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Water Futures and their Influence on Sovereignty in the Marshall Islands

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(Chapter for 'Water, Sovereignty, and Borders')

Introduction

Several chapters in this book have explored the human responses to living near shorelines which form the boundaries between the sea and the land, between fresh and saltwater environments. There are, however, areas where the sea prevails both in expanse and in day-to-day presence, while the land is marginal and human life is precariously balanced. Human life on the small islets that make up the atolls in the world's oceans is dependent on the presence of potable fresh water, while at the same time is imperilled by the ever present threat of the sea inundating the low-lying islands. In response to these threats, island societies have developed response mechanisms that ensure, to the extent feasible, human and societal survival.

Life on coral atolls can be very precarious. The sand cay islets are low-lying (in the main less than 2m above high water) and small. Only the larger islands (over 500m by 1000m) are suitable for permanent human habitation, as they possess a fragile lens of freshwater floating on top of a saltwater base. It is this lens of groundwater that allows for a variety of plant life, and it is this source of fresh water that allows humans to exist on the island. Environmental disasters, such as typhoons with waves of over 10m washing across an entire islet, can swamp the groundwater lens with saltwater, causing salinisation and thus imperilling human survival.

This paper describes the situation on the Marshall Islands, a small atoll nation comprising 29 atolls and 5 islands, located in the north-west equatorial Pacific, about 3,790km west of Honolulu, 2,700km north of Fiji and 1,500km east of Ponape. With the exception of the two northwestern atolls, Enewetak and Ujelang, the Marshall Islands are arranged in two island chains running roughly NNW to SSE: the western Ralik Chain and the eastern Ratak Chain (figure 1). Unlike the high volcanic islands of Hawaii or Fiji, the atolls of the Marshall Islands are a series of low-lying sand cays with a maximum natural elevation not exceeding 3m.

As will be shown, in order to reduce the consequences of the environmental disasters, traditionally the Marshallese chiefs had land holdings scattered over several islands of the same atoll, as well as land rights and, importantly, rights to resources, on other atolls. In times of disaster there were thus other resources to call upon. That level of connectivity allowed the Marshallese society to thrive on the marginal land they inhabited.

With the spectre of rising sea-levels looming, the environmental challenges are now more pressing than ever before. As their traditional predecessors before them, the current leaders of the are faced with challenges to ensure the survival of the population under their charge.

Environmental Parameters

While the climatological patterns may be subject to change due Global Climate change and associated phenomena such as sea-level rise and changes to typhoon patterns (see p. 16), the underlying geophysical parameters remain the same. As they circumscribe the conditions of past, present and future life on the atolls of the Marshal Islands, they need to be briefly addressed here.

Geomorphology

The principal agent supporting life on atolls is the small freshwater lens on each of the islets that stud the atoll rim. To understand the nature of the lens, some geomorphology is required.

Live coral originally formed barrier reefs around raised islands. Once the island's core gradually submerged, the coral continued to grow, effectively forming rings of coral in the sea. The shape of the atoll reflects the original shape of the barrier reef. The atolls can be as small as Taka Atoll with only 0.6 km^2 combined land area or as large as Kwajalein Atoll, the world's largest atoll with a lagoon area of 2,174 km^2 but only 16.4 km^2 combined landmass (Bryan 1971). The atolls rise steeply from the ocean floor, often over 1500m, and slope gently into the lagoon, which is commonly not any deeper than 40-80m. Water exchange between the lagoon and the sea is maintained through passes, as well as across the reef platform at high tide.

The only parts of an atoll that are permanently above mean high seawater level are the sand cays or islets, made up from erosion products of the reef, predominantly calciferous sand and coral rubble. The particle size of the material decreases from the ocean side to the lagoon side.

In addition, there is variation between the islets of an atoll depending on the location of the islet in relation to prevailing wave action. Islets on the leeward side of the atoll tend to be larger and have finer sediments, while islets exposed to the swell, and more likely to be water-washed during strong storms, tend to have more coarse-grained sediments.

Freshwater Lenses

Because of the total lack of physical elevation and hence orographic rainfall patterns, the precipitation in the Marshall Islands is solely governed by the general Pacific-wide climatic belts as well as by highly localised micro-climatic rainfall over the lagoons. On the regional scale, there is a distinct precipitation gradient running from the equatorial zone in the south to the north. The further north the atoll is located, the less precipitation can be expected. Thus Jaluit, located at 5°47'N has a precipitation of almost 4000mm per annum, while Wake, located at 19°28'N has only a precipitation of less than 1000mm per annum (Williamson & Sabbath 1982; Spennemann 2006a). Intense tropical storms of short duration contribute to much of the total rainfall, and the incidence of the storms themselves is quite variable from one year to the next for a particular island or atoll.

Any rain that is deposited on the atoll is dependent on the vicariousness of the clouds. In many instances, especially during the drier season, rain-bearing clouds may be seen to pass over a particular stretch of land, but may miss another completely, or discharge into the lagoon. Unless rain falls on an islet is of no use to the land ecosystem.

The flat landscape, permeability of the underlying rock, and the composition of soils and reef-derived sediments prevent the occurrence of streams or creeks. Therefore, after the wetting loss (the amount of moisture needed to wet the surfaces of plants and roofs etc to such a degree that additional moisture will run off) all of the rainfall dropping on a given islet will percolate through the sand and settle into the ground. As rainwater has a lower specific gravity than saltwater, the rainwater will in effect 'float' on top of the saltwater (Ghyben-Herzberg principle; Drabbe & Badon Ghijben 1889; Herzberg 1901). Moreover, because of weight, it will gradually depress the surface of the saltwater, creating a lens-shaped region of

fresh-water. As the lens grows, some of the lens will run out at the edges of the islet (Figure 2). As rain falls on the islet, the lens will become thicker, with the interface with the seawater being gradual. As there is no wave action inside the islet's core, the integrity of the lens is maintained. Limited mixing of the salt and fresh-water will occur at the boundaries of the lens, caused by water-level fluctuations as a function of the tidal movement or as convective forces due to capillary action. The underlying substrate is not homogenous however, as it is made up of the old reef platform with various coral heads, intermixed with now consolidated but formerly loose sediment that accumulated between the coral. Thus the 'storage capacity' of different substrates will differ (Arnow 1954; Cox 1951; Anthony *et al.* 1989 Wheatcraft & Buddemeier 1981).

