MARGINAL ISLANDS AND SUSTAIN ABILITY: 2,000 YEARS OF HUMAN SETTLEMENT IN EASTERN MICRONESIA

MARGINALNI OTOCI I ODRŽIVOST: DVIJE TISUĆE GODINA NASELJENOSTI OTOKA ISTOČNE MIKRONEZIJE

Frank THOMAS
Oceania Centre for Arts,
Culture & Pacific Studies
University of the South Pacific
Suva, Fiji Islands
thomas_fr@usp.ac.fj

Received / Primljeno: 12. 9. 2014.
Accepted / Prihvaćeno: 1. 7. 2015.
Original scientific paper / Izvorni znanstveni rad
UDC / UDK 502.3(966.4)
94(966.4):[504.03+574]

Summary

Low coral islands in the Pacific are often perceived as marginal habitats for human settlement. This view is supported by the small and fragmented islet landmass, poor soils, lack of perennial surface fresh water, and extreme vulnerability to flooding by storm waves, and more recently, rising sea-level attributed to global warming. The atolls and table reefs of Kiribati and the Marshall Islands have produced some of the earliest dates for human settlement of eastern Micronesia. Sustainability for the last 2,000 years was just as likely the result of relatively low population densities, low impact extractive technologies, and efficient use of limited resources, as the application of intentional and unintentional conservation practices.

Key words: Kiribati, Marshall Islands, historical ecology, conservation
Ključne riječi: Kiribati, Marshallovo otočje, povijesna ekologija, očuvanje prirode

1. INTRODUCTION

With over 40,000 years of human settlement, the Pacific islands display great ecological and cultural diversity. Yet, the forces of globalization are an ever present threat. Although environmental degradation and the loss of traditional languages and cultures by the advent of modernity are not limited to islands, the latter appear more vulnerable to disturbance compared to continental areas. Until relatively recently, it was generally assumed that anthropogenic impacts on island ecosystems were the result of Western influence via the introduction of alien crops, ornamental plants, and animals, causing widespread damage to the environment.[1] No one can deny that threats to island biodiversity continue at an accelerated rate as a consequence of human population growth, urban expansion, monoculture, pollution, and overfishing. A half century of research has, however, revealed that indigenous people were also capable of altering their terrestrial environments to a significant degree prior to the arrival of outsiders.[2] These impacts can sometimes be traced to the early stages of human settlement, leading in some cases to resource depression, extirpation, and extinction. By contrast, the influence of indigenous societies on marine resources is less well documented,[3] and remains a fruitful topic for research in light of suggestions that rapid disper-

[1] A.W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* 2nd ed. (Cambridge: Cambridge University Press, 2004).

[2] P.V. Kirch and T.L. Hunt, ed., *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change* (New Haven: Yale University Press, 1997).

[3] A. Anderson, "Short and sometimes Sharp; Human Impacts on Marine Resources in the Archaeology and History of South

sal, notably in the case of the Lapita expansion across the southwest Pacific beginning about 3,500 years ago, could have been driven in part by the impact of early humans on nearshore and intertidal resources of high value that could be efficiently harvested, such as flightless birds, colony-breeding seabirds, turtles, large reef fish, and invertebrates.[4]

2. LOW CORAL ISLANDS

It is argued that without a fair amount of human-induced environmental impact, Remote Oceania (the islands lying to the north and east of the main Solomon chain, Figure 1) would not have been successfully colonized by people lacking a well-established agricultural base.[5] While the importance of food production to early colonizing groups needs to be demonstrated[6], agriculture subsequently expanded to the extent that islands became largely transformed into anthropogenic landscapes. Some human-induced impacts had a destructive effect on island biota, but it is difficult to imagine life on some islands, especially low coral islands - atolls and table reefs or low coral islands lacking a lagoon (Figure 2), without introduced root and tree crops. Patrick Kirch characterized such islands as 'consummate man-made environments'.[7]

