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**POPULATION PRESSURE ON CORAL ATOLLS:
TRENDS AND APPROACHING LIMITS**

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ABSTRACT

Coral atolls are oases amidst an oceanic desert. However, most are extremely isolated and are subject to natural hazards, and are covered by barren coral rubble with a vulnerable fresh water lens. Atoll production systems include tree crops, root crops, fisheries, mariculture, and cottage industries; some atolls have experimented with commercial fisheries and tourism. Land is generally equitably distributed. Atoll communities are substantially dependent on metropolitan powers and high islands. The dependent groups have smaller populations, low growth rates, higher per capita aid, emigration privileges, and minimal urbanization. Independent groups appear to be closest to their carrying capacities. Regional disparities in population distribution can be explained by an analysis of carrying capacity. The proposed model begins with increased expectations and perceived needs. This results in migration from outer islands and signs of population pressure in district centers; leading to urbanization, emigration, and carrying capacity overshoot in both the region and overseas.

INTRODUCTION

Atolls are island studded coral rings surrounding clear, deep lagoons. They are remnants of volcanic islands which have now sunk thousands of feet below the surface of the sea. They are located in archipelagoes, clusters, and as single isolates scattered across the oceans. The great majority of them occur in the Pacific, though there are also many in the Indian Ocean. They are rich, mutually supporting, and self-sustaining communities of marine and

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terrestrial organisms, and are one of the great miracles of nature.

The equilibrium of interacting living communities on atolls is balanced precariously and is periodically disturbed by drought, hurricanes, and tidal waves. Most atolls support human populations, typically numbering in the hundreds. However, human existence on atolls does not have the safety margin available in continental and large insular regions. There are usually only a few square miles of land area; in some cases, less than a single square mile. Considerable effort is needed for exploitation of atoll soils which are poor in available plant nutrients, and subject to periodic drought, deluge, and salt inundation. Although reefs can sustain a large animal biomass, they can be adversely affected by human population density. Marine resources are relatively abundant, but are dependent on the skills and technology available to local populations.

Both population pressure and the resulting intensification of use of natural resources can eventually erode the land; pollute the soils, reefs, and lagoons; and endanger a uniquely balanced biotic community which is perfectly adapted to the atoll habitat. The growing demand for outboard engines, chemical fertilizer, and industrial development poses threats to the natural environment even if population were to remain stable. Finally, intervention by external political influences have played a role in the changing of atoll society. Thus, any discussion of the implications of population pressure must also consider the effects of urbanization and foreign relations.

This study provides an analysis of population-environment relations on the major atoll groups. It first considers the indigenous resources, production systems, and resource distribution. This is followed by a review of demographic trends including population growth, migration, urbanization, and political dependency. The concept of human carrying capacity is explored. Traditional models are criticized because of their inability to account for external linkages. The proposed approach assumes a dynamic carrying capacity based on perceived needs and overseas linkages; explains regional disparities in population distribution; and provides a continuing model for population movement from outer islands to district centers and mainland areas.

THE ATOLL ENVIRONMENT

Physical Geography

Some of the most important environmental studies of

coral atolls have been conducted in the preparation for atomic testing in the former U.S. Trust Territory of the Pacific Islands. In response to a request from the South Pacific Commission, many expeditions were sent out by the Pacific Science Board, a branch of the National Research Council of the National Academy of Sciences. Interdisciplinary physical and biological studies of atoll lands, reefs, and lagoons were carried out. Many of these studies have been published in the Atoll Research Bulletin. A major contribution was also made by Wiens (1962) who compiled a useful volume on atoll environment and ecology based on the previous research. The following description is indebted to these studies.

Atolls are generally described as oval shaped coral reefs surrounding a lagoon in which there are no islands except for slightly submerged reefs. According to current theory, atolls were formed by subsidence of a volcanic island and the gradual rise of the fringing reef. Present living reefs veneer a much older surface in part marked by glacial and interglacial sea level fluctuations. In true atolls there is complete subsidence of the oceanic island; in almost atolls, volcanic peaks remain as islands within the lagoon; in raised atolls, the reef is raised considerably above sea level through tectonic processes. The highest point on an islet is usually no more than 10-15 feet above sea level. It typically occurs at a coral rubble ridge located on the ocean side of an islet and is built up by storm waves over many years from sediment produced by erosion during major storms of the outer reefs. Finer sediments occur in the lee of the rubble ridge. The interior of an islet is covered by a surface of coral rubble or sand in which a variety of drought and salinity resistant species of land plants can take hold. Like all islands, they are colonized by drift and by migrating seabirds. The natural atoll forest is dominated by species such as Pisonia, Tournefortia, Guettarda, Cordia, and other species, forming a canopy forest. Cocos, Artocarpus, Cyrtosperma, and perhaps Pandanus, have been introduced to most inhabited atolls. Approaching the lagoon side of the islets, the coral rubble becomes increasingly finer until at the lagoon beach it is usually composed of fine sand.

Atoll long axis lengths range from about twenty miles or more, to five or less. The largest lengths occur in the Marshalls, the Tuamotus, and the Maldives. Between the islets, the reefs are submerged only a few feet, and can usually be easily traversed by foot during low tides. Some third of all atolls have a deep, natural channel across the reef, allowing for the passage of boats, sharks, and large fish into the lagoon. Lagoons are generally shallow in the small atolls (less than 25 fathoms) and are deeper in the

wide atolls (typically ranging from 30 to 45 fathoms). Patch reefs are present inside the lagoons and are important for the associated assemblage of coral, clams, crustaceans, eels, and fish. The large atolls more frequently have passes and are rich in their lagoon fisheries potential. Small atolls have to rely to a greater extent on hazardous open sea fisheries.

Most atolls are subject to periodic droughts and severe storms, but a few face extreme environmental challenges. In particular, the Northern Marshalls, the Southern Gilberts, the Line Islands, and the Phoenix Islands (Kiribati) are prone to severe periodic droughts. Western Micronesia is prone to hurricanes more often than some of the others. Atolls can be affected by devastating tsunamis and wave trains from major storm centers which can propagate for thousands of miles from their source. Atolls subject to these natural hazards have a very small margin for carrying capacity. Following severe storms and droughts, coconuts, breadfruit, and taro pits may take years to recover. Reconstruction of housing, water catchment sites, and public buildings can be a severe drain on labor, income, and natural materials.