The shape of the island determines the thickness of the lens. Ignoring any variations in the coral limestone substrate, the thickest possible lens would result from a circular island. As a real island's shape on the atolls is either oblong or triangular of some description, the greatest thickness of the lens is predetermined by the width of the island (Figure 3).

Vegetation Patterns

The freshwater lens provides a stable water supply for any vegetation growing on the islet. On small and very low-lying islets the vegetation is limited to hardy shrubs that can withstand both the salt spray from the ocean and can thrive on a supply of brackish water. On the larger islets, the freshwater lenses allow other vegetation to grow, such as breadfruit (*Artocarpus altilis)* which are dependent on non-saline water. The gradation of the soil/sand substrate, availability of freshwater, wind, wave action and the concomitant salt spray cause the vegetation on the sand cays of the coral atolls to occur in clearly defined zones, reaching from the lagoon side to the ocean side of the island. The area of greatest productivity is in the

centre where a thick fertile soil can built up from decaying plant matter, which, coupled with easily accessible permanent freshwater sources, *ie* the freshwater lens, allows many trees, particularly breadfruit trees to grow well (summarised from Fosberg 1990; Spennemann 1990a; 2006a). The vegetation zonation on any given island depends on the island's location on the atoll, with leeward islands, away from the swell and strong salt spray, being generally more conducive to complex vegetation patterns than windward islands. Moreover, as stated, the latitude of the atoll determines the overall rainfall, which in turn has implications on the viability of vegetation.

Traditional Responses

The environmental parameters let to a number of traditional responses, mainly in terms of settlement patterns and land ownership, which combined with the vicariousness of existence, had implications on the social structure of the Marshallese community.

Settlement Patterns and Land Ownership

The low-lying sand islands of the coral atolls are exposed to environmental hazards and changing conditions. Therefore, the atoll environment faced by the prehistoric, early historic and also the present-day settlers of the Marshall Islands, defines very clearly the way their settlements, their horticultural (agricultural) sites and their ritual sites, such as cemeteries, are arranged on any island of a given atoll. The environmental parameters to be considered are:

- availability of freshwater
- availability of gardenable/arable land
- availability of a protected anchorage for boats
- availability of a protected area for housing

Given the zonation of the vegetation on any given island, the traditional land divisions, the *wato*, were laid out as strips of land running from the ocean side of the islet to its lagoon side, thereby ensuring that each household had access to all environmental zones. Figure 5 shows the modern pattern at the left, and the reconstructed prehistoric patterns at the right (after Spennemann 1990a). The *wato* on larger islets, especially on the environmentally favoured, southern atolls, are narrower than on the smaller islets of the same atolls. On the drier and thus less favourable northern atolls the *wato* are wider.

The prehistoric settlement pattern is almost entirely defined by these environmental constraints. Archaeological and historical site surveys found that the settlement on a major southern atoll, such as Majuro, favours larger islands. The coral gravel spreads, indicating house sites, were concentrated on the larger islands, and where a more detailed analysis was possible, it was found that the settlements were located on both sides of the breadfruit zone, with the main settlements on the lagoonal side. The habitation sites would begin some 30-50m inland from the present lagoonal edge, well above the storm high tide mark and behind a small natural strand wall. Going inland, these gravel spreads would gradually change to shell middens, indicating cooking facilities and associated rubbish dumps on the inland, the "backward" side of the houses. Inland of these rubbish heaps an area of burials is encountered, located between the houses and the gardening centre. In the fertile middle of the island the breadfruit trees and a dense zone of taro patches are found. Going towards the ocean side one would encounter another, narrower zone of habitation and then would get into a dense salt resistant shrub and broadleaf forest fringing the ocean shore. In this zone some burials can also be expected (Spennemann 1992; 1999).

The settlement patterns described for a fertile, ideal atoll islet in the southern Marshalls is open for modifications in other parts of the Marshall Islands. A decreasing variety in plant life, and correlated with this a decreasing availability of food, are directly related to decreasing rainfall intensity the further north an atoll is located. On Ailuk Atoll, for example, the climate is too dry for breadfruit trees (*Artocarpus altilis*) to exist. The food available to the people on that atoll is restricted to coconuts (*Cocos nucifera*), Pandanus and arrowroot (*Tacca leontopetaloides*). Further north, such as on Bikar, the climate is too dry for coconut palms and Pandanus to exist. It is not surprising that Bikar was apparently never settled on a permanent basis.

As productive and habitable land was in limited supply, the Marshallese population had to ensure that the limited resources were not overexploited. While some natural resources, such as fish, turtles and sea-birds, could be managed through seasonal and social taboos (Tobin 1952), terrestrial resources had to managed through a regime of population control that only allowed to children per couple (of common people)(Spennemann 1995).

Vicariousness of Existence

The single most destructive climatological phenomenon affecting atolls are typhoons ('cyclones' south of the equator). These high-speed circular wind systems are created around a central area of low air pressure. Spawned as tropical depressions in areas of warm seawater, located at the interface between two opposing air currents, these systems can pick up wind speed and thus strength if the required movement of air in the central column is sustained over a long period, and if a strong jet stream overhead creates a sucking motion. Tropical storms of gale force have sustained wind speeds (for ten minutes or more) of 88 km/h and can

develop into typhoons with minimum sustained wind speeds of 117 km/h. Sustained wind speeds of close to 200 km/h are not uncommon among 'super typhoons.'

Tropical storms and typhoons are *the* most frightening natural phenomenon, especially for those living on a coral atoll where the maximum elevation is rarely more than 2m above sea-level. The waves associated with such events can be 10m and more, on occasion compounded by tidal fluctuations. The damage to the islands varies. Low-lying islands and islets of the coral atolls, however, suffer both from wind effects and from inundation. Often the entire islet is awash. Not only does the inundation with saltwater contaminate the fragile freshwater lens within the islets, the wave action also suspends much of the topsoil, washing it away and filling the taro patches in the centre of the islets with saltwater and sediment.

