whether the water supply improves in the greater Suva area after a U$150 million project by the Asian Development Bank will be completed by 2007. The PWD is also in charge of water billing and the collection of water rates. Revenues earned are turned over to the Government's consolidated fund and the PWD in turn is financed through government budgetary allocations.

There is little incentive for the PWD to improve its financial efficiency. The revenues collected at present are insufficient to cover even operating costs. The situation is even worse as a huge proportion of water revenues are not collected reducing the financial capability of the Government to tackle the various problems (Table 3).

Table 3. Collection and arrears of water revenues in Suva

Year	Revenue collected US$	Arrears of revenue US$	Outstanding (%)
1998	11,047,150	9,252,285	45.6
1999	10,054,348	11,127,944	52.5
2000	11,470,720	16,126,473	58.4
2001	12,872,907	18,231,934	58.6
2002	n.a.	21,078,072	n.a.
2003	n.a.	23,412,841	n.a.
2004	n.a.	24,152,022	n.a.

Source: Report of the Auditor General, Audit report on the Infrastructure Sector, Suva, various years

Another major cause is corruption within the department. Having no water is just more than an annoyance. Having no water over an extended period of time makes life in a particular place miserable, if not impossible. 'Solving the problem' often costs money, even though the services ought to be free. In October 2003 there were reports that truck drivers from private companies distributing water to areas where supply had ceased asked a fee for their valuable load. Acting on behalf of the PWD charging money for this water service was illegal. Earlier in 2003 an investigation was started regarding allegations that private water truck operators had given PWD officials bribes for cutting off the water supply to entire neighborhoods to stimulate the water-trucking business. Watermains had intentionally been shut off so that water trucking was required (PINA Nius, October 9, 2003). For a few companies Suva's 'water crisis' turned out to become a spring of money that never runs dry. In an investigation report on irregularities that occurred during Suva's water crisis in 2002, the Auditor General noted that a range of issues hinted at corruption (Auditor General 2003). One company, not observing tender procedures, was awarded contracts for supply of hoist trucks and water tankers avoiding existing contractors. The PWD hired trucks and other equipment at much higher rates than that which the cheapest contractors had asked for. Payments were made for services provided by vehicles that were under repair/scrapped at the time for which the invoice had been issued. Payments

were made for a day that does not exist in the calendar (September 31 (!!!)). Water tankers were hired at exorbitant rates; hiring rates paid for several vehicles were equivalent to the purchase price of new vehicles. The report concludes: "From the various defects, anomalies and irregularities noted during our investigation on vehicle/plant hires, it appears highly likely that official corruption exists at Suva Water Supply & Kinoya Sewerage Treatment Plant" (Auditor General 2003).

It is very difficult to establish how much the Government lost through such fraudulent practices. The Opposition in Parliament gave figures that the PWD scam costs tax payers more than the $30 million lost during the Agriculture scam (Fiji Times, April 12, 2003). All in all it is estimated that Fiji annually loses more money through the abuse of public funds than the amount of foreign aid given to the country (PINA Nius, Nov. 27, 2003).

Wastewater and Sewerage

In 1986 a little more than 61% of Suva's population had a flush toilet in which wastes were either retained in septic tanks or discharged into the local sewerage system. Septic tanks are rather problematic to operate in the Suva area as much of the city's area is located on soap stone which does not allow septic tank effluents to percolate properly. In addition to this the high annual rainfall of more than 3,000 mm on an average results in frequent saturation of the soil which tends to prevent oxygen penetration. As a result the natural treatment in Suva's septic tanks is rather slow and inefficient. Widespread seepage of sewerage waste into Suva's numerous creeks occurs rather frequently and some of the creeks, such as Nubukalou Creek, have been described as "sewers rather than creeks" (ESCAP, 1999).

What happens in Suva is symptomatic to many Pacific Island capitals where planning and development activities in the water sector cannot keep pace with rapid urban growth. Islands with a tiny land mass are especially affected by this, as sewage waste often accumulates very close to human settlements causing many waterborne diseases. But not only freshwater resources are a concern, marine pollution is a reason for concern in places such as Suva and the lagoon of Tarawa atoll in Kiribati. The results of a study undertaken by the University of the South Pacific indicate that the general water quality status of Suva harbor is above acceptable levels. The faecal coliform counts in the water showed frequent occurrences of unacceptably high values at several sites, far above the levels of the World Health Organization (WHO) give as limits for recreational waters (ESCAP, 1999).

Average faecal coliform concentrations greatly exceed internationally acceptable standards in most, if not all, of Suva's creeks. Of particular concern is Nubukalou Creek which drains a major area of the city that is

without sewerage. The National State of the Environment Report states that "with faecal coliform levels thousands of times above an acceptable level it should be regarded as a sewer. The continued sale of fish along the creek bank, with the consequent use of its water for washing them, is a serious health hazard" (Watling et al., 1992).

In Suva the principal sewage treatment plants of Kinoya and Raiwaqa are frequently not able to function efficiently. Effluents that are discharged to surrounding waters are very often not completely treated. Through the Vatuwaqa River they finally end in the Laucala Bay. A similar scenario exists in Lami and Nasova where sewage effluents are discharged into the Wailada Creek and the Leveti Creek respectively.