Fresh water is the most limiting requirement for settlement on atolls. Islet material is generally so porous that drainage by percolation occurs almost instantaneously. Some water is held in capillary openings in the soil and remains available to shallow rooted plants. The surplus seeps down to a lens of fresh water saturating rock and sand. The shape of the lens depends on local geologic conditions, shape of the islet, tidal movements, and inputs of rainfall. Today, atoll societies rely on ground water and catchment, but in previous times some atoll communities survived solely on coconut water and occasional water collection in excavated coconut trunks. Most atoll plants can survive on the periodic moisture in the unsaturated zone of the soil but taro, bananas, and breadfruit require the presence of ground water. Coconut and pandanus can survive without ground water but do best in wet climates.

Human effects on the reef in previous times have generally been minimal. However, today, a variety of development related projects are likely to have a deleterious effect on the reef system. Reef blasting for boat channels is suspected to be linked to ecological disturbances favoring the spread of ciguatera and other problems. Mining the reef for construction material may cause even more extensive damage. Urbanization can cause depletion of species and contamination of the lagoon. Since initial settlement, human effects on the land have been significant on virtually every atoll group. The natural

forest has largely been replaced by introduced species, while copra export and loss of seabird nesting colonies have led to soil depletion of potash and other elements. Copra has brought greater security in food supplies and eased man's labor in many respects but recent price fluctuations have endangered even this resource.

Production Systems

Data on productivity and yield of indigenous Pacific Island production systems are extremely limited. Regional studies in the South Pacific (Ward and Proctor, 1980) and the North Pacific (U.S. Congress, 1987 and Mark, 1982) have mainly been concerned with reviews of high island production systems. Notable exceptions include the South Pacific Commission Conference on Atolls (S.P.C., 1982; and numerous unpublished papers), the UNDP Integrated Atoll Development Project (Liew, 1986), and the ongoing UNESCO Man and the Biosphere Project. There have also been important studies of traditional fisheries (Johannes, 1981), tuna fisheries (see S.P.C., 1981), and subsistence agriculture (University of Hawaii SPRAD Program).

A variety of marine resources are available on atolls and probably were the major source of food for the initial colonists. Even today fish is the major item of diet on many atolls, and after a major storm, tidal wave, or drought, when most of the terrestrial reserves can be devastated, life continues by relying on the sea. Reef, lagoon, and sea organisms are diet staples on all atolls and include crabs, fish, clams, eels, turtles, octopi, holothurians, and even worms. Atoll fishermen have an extraordinarily detailed knowledge of fish ecology and habits. Yield has further improved--though often at the cost of resource depletion--as a result of modern nets, spearguns, nylon line, and outboard motors.

An excellent review of fisheries potential is provided by Salvat (1980): Productivity is limited by the absence of continental shelves, shallow lagoons, no important zones of upwelling, little input from land drainage, deep thermoclines, relatively barren oceans, and increasing international exploitation. In the midst of this oceanic desert, the coral reef ecosystem is among the most productive on earth and is sustained by symbiotic relationships which keep energy loss to a minimum. Fisheries on the small islands have traditionally relied primarily on the reef and lagoon resources but there is currently interest in increased exploitation of both the outer reef slopes and the surrounding ocean.

Reef and lagoon fish are characterized by great species

diversity and small sizes of edible fish, which does not favor commercial production. The presence of coral heads also favors the use of individualized fishing methods such as lines, traps, nets, drives, and spears. Species caught belong to the families Siganidae, Serranidae, Carangidae, Lethrinidae, Acanthuridae, Ballistidae, Exocotidae, Mullidae, Mugilidae, and many others. Intensification of fisheries using modern methods leads to stock depletion since most reef species tend to be highly territorial. Introduced methods have already severely damaged the lagoon ecosystem in some atolls. Constraints are also posed by the prevalence of fish toxicity and vulnerability to pollution. Other reef genera that have been traditionally exploited include Pinctada, Tridacna, Trochus, and Holothuria. These can all be an important source of income for atolls, though pearl farming may require the right conditions and substantial investment.

Outer slopes of atolls typically descend at steep angles to the ocean floor. There is little live coral below fifteen fathoms but there is a substantial amount of demersal fish including Lutjanus, Pristopomoides, Aprion, and others. These are large fish which live at great depths and can also be caught by individual fishermen in small canoes. However, they are often underexploited because of the lack of the means and knowledge to work these depths. Deep sea resources include Thunnus, Katsuonus, Acanthocybium, and others. Traditional deep sea fishing (trolling with lure or fish) was often an incidental activity of interisland voyaging but it is now becoming increasingly commercialized using a variety of modern methods (see Salvat, 1980). There is believed to still be considerable room for expansion of the skipjack fisheries (S.P.C., 1981).

Terrestrial resources are considerably more limited than marine resources. Atoll soils are composed almost entirely of calcium and magnesium carbonate, and are derived primarily from coral and calcareous algae, and also from shells and foraminifera. Iron, nitrogen, and other mineral elements are deficient. This poses severe limitations on horticulture. The coconut is the most important tree on atolls and the majority of land is devoted to it. Human populations are dependent on the coconut for food, drink, fuel, construction, and textiles. The availability of coconuts has increased as a result of the copra trade as well as the imposition of peace during the colonial period (Wiens, 1962). However, production is limited by neglect and overcrowding, partly due to copra price fluctuations. Breadfruit is also a very important source of food. It does not require high rainfall and is found even in the Northern Marshalls (Pollock, 1970). It tolerates salinity poorly and

is generally planted on the lagoon side and interior of the islet. Pandanus is part of the indigenous forest system and is utilized for food, textiles, and handicraft production. A large variety of the above species are cultivated but have been incompletely documented in the scientific literature.

While Colocasia is cultivated on some of the wetter atolls, Cyrtosperma (pit-taro) is the traditional root crop on most atolls. It is nutritionally superior to white flour and rice, can be produced indigenously without foreign technology, and is especially important for feasts and ceremonial occasions. Pits are dug down to the fresh water lens, a compost of leaves is added, and a muck soil is produced that can be sustained indefinitely. Cyrtosperma is relatively disease resistant compared to other taros. However, the work is labor intensive and the tubers may require a lengthy maturation period (Bayliss-Smith, 1980). It requires lengthy hours of work, often while being harassed by mosquitos. Its production has unfortunately declined in most atolls. In some cases, this was due to infestations of leaf blight and weed introductions. In other areas, epidemics, social breakdown, and extensive copra plantation may have been responsible (Thaman, 1984). The impacts of natural hazards and foreign dependency can also not be discounted. Probably the major reason for their neglect is the fact that their productivities cannot compete with the returns usually available from the commercial economy (Bayliss-Smith, 1986).