Typhoons have been a fact of life for the people in Micronesia since the time of their initial settlement thousands of years ago. The vicariousness of (semi-)traditional life on an atoll is best illustrated by describing the impact of a particular typhoon that struck the southern Marshalls on 30 June 1905 and that is well documented in the German colonial records (Spennemann 2004b).

On 30 June 1905 a strong typhoon passed over the southern Marshall Islands, severely affecting *Nadikdik* (Knox) (6°20'N 172°10'E), *Mile*, *Arno*, *Majuro* and *Jaluit* Atolls. Other atolls, namely *Aur* (8°12'N 171°06'E), *Maloelap* (8°40'N 171°00'E), *Ailinglapalap*, *Ebon*, and *Ujelang* were also affected but to a lesser degree. Over 227 Marshallese lost their lives on that day on the affected atolls, most of them on Nadikdik and Mile. Many more people were injured. Hardest hit was *Nadikdik Atoll*, located just to the southwest of Mile. This atoll was completely washed over, all inhabited islands completely reduced to the bare reef platform

and the human population of that atoll (seventy people) completely extinguished save for two boys who, clinging to an uprooted breadfruit tree, survived a 24-hour drift voyage to the southern coast of Mile (Jeschke 1905). Following the destruction of all food stocks and fruit on the trees, approximately another 90 people died during the subsequent months due to starvation. Immediately following the event, the lagoon of Mile and to a lesser extent that of Jaluit were reported to be congested with floating debris: trees, bushes, houses, broken canoes, wooden utensils and corpses. The concentration of drift material in the waters of the Marshalls during July and August 1905 was so high that it constituted a serious shipping hazard, making the very limited relief operations not any easier. The flooding of several islets by saltwater caused die back of fruit trees as well as the contamination of the freshwater lens (see Spennemann 2004b for further details).

Social Structure

Given the vicariousness of human existence on a single atoll, it is not surprising that the Marshallese designed social structures that mitigated such impacts both within an atoll and between atolls. Marshallese society is matrilineal and matrilocal (Erdland 1909; 1912; 1914; Krämer 1906). The status and resource rights of the parents influenced the status and rights of the children, with the mother's rights and status being stronger. The Marshallese social structure at the time of contact as presented by Erdland (1914, p. 99 ff) saw four main tiers of increasing land ownership:

- *kajur,* commoners, effectively serfs, with rights to (some of) the resources on single allotment of land but no control over land management decisions;

- *ledikdik* of common descent lines, but because of capacity elevated to ‘adviser’ to the chiefs with ownership rights to a single allotment of land, given to him by a *buirak* or *irooj* as feudal holding in perpetuity and inheritable by the next generation;
- *buirak*, of chiefly lineage but subordinate to the *irooj* with absolute rights to more than one allotment of land, usually on the same islet, but certainly on the same atoll, and rights to produce and resources from other allotments; and
- *irooj*, high ranking chiefs, with absolute rights to more than one allotment of land, usually on the same atoll (on occasion on more than one atoll) and who exercised rights to produce and resources from allotments on other atolls.

The allotments were bounded by other allotments and the shorelines. Traditional rights extended as far into the lagoon or ocean as the chief could physically stand to fish (Erdland 1914). Given that fact that the shape of an islet was subject to continual change caused by the processes of erosion and accretion, such a stipulation makes a great deal of sense. If and when two islets merged, the boundary line was drawn at the locality of the actual merger.

The German colonial administration (1886-1914) intentionally, directly and indirectly, consolidated the hierarchical structure and the power position of the *irooj*. On the one hand it prohibited warfare as a legitimate means of altering the balance of power, while it also introduced a head tax in 1888 (Sonnenschein 1888a, 1888c; Biermann 1889; 1890) with consequences to the hierarchy. Levied on every Marshallese subject, the tax could be forcefully collected if those levied were to default (Sonnenschein 1888b). Whereas traditionally the *irooj* had only a share of the food and other produce, as well as a share of his people's labour the introduction of the head tax, payable in the main commercial export article of the Marshall Islands, copra, led to the development of a formal payment of the *irooj’s* share in copra. As the German authorities collected the tax as well as purchased any other

copra from the *irooj* rather than directly from the individuals, the power position of the *irooj* was strengthened and essentially formalised. As a result of these and other more subtle colonial changes, the traditional tenure structure has been collapsed into three levels (Tobin 1952; 1958):

- *dri-jerbal*, or workers, with ownership rights to aspects of a single allotment of land;
- *alap*, or 'land manager,' who has rights to more than one allotment of land, usually on the same islet, but certainly on the same atoll; and
- *irooj*, who had rights on one or more entire atolls, as well as rights to resources on other atolls.

In practical terms, the increased movement from the outer islands to the population centres since the 1970s has created a new fourth level: those people who have no traditional rights whatsoever to the land allotment they reside on, but who are tolerated as squatters subject to the approval and good will of the *irooj*.

As the strength of the socio-political position of an *irooj* depended on his capacity to provide for his commoners, whom he needed in order to be able to wage war, an *irooj* was reliant on the productivity of the island and its people. The traditional societal structure with land ownership scattered over several islets of an atoll and resource rights to islets on other atolls, ensured that *irooj* and to a lesser degree *buirak*, had access to a range of natural resources. This was an effective strategy for both physical and social survival in a fluctuating environment. Because rainfall intensity varies not only between but also *within* atolls, the productivity of some of the land allotments was patchy, even without taking into account climatic extremes such as typhoons or drought. During times of devastation wrought by typhoons or extended drought, the spread of such land holdings was especially important as it

ensured that carbohydrate food stuffs were available for redistribution to the starving community members (a typhoon devastated community cannot live of fish alone).

Connectivity

Traditional inter-atoll obligations are on record for the early contact period as well as for the early German colonial period. Traditional inter-atoll obligations existed throughout with islanders providing a share of produce to the higher-ranking chief. Redistribution of wealth, and the flow of important items to the highest ranking chief, have been observed from early European contact times onwards (cf. redistribution of iron from Wotje to Aur; Chamisso 1836; Kotzebue 1832; Spennemann 2004a). This could take on substantial dimensions. The German Otto Eisenhardt (1888), stranded on Ailuk Atoll in 1871, for example reported that once a year most of the islanders would sail to another atoll, some 150 nautical miles distant (most likely Wotje Atoll) to pay their obligations in the form of food especially arrowroot starch (Spennemann 1992) and dried Pandanus paste (Krämer & Nevermann 1936).