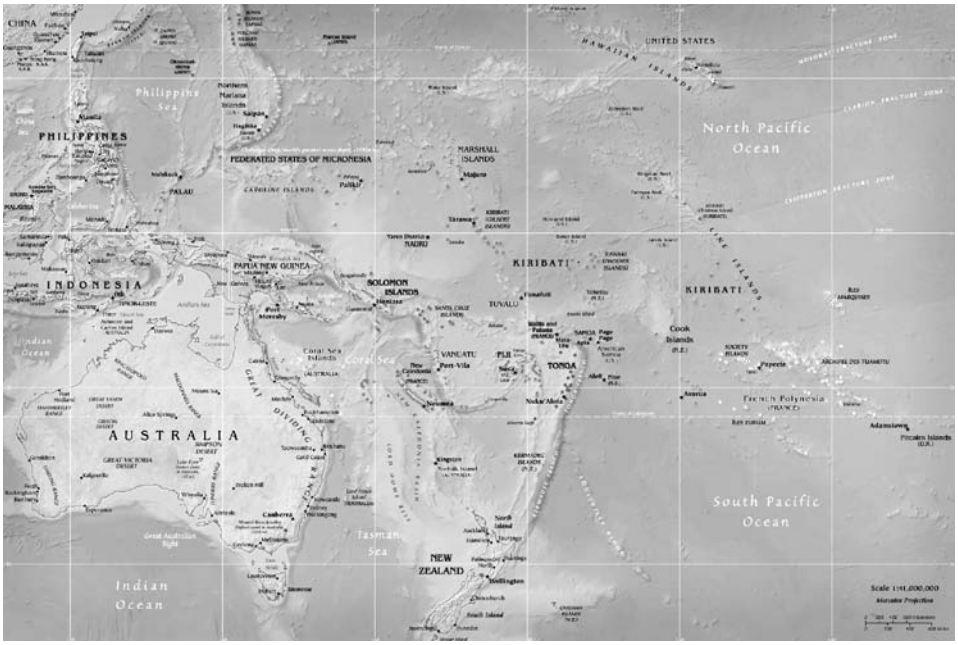

Figure 1

Polynesia," in *Human Impacts on Ancient Marine Ecosystems: A Global Perspective*, ed. T.C. Rick and J.M. Erlandson (Berkeley: University of California Press, 2008); J.M. Erlandson and T.C. Rick, "Archaeology Meets Marine Ecology: The Antiquity of Maritime Cultures and Human Impact on Marine Fisheries," *Annual review of Marine Science* 2 (2010); A.E. Morrison and T.L. Hunt, "Human Impacts on the Nearshore Environment: An Archaeological Case Study from Kauai'i, Hawaiian Islands," *Pacific Science* 61 (2007).

4 M.A. Mannino and K.D. Thomas, "Depletion of a Resource? The Impact of Prehistoric Human Foraging on Intertidal Mollusk Communities and its Significance for Human Settlement, Mobility and Dispersal," *World Archaeology* 33 (2002); K. Szabó and J.R. Amesbury, "Molluscs in a World of Islands: The use of Shellfish as a Food Resource in the Tropical Island Asia-Pacific Region," *Quaternary International* 239 (2011).

5 P.V. Kirch, *The Lapita Peoples: Ancestors of the Oceanic World* (Oxford: Blackwell, 1997).

6 D. Kennett, A. Anderson, and B. Winterhalder, "The Ideal Free Distribution, Food Production, and the Colonization of Oceania," in *Behavioral Ecology and the Transition to Agriculture*, ed. D. Kennett and B. Winterhalder (Berkeley: University of California Press, 2006).

7 P.V. Kirch, *On the Road of the Winds: An Archaeological History of the Pacific Islands before European Contact* (Berkeley: University of California Press, 2000,) 181.