Industrial areas around Suva, such as Lami, Walu Bay, Vatuwaqa and Laucala Beach Estate are another source for water contamination. The water pollution from these areas significantly reduces water quality in the near-shore waters around Suva and its neighboring settlements, especially Lami. There are no effective regulations to control the profusion of water pollution sources in those industrial estates, and the streams and creeks that drain those areas are probably the most polluted in the country (Gangaiya et al., 2001).

CASE STUDY 3: LAND TENURE AND WATER

Land tenure is the way in which people obtain, use and distribute rights to land. "There is no place in the world where anyone owns all rights to any piece of land. People own rights in and over land which may or may not be freely disposable. These rights are always subject to rights of other persons, entities and institutions in and over the same land" (Namai, 1987).

Land is a very sensitive issue in Fiji. Land in the Fijian language is called vanua, which is more than a resource. Vanua gives identity to the people of Fiji as their lives are closely connected to their land. Land presents the major source of security, both in a material, social and even psychological sense. Through the land an individual is tied to a social group. Closely related family groups live together in villages, cultivating well-defined land areas originally acquired by conquest or occupation of empty land. Several such family groups, claiming descent from a common ancestor, are linked in a larger social units – the *mataqali*. A number of mataqalis are grouped into yavusa of varying rank and function. Several yavusa form a vanua and several vanuas make up a province. There are 14 provinces in all: Ba, Ra, Serua, Nadroga, Namosi, Bua, Macuata, Lau, Cakaudrove, Naitasiri, Lomaiviti, Tailevu, Rewa and Kadavu. The provinces form three confederacies: Kubuna, Tovata and Burebasaga.

The land belongs to all of the mataqali members, not to private people. They can use it like private land. The land is given to them by their chief (Turaga ni mataqali). It is the individual who benefits from his or her efforts when cultivating the land, but it is not theirs.

Each distinctive social unit and subunit (except the *tokatoka* subdivision) is headed by a chief (turaga). Consequently, chiefs are placed at different levels on the hierarchy, but the *mataqali* subdivisions are the basic landowning social units. They own about 90% of the total land area in Fiji. However when payment for land leases are made the chiefs of all the other, higher social units get a hefty share, despite the fact that they are not the owners of the leased land.

Although native land is owned by the mataqali, the leases are administered by the Native Lands Trust Board (NLTB) established in 1940 under the Native Land Trust Act. The NLTB even has the power to lease the land that is not required for occupation by the members of a mataqali without the consent of the mataqali. Some of the excess land has historically been used for growing sugar cane and other crops, mainly by descendants of indentured Indians. More recently coastal land has been used for tourism schemes.

The formula for sharing the rent from the leases is 15% for the NLTB, 5% for the chief of vanua, 10% for the chief of the yavusa and 15% for the mataqali chief. The remaining 55% is shared amongst the members of the mataqali (which can number in hundreds, Table 4).

Table 4. Distribution of rent amongst different levels of traditional land-owners

Unit	Chief/Headman	No. of families	Share from lease
Native Lands Trust Board (NLTB)			15 %
Vanua	Turaga-Ni-Taukai	1	5%
Yavusa (tribe)	Turaga-Ni-Qali	1	10%
Mataqali (clan)	Turaga-Ni-Mataqali	1	15%
Members of Mataqali		Upto several 100s	55%
Totatoka (family group)		0%	

On September 25, 2005 more than 300 people, mainly villagers from the central highlands of Viti Levu, filled the Supreme Court room in Suva to follow the F$52.3 million compensation case between Monasavu landowners and the Fiji Electricity Authority (FEA). Monasavu dam is Fiji's biggest hydro-project. The 80 MW power station about 60 kilometres northwest of Suva supplies electricity to most parts of Viti Levu. 80–90% of FEA's customers on Viti Levu receive power generated at this site. Before Monasavu dam was completed in 1983 Fiji depended mainly on

diesel-driven generators for its electricity supply. In 1982 Fiji generated 924 TJ (Terajoule) of its electricity supply through diesel generators. By 1986 this had come down to 67 TJ. Hydro-power increased from nothing in 1982 to 1067 TJ in 1986 (Prasad 1998).

Even today FEA and its customers are very aware of the importance of Monasavu dam. In drought years, when the water table of the dam is too low to allow an outflow to run the generators, FEA has to switch back to expensive diesel generators. High prices for fossil energy makes this an expensive endeavor. Fiji has a huge hydro-power potential. High volcanic mountains on all of the bigger islands, an average annual rainfall of more than 4000 mm, and extensive water catchment areas in the very sparsely populated interior parts of the major islands make ideal conditions for the use of water for electricity generation. Not many countries in the Pacific Island states are fortunate enough to have such extensive potentials for hydro-power. It is estimated that Fiji's total potential of hydro-power is over 1 GW, more than 10 times the amount used at the moment.

Despite all these positive news Monasavu hydro-dam and other projects there had been often in the limelight in recent years. Huge problems can emerge when various institutional arrangements over land control and management conflict with each other. It is not the conflicting water rights that have created all the problems. The land on which the Monasavu dam was built, the artificial lake that has submerged a lot of land as well as the catchment to provide water to the Monasavu reservoir are under dispute till today between the traditional landowners and the FEA.