Traditionally, atoll communities practiced numerous conservation and management strategies. Some of these are listed by Liew (1986). One of the most important practices was the imposition of periodic taboos on plantations and on reefs. Other practices included size limitations for certain species; cooperative sharing of swordfish, turtles, and large fish catches during the spawning season; quota systems for families and kin groups; and preservation of forest groves and tabu islets for canoe building, construction, bird nesting, and religious purposes. With the decline of traditional authorities, and with the greater reliance on external inputs (eroding the perceived need for self-sufficiency), these regulations have weakened or been lost altogether.

In his survey of Ontong Java, Bayliss-Smith (1986) finds that in order to cope with an expanding population, the atoll society will have to respond with full use of subsistence resources, an intensification of copra making, or further exploitation of holothuria. He notes that most subsistence activities are labor demanding and are already close to being fully utilized. Because of the substitution effect of the commercial economy and decreasing tolerance of

an unmodified traditional diet, further erosion of self-sufficiency is expected. Unfortunately, he adds, there is no foreseeable increase in local income in the near future.

Because of the price instability, decreasing value, and susceptibility to natural hazards of copra production, and the limited potential for atoll agriculture and handicraft production, alternative modes of production have been proposed (see U.S. Congress, 1987). Commercial export fisheries and tourism have been successfully implemented in the Maldives and now provide the major source of income for a large atoll population that receives much less development aid than other atoll groups. These ventures have been reviewed by a World Bank economic survey (World Bank, 1980). The fisheries industry is handled and marketed by Japanese companies with sophisticated collection vessels moving from atoll to atoll with freezer facilities. The fisheries sector now accounts for one third of the GDP, almost half of all employment, and nearly all visible export earnings. Tourism exists in the form of resorts on outer islets of the main atoll. Because of their location, there has been minimal deleterious cultural effect on the islanders. It accounts for a tenth of the GDP and is the most important foreign exchange earner.

These industries are being increasingly investigated as options in the Pacific because they have been demonstrated to reduce the reliance on unstable aid, generate employment for land-poor persons, outer islanders, and urban populations, and stimulation of other sectors, including agriculture. However, their applicability to the Pacific region is questionable (Castle, 1980). The remoteness of Pacific atolls greatly adds to transport expenses. Smaller populations and reef areas do not allow for the economies of scale available in the Maldives. There may also be some major societal costs for industrial development that is not carefully regulated, including the likelihood of class division and environmental degradation.

Resource Distribution

Atoll societies have typically been very egalitarian (see Sahlins, 1971). Extended families shared fish that were caught, often cooperated in other subsistence activities, and helped with construction projects. Frisbie (1921) provides a first hand description of a traditional atoll society:

"Puka-Puka is, perhaps, the only example on earth of a successful communistic government. . . Here there is no private ownership of lands other than the tracts upon which the houses are built, and even in this case the land really belongs to the villages, which give the

residents unlimited lease to live thereon. When the villagers move for a few weeks sojourn on their respective islets, the coconuts are gathered, stacked in the temporary village, and then equally divided among the men and women, a small share being reserved for the children. The nuts are then opened and dried for copra. . .The money received is either divided equally among the villagers or used to purchase clothing, tobacco. . .which is then divided. Likewise, when it is found that the puka trees are full of young birds, the men catch them and the same division takes place. Even the fishing is often managed in this manner. . . Of course, if they had the slightest taint of ambition, their system would fail, for under it, it is quite impossible for one man to be richer than another. When, in the course of decades or generations, some unnatural go-getter happens to be born, he soon finds life so intolerable that he emigrates to an island where communism doesn't prevail. But Puka-Pukans, with very few exceptions, are wholly satisfied with their system. They avoid all land disputes, and no one is faced with the problem of how to make a better appearance in the world than his neighbor."

Other Pacific atolls are also generally less hierarchical and more egalitarian than their large insular counterparts (See for example, Sahlins, 1971; Pollock, 1970; Alkire, 1978; Chambers, 1982; and Bayliss-Smith, 1986).

Although cooperative stores have been successfully introduced to many atolls (see for example, Howard, Plange, Durutalo, and Witton, 1982; and Geddes et al, 1982), there is increasing decline of the cooperative ethic as a wage based economy replaces the traditional subsistence lifestyle. Cash income is used to purchase imported food, fuel, clothing, construction materials, and outboard engines. Profits from fishing and diving are becoming increasingly restricted to families with government employment who can afford the necessary equipment (Bayliss-Smith, 1986). There is also a tendency towards individualization of land tenure, a shift to the nuclear family system, and urban/rural social distancing (Ward and Proctor, 1980). In the subsistence economy, there was little need for excess acquisition of land by any one individual or family. As land--as well as labor--acquires an exchange value, there is a trend towards alienation by entrepreneurs.

This trend has received encouragement by some scholars. In a study sponsored by the U.S. Congress, Mark (1982) advocates increased land use controls including property taxes in order to "increase the efficiency of the present

real estate market and thereby facilitate the transfer and consolidation of parcels for agricultural use." Similarly, Crocombe (1971) notes that increased yield may be obtained under individualized tenure and even greater yield possible using industrial methods designed to maximize production. Both Mark and Crocombe refer primarily to the high islands, but the arguments are likely to be supported in the atolls as well. Although Geddes et al (1982) correctly note that land reform is not generally needed on most atolls, there is a definite trend which may ultimately lead to serious maldistribution in the not too distant future. Better technology, the availability of mechanized transport, the possibility of absentee ownership, distant political administration, codification of tenure rights, increasing immigration and emigration, and urbanization, are all acting to foster maldistribution of land and other resources in many part of the Pacific (Crocombe, 1971). Preservation of traditional tenure systems may also be desirable in view of the surprisingly high productivity in some areas.

Maldistribution is particularly problematic in the Maldives. In this Indian Ocean atoll group, with a trading and mercantile history dating back over a thousand years, wealth is overwhelmingly concentrated in the hands of a few families in the capital. Land is officially owned by the state but it is leased to private developers who exploit the land without regard to long term environmental consequences, resulting in a large class of land poor residents, with adverse consequences to the health of both the population and the environment. Unfortunately, once alienation has been accomplished, it is quite difficult to reverse. Crocombe (1971) correctly notes that political elites may publicly support land reform because the voters want it; but in private, and in practice, they oppose it because reform would deprive them of their political and economic power.

SUMMARY

Atolls have limited land area, scarce water supplies, barren soils, and a vulnerable ecosystem. They are subject to hurricanes, tsunamis, and droughts; and may even be inundated by rising sea levels in future years. Atoll societies have traditionally survived on subsistence fisheries and horticulture. A great diversity of foods is available in lagoons, reef flats, near shore waters, and the deep seas. Horticulture is generally limited to pit-taro, coconuts, and breadfruit. In most areas, a level of subsistence-affluence could be maintained through use of resource conservation. However, these constraints are currently in decline. Both reefs and land are becoming increasingly endangered by new exploitation technologies, population pressure, urbanization, blasting, reef mining,

forest clearing, and erosion. Industrial enterprises are being investigated in some areas but the environmental and cultural costs may outweigh the benefits.