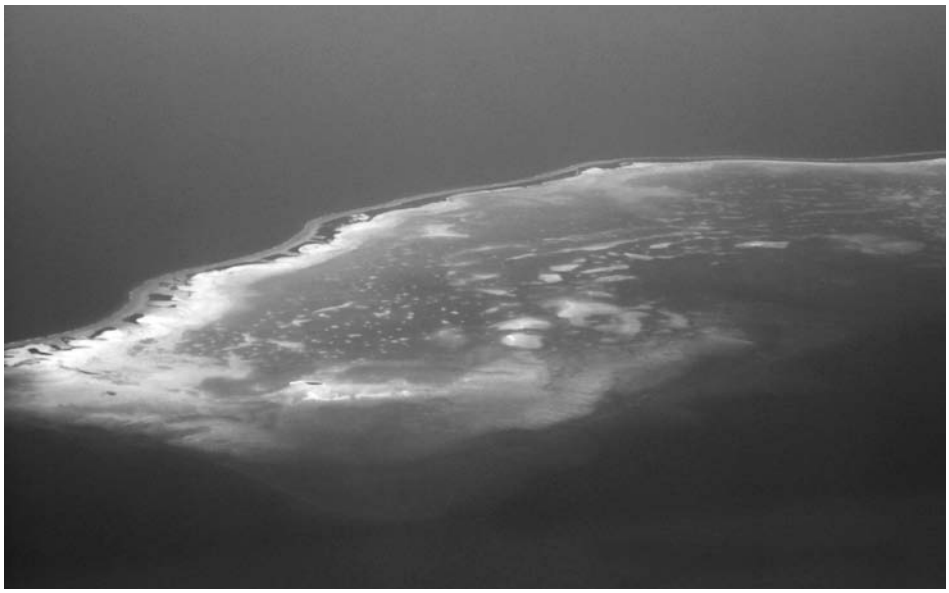

Figure 2

Low coral islands best exemplify the close links between marine and terrestrial ecosystems. As islands formed by biogenic agents (unconsolidated carbonate sediments deposited by waves on reef platforms), atolls and table reefs can be regarded as especially constraining habitats for human existence. The challenges faced by people, both past and present, include low soil fertility, absence of perennial surface fresh water, and extreme vulnerability to flooding by storm surge because of low elevation of the highly fragmented landmass, only a few meters above mean sea-level.[8] There are some 300 atolls and low coral islands in the Pacific Islands region and many more individual islets. Several archipelagoes are dominated by these limestone islands, such as the Tuamotu, Tuvalu, the Marshall Islands, and Kiribati, and their vulnerability to environmental disturbance is well known.[9] Kiribati (Gilbert Islands Group or western Kiribati) and the Marshall Islands have produced some of the earliest dates for the human colonization of eastern Micronesia, about 2,000 years ago coinciding with the post-mid-Holocene drawdown in sea-level, which resulted in the atolls and table reefs to become emergent and habitable.[10]

3. FOOD PRODUCTION

Once coral islands became suitable for human habitation, colonists continued to face several challenges, notably in setting up a viable subsistence base given low soil fertility and in some cases insufficient rainfall. The range of food crops that could sustain people on low coral islands was limited compared to what could be grown on the more fertile volcanic islands. Nevertheless, coral island societies

[8] J. Liew, "Sustainable Development and Environmental Management of Atolls," in *Sustainable Development and Environmental Management of Small Islands*, ed. W. Beller, P. d'Ayala, and P. Hein (Paris and Park Ridge, NJ: UNESCO and Parthenon Press, 1990).

[9] A. Alling et al., "Catastrophic Coral Mortality in the Remote Central Pacific Ocean: Kirabati [sic] Phoenix Islands," *Atoll Research Bulletin* 551 (2007); J. Barnett and N. Adger, "Climate Dangers and Atoll Countries," *Climate Change* 61 (2003).