When the Monasavu dam was constructed in the late 1970s an agreement between the landowners and government representatives had been reached that the landowners should be paid F$400 (US$238) per acre. FEA thus holds the view that it bought the land on which the dam and the reservoir is built for about F$1 million. Later however the landowners demanded a compensation for the 22.500 acres of catchment area. They argued that they were restricted in the use of the land as logging is prohibited to avoid a siltation of the lake. In June 1998 violent clashes near the power station brought the landowner's demands into the national press. They demanded an additional F$35 million compensation from the Fiji Government, and threatened to close down the power station, if their demands were not met (Daily Post, June 30, 1998). The Fiji Government then sent 100 armed soldiers and riot police to the site (Daily Post, July 2, 1998), but also started negotiations with the landowners about their claims (PACNEWS, July 8, 1998). Early October the Fiji Government offered the 19 land-owning groups a compensation of F$10.3 million for their land and another F$4.3 million for the timber standing on the land as compensation for the loss of productive use of the land (Fiji Times, Oct. 7, 1998). Some of the landowners rejected this offer and started legal action against the Government. In

November the Fiji High Court issued an injunction to a group of Monasavu landowners preventing the Native Lands Trust Board (NLTB) from paying F$14.6 million compensation to the landowners until the matter is sorted out by the court (PACNEWS, Nov. 10, 1998).

It took almost two years before the landowners of Monasavu again appeared on the front-pages of Fiji's newspapers. On May 19, 2000 Fiji experienced its third coup d'état after the two military coups of 1987. While coup leader George Speight and his followers kept the elected Fiji Government hostage in the Parliament building for almost two months Monasavu landowners again seized the power station, took FEA workers hostage and stopped the flow of water from the dam (PINA Nius Online, July 7, 2000). Although the military could get control over the dam by August 10, most places in Viti Levu experienced frequent power blackouts until the last week of August (Radio Australia, August 11 and 23, 2000). After the military intervention to regain the dam the Fiji Army established a permanent presence at the Monasavu dam. Despite that the Fiji Government wanted to have the dispute settled. In August 2000 there had been a meeting between FEA officials and the landowners, where the FEA offered a compensation of F$52.8 million. In June 2001 the same amount was reported in the national press. The Cabinet agreed to allow the FEA to sign an agreement that sets the compensation at F$52.8 million to be paid out over a 99-year period, provided that the landowners discontinue all legal proceedings against the FEA and to refrain from disrupting FEA work (Fiji Times, June 13, 2001). Despite all the positive announcements no payment has been made until today.

Monasavu surely is the most spectacular case where land rights of traditional landowners are conflicting with modern development efforts. However it is by far not the only case. In recent years a large number of such cases came up, and very often water- related issues were involved. In a conflict comparable to the one in Monasavu landowners of the Wainiqeu Mini-Hydro Scheme outside Labasa, the biggest town on Vanua Levu, wanted the Fiji Electricity Authority to pay F$ 7,302,880 (US$ 3,373,931) as compensation for the hydro-plants's water catchment area. Also landowners of the Navau water catchment area on Vanua Levu were demanding F$ 2,851,680 (US$ 1,317,476) from the Government (Daily Post, Sept. 8, 2000). In August 1999 another landowner group near Labasa had threatened to block the road to the Benau reservoir and water treatment plant, if the Government would not pay a compensation of F$150,000 for the land the reservoir is build on (Fiji Times, September 1, 1999). In Suva the landowners of the Wainibuku reservoir are demanding US$150,000 as compensation for the PWD's use of the land (Radio New Zealand International, June 5, 2003). Also the water supply in Lautoka, Fiji's second biggest city, is at the mercy of landowners. On April 15, 1999 landowners closed the pipeline

that brings water from the Varaqe Dam in the highlands near Lautoka to the Suru Reservoir, which supplies water to Lautoka hospital, the main city area and outer areas of the south (Daily Post, April 16, 1999). In early 2003, Qerelevu Hindu School had to close down as landowners demanded money for the water supply of the school. For the past 30 years water for the school had been drawn from the community water supply system of Toge village, but then the landowners from the village stopped water supply demanding a goodwill payment. The school's headteacher is quoted by Fiji Sun (Feb. 3): "Now, without any written order, the landowners are demanding that we pay F$5,000 in goodwill and F$1,000 per household to get water. After we informed them that it was impossible for us to pay, as most of the people here can not afford it, they disconnected the water supply. It's almost three weeks now".

Not only water supply of many places are threatened by high demands of traditional landowners. In November 2000 landowners on which the government owned Ratu Kadavulevu Secondary School is built demanded F$0.5 million as goodwill payment to renew the lease for the land. They threatened to close the school if the amount is not paid within a week. The Government finally decided to pay F$196.000. For many years the Nadrau landowning unit of Saunaka village near Nadi International Airport were demanding compensation for the land Fiji's biggest international airport is built on. In 1999, when the Airport was privatized, they demanded F$48 million for the land. The conflict dragged on for a while and in July 2001 the landowners threatened to close down the airport if the Government wouldn't pay F$7 million compensation for the 434 acres of land. The landowners argued that during World War II, when the airport was built as an airfield used by the United States Air Force, they had given their land for public use, but now it is used for commercial purposes and they want to have a share in it (Daily Post, July 24, 2001). In August 2001 the government finally agreed to pay F$1.1 million to the landowners.