Typhoon food shortages have always been a problem in the atolls, and traditionally in times of starvation people would "cash in" on inter-atoll alliances and would move part of the population to other atolls. We know, for example, that the following reciprocal obligations existed:

- The typhoon of 1857, which seems to have devastated Ebon Atoll, resulted in severe starvation and the move of some 800 people of a total of 1300 temporarily from Ebon to Jaluit Atoll (Krämer & Nevermann 1938, p. 30);

- The movement of people from Mile to Arno, and the supply of coconuts, *Pandanus* and breadfruit preserves from Arno and Majuro to Mile after the typhoon of 1905 indicates the perseverance of such a safety network (Spennemann in prep).

These contacts and reciprocal obligations were not random throughout the Marshall Islands. Any connectivity was derived from the productivity of the atoll, the proximity of the atolls to each other, and the sailing conditions encountered. Based on a variety of data ranging from historic accounts, linguistic analyses, epidemiological data as well as biogeographical information, the connectivity of the atolls of the Marshall Islands can be speculatively reconstructed for the contact period and the first half of the nineteenth century (Spennemann 2005). The majority of the communications occurred *within* each of the two chains, with inter-chain communications very rare, except at the southern end. In part this is a factor of the greater population density on the southern atolls.

Modern Challenges

The traditional responses to the environmental conditions have faced a range of challenges in the post World War II period. The introduction of Christianity terminated the traditional method population control (Spennemann 1995). Natural demographic growth saw the population of the Marshall Islands swell from about 8,700 in 1880 to 9,800 in 1945. Improved health care systems and natural demographic gains accelerated population growth to 20,500 in 1970 and an estimated 67,800 in 2007 (Gorenflo & Levin 1994; Spennemann 2000; CIA 2007). While much of the population growth on the outer atolls has been absorbed by internal migration to the capital, Majuro, as well as Ebeye Island on Kwajalein Atoll, where employment opportunities are perceived to exist, a substantial number of residents migrated overseas, particularly to Guam, Hawai'I and several states of the mainland USA (Ogden 1984; Gorenflo & Levin 1989; Allen 1997; Hess *et al*. 2001; Spennemann 2006b).

Internal Connectivity and Settlement Patterns Today

The centralised colonial governments which consolidated the position of the *irooj* on the one hand, and the paternalistic stance the colonial administrations took towards the Marshallese (for an exception see Spennemann 1998), relieved the *irooj* of most their traditional responsibilities to provide for their people in times of distress. Modern aid and emergency relief supplies, provided first by the colonial German administration (cf. Spennemann 2004b for partial history) and today, even after independence, by the US Federal Emergency Management Agency, have obviated the need for such inter-atoll connectivity.

Artefacts of history, such locating the US World War II naval and air base on the western end of Majuro Atoll, and the subsequent siting of the US Trust Territory administration in the existing infrastructure has meant that human settlement spread to areas traditionally only sparsely settled because of their low productivity and their exposure to typhoon events (Spennemann 1996). Moreover, modern-day food imports, as well sophisticated tapping of the fresh water lens, combined with desalination plants on some atolls, have allowed the population living on the atolls of the Marshall Islands to swell to more than ten times the traditional carrying capacity (Spennemann 1999) despite the above-mentioned out-migration. This had implications on settlement patterns and land use (Spennemann 1990b), which led to further, and increasingly dense, settlement on (traditionally) even more marginal land (Spennemann 1990b). This is in particular the case on Majuro, the current capital, and on Kwajalein, a major US missile testing base, where mare than 9000 Marshallese live on neighbouring Ebeye and a group of other very small islands with a combined land mass of less than 0.4 km^2 (SOPAC 2001).

While there is no longer an urgent need to maintain traditional settlement and connectivity patterns, the land rights generated by traditional custom, however, remain and have adapted to new economic circumstance. Current day *irooj*, for example, request, and obtain, their share of rental payments (from businesses for example) as well as shares of atoll-based incomes such as derived from compensation for the lease of some islands of Kwajalein Atoll to the US military. By reciprocal action, commoners can call on the *irooj* for permission to squat on *irooj*-controlled lands on Majuro and Kwajalein.

Global Climatic change and Sea-Level rise

A new level of complexity is now introduced through the potential impact of global climatic change and corresponding sea-level rise. Studies of global climatic change predict a probable rise in world sea-levels between 0.18m and 0.59m by the end of the twenty-first century (IPCC 2007a-b). Worst-case scenarios, such as the collapse and melting of the West-Antarctic Ice Sheet, could see a sea-level rise of up to 6m (Tol *et al* 2006). What are the implications of this for atoll nations such as the Marshall Islands?

Despite media coverage to that effect, the projected rise in sea-levels does not imply that the islands will drown. Indeed, dramatic sea-level rises have occurred in the past, such as at the start of the Holocene some 8000 years ago, and the sea level has been higher than present some 4,000 years ago (Buddemeier *et al.* 1975; Tracy and Ladd 1974). At these times, the coral growth eventually caught up the sea-level rise and new islets were formed from coral-based erosion products. Thus, the question to be addressed here is not whether the islands will survive in the *long term*, but whether the corals can keep up with the projected rise in sea-level (Hughes *et al* 2003) and whether (through wave action) sufficient amounts of sand can be generated that will maintain the existence of the islets as we know them in the *short term.*

If the corals cannot keep up, then the islets will temporarily disappear with the sediment washed into the lagoon.

The disappearance of some or all islands will then have serious implications on the construction of sovereignty as we define it today (Barnett & Adger 2003). At present, the territoriality of a country requires that a habitable spot of natural land is permanently above water. As long as a country maintains natural areas above sea-level, it will have a sovereignty and territorial existence in international law.[1] Artificial structures, such as the World War II anti-aircraft platforms outside the territorial waters of the United Kingdom or oil drilling or production platforms, for example, do not qualify as they do not have natural territory nor are they recognised by other states. In the case of coastal nations, the external points of the territory also define the territorial waters and the size of the 200nm Exclusive Economic Zone (EEZ)(United Nations Convention on the Law of the Sea of 10 December 1982). If, in the case of the Marshall Islands, some of the atoll might temporarily disappear, then by implication, the EEZ will also shrink. At present, international law is unclear as how to deal with a situation where an island might temporarily disappear and then re-emerge. Examples were this happens, such as Fonualei Volcano in Tonga (eg Spennemann 2004c), are fully within the country's EEZ—and thus their disappearance has no territorial implications.