[10] S.J. Barry, P.J. Cowell, and C.D. Woodroffe, "A Morphodynamic Model of Reef-island Development on Atolls," *Sedimentary Geology* 197 (2007); M.T. Carson, "Austronesian Migrations and Developments in Micronesia," *Journal of Austronesian Studies* 4, no. 1 (2013); A. Di Piazza, "Te Bakoa. Two Old Earth Ovens from Nikunau Island (Republic of Kiribati)," *Archaeology in Oceania* 34 (1999); W.R. Dickinson, "Impact of Mi-Holocene Hydro-Isostatic Highstand in Regional Sea Level on Habitability of Islands of Pacific Oceania," *Journal of Coastal Research* 19 (2003); W.R. Dickinson, "Beach Ridges as Favored Locales for Human Settlement on Pacific Islands," *Geoarchaeology* 29 (2014); M. I. Weisler, H. Yamano, and Q. Hua, "A Multidisciplinary Approach for Dating Human Colonization of Pacific Atolls," *Journal of Island and Coastal Archaeology* 7 (2012); C.D. Woodroffe and R.J. Morrison, "Reef-island Accretion and Soil Development on Makin, Kiribati, Central Pacific," *Catena* 44 (2001); C.D. Woodroffe, B. Samosorn, Q. Hua, and D.E. Dart, "Incremental Accretion of a Sandy Reef Island over the Past 3000 Years Indicated by Component-specific Radiocarbon Dating," *Geophysical Research Letters* 34 (2007).

Figure 3

devised various strategies that took full advantage of edible wild resources, including abundant marine life, in addition to foods that were successfully introduced.[11]

Pits excavated down to the brackish water lens for the cultivation of giant swamp taro (*Cyrstosperma chamissonis*) are among the most outstanding features of the landscape, particularly on the wetter islands (Figure 3). In Kiribati, over 20 cultivars have been identified, with some varieties grown mainly for prestige and ceremonies. Swamp taro cultivation entails a sophisticated system of mulching and fertilization using leaves from a variety of trees. Pits were commonly excavated in the middle of islets where the lens is thicker. Some of the pits were lined with coral boulders to stabilize the walls. Those who still practice this form of food production have their own secret techniques of composting.

Taro pit cultivation has witnessed a general decline for variety of reasons, including damage by historically-introduced pigs, crop disease, tropical storms, growing dependence on food imports, and increasing salinization of the water table associated with global warming and sea-level rise.[12] Given the dynamic nature of atoll geomorphology, anthropogenic traces on the landscape can easily be obliterated unless located well inland, such as swamp taro pits and associated mounds.[13] Excavation and dating of ancient surface soils under taro pit spoil dirt in adjacent mounds yielded evidence of early land clearing.[14] Accordingly, the oldest dates for human occupation usually will be found in association with landscape alteration. One of the first tasks that colonists needed to perform was to clear vegetation in preparation for taro pit digging, because corms (swollen underground plant stems) can take nine months to several years to mature.[15]

Coral island societies relied heavily on tree crops, such as breadfruit, pandanus, and coconut, to meet dietary needs and provide material for a host of products.[16] Agroforestry (Figure 4) is a distinguishing

[11] G. Clark, "Micronesia," in *Early Human Expansion and Innovation in the Pacific: Thematic Study*, co-ordinator I. Lilley (Paris: International Council on Monuments and Sites – ICOMOS, 2010).

[12] F.R. Thomas, "Kiribati: 'Some Aspects of Human Ecology', Forty Years Later," *Atoll Research Bulletin* 501 (2003).

[13] P. Webb and P.S. Kench, "The Dynamic Response of Reef Islands to Sea-level Rise: Evidence from Multi-decadal Analysis of Island Change in the Central Pacific," *Global and Planetary Change* 72 (2010); H. Yamano, H. Kayanne, F. Matsuda, and Y. Tsuji, "Lagoonal Facies, Ages, and Sedimentation in Three Atolls in the Pacific," *Marine Geology* 185 (2002).

[14] M. I. Weisler, "The Antiquity of Aroid Pit Agriculture and Significance of Buried A Horizons on Pacific Atolls," *Geoarchaeology* 14 (1999).

[15] F.R. Thomas and M. Horrocks, "'Sustainability Archaeology' and Landscape Transformation in Eastern Micronesia: Kiribati Case Study," (In prep).

[16] R.R. Thaman, "Kiribati Agroforestry: Trees, People, and the Atoll Environment," *Atoll Research Bulletin* 333 (1990).