In March 2001 it was decided to relocate the Sigatoka Hospital. To renew the lease for the land the hospital had been built on the landowners demanded goodwill payment of F$700,000. While the Government and the Native Lands Trust Board (NLTB) had repeatedly pointed out that Fiji's land laws make no provision for such goodwill payments or any other payments to facilitate the renewal of a lease, the NLTB apparently had offered F$200,000 as a goodwill payment (Fiji Sun, April 1, 2004). The cases are endless. Land is used more as an economic and political weapon. However there is justification in some of the demands of traditional landowners. Often they become victims of modernization, of a modern administrative structure that just did not acknowledge their rights. As in the case of Fiji's mahogany plantations, the world biggest and worth several hundred millions of dollars. When the lease was negotiated in the

1950s and 1960s the landowners just did not know how valuable the trees were. No wonder that now – when the trees are ready for harvesting – they have come up with their demands.

However there are also so many cases, when the landowners misuse their powers. Such cases can be very small and only locally relevant like the demands of landowners near Lautoka, who had erected road blocks and were charging people one dollar each time they crossed the barrier. The road in question serves about 80 families, a primary school, a Hindu temple and a tourist attraction (Radio New Zealand International, May 7, 2003). A similar case occurred in the rural hinterland of Sigatoka, Fiji's salad bowl. A roadblock saw several hundred ethnic Indian farmers trapped and being forced to pay US$20 each trip to reach markets or hospitals. Finally the government agreed to pay US$14,000 to the landowners to lift the roadblock (Radio New Zealand International, Feb. 25, 2003).

Other cases however are large enough to threaten Fiji's economic and political well-being, such as the expiry of land leases in Fiji's major export sector, the sugar economy. Land leases in the sugar sector are regulated by the 1966 established Agricultural Landlord and Tenant Act (ALTA). According to ALTA the lease expires after 30 years and the land goes back to the landowners if the lease is not renewed. More than 6,000 leases expired between 1997 and 2004 and a large number of them were not renewed. In each individual case this meant the loss of livelihood for the family of a sugarcane farmer. It also meant the loss of the home as the houses were built on leased land too. Between 2005 and 2028 another 7100 sugarcane leases will expire. In such cases farmers could convince the landowners to renew their leases after a goodwill payment of several thousand dollars.

The reasons why the Fijian landowners are very reluctant to renew the leases are complex. Sometimes they want to use the land for themselves, e.g. to profit from the high subsidies the European Union gave sugar producers in Fiji for decades. Often the landowners are no longer happy with the rent payment that earns them between F$45 and F$480 per hectare depending on the quality of land. The rent is not lower than what would be paid in other countries, between 3 and 11% of the value of the gross production, but the number of those who want to benefit from the payment can be huge. A share of 15% straightaway goes to the NLTB, another 30% to the different chiefs and the rest is distributed amongst the members of the mataqali. The question here is how big the landowning group is: there are cases where a member gets just F$2 from the rent, in other cases this can be more than F$4,000. 'Goodwill payments' are therefore welcomed, when the negotiations about the renewal of the lease are due. What would be considered as blackmailing elsewhere has become common practice in Fiji: to ensure that the lease is renewed a few thousand dollars change owners, tax-free of course.

In many cases however there are obvious political motivations behind the non-renewal of land leases. In 1975 Sakiasi Butadroka, leader of the Fijian Nationalist Party brought in a motion in the Fiji Parliament to deport all people of Indian descent back to India. Families who lived in Fiji for three generations, people who never had been to India, without any land or other form of property there. Although the motion was declined it expresses fairly accurately the ethnic conflict in Fiji. On the one side there are the indigenous Fijians. Many of them still live in rural areas in a semi-subsistence agricultural economy. For them land rents are a way to improve their cash income. On the other hand are the descendants of Indian plantation workers. Many of them are still in the agricultural sector, cultivating sugarcane on small holdings of not more than 4-5 hectares which they have leased from indigenous landowners.

However it would be too simplistic to see the land and water conflicts in Fiji mainly as the result of the ethnic conflicts of the country. There are various conflict lines: the conflict between traditional leaders and the modern state. Traditional leaders who want to get their share from the development efforts of the state. They are powerful as traditionally they can mobilize support from their kin and clan members. Also economically the chiefs can count on their support as they get some of the lease money or compensation. However in the end the chiefs are the ones who get the major share, who get huge amounts. Politically they can find support with their demands in Fiji's parliament and from Fiji's government, but only as long as they hold the political power.

Such conflicts are not unique to Fiji. One can find them in many parts of the Pacific Islands. Since many years the water and power supply of Port Moresby, the capital of Papua New Guinea has been under constant threat as landowners demand compensation for the land of the Rouna hydro-electrical scheme and the Sirinumu water supply project (The Post-Courier, Aug. 24, 2005). Earlier water and power supply to Port Moresby had been frequently interrupted (The Post-Courier, Nov. 19, 2004). Similar conflicts occur in the tourist town of Madan (The Post-Courier, April 2, 2003), and the two towns in PNG's highlands, Goroka and Mt. Hagen (The Post-Courier, Jan. 21, 2001).