ATOLL POPULATIONS

Contemporary Trends

Many Pacific atolls once supported larger populations than they do today. This does not, however, imply the desirability of restoring these population levels in the atolls. Early accounts often indicated a "miserable existence for the inhabitants of many atolls visited" (Wiens, 1962). Social taboos and restrictions were necessary in historical times and these were often inadequate, leading to starvation, emigration, and war (Alkire, 1978 and Pollock, 1970). What is the situation like today?

Satisfactory analysis of the problem of population pressure on food and other atoll resources has been difficult to achieve because of limited cartographic and demographic data as well as methodological problems in the areal estimation of productivity of land and reef. It is clear, however, that improved medical supplies, education, and sanitation are decreasing mortality rates while the cultural controls on birth have largely been removed due to missionary influence. In spite of migration to high islands and mainland countries, on many atolls there is an increasing population pressure upon resources. Rising populations, intensified exploitation of resources, and increasing pollution of an extremely fragile and limited environment is likely to negatively affect long range carrying capacity (see Alkire, 1978; Connell, 1983).

It is difficult to appreciate the implications of population pressure on an atoll without having been there. Crowding in a community on a tiny islet is a much more socially intense situation than denser crowding in a town in the midst of open country. These effects are rarely described in statistical studies, but are important for an understanding of the meaning of population pressure. An anecdotal example may thus be appropriate. Fale is the main village of Fakaofu Atoll in the Tokelau Islands. The village is located on an islet of eleven acres. The houses are clustered right next to each other and right down to the water. There are no beaches because the land has been extended by sea walls for construction purposes. There is no empty space in the village except for the small clearing in the village center and a rocky peninsula with pig pens. Young people who would like to meet alone in the evening must go to extraordinary lengths to find some privacy, often

using the pig pens or even the over water latrines! A U.N. volunteer living on the islet referred to it as a "pressure cooker."

Emigration to urban areas on atolls (e.g. Majuro, Tarawa) has resulted in lawlessness, drunkenness, and social disintegration, leading to an increasing dependence on foreign aid (Connell, 1983). It has in some cases resulted in squatter settlements on the fringes of the main atoll center which are subject to discrimination by the larger community. In good times, remittances are sent to outer island relatives which further attract migrants. In bad times, migrants are a drain on their home islands. The loss of able bodied persons--to the economic and social incentives provided by urban centers--may leave the outer islands with insufficient labor, acts as a disincentive to subsistence agriculture and fisheries, and places a strain on the island communities. Subsidized medical care, shipping, schooling, and food supplies may be necessary to maintain outlying communities that can no longer engage in subsistence activities (see Yen, 1980). Modern transportation has furthermore had the paradoxical effect of increasing isolation between neighboring islands which formerly relied on continuous interisland canoe voyaging (Proctor, 1980).

Alkire (1978) predicts that unless there is a revitalization of subsistence horticulture and maritime exploitation, there is a very real possibility that the standards of living for coral islanders will further decline. The only other options are increased subsidization and emigration. (He notes, however, that coral islanders have previously survived resource shortages and population displacements by adaptive strategies that maximized options.) Similarly, Bayliss-Smith (1986) notes that in Ontong Java, population projections and carrying capacity calculations show that severe strains on island resources are likely within ten years. Concern about imminent population pressure has also been raised in the Marshalls (Pollock, 1970), Kiribati and Tuvalu (Geddes et al, 1982), the Maldives (World Bank, 1980), and many other atoll groups (Connell, 1983).

Population growth is widely believed to have adverse consequences for economic growth (Coale and Hoover, 1958; McNamara, 1977). This position has been challenged by some who believe that population growth may be beneficial since it results in economies of scale and promotes technological progress (Boserup, 1981; Simon, 1977, 1981). Similarly, the argument that population growth leads to emigration and unmanageable urbanization has been challenged on the grounds that rapid population growth can in fact decrease the rate

of urbanization by the increased supply and decreased value of labor; while promoting agriculture, which can be intensified. This effect is--arguably-- reinforced by the higher demand for food associated with population growth (see Ahlberg, 1986). Natural limits to urban growth are postulated to be related to increasing urban "disamenities" (crowding, crime, and health problems). However, on atolls, it is likely that even the pro-growth theorists would advocate caution.

The following sections will present a demographic survey of the major atoll groups. They are divided into two super-groups, based on political dependence, an important criterion which will be seen to be linked with population pressure, urbanization, and other variables. The large group of atolls in the Federated States of Micronesia are considered dependent because they are administered from four high island district centers whose environment and society is quite different from outer island settlements. The Marshall Islands are considered independent since they are not governed by a high island or metropolitan country. The Tuamotu Archipelago is dependent since it is externally administered. The data used excludes the high, volcanic islands of Micronesia, but some of the raised atolls in Micronesia and the Tuamotus were included in the aggregated data. The data for the Tuamotus also includes the Gambier Group which was aggregated with the Tuamotus in demographic surveys. The comparisons are based on census data from 1977-83, which have been compiled in Connell (1983), the Pacific Islands Year Book (1984), and the World Bank (1980).

Dependent Groups

The dependent atoll groups include (in order of increasing population size) the Tokelau Islands, the Northern Cook Islands, the Tuamotu Archipelago, and the Federated States of Micronesia. These groups generally have low total populations compared to the independent groups. Average population per atoll in all groups is a few hundred persons. Overseas development aid per capita is generally higher than in the independent groups. There is little urbanization since district centers are located outside of these atolls (table 1). Population levels are generally stable (table 2).

Tokelau is a group of three atolls in close proximity to each other about three hundred miles north of Western Samoa. The atolls are small, but there is adequate rainfall. It is a territory of New Zealand and is administered jointly by a council of elders on each atoll, a Tokelauan public service office in Apia, Western Samoa, and the New Zealand Ministry of Foreign Affairs. It is perhaps the most conservative and

traditional of all the atoll groups in the Pacific. Private enterprise and tourism are discouraged. A subsistence economy based largely on fisheries and coconuts is supplemented by aid, remittances, government employment, philatelic sales, and handicrafts. There are high rates of natural increase, relieved only by migration to New Zealand, where migrants have become fairly well integrated into the society, and are important contributors to the labor force.