Figure 4

characteristic of the earliest agriculture in the Pacific Islands and is still an important component of contemporary atoll landscapes, even in urbanized settings in houseyard and urban gardens. In addition, food preservation technology reached its zenith on coral islands, as people developed ways to process certain foods that they could last through periods of scarcity and for use as sea rations among communities that regularly traveled between islands . Fermented breadfruit, dried pandanus paste, and dried arrowroot starch could be stored for years.[17]

As most of Kiribati and the northern Marshall Islands are located in the dry belt of the equatorial oceanic zone, periods of drought are common. The usual way of accessing water was through the digging of wells, but water was also collected from coconut palm fronds and trunks, as well as empty giant clam shells. Coconut water and toddy (coconut sap) could provide additional nutrients.

4. MARINE RESOURCES

If opportunities for agricultural intensification in the past were limited, the lagoons generally teemed with fish and other marine organisms, providing food as well as raw material (fish bone, shells, coral) for the manufacture of tools and ornaments.[18] Fishponds and fish traps made from loosely built walls of coral boulders were extensively used prior to European contact (Figure 5).[19] What is less clear, however, is the extent of human impact on the marine environment. Elsewhere in Oceania, there is evidence that overfishing by indigenous communities resulted in a decrease in the average size of available resources, particularly of shellfish, that can be distinguished from the effects of natural disturbance.[20]

---

17 M. Merlin et al., *Keinikkan Im Maḷan Aelõń Kein: Plants and Environments of the Marshall Islands* (Honolulu: East-West Center, 1997).

18 G. Koch, *The Material Culture of Kiribati* (Suva: Institute of Pacific Studies, University of the South Pacific, 1986); B.G. Moir, *Mariculture and Material Culture on Takuu Atoll* (PhD diss., University of Hawai'i, Ann Arbor: University Microfilms International, 1989).

19 F. Dieudonne, *The Pacific Islands and the Sea: 350 Years of Reporting on Royal Fishponds, Coral Reefs and Ancient Fish Weirs in Oceania* (Encinitas, CA: Neptune House, 2002).

20 M.S. Allen, "Resolving Long-Term Change in Polynesian Marine Fisheries," *Asian Perspectives* 41 (2002); Allen, M.S., "Human Impact on Pacific Nearshore Marine Ecosystems," in *Pacific Archaeology: Assessments and Prospects*, ed. C. Sand (Nouméa: Département d'Archéologie, Service des Musées et du Patrimoine de Nouvelle Calédonie, 2003); D.H.R. Spennemann, "Availability of Shellfish Resources on Prehistoric Tongatapu, Tonga: effects of Human Predation and Changing Environment." *Archaeology of Oceania* 22 (1987).

Figure 5

While marine losses have not been widely reported from coral islands and the chronology of some documented losses remains uncertain,[21] the very high ratio of reef to land would have ensured abundant protein resources, with little noticeable impact by human communities that remained generally small. However, resident human populations might have had a noticeable effect on less mobile organisms, such as certain shellfish. It has been suggested that people on Utrōk Atoll in the northern Marshall Islands may have extirpated the Bullmouth helmet shell (*Cypraecassis rufa*) sometime in the past. However, the presence or absence of marine species in a particular habitat is largely determined by chaotic or unpredictable recruiting of juvenile organisms that shape the structure of reef assemblages over time.[22] This is not to deny that some species, by virtue of biological, ecological, and behavioral attributes, display levels of resilience to human exploitation.[23] Less resilient organisms, like the giant clam, *Tridacna gigas* in the Marianas, New Caledonia, and Fiji disappeared presumably because of being overexploited.[24] Along with other members of the *Tridacna* family, this species is considered vulnerable to gathering pressure, even when using traditional gathering methods.

5. COPING WITH ENVIRONMENTAL STRESS

Environmental stress can be reduced by the use of social capital. Land tenure systems and kinship networks enabled people living on coral islands to maximize choice of residence and group affiliation to access resources. In reference to the Marshall Islands, Hart[25] highlighted the underlying collective effort required to ensure survival, as illustrated by strong mutual social obligations. This framework could be regarded as a prerequisite for effective resource management.