Even if the islets survive more or less in their present form, any factors that affect the make-up of the island will have implication on the suitability of the island for human habitation because the size of the groundwater lens is directly related to the size and shape of the islet. With any rise in sea-level, there will be lag between the actual rise of the sea-level relative to the island and there commencement of coral growth. The lag is caused by the facts that corals have reached their maximum growth height; that the reef platforms are covered intertidally

with solar-heated water; and that corals do not like to grow in water with high temperatures. During that time the shape and thickness of the groundwater lens will change, with the lens capacity being reduced (eg Bobba 1998; Titus 1990; Roy & Connell 1991; Burns 2000).

In addition to the straight rise in sea-levels, atoll populations will also have to content with changes to the climatic patterns. The increased global temperatures will have influences on the sea surface temperatures (IPCC 2007a), which are directly related to the spawning of tropical depressions and which have a direct influence on the strength and maintenance of typhoons. Even comparatively small changes sea surface temperatures, such as those during El Niño events have serious implications not only on the frequency of typhoons affecting the Marshall Islands (Spennemann & Marschner 1996), but also on typhoon intensity and on the availability of rainfall outside the typhoon season (Burns 2002; UNFCCC 2005). These typhoon systems are not only destructive on infrastructure and human habitation, but through storm waves and raised sea-levels during the event, typhoons also affect the physical integrity of the low-lying islets. The study of historic typhoon events in the region (Spennemann 2004b) has demonstrated that islets can be temporarily submerged during such events or, on rarer occasions, be totally washed off the reef platform. Temporary inundation of the islet will lead to the contamination of the fresh-water lens with salt water.

Both the reduction of the freshwater lens due the time lag between actual rise of the sea-level relative to the island and there commencement of coral growth, a well as the potential inundation of the lens due to typhoon-induced storm surges will have a direct impact on the availability of potable water on the atolls of the Marshall Islands, any shortcomings thus generated can be overcome through technological means, such as desalinisation plants. Mitigation through technological means, however, is not possible for the environmental

changes to vegetation that will occur as well. Even though the younger population of the Marshall Islands, like other islands of Micronesia, has increasingly come to rely on, and to prefer, Western-style foods over traditional ones (O'Neill & Spennemann 2006; 2008), there is still a considerable interest in the maintenance of traditional food options among the adult generation.

Towards Future Solutions

The current leaders of the Republic of the Marshall Islands (RMI) are faced with three discrete, yet interlinked problems that the effects of global climatic change, and the associated sea-level rise will pose: i) the ability of citizens to relocate and reside in other countries without being compelled to surrender their nationality; ii) the ability to maintain a resident population on the home atolls, even if the conditions for habitation might be deteriorating and the quality of life might be reduced; and, finally, iii) the ability to maintain sovereignty over the current territory and EEZ of the RMI, even if some or all atolls were to be temporarily submerged in order to main the existence of the nation state of the Republic of the Marshall Islands and its rights to terrestrial (as llimited as they are) and marine resources.

The ability of citizens to relocate and reside in other countries

The immediate past leaders of the RMI have ensured this right through appropriate negotiations in the 1980s. Following the termination of the Trust Territory of the Pacific Islands, the Marshallese population, like that of Chuuk, Kosrae, Pohnpei and Yap (now Federated States of Micronesia–FSM), rejected the option of full independence and chose a close affiliation with the USA, which provided for independence in all aspects bar military matters (CFA RMI 1986). In return for granting the USA the right to decide on defence

matters within the territorial boundaries of the RMI—and through additional Compacts also within the FSM (CFA FSM 1982) and the Republic of Palau (CFA Palau 1993)—the RMI obtained substantial financial and other support from the USA. In addition, the signing of the Compact of Free Association between the USA and the RMI in 1986 (effective 1989) (CFA RMI 1986) gave Marshallese citizens the right to reside in the USA and its territories. The Compact was renewed in 2001 (effective 2003) with a series of additional accountability provisions (CFA RMI 2003).

Despite comments that the new Compact is restrictive and reduces independence (Underwood 2003), the Compact status ensures that RMI citizens can travel freely to and reside in the USA. These expatriate communities are both an asset, as they provide revenue through remittances sent back to families back on the home atolls (eg Odgen 1984; Connell & Conway 2000), and a source of potential problems, as the expatriate Marshallese are a source of external influences (O'Neill & Spennemann submitted) which is facilitated through on-line discussion forums and chat rooms, and increasingly also through cheap Voice-over-Internet Protocol telephone calls (Spennemann 2006b). The leaders of the RMI can ill-afford to loose the migration option in view of the size of the population on the atolls and the current population growth rate (2.21%; CIA 2007) which shows no sign of slowing down despite a range of programs. If in the light of projections of sea-level rise the conditions for habitation in the atolls of the RMI worsen, the reliance on out-migration will increase, which is likely to require the RMI to be more compliant with the wishes of the USA than is already the case.

The ability to maintain a resident population on the home atolls

The solution to this issue is purely a matter of the RMI's economic ability to pay for the technological options required to support a population (desalination plants, shoreline

protection, infrastructure upgrades) and for the resident population to pay for the food products and other consumer goods required. The economy of the RMI is at present reliant on subsidies paid by the USA under the provisions of the Compact; and to a lesser degree on aid monies provided by various nations (such as the People's Republic of China and by Taiwan), as well as on loans extended by international organizations such as the Asian Development Bank. Given this dependency on the USA, the RMI can again ill afford to alienate its Compact partner and will be required, as indicated before, to be more compliant with the wishes of the USA than is already the case

The ability to maintain sovereignty over the current territory and EEZ of the RMI

The biggest challenge for the leaders of the RMI will be the ability to maintain sovereignty over the current territory and EEZ of the RMI, even if some or all atolls were to be temporarily submerged in order to main the existence of the nation state of the Republic of the Marshall Islands. At present, a nation state requires a territory, and that territory cannot be an artificial structure such as an oil platform. Given the lack of territorial recognition other traditional immigrant countries such as Australia or the United States of America give to the self determination and autonomy of their own Indigenous populations, it is highly unlikely that either of the countries would be prepared to cede part of their land mass to the RMI to establish its own nation state on (formerly) Australian or American soil. Thus solutions have to be found that ensure that the existence of a nation state and its territory can be enshrined in perpetuity based on that nation states' appearance at a given cut off date, irrespective of whether that nation state will remain above water or not. Given that this is a global problem, the solution will have to be found in the global arena of the United Nations. An alternative approach is the de-coupling of sovereignty with territoriality. This approach has been

advocated by a range of ethnic groups that see states as an obstacle to their own claims to sovereignty (Richmond 2002).