In recent years similar conflicts occurred in Honiara, the capital of the Solomon Islands. In June 2000 militants blew up a pumping station with dynamite. As a result, 90% of the homes in Honiara were left without water supply for more than a year (Radio Australia, March 24, 2002). In November 2001 the landowners of the Kongulai water supply shut down the supply of water to most parts of Honiara. While negotiations with the government continued over months power and water were frequently interrupted.

Insecure water supply in larger islands of Melanesia is the result of conflicts in institutional arrangements such as property rights, scarcity of financial resource and a lack of Good Governance and accountability in water administration. Insecure water supply often is also the result of civil unrest or even civil war. There are situations when naturally caused water scarcity like ENSO-induced droughts can create difficulties for particular sections of the societies in Melanesia, but proper resource management and disaster mitigation efforts surely would be able to minimize these problems as we can assume that enough water could be made available, if a proper water resources management would exist.

The last case study looks at an environment that is much more vulnerable to natural hazards than rather big, mountainous islands are. Coral atolls are amongst the harshest environments on earth: flat ribbons of sand, little land for an expanding population, with scarce freshwater supply; supporting a limited range of vegetation making agriculture difficult and restricted to a few crops, extreme geographic fragmentation and isolation making transport and communications costly and difficult. South Tarawa, the capital of Kiribati, is such an atoll island. Not only water-related problems make one wonder how people can survive in such an adverse environment. But they do, despite the fact that over time conditions do not improve, but deteriorate.

CASE STUDY 4: WATER SUPPLY IN SOUTH TARAWA, KIRIBATI

The Republic of Kiribati consists of 33 islands spread over three island groups, the Gilbert, Phoenix and Line Islands. 32 of the islands are coral islands or coral atolls, while one, Banaba, is a raised island. All the three groups are often subject to severe droughts (Rapaport, 1990).

With a land area of about 800 km^2 Kiribati belongs to the world's smallest states. However is stretches over almost 5,000 km from East to West and more than 2,000 km from North to South. The Exclusive Economic Zone is more than 3.5 million km^2, giving Kiribati's territory an expansion comparable to the land area of the USA. Most of the islands are not more than 2 km wide and less than 5 m above sea level. There are only four flights a week in and out of the country. Distance and access to markets are challenges of a magnitude faced by few countries. This is even true internally, where it is difficult to maintain a communication and transport network that covers the entire territory of the country. Kiribati has the largest atoll population in the Pacific with about 85,000 people in the last census of 2000. The annual growth rate between 1995-2000 had been 1.7% with high urban growth rates (UN 2002).

The resource base is very narrow. The climate and poor soil offer little potential for agricultural or industrial development. The public sector dominates all spheres of economic activity. Fishing licensing fees are the major source of foreign exchange and government revenue. However compared to the annul value of Kiribati's tuna resources that are caught by foreign fishing vessels,the US$20 million that the Kiribati's Government is getting for issuing fishing licenses is rather low (Islands Business Magazine, Feb. 11, 2005). Import duties and remittances from I-Kiribati employed in foreign shipping fleets provide significant additional government revenue and foreign exchange, respectively. The population is concentrated in the Gilbert Islands Group, which includes Tarawa, the capital. Soon a half of the population will live in South Tarawa, while the Phoenix Group is virtually uninhabited. If present trends continue, population will double within 20 years presenting even greater challenges to overcome environmental and health problems, particularly in Tarawa.

The scattered nature of the islands, isolation from each other and the region, poor soil and harsh climate, pose a big development challenge to the government of Kiribati and its people. Kiribati ranks 11th of 14 Pacific island countries and 129th in the world in the UNDP's Human Development Index. In terms of infant mortality and child morbidity, per capita GDP, and access to water and sanitation, Kiribati is among the lowest in the region (UN 2002).

Amongst the most restricting factors for development is the scarcity of freshwater. Rainfall is very unevenly distributed within and between the years. Droughts that can last ten months or more are common in Kiribati (Metutera, 2002). With an increase in population Kiribati's very fragile freshwater lens has become extremely vulnerable to depletion, intrusion of seawater, contamination with sewerage and other pollutants and is causing severe health problems. This is especially true for South Tarawa, Kiribati's capital, a place with the highest population density in the Pacific Islands.

South Tarawa – A Thirsty Capital

Tarawa atoll in the Gilbert Group consists of more than 20 islands, of which 8 are inhabited. The western part from Bonriki, where Kiribati's international airport is located to Betio with the port and the copra mill, Tarawa's only industry worth mentioning, is called South Tarawa. This stretch of Tarawa is about 35 km long. Various causeways connect the islands of South Tarawa from Betio to Bairiki. The longest is the Betio-Bairiki Causeway with 3.4 km. It was built in the middle of the 1980s by a Japanese company.

Most of the land is less than 3 metres above sea level, with an average width of only 430-450 metres. About half of Kiribati's population of 93,100 people live on South Tarawa's land area of 12,56 km^2. Migration from outer islands of Kiribati resulted in an annual population growth rate of 5.2%. Should this rate continue South Tarawa's population will double in just 13 years reaching 73,400 by 2013 (Haberkorn, 2004).