---

21 J. Drew, C. Philipp, and M.W. Westneat, "Shark Tooth Weapons from the 19th Century Reflect Shifting Baselines in Central Pacific Predator Assembles," *PLOS One* 8 (2013); D.W. Steadman, "Extinction of Birds in Eastern Polynesia: A Review of the Record and Comparisons with other Pacific Island Groups," *Journal of Archaeological Science* 16 (1989); F.R. Thomas, *Archaeological Survey of Wōtto Atoll* (Majuro, Marshall Islands: HPO Report 2004/01, Republic of the Marshall Islands Historic Preservation Office, 2004).

22 G. Paulay, "Benthic Ecology and Biota of Tarawa Lagoon: Influence of Equatorial Upwelling, Circulation, and Human Harvest," *Atoll Research Bulletin* 487 (2001).

23 C.P. Catterall and I. Poiner, "The Potential Impact of Human Gathering on Shellfish Populations, with Reference to some NE Australian Intertidal Flats," *Oikos* 50 (1987); I. Poiner and C.P. Catterall, "The Effects of Traditional Gathering on Populations of the Marine Gastropod *Strombus luhuanus* linne [sic] 1758, in Southern Papua New Guinea," *Oecologia* 76 (1988).

24 J.L. Munro, "Fisheries for Giant Clams (Tridanidae: Bivalvia) and Prospects for Stock Enhancement," in *Marine Invertebrate Fisheries: Their Assessment and Management*, ed. J.F. Caddy (New York: John Wiley & Sons, 1989).

25 K. Hart, *Sung for Anidreb: A Brief History of the Marshall Islands* (Majuro, Marshall Islands: Equatorial Publishing, 1998).

Land tenure systems developed to safeguard terrestrial production among kin groups, while being flexible enough to enable neighboring communities to access resources in time of need. Various cooperative strategies ensured that people could claim rights to resources, made possible, for example, by adoption and intermarriage, trade, and sometimes cyclical migrations to alleviate problems of over- and under-population, thus contributing to sustainable practices.[26] Despite their abundance on most atolls, marine resources were at times subjected to avoidance practices, which would have enabled stocks to recover.[27] For example, the concept of *mo* (taboo) in the Marshall Islands still applies within some inhabited and uninhabited atolls where large bird colonies live and turtle nesting is known. By chiefly decree, northern atolls lacking sufficient rainfall to support permanent human settlement were designated as 'game reserves' to be exploited at certain times only and in an orderly and ritualized way.[28] These atolls have also retained much of their original flora, however sparse.[29]

On small marginal islands, the need to devise strategies for managing population growth may have arisen quickly, so as not to outstrip resources.[30] Warfare, cannibalism, infanticide, and abortion may contribute to population regulation, but there were also non-destructive means such as ritual celibacy, prolonged lactation, and adoption as an alternative to ensuring continuity of the family line. However, it may be that in some instances under-population was a more serious threat to community survival than population pressure.[31] Initially at least, relatively large families and clans would be necessary to ensure adequate levels of resource production.[32] Populations responded to the vagaries of environmental perturbation in a most successful way:

The atoll populations used flexible social processes for the control of fertility and rates of reproduction; they actively managed recovery from the demographic challenges of contingency events and ensured their continuity as atoll populations occupying enduring settlements.[33]

While European- introduced diseases between 1850 and 1900 contributed to population decline in Kiribati, the Marshall Islands, and other several other localities because of the inhabitants' relative epidemiological isolation, depopulation also followed in the wake of Western-induced labor migrations during the same time period to various other Pacific Islands and beyond to work on plantations and mines. Another important cause of depopulation was inter-group warfare encouraged by political, economic, and religious rivalries, with the establishment of external trade and missionary influence.[34]

Interisland contacts would confer advantages in the event of demographic instability and shortages in food and raw materials as a result of environmental perturbation, such as that caused by drought or cyclones.[35] Because of their marginality for human existence, coral islands occupy a prominent posi-

---

[26] W.H. Alkire, *Coral Islanders* (Arlington Heights, IL: Ahm, 1978); I. Ushijima, "A Reinterpretation of the *Sawai* Overseas Exchange System of the Caroline Islands," in *Cultural Adaptation to Atolls in Micronesia and West Polynesia: A Report of the Cultural Anthropological Research in Caroline, Marshall and Ellice Islands*, ed. E. Ishikawa (Tokyo: Committee for Micronesian Research 1985, Tokyo Metropolitan University, 1987).