In that quest, however, the RMI are not alone: other atoll nations, such as much of the Federates States of Micronesia, Tuvalu, Kiribati, the Cook Islands, the Maldives, and the Seychelles, as well as several Caribbean nations, such as the Bahamas, are in the same predicament. While it can be argued that neither of these nations have much political influence on a world scale, there are, however, also other global players that have a vested interest in a positive outcome to the matter. For example, France currently controls a large area of the South Pacific through its EEZ based on the coral atolls of the Marquesas and Tuamotus. In the Indian Ocean, France controls a sizeable EEZ through the isolated atolls Bassas da India and Europa (between Madagascar and Mozambique) and Tromelin (north-east of Madagascar), the United Kingdom controls a large and scattered EEZ through its British Indian Ocean Territory, made up from the Chagos Archipelago (including Diego Garcia), and India controls a substantial additional EEZ through its atoll groups of the Lakshadweep (Lakkadives). Even the USA is a major player, through its possessions of Midway, Wake, Johnston, Jarvis, Palmyra, Howland and Baker in the Pacific, all with their own EEZs. Finally, we need to include Japan, which through its possession of Minami Torishima (Marcus Island) has an isolated full 200nm EEZ to the southeast of the Bonin Islands.

While in all these cases the potential sea-level rise does not threaten the existence of the British, French or Indian nation state, it does affect substantially its economic area, and here in particular the rights to the mineral resources on the ocean floor as well as the ever-decreasing fish stocks. It can be speculated that an increasing demand on the Earth's

resources will make the exploration and exploitation of submarine mineral sources a viable option. In that case, the legal protection of these resources will gain prominence, especially among natural resource poor nations such as Japan, France and the United Kingdom.

Outlook

Just as the environmental situation and vicarious nature of human settlement faced by the Marshallese of traditional times required their chiefs to develop unique solutions, so do the new challenges require the current leaders of the Republic of the Marshall Islands to find innovative solutions. While the traditional responses to safeguard the survival of an atoll's population lay in the development of a system of distributed land- and resource-rights and a network of reciprocal rights and obligations across several atolls, the current and future problems will require the leaders to develop a system of rights *beyond* the territorial confines of the current nation state of the Republic of the Marshall Islands.

Endnotes

[1] . Based on the Montevideo Convention on the Rights and Duties of States (26 December 1933) §1, "the state as a person of international law should possess the following qualifications: (a) a permanent population; (b) a defined territory; (c) government; and (d) capacity to enter into relations with the other states."

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Biographical Note

A/Prof Dirk Spennemann (PhD ANU) was the government archaeologist of the Marshall Islands (1989-1993) and has extensively published on the history and cultural heritage Micronesia, in particular the Marshall Islands and the Marianas. He has just completed a book on the history of typhoons in Micronesia (until 1914) and is in the process of competing a study of the impact of typhoons on atoll populations in Micronesia.