The 2000 census counted a population of 84,494 for the whole of Kiribati, an average growth rate of 1.7% per year from 1995-2000 with an urban growth of 5.2% and rural decline of 0.6%. South Tarawa had 36,717 people or 44% of the national population compared to 37% only five years earlier (UN 2002). When Tarawa became the capital of the Gilbert and Ellice Islands Colony in 1947 South Tarawa had a population of 1,643, representing 6% of Kiribati's population (Lea/Connel, 1995). Environmental problems (water quality; waste; sanitation; lagoon pollution) are created by South Tarawa's congestion. Crowded and unsanitary conditions contribute to a high incidence of diarrhoeal diseases with more than 700–800 reported cases per month (Hunt, 1996) and a high death rate especially among young children.

Although the exact number is not known a big share of South Tarawa's population live as squatters, especially those who in the last decades migrated to Tarawa from the outer islands. A concentration of squatter settlements is in the area of Betio, Bairiki and Bikenibeu. In Betio it is estimated that more than one-third of all households are squatters. Squatting occurs mainly on Government leased or owned lands such as along causeways, foreshore areas and areas adjoining rubbish dumping sites. On Government leased lands, 'informal' housing arrangements based on kinship obligations can be made with landowners, despite the fact that the land has been leased to the Government. Most squatters lack access to land, water supply and sanitation facilities. Based on population estimates, the number of housing plots required to accommodate the proposed 2010 population is in excess of 2,000 units (Urban Management Plan, 1995).

The extremely dense, congested and unregulated housing arrangements have contributed to many health, social and environment problems. The 2000 census records an average household size of 6.7 persons for the whole of Kiribati. However in South Tarawa 8.1 persons live on an average in a household. More than 30% of all households have more than 10 persons. The negative impact on Tarawa's water supply is surely the most serious one. Most of the water is pumped from a subterranean water lens in the northern and eastern parts of Tarawa. Some of the lenses are already so polluted that they are no longer safe to use (ADB 2004) and others are significantly overstretched by growing demand, illegal connections, spread of settlements onto land above the water lens, and the widespread use of pit and water seal toilets. A traditional I-Kiribati practice is to use the sea

as a toilet. In many of the squatters' houses there are no proper toilet facilities. On islands that are less populated this poses little risk to public health but on over-crowded Tarawa, where 53% of households regularly use the beach, it has created serious health problems (UN 2002).

Water Supply in South Tarawa

There are three different sources for potable water available to the population of South Tarawa: rainwater, ground/well water and reticulated water. In addition to this there had also been a number of trials with desalination which technically turned out to be too risky to entirely depend on. Two of the three desalination plants broke down soon after installation and it took months to get spare parts from overseas to repair them (Metutera, 2002).

Rainwater is used in Kiribati as a supplementary water source since long. The collection of rainwater is a more efficient way to produce freshwater than groundwater extraction. To rely entirely on rainwater is rather risky. Unequal distribution of precipitation can lead to months-long drought and storage facilities are not large enough to help bridge such events. However rainwater collection can reduce the pressure on other water resources, especially the one on the freshwater lenses.

The reticulated water is extracted from the freshwater lenses at Buata and Bonriki (north to the airport) at a maximum rate of 1,250 cubic metres per day. In 1989 the sustainable yield for the two pumping zones had been estimated at 950 cubic metre a day. In 1992 a review was carried out and after that the sustainable yields estimates were 1000 and 300 cubic meters a day for Bonriki and Buata respectively. The latest calculations (2002) hint at a sustainable yield 1700 m^3/day (Bonriki: 1350 m^3/day, Buota: 350 m^3/day) (Metutera, 2002). There are more than 3,500 connections that provide 1-2 hours of water each in the morning, at lunch time and in the evenings. (Urban Management Plan 1995). As reticulated water is not available around the clock there is still a very heavy reliance on traditional wells and the collection of rainwater. According to the 1990 census for 49% of all households in South Tarawa wells were the major sources of water supply, while 35% used mainly rainwater (Urban Management Plan 1995). A problem with intermittent water supply is that an equitable distribution of water cannot be achieved this way. Those living close to the elevated tank/reservoir will always receive more water than those living downstream who receive little water or no water at all.

South Tarawa's water problems grow as fast as the population does. In 2000 water demand for a population of 36,227 persons was 1159 m^3/day. Even if Kiribati's government finds means to slow down the population