[27] T. Akimichi, "Conservation of the Sea: Satawal, Micronesia," in *Traditional Fishing in the Pacific: Ethnographical and Archaeological Papers from the 15th Pacific Science Congress*, ed. A. Anderson (Honolulu: Pacific Anthropological Records No. 37, B.P. Bishop Museum, 1986); G.A. Klee, "Oceania," in *World Systems of Traditional Resource Management*, ed. G.A. Klee (New York: John Wiley & Sons, 1985).

[28] M. Merlin et al., *Keinikkan Im Meļan Aelōń Kein: Plants and Environments of the Marshall* Islands (Honolulu: East-West Center, 1997).

[29] F.R. Fosberg, "A Review of the Natural History of the Marshall Islands," *Atoll Research* Bulletin 330 (1990).

[30] R. Bedford and B. Macdonald, "The Population of Kiribati: A Review of some Myths about Migration and Depopulation" (Unpublished paper, Department of Geography, University of Canterbury, Christchurch, 1982).

[31] N. McArthur, I.W. Saunders, and R.L. Tweedie, "Small Population Isolates: A Micro-Simulation Study," *Journal of the Polynesian Society* 85 (1976)

[32] J.D. Nason, "The Strength of the land: Community Perception of Population on Etal Atoll," in *Pacific Atoll Populations*, ed. V. Carroll (Honolulu: University Press of Hawai'i, 1975).

[33] V.J. Green and R.C. Green, "An Accent on Atolls in Approaches to Population Histories of Remote Oceania," in *The Growth and Collapse of Pacific Island Societies*, ed. P.V. Kirch and J-L. Rallu (Honolulu: University of Hawai'i Press, 2007), 253.

[34] F.X. Hezel, *The First Taint of Civilization: A History of the Marshall Islands in Pre-colonial Days 1521-1885* (Honolulu: University of Hawai'i Press, 1983); H.C. Maude and H.E. Maude, "Tioba and the Tabiteuean Wars," *Journal of the Polynesian Society* 90 (1981).

[35] T.L. Hunt and M.W. Graves, "Some Methodological Issues of Exchange in Oceanic prehistory," *Asian Perspectives* 29 (1990).

tion in discussions centered on exchanges. Atolls may be connected to 'high' volcanic islands,[36] but in the absence of the latter, elaborate internal networks were established.[37] These networks functioned to distribute resources between coral islands that differed in terms of productivity, both terrestrial and marine.[38] These differences were linked to variation in rainfall, and also to intra- and inter-islet size, as well as the degree of lagoon closure, shape, and depth.

As with other coral island groups, populations in the Marshall Islands were linked by inter-community support networks, which were adaptive in light of latitudinal variation in rainfall, resulting in differential production of foodstuffs between the dry north and the wetter south and the risk of cyclone damage, prompting Marshallese chiefs to secure land holdings scattered over several islets of the same atoll, as well as land rights to resources on other atolls.[39] Inter-island links in the Gilbert Islands formed smaller regional network clusters.[40]

6. HISTORICAL ECOLOGY

In recent years, historical ecology has emerged as one of the most useful and comprehensive approaches to understanding how environments and landscapes were affected by climate change, early human settlement, historical interactions, and modern development and industrialization.[41] This approach, which combines the natural and social sciences using paleoecology, archaeology, land use history, and long-term ecological research, has potential for examining natural and cultural phenomena that generated changes to island ecosystems.[42]

Compared to 'high' volcanic islands, atolls and table reefs have received scant attention from archaeologists focusing on historical ecology. More specifically, little is known about paleoclimatology, the introduction of exotic fauna, the extent of human-induced environmental impacts, and social transformations on low coral islands prior to Western contact.[43] Given the unique environmental challenges posed by coral islands, it is all the more surprising that pre-European ecological research has been largely neglected. By contrast, the last two decades have witnessed a host of environmental studies, from sea-level rise to contemporary human impact on terrestrial and marine ecosystems.[44] As noted above, a number of studies have looked at the long-term effects of human exploitation and environmental change on fish, invertebrate, and sea mammal populations, resulting in declines in species diversity and reduction in

---

36 W.H. Alkire, *Coral Islanders* (Arlington Heights, IL: Ahm, 1978).

37 A. Grimble, *Migration, Myth and magic from the Gilbert Islands* (London: Routledge and K. Paul, 1972); I. Williamson and M.D. Sabath, "Small Population Instability and Island settlement Patterns," *Human Ecology* 12 (1984).