for full Cv see http://csusap.csu.edu.au/~dspennem

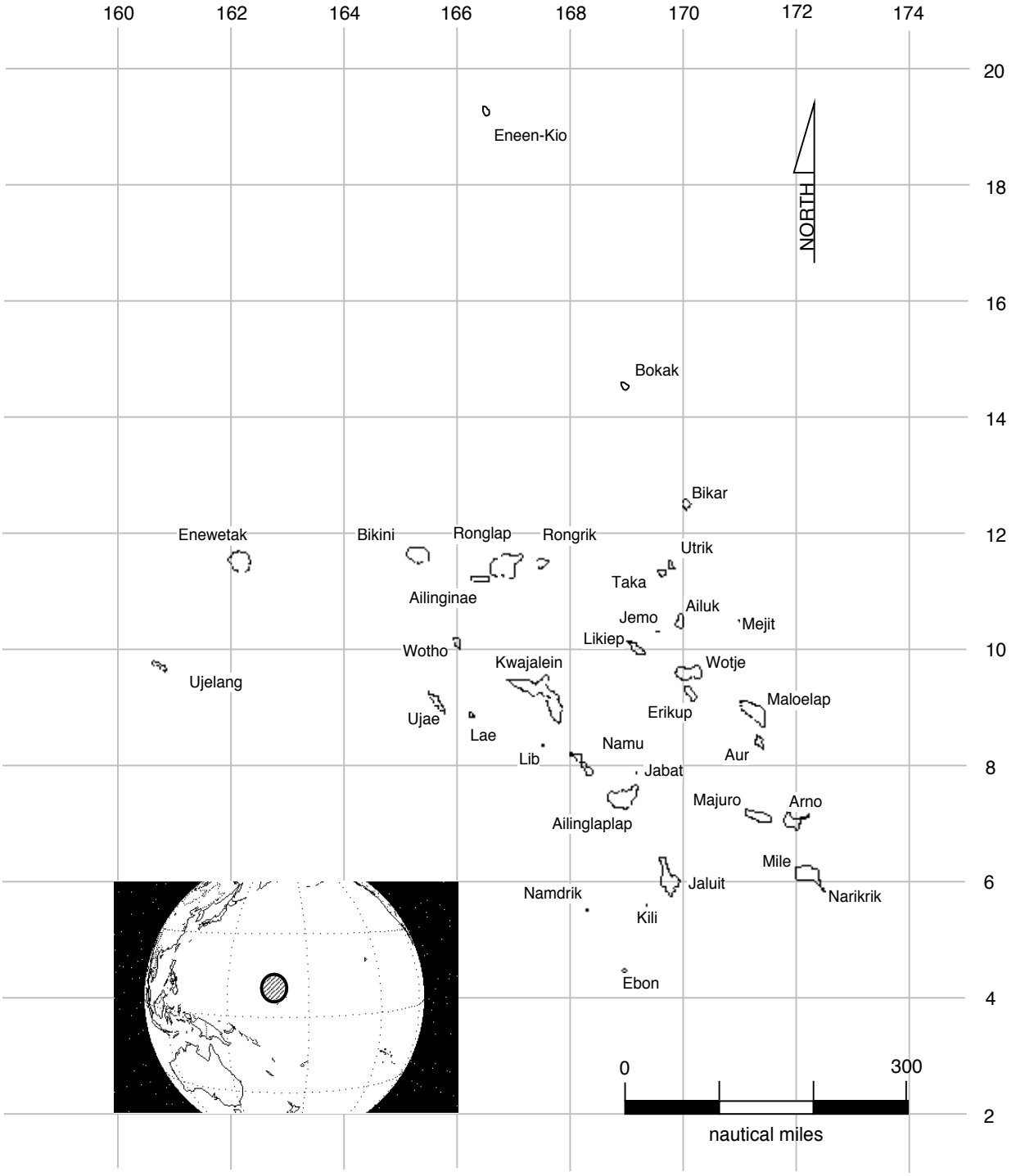

Figure 1.Index map of the Marshall Islands showing the atolls mentioned in the text.

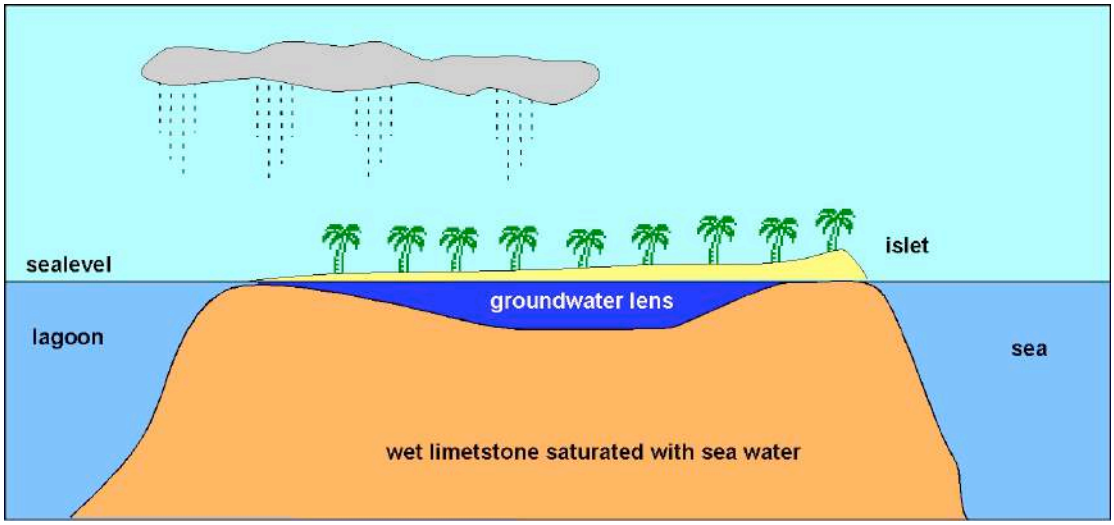

Figure 2. Concept of the freshwater lens.

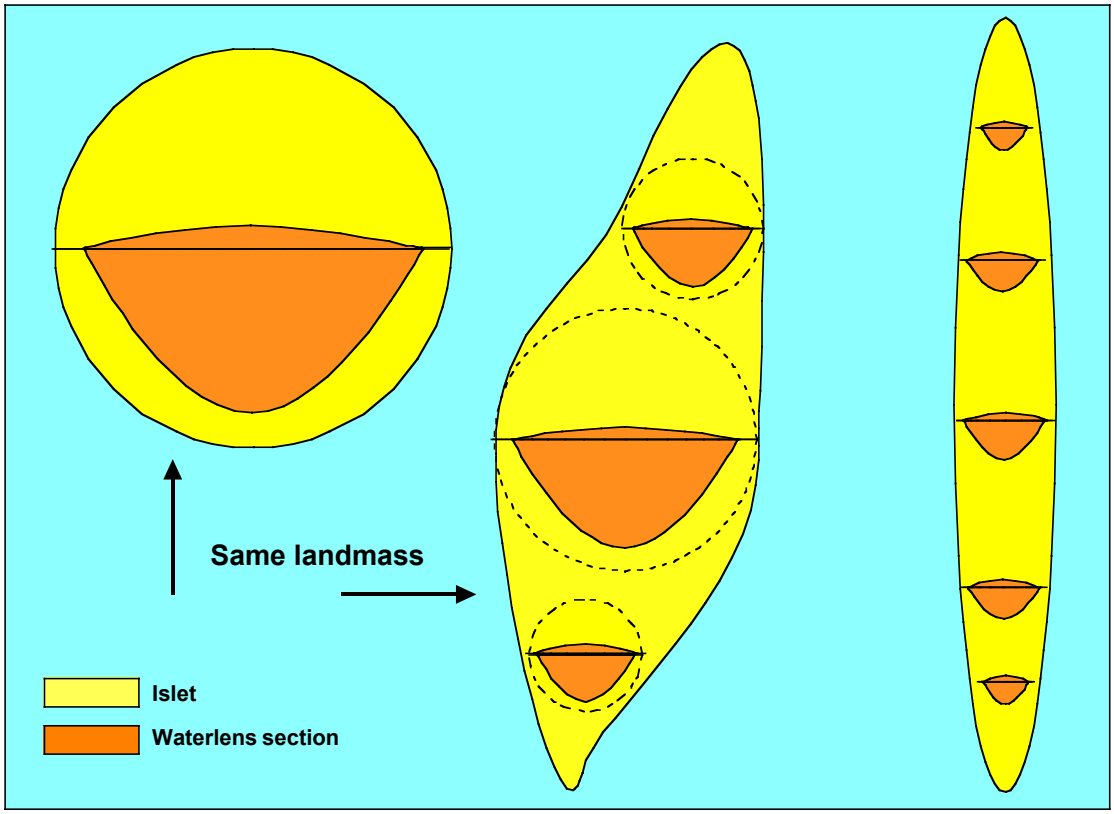

Figure 3. Conceptual relationship between island size, island shape and water lens.