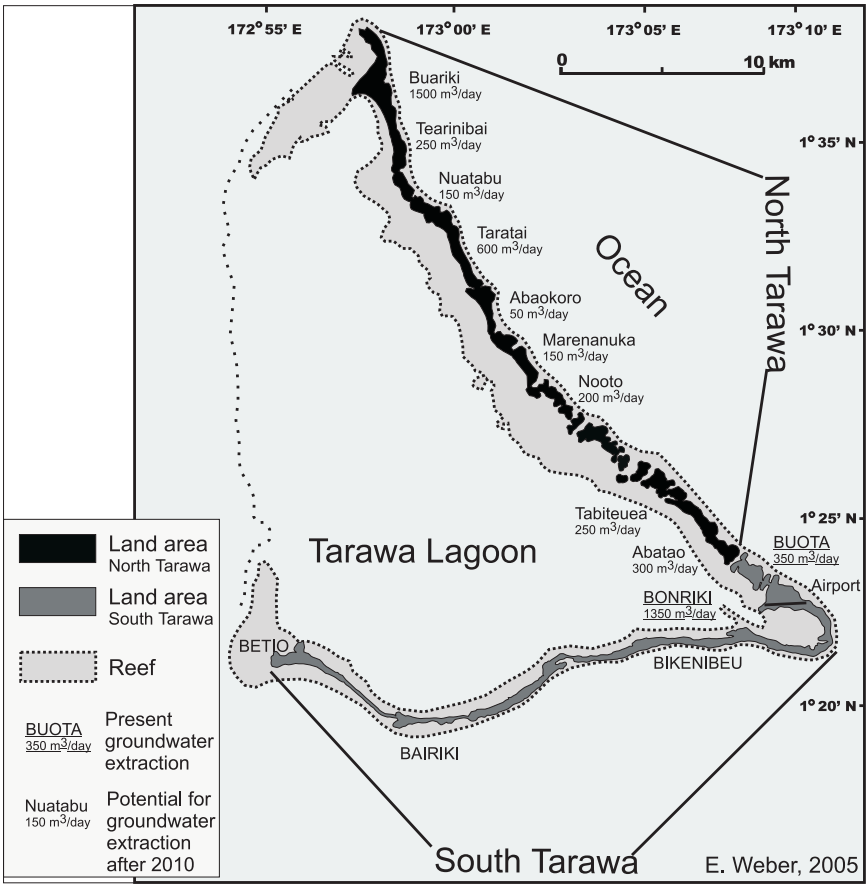

Fig. 8. Present and potential groundwater sources on Tarawa

growth on South Tarawa, more than 2100 m^3/day will be required by 2020 to ensure 40 litres water per head and day. If population increases at the present rate there will be almost 100,000 persons living on South Tarawa in 2020, 7,600 persons per km^2, consuming 3151 m^3 water per day, almost three times of the demand in 2000.

It is estimated that the present freshwater lenses can meet South Tarawa's water demand until 2010. Beyond that new water sources have to be found or developed. North Tarawa, which at present is not used to procure water for the capital might be a solution (Fig. 8). An estimated sustainable yield of 3450 m^3/day could be achieved there. Extracting water from lenses in North Tarawa however might become expensive and time consuming as the landowners in North Tarawa are hesitant to lease or sell their land to the Government (Metutera, 2002).

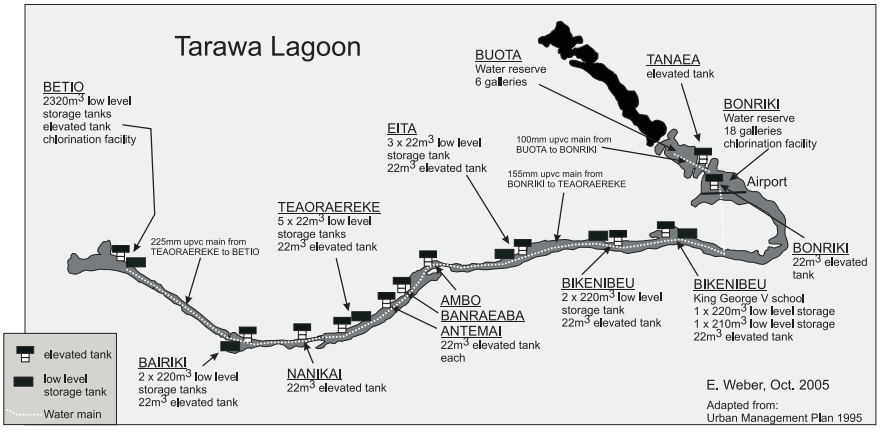

Fig. 9. South Tarawa's water supply system.

One of the most serious problems connected with traditional wells is the danger of polluted groundwater. Open hand-dug wells are the traditional methods used by the people of I-Kiribati to obtain freshwater. As the depth from the surface to the groundwater table is only a few metres and the soil is fairly easy to excavate open wells are easy to construct. Wells constructed in this way have the obvious drawback that water can easily get contaminated (Metutera, 2002). Surface pollution is widespread from septic tanks, latrine pits, domestic waste as well as open human and animal defecation especially from pigs. In areas of South Tarawa with high population densities all the remaining old open dug wells are now a severe health hazard. The poor quality of well water is reflected in the very high rates of diarrhea throughout South Tarawa. Polluted water was the reason why the former water lenses in Betio and Teaoraereke were closed for the reticulated water supply.

The pumping zones for South Tarawa's water supply are away from highly populated areas. In addition to this a number of technical and institutional measures have been started to protect the freshwater lenses that contribute to South Tarawa's reticulated water supply. In order to protect the freshwater lenses in the areas that provide reticulated water for South Tarawa a Water Reserves Committee has established a 50 meter 'setback zone' around each zone as water reserves. The dwellers of informal settlements within these zones were asked to resettle voluntarily, which turned out to be rather difficult in some cases, as alternative vacant land is very scarce in Tarawa. In addition new migrants arriving from outer islands are putting extra pressure on available open land areas and the newcomers are eyeing the cleared reserves in the setback zones with increasing interest (ADB 2004). Also cultural issues contributed to the problems of the project. Like many atoll societies the I-Kiribati society is

very egalitarian. The major social units are extended families, where values like cooperation, solidarity and reciprocity play very important roles (Frisbie, 1921). The resettlement of squatter communities within the water reserve zones turned out to be difficult also because I-Kiribati culture expects people to be modest and humble, and not placing oneself above others. Even forcing squatters to leave protected areas thus is against cultural norms of the people of Kiribati (ADB 2004; White et al., 1999).