The Northern Cooks are scattered from each other by considerable distances and from Rarotonga (the capital) by even greater distances (several days boat journey). Puka-Puka has reportedly not changed considerably from Frisbie's time, but the other atolls have developed considerably because of local pearl industries. They are also reported to be less egalitarian than in Puka-Puka. New Zealand is a major aid benefactor of the Cook Islands. The Cook Islands are independent, but the atoll dwellers must compete with the Southern Cooks for their share of the funding. The aid, labor privileges, and emigration opportunities are expected to continue into the foreseeable future. There is considerable migration to both Rarotonga and New Zealand which has led to a negative population growth rate in the Cook Islands.

The Tuamotu Archipelago is the easternmost group of atolls in the Pacific and the largest assemblage of atolls in the world. It is administered by France as part of French Polynesia. It is subject to frequent devastation by hurricanes, which may have led to the decline in root crop production during the copra era. The atolls were frequently visited by missionaries and traders, and traditional culture is not as strong as in the other groups. The French Government has taken steps to promote development in the atolls. Employment has also been generated by the introduction of tourism and military bases. A number of innovative research projects are under way on the atolls including irrigated horticulture and alternative energy sources. There is considerable emigration to Papeete, the capital of Tahiti. There is, if anything, a problem of negative population pressure on most atolls.

The Federated States of Micronesia is an extended group of atolls, raised atolls, mixed atolls, and high islands spanning a great distance across the Northwestern Pacific, and is frequently visited by hurricanes. Formerly a U.S. territory, it became independent recently and is now in a Compact of Free Association with the U.S. The four states of Truk, Ponape, Kosrae, and Yap are each administered from a central high island but only the atolls are considered here. There is extensive reliance on U.S. aid. The atolls are still traditional but material aspirations are gradually

increasing. Atoll residents have reportedly had little input into the planning process (Kent, 1982) and there is also inappropriate delivery of western style health and education services (Robillard, 1984). These difficulties are compounded by different languages and cultures and little essential unity. There is considerable migration to high islands, but the status of these atoll minorities is very low compared to the situation in Rarotonga and Papeete, and is related to cultural factors including poor communication, rigid hierarchies, and caste differentiation (personal communication, B. Robillard and B. Raynor). Population levels are stable in Ponape and Yap but they are increasing in Truk (possibly due to limited employment in the already overpopulated district center).

Independent Groups

The independent atoll groups include (in order of increasing population size) Tuvalu, the Marshall Islands, Kiribati, and the Maldive Islands. The Maldives are by far the most populous atoll group and comprise the only major atoll group outside of the Pacific. However, as in the Tuamotus, the population density is partially alleviated because of the large land area. Large urban populations are present in the Marshalls, Kiribati, and the Maldives (table 1). Population growth is increasing dramatically in every one of these groups (table 2). Although rates of increase are similar, the absolute population growth is largest in the Maldives because of the large standing population. If present trends continue, extrapolation of present growth rates would predict dramatic increases in the populations of all of these groups by the turn of the century.

Tuvalu is a group of eight medium sized atolls with adequate rainfall not far from Tokelau. It is fortunate in that (like in Tokelau) its community cohesion is generally very strong and its sharing ethic buffers the vagaries of nature and the world economy (see Chambers, 1982). It has the smallest (and youngest) urban center but it is already beginning to manifest some of the considerable problems that plague Majuro, Kwajalein, and Male including crowding and the creation of an urban elite (personal communication, numerous travellers). Because of the small size of the atolls, there is a high population density. In the past, employment in Nauru and Tarawa provided an important source of remittance and relief of population pressure. However, as Tuvalu became separated from Kiribati, and as the phosphate reserves dry up, these limited opportunities dry up while the population in Funafuti expands. There has been a small trickle of migration to neighboring islands (from Funafuti), and while family planning programs are being advocated by the administration, population continues to climb.

Kiribati comprises three major atoll groups including Kiribati proper, the Line Islands, and the Phoenix Islands. It spans an enormous distance across the Pacific. All of these groups are subject to severe droughts. Kiribati has the largest atoll population in the Pacific. Its capital, Tarawa, is also the largest urban center in the Pacific atoll groups. It has been affected by crime, water pollution, water supply problems, unemployment, and malnutrition. Urban political power has increased "under the weight of sheer numbers and militant, urban based labor unions" (see Connell, 1983). Kiribati is attempting to cope with these problems by initiating a number of research and development projects including aquaculture, commercial fisheries, a maritime training school, and encouragement of cottage industries. The indigenous culture has traditionally been favorable to commercial enterprise. However, overseas migration and employment opportunities are extremely limited and Kiribatians are reluctant to migrate to the drought prone atolls in the Line and Phoenix Islands. To cope with rising population pressure, a family planning program has been initiated (Macrae, 1983).

The Marshall Islands are composed of two atoll chains running in a north-south direction at the eastern fringe of Micronesia. Kiribati is the nearest neighbor. Periodic drought poses natural limitations which severely restrict the potential for further population growth. It has the highest growth rate in the Pacific and the largest percentage of urban population (sixty-three percent in 1980). These data may be related to migration from northern atolls because of droughts and radioactive contamination from U.S. nuclear tests in the 1950s. This has, in turn, led to the worst urbanization problems in the Pacific including the emergence of gangs, drunkenness, fights, malnutrition, lagoon pollution, and recurrent epidemics; prompting the administration to initiate an "operation exodus." Marshallese have the option of employment in the U.S. but few have taken advantage of this opportunity.

The Maldivé Islands are the only major group of atolls in the Indian Ocean and are culturally [quite] distinct from the Pacific atolls. A comprehensive socioeconomic survey was recently conducted (World Bank, 1980). The summary below relies on this report, supplemented by personal communication (A. White): The Maldives are a group of about twenty large, inhabited atolls closest to India and Sri Lanka. They are the most populous group of atolls in the world and are notable for the pervasive influence of a cash economy even on the outer atolls. The society is hierarchically organized into classes. There is presently severe maldistribution of resources, as mentioned above.

Outer atoll administrators are usually persons from the capital. Even the fisheries profits on outer atolls mainly accrues to a few boat owners. Land is leased to developers for private enterprise who have little interest in long term conservation. Consequently, the natural forest has largely been stripped to a virtual desert environment, the reef coral is excavated for construction, and consumption is based largely on imported food. Similarly, profits accruing from tourism are poorly distributed. In contrast to Pacific atolls, there is a low life expectancy, leprosy, tuberculosis, malaria, and widespread malnutrition. Health facilities are meager and education is provided mainly by Koranic schools. In spite of the rapid growth rates, the culture is adverse to family planning.