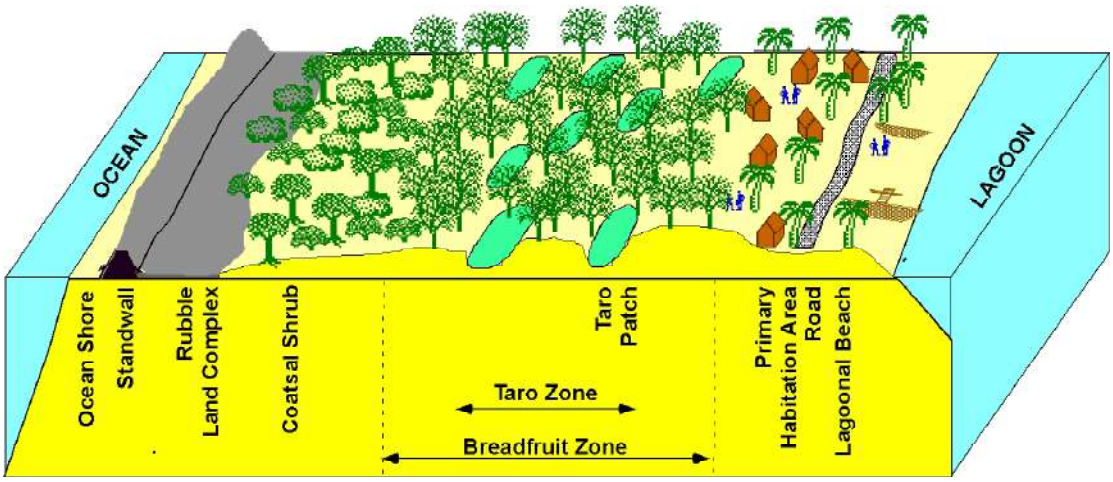

Figure 4. Schematic representation of the vegetation zonation across a leeward atoll islet in the central and southern Marshalls (after Spennemann 1990a with modifications).

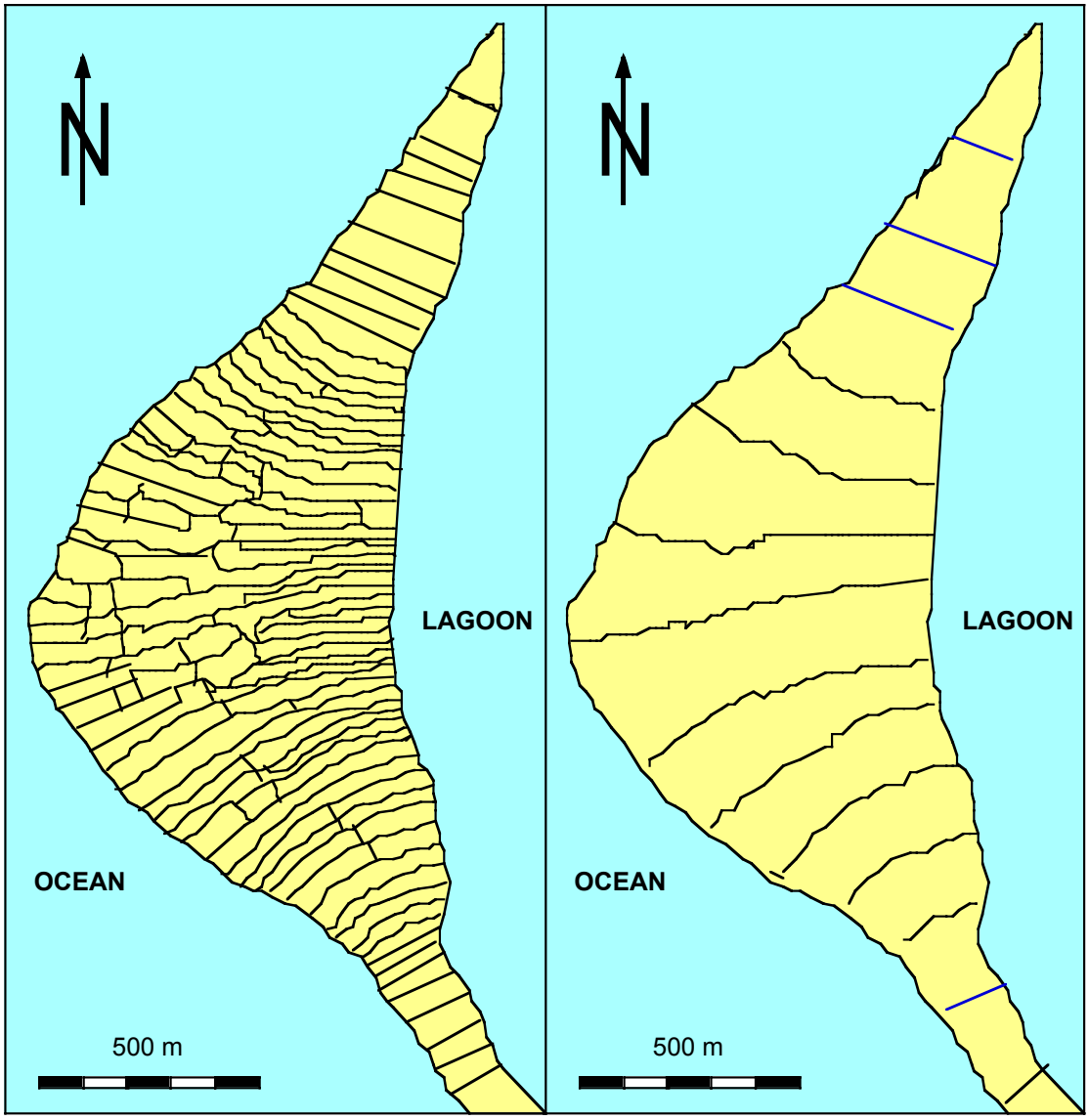

Figure 5. Land Allotments on Majuro Islet ('Laura'), Majuro Atoll. Left: allotments as they appear today. Right reconstructed size and appearance of allotments based a reversal of the fission sequence (after Spennemann 1990a).