To allow the freshwater lenses to recharge faster the South Tarawa Water Supply System has used infiltration galleries since the late 1960s (for technical details, see Metutera, 2002; White, 1996; White et al., 1999). The galleries consist of some form of horizontally laid permeable conduit to allow water to infiltrate from the surrounding saturated zone. An open area such as Tarawa's airport acts as a catchment that can rapidly recharge the aquifer after heavy rains.

Altogether there are 24 infiltration galleries strengthening South Tarawa's water supply, six on Buota and eighteen on Bonriki. The length of each of the galleries using perforated pipes is about 300 m. Thus the total length of the galleries is 5,100 m for Bonriki and 1,800 m for Buota.

Water quality in South Tarawa is closely connected to the quality of sewerage treatment/disposal. A reticulated sewerage system had already been introduced in South Tarawa between 1978 and 1982 in response to a major cholera epidemic in 1977. The system covers only areas of Betio, Bairiki and Bikenibeu, the most populated parts of South Tarawa, about 30% of the size and 60-70% of the population. "In reality however, the coverage in these urban centers is mainly limited to the low density permanent houses, Government building and communal toilet blocks" (Metutera, 2002). The households connected to the system use salt water for toilet flushing, which discharge into three separate ocean outfalls over the reef edge.

The water supply system like the sewerage system is under increasing strain and already operating above capacity. Lack of financial resources, spare parts and expertise has deteriorated the system. Pump stations are frequently out of functioning, sewer mains are leaking with salt water and sewage, the communal toilet blocks are in a state of disrepair having been vandalized or just let to run down with salt water pipe leakages, structures collapsing and an estimated 70% of cisterns broken (Urban Management Plan 1995).

Global Climate Change and Water Resources

Like many atoll islands Kiribati is also highly vulnerable to global climate change. The 2001 synthesis report of the Intergovernmental Panel on Climate Change concludes that global warming is underway. It is very

likely to increase during this century at rates unprecedented in the past 10,000 years. For small islands, the IPCC warns of deteriorating coral reefs, mangroves, and sea-grass beds; major species loss; worsening water balance in atoll nations such as Kiribati; and declines in vital reef fisheries. For the Pacific islands as a whole, the World Bank warns of reductions in agricultural output, declines in groundwater quantity and quality, substantial health impacts (increased diarrhea, dengue fever and fish poisoning), extensive capital damage due to storm surges, and lost fish production. Countries like Kiribati and the neighboring Tuvalu are predicted to suffer the greatest impact of climate change including disappearance in the worst case scenario. Although most media attention has focused on sea level rise, the expected impacts – particularly for atolls – are likely to be reduced agricultural output (due to changing rainfall patterns and increased temperatures), a decline in groundwater quantity and quality (sea level rise and possibly drought) (IPCC 2001). The World Bank concludes that: "Managing change will be particularly critical in the area of climate change, a subject of immense and immediate impact on Pacific Island countries. Choosing a development path that decreases the islands' vulnerability to climate events and maintains the quality of the social and physical environment will not only be central to the future well being of the Pacific Island people, but will also be a key factor in the countries' ability to attract foreign investment in an increasingly competitive global economy" (World Bank, 2000).

All atolls in Kiribati will be severely affected by global climate change. As infrastructure is most developed in Tarawa it is expected that the material losses will be highest there. By 2050 Tarawa could experience annual damages of about US$8-US$16 million. "In years of strong storm surge, Tarawa could face capital losses of up to US$430 million in land and infrastructure assets destroyed by inundation. Relocation of communities might be the need if the loss of land and freshwater supplies becomes critical. Climate change is thus likely to place a substantial burden on the people and economy of Kiribati. The projected losses could be catastrophic for a country with a 1998 GDP of only US$47 million" (World Bank 2000).

Global climate change affects Tarawa through variations in sea-level, rainfall, evapo-transpiration and through extreme weather events. In a worst case scenario with a sea-level rise by 0.4 meters, a decline of rainfall by 10% and a reduction of the width of the atoll the thickness of the groundwater lens could decline by as much as 38% (World Bank 2000).

Global climate change is surely the biggest threat to many of the Pacific Island states, not only to the small, low atoll islands. The case studies above however show that many severe problems around a safe and secure water supply exist throughout the Pacific Islands. Problems severe enough to threaten the existence of settlements in particular places, and to endanger

the livelihoods of big proportions of Pacific Island populations. Especially in fast growing urban areas in the Pacific Islands the gap between demand and supply of water is increasing rapidly. However one needs to be aware that water supply is only one of many issues that affect the well-being of the urban population. The major problems in urban centers in the Pacific include a serious shortage of land and conflicts with traditional land tenure, falling standards of infrastructure, an increase in the number of squatter settlement and informal housing, poverty, vulnerability and environmental degradation (UNEP 1999). It is very likely that these problems not only continue to exist, but that they are becoming bigger even when huge investments are made to improve living conditions. The future especially for urban areas in the Pacific Island thus does not look too optimistic.

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