SUMMARY

Populations in the Tokelau Islands, the Northern Cook Islands, the Tuamotu Archipelago, and the outer islands in the Federated States of Micronesia are characterized by low growth rates, continuing migration, and minimal urbanization. In some areas, there is a concern with excessive depopulation to high islands and the mainland. In contrast to these areas, on Tuvalu, Kiribati, the Marshall Islands, and the Maldive Islands, there is concern about population pressure in district centers due to high birth rates, and limited opportunities for migration. Crowding in district centers has led to pollution, recurrent epidemics, malnutrition, crime, social disintegration, and foreign dependence; and there are concerns that standards of living will further decline.

CARRYING CAPACITY

Traditional Models

Carrying capacity is defined as the maximal population supportable in a given area. Biologists often use the term to refer to the amount of plant and animal biomass that can be sustained on land or in the water. Carrying capacity has been used more specifically by social scientists in reference to human populations. The problem of feeding growing populations with limited resources was enunciated clearly by Malthus in 1801 (Malthus, 1929), who postulated,

"First, that food is necessary to the existence of man. Secondly, that the passion between the sexes is necessary, and will remain nearly in its present state. . . Assuming then, my postulates as granted, I say, that the power of population is indefinitely greater than the power in the earth to provide

sustenance for men. Population, when unchecked, increases in a geometrical ratio. Sustenance increases only in an arithmetical ratio."

The earliest quantitative model for carrying capacity is the logistic equation, developed independently by Verhulst (1838) and Pearl and Reed (1920). The key parameters are the rate of natural increase and the maximal carrying capacity. The variable is the number of persons in the population. The result is a sigmoidal curve in which the growth rate first accelerates; then decelerates. The determinants of the equation have been an issue of intense debate. Proposed mechanisms include technological, physiological, and sociological responses to increasing density. However, the logistic equation has numerous crippling assumptions such as the absence of life history characteristics, time delays, non-linear effects, and differences among segments of the population (Wilbur, 1972; Wilson and Bossert, 1971). Shifting cultivation models represent a more analytical approach and have been reviewed by Feachem (1973). Originally designed to study tropical, subsistence societies, they attempt to relate land, crop yield, and consumption in order to calculate the maximal population supportable in a unit area. They have been criticized by Street (1969) because of erroneous assumptions including constant farming technology, land-use allocation, and consumption; and losses due to pests, disease, and erosion. These models (and others) are reviewed in detail by Fearnside (1985).

Carrying capacity is particularly relevant to small islands where spatial constraints on production and population expansion can be unusually severe. In a study of the Polynesian outlier atolls in the North Solomon Islands, Bayliss-Smith (1974) relates the maximal sustainable population to land area, desired foods, net productivity, minimal consumption levels, and nutritional requirements. Although land area and per capita nutritional requirements remain fixed, the other parameters vary in response to population pressure. He attempts to avoid the shortcomings of previous models by estimating the perceived carrying capacity and by including location-specific demographic and economic factors. However, he also finds it necessary to accept several unproven assumptions including minimal influence of trade, social production, and technological advancement. A second model is provided by Bayliss-Smith (1980) in the Man and the Biosphere Project in Eastern Fiji. Adaptation and change is explicitly accounted for by a hypothesized inverse relationship (empirically validated for Pacific taro cultivation) between labor inputs and product outputs. As intensification increases, areal productivity increases but hourly productivity decreases. This increased

work load eventually requires technological innovation, fertility regulation, or migration. He provides models simulating different historical periods and allows for varied land-use allocation and technological change.

As part of the above project in Eastern Fiji, Hardaker (1980) develops an economic model using a linear programming method. It attempts to optimize productivity of an island based on various production sectors and varying land uses. He allows for variation in crop prices, quota impositions, land availability, and land redistribution. Although the model is intended for optimizing production, it could just as easily be used to optimize population or any other variable. It can thus be used for estimation of carrying capacity.

All of the above models relate production to consumption. The more sophisticated models utilize graphics and computer programming and allow for the possibility of parameter changes. However, numerous problems remain with all of these models. Historical reconstruction is speculative; future forecasting is even more hazardous. Technological innovations may occur randomly at discreet intervals, without a uniform or predictable basis. Virtually none of the above models have been able to offer a convincing model which includes the impact of political linkages. Nevertheless; while technological and cultural changes may unpredictably affect carrying capacity in the future, there is still a need for a contemporary projection of present trends in population growth and resource availability. Urban and rural areas are increasingly being affected by fluctuations in population which affect the health of the society and the environment. Some of these events may irrevocably affect future generations, and require a contemporary consideration of carrying capacity.

The Influence of the West

In an otherwise admirable synopsis of human ecology on atolls, Alkire (1978) presents a rather simplistic typology which classifies atolls based on the degree of isolation. At the solitary extreme are atoll isolates, characterized by extreme isolation and restriction of the population to a single atoll. In these communities there is typically a history of overpopulation; limited agricultural intensification; resource shortages; and varying responses, including feuding, raiding, tenure alterations, fertility controls, and other demographic control measures. Coral clusters are an intermediate category in which two or three atolls are in close proximity to each other, and thus have greater options. In periods of population-resource

imbalance, their proximity allows economic exchange and personnel movements, including interatoll warfare and raiding. The coral complex is a third category in which the atolls are part of a complex chain of atolls, often associated with high islands. Microclimatic differences thus allowed for even greater development of a diversified, interdependent cultural system whose limits were considerably expanded.

The problem of this categorization, as Alkire himself admits, is the fact that the expansion of Western influence, along with modern transport and communications, is lessening the importance of a purely physical isolation as the significant parameter in categorizing human ecology on atolls. Beginning with the development of the copra trade by various continental powers, atolls have become more and more closely tied to world economic conditions. Extensive planting of coconut has led to a dramatic alteration of the original habitat which was formerly a complex ecosystem of unique atoll species. The copra trade initiated a period of relative affluence when islanders were able to supplement the indigenous economy with imported goods. In some areas, the exploitation of phosphates led to substantial affluence. During this period, atoll societies gradually shifted away from reliance on pit-taro, breadfruit, pandanus, coconuts, other land species, and traditional fisheries. Much of the traditional agricultural, fisheries, and navigational techniques, as well as the allied technology and social structure that had evolved to maintain this system has been lost.

Further events have also occurred which have affected atoll carrying capacity. Along with the world recession and related factors, copra prices have declined--and transport costs increased--to the point that many atoll plantations go unharvested. Perhaps more significantly, atoll expectations in terms of living standards and social services have been raised to the point that extensive international aid has been necessary just to maintain minimal basic services. Emigration to high islands and continental powers has provided a source of remittances which provide a major source of income. These influences have locked atoll economies into a dependence system which has a depressing effect on local production since the returns cannot compare with the income provided by overseas employment or aid-sponsored wage salary. Along with the decline in subsistence horticulture, outboard motors are replacing paddles and sails, and population pyramids "resemble hourglasses" (Alkire, 1978). Moreover, local interisland transport has decreased so that some islands are more closely tied to metropolitan powers than their neighbors (Proctor, 1980).

Alkire's typology would be appropriate if atolls were to seek self reliance, return to subsistence lifestyles, and wean themselves from western aid, as advocated by Geddes, Chambers, Sewell, Lawrence, and Watters (1982) in a study of atoll economies in Kiribati and Tuvalu. Following the advice of Schumacher (1973) external development aid is compared to "a foreign body that cannot be integrated and will further exacerbate the problems." A future is envisioned in which there is revitalization of the traditional sector, import substitution, and gradual inclusion of appropriate and affordable aspects of western technology. To discourage urbanization, they recommend decentralization of government services, creation of regional substations on outer islands, elimination of town subsidies, import taxation, and financial maneuvers to discourage rural-urban migration. However, there are few atoll societies that have elected for this path. Tokelau is virtually the only atoll group that discourages both tourism and private enterprise. Yet it also relies on extensive foreign aid and migration opportunities offered by New Zealand (Rapaport, 1987). The underlying ideology that is most often heard in the islands favors a continuation of foreign aid, urbanization, and migration opportunities. It is based on the short term material advantages afforded to an educated elite residing in district centers and is supported by rural populations benefitting from modern health and education facilities.

This latter view is worded succinctly by Hau'ofa (1980), a sociologist at the University of the South Pacific (Fiji) and a native Pacific Islander: Attempting to maintain the traditional social systems would be "an exercise in futility." Given the present orientation of island governments, the best solution is to

"do away with the preoccupation with small-scale operations and to put at least some aspects of agricultural and economic development on a large scale, high technology level. The social and cultural costs will be high but it must be made clear to the islanders that they cannot have their cake and eat it too. They cannot have the basically western lifestyle based on the high per capita GNP to which they aspire, without changing in a very fundamental way the systems of social relations and community life, all of which arose from and are therefore appropriate to subsistence existence. . . Furthermore, the smaller countries have to give up narrowly defined definitions of independence and acknowledge the likelihood of continued dependence on foreign aid because of their narrow resource base. They must expect changed life styles and, given the

continuation of the present day opportunities for overseas migration, . . . will have to put up with continued disruptions of family life and its social implications. (Rural-urban movement) may reduce the problems of providing services to some remote rural areas. . . and the children of rural dwellers must be trained to move into non-agricultural sectors of the economy. . . . To introduce models of smallholder labor-intensive commercial agricultural development devised elsewhere for true peasant societies is tantamount to introducing a program for trapping people in rural poverty."

This is a pragmatic viewpoint that attempts to optimize the material welfare of the islanders at the cost of increased dependence on outside powers.

A Dynamic Model

The theoretical basis of the proposed model rests on the following premises: The carrying capacity of an environment may be altered due to environmental changes. Natural disasters can affect the physical shape of the land and reef as well as the allied flora and fauna. The successive stages in island colonization by living species are related to fluctuations in these conditions by the process of evolution and differentiation. Thus, the carrying capacity of an area for a biological community depends on characteristics that were derived by adaptation. Adaptive traits will cause the carrying capacity for that species to rise compared to the non-endemic species. Furthermore, carrying capacity depends on the behavior of the species. Alterations in feeding, reproductive, and other social behavior affect the amount of supportable individuals.

Human populations on small islands are affected by changes in the land, reef, and water due to both natural and social interventions. They are also affected by fluctuations in world economic conditions. Most atoll societies are linked to high islands and metropolitan powers by trade, remittances, aid, work opportunities, and migration. This

"all affects the amount of supportable individuals on the islands. Changing perceptions of needs and standards of living are directly related to travel, modern education, and international communication. This, too, tends to modify the community requirements. In outlying areas, these expectations may cause the carrying capacity to contract. In district centers, employment, educational, and other factors may cause the carrying capacity to expand. A steady-state

equilibrium is determined by inter-regional factors which bind outer atolls, district centers, and metropolitan powers into a single system. This model follows the suggestion of Bayliss-Smith (1980) in noting the significance of the perceived carrying capacity."

Carrying capacity is thus largely dependent on the expectations and the perceived needs of the population. To calculate carrying capacity based on survival alone would be useless; it would constitute an unrealistic model that ignores the desire for the quality of life. The key determinants, then, are the amount of consumption and the total resources. In a subsistence economy, the carrying capacity is determined mainly by the available food on the reefs and on land. When one of these becomes limiting, the population cannot expand further, and must either migrate, control population growth, or be curtailed through hunger or war. Contemporary atoll societies rely on a mixed subsistence and wage economy. Outer islands generally still rely heavily on subsistence production, but there is an increasing reliance of wage and aid based income. In the urbanized district centers, there is almost total reliance on income.

On the dependent atolls and on some of the independent atolls, outer island populations are static or decreasing. This indicates a contraction in the carrying capacity as perceived by outer islanders, for whom income availability, rather than food, becomes the limiting factor. Excess persons tend to migrate to the main islands. While the carrying capacity thus declines in outer islands, it expands in district centers, since imports allow the support of a greater population than allowable through indigenous food production. When the district center population demand exceeds the available support available through local jobs, the carrying capacity is perceived to be approaching its limits, and persons attempt to migrate to mainland countries. Where this option is not generally available, as in the independent groups, the available resources are no longer adequate, and the carrying capacity is overshot. Similarly, when excessive immigration to metropolitan powers becomes problematic, their own cities suffer from resource shortage. In both cases, family planning becomes imperative to avoid serious malnutrition. As the maximal carrying capacity is approached, environmental pollution and social ills becomes limiting factors.

Data have been presented which demonstrate a variety of environmental and social problems besetting overpopulated urban areas in the independent groups. These include lagoon, reef, and land pollution; violent crime; infectious

and chronic disease; mental illness; adolescent suicide; family problems; and malnutrition. These are all symptoms of carrying capacity overshoot; and are quite similar to the problems facing subsistence societies who exceeded their carrying capacity. However, the colonization and settlement of new islands is generally no longer feasible; and some of the options open to subsistence societies, such as infanticide and war, are no longer condoned. The result is a crowded district center that faces chronic population pressure, leading to gradual deterioration of both social welfare and the environment. Unlike the situation in subsistence economies, the deleterious effects of carrying capacity overshoot may be difficult to reverse, and they also result in a spillover effect to mainland immigration centers.

Philosophical Considerations

Following the contraction of the earth's frontiers and resources, and increasing maldistribution and environmental degradation, a renewed interest in Malthusian theory resulted in a Club of Rome study of the "World Problematique". This resulted in a new approach to progress which emphasized equilibrium rather than growth (Meadows, 1974). This came as a rude awakening to a society accustomed to equate growth with success. Their predictions were disputed by an English Research team at the University of Sussex (Cole, Freeman, Jahoda, and Pavitt, 1973), who argued that technological innovation and societal responses would solve the population problem without recourse to stringent growth control measures.

In a response to the Sussex team, Meadows, Meadows, Randers, and Behrens (1973) point out that a fundamental difference in the concept of man exists between the two groups. The first approach believes

"that man is a very special creature whose unique brain gives him not only the capability but the right to exploit for his own short term purposes all other creatures and all resources the world has to offer. . .man is essentially omnipotent, he can develop at no cost a technology or a social change to overcome any obstacle, and such developments will occur instantly upon the perception of the obstacle."

The opposite concept of man is rooted more closely in Eastern traditions and assumes

"that man is one species with all other species embedded in the intricate web of natural processes that sustains and constrains all forms of life. . .man is

one of the more successful species, in terms of competitiveness, but his very success is leading him to destroy and simplify the natural sustaining web, about which he understands very little. . .human institutions are ponderous and short sighted, adaptive only after very long delays, and likely to attack complex issues with simplistic and self-centered solutions. . .much of human technology and 'progress' has been attained only at the expense of natural beauty, human dignity, and social integrity. . .those who have suffered the greatest loss of these amenities have also had the least benefit from economic progress."

The atolls appear to be an environment in which the former perspective is extremely dangerous. Population pressure in urban centers indicate that the carrying capacity is being approached. The independent groups have felt this pressure most acutely, and have instituted appropriate family planning measures. However, a substantial lag period is expected before growth tapers, and by then population pressure will have further been exacerbated. Standards of living can be expected to decline as predicted by Alkire (1978) and Bayliss-Smith (1986). The overshoot predicted by Meadows is already being seen in these areas. The search for intensified methods of resource exploitation by development planners is risky because by attempting to remove the symptoms of impending limits, they divert attention from a pattern of growth that continues to spiral upwards. Emigration and aid can worsen the situation because, rather than addressing the issues directly, they allow a procrastination of growth control while the population continues to further expand.

SUMMARY

Carrying capacity is defined as the maximal population an environment will support. Traditional models have tended to view carrying capacity in terms of a closed system and have paid insufficient attention to political factors and contemporary demographic trends. The proposed model begins with increased expectations and perceived needs. This results in lowered carrying capacity for outlying areas, and expanded carrying capacity in district centers, leading to urbanization, emigration, and carrying capacity overshoot in both regional and mainland areas. Although it is difficult to forecast future trends, present indications of population pressure, as well as the possibility of a substantial lag period, would appear to mandate policy intervention by regional administrations and island communities.

CONCLUSION

Summarizing the above discussion, I will attempt to prioritize policy issues and highlight region-specific pressure-points by which timely and appropriate intervention could most effectively alleviate population pressure on atolls.

The natural environment is still the basis of survival on most atolls. The limited resources available should be treated with the maximum caution. Many atolls are drought prone and are likely to face serious resource shortage on a periodic basis. Indigenous varieties of trees, root crops, and other species should be carefully preserved and thoroughly investigated. Additional research is needed to identify and develop drought and salt resistant varieties. It is essential to preserve the integrity of the fresh water lens on the islets, which may be threatened by overland latrines and irrigation projects. It is also important to limit damage to the reef caused by construction, blasting, and pesticides. Subsistence production provides a long-term, ecologically secure method for survival on atolls. It is unfortunately declining throughout the Pacific in response to aid-based wages and natural disasters. Further investigation of both traditional horticulture and fisheries is needed.

At present, most atolls have very limited contact with the outside world. Regional cooperation and collaboration are hindered. Improved communications, transport, and shipping will be needed for industrial development. Tourism, export industries, pearl cultivation, and handicraft production are income generators but the shift to a money economy often yields unanticipated results. Urbanization has the ability to temporarily expand the carrying capacity of an island but eventually the carrying capacity is overshot, leading to environmental pollution, resource maldistribution, and social disintegration. The greatest problems of population pressure are currently seen on the independent atoll groups. In the dependent groups, the availability of migration and foreign support simply transfers the problem to the host countries. In most areas, an equilibrium is reached where environmental problems, scarcity of employment, social problems, and government restrictions constrain further outmigration from home areas. Anticipation of these conditions by directly addressing the population growth in home areas would strengthen local communities and alleviate spillover effects in overseas areas.

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Table 1. COMPARATIVE STATISTICS ON ATOLL GROUPS

Censuses from 1977-1983.

Source: Connell (1983); Pacific Islands Year Book (1984); World Bank (1980)

Tokelau Is.	N. Cook Is.	Tuamotu Arch.	F.S.M. Atolls	Tuvalu	Kiribati	Marshall Is.	Maldiv Is.
NUMBER OF INHABITED ISLANDS							
3	6	17	29	9	20	26	20
TOTAL LAND AREA (Square miles)							
4	10	280	22	10	278	69	298
TOTAL POPULATION							
1570	2260	9800	1410	7300	59800	30900	142800
AVERAGE OUTER ATOLL POPULATION							
500	400	600	500	580	1750	460	5600
POPULATION DENSITY (Per sqm.)							
341	217	35	641	734	202	447	479
TOTAL URBAN POPULATION							
				2100	21000	18400	29500
PERCENT URBAN							
				31	32	69	21
PERCENT WAGE EMPLOYED							
12	7	20	16	12	12	13	40
DEVELOPMENT AID (Per cap. annually, \$U.S.)							
1212	593	200	450	653	327	450	4851

Table 2. DEMOGRAPHIC TRENDS FOR ATOLL GROUPS

Thousands of persons

Source: Connell (1983); Pacific Islands Year Book (1984);
World Bank (1980)

	1950*	1960*	1970*	1980*
TOKELAU IS.	1.3	1.8	1.6	1.6
N. COOK IS.	2.4	2.8	2.3	2.3
TUAMOTU ARCH.	8.5	9.6	8.2	9.8
F.S.M.	9.2	11.5	12.2	14.1
TUVALU	4.4	5.0	5.8	7.3
KIRIBATI		43.3	51.9	59.8
MARSHALL IS.	11.0	17.1	25.0	30.9
MALDIVE IS.			103.8	142.8

*Note: Censuses used were closest to the year indicated