38 I. Williamson and M.D. Sabath, "Island Population, Land Area, and Climate: A Case Study of the Marshall Islands," *Human Ecology* 10 (1982).

39 D.H.R. Spennemann, "Freshwater Lens, Settlement Patterns, Resource Use and Connectivity in the Marshall Islands," *Transforming Cultures eJournal* 1, no. 2 (2006).

40 W.H. Alkire, *Coral Islanders* (Arlington Heights, IL: Ahm, 1978), 109.

41 W. Balée, "The Research Program of Historical Ecology," *Annual Review of Anthropology* 35 (2006); S.M. Fitzpatrick and W.F. Keegan, "Human Impacts and Adaptation in the Caribbean Islands: An Historical Ecology Approach," *Earth and Environmental Science Transactions of the Royal Society of Edinburg* 98 (2007); R. Ono and D.J. Addison, "Historical Ecology and 600 Years of Fish Use on Atafu Atoll, Tokelau," in *Prehistoric Marine Resource Use in the Indo-Pacific Regions*, ed. R. Ono and D.J. Addison (Canberra: ANU E Press, 2013); T.C. Rick and J.M. Erlandson (eds.), *Human Impacts on Ancient Marine Environments: A Global Perspective* (Berkeley: University of California Press, 2008); E.W.B. Russel, *People and the Land through Time: Linking Ecology and History* (New Haven: Yale University Press, 1997).

42 S.M. Fitzpatrick and M. Intoh, "Introduction: Archaeology and Historical ecology in the Pacific Basin," *Pacific Science* 63 (2009); P.V. Kirch and T.L. Hunt, ed. *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change* (New Haven: Yale University Press, 1997).

43 M.S. Allen, "New Ideas about Late Holocene Climate Variability in the Central Pacific," *Current Anthropology* 47 (2006); A. Anderson, "The Rat and the Octopus: Initial Colonization and the Prehistoric Introduction of Domestic Animals to Remote Oceania," *Biological Invasions* 11 (2006); G.K. Pregill and M.I. Weisler, "Lizards from Prehistoric Sites on Ebon Atoll, Marshall Islands," *Micronesica* 39 (2007); J.P.D. Sachs et al., "Southward Movement of the Pacific Intertropical Zone 1400-1850," *Nature Geoscience* 2 (2009).

44 F.R. Thomas, "Kiribati: 'Some Aspects of Human Ecology', Forty Years Later," *Atoll Research Bulletin* 501 (2003).

average age and size.[45] It is possible that low coral island societies were more acutely aware of resource limitations than communities on larger 'high' islands, and thus realized early on the need to conserve resources.[46] This assumption needs to be critically examined. Optimal foraging models derived from human behavioral ecology[47] have been very useful in distinguishing conservation behavior *per se* (conservation by design) from its effects.[48]

7. CONCLUSIONS

Because of their small size, limited and at times fluctuating resources, and relative isolation, low coral islands are of interest for evaluating aspects of past human adaptation to challenging environments. Much remains to be learned regarding their cultural transformation to sustainability before European contact. What stands out is that several communities were able to live sustainably through the interaction of factors such as relatively small populations, low impact technology, efficient use of resources via the application of specialized agricultural techniques and fishing methods and an understanding of environmental cues and fluctuations, and conservation practices (both intentional or by design such as the presumed deliberate extirpation of resource-competing pigs and unintentional as illustrated by optimal foraging strategies).[49]

In a general sense, it can be argued that islands, and especially low coral islands, are microcosms of larger, but equally fragile environments.[50] From some of the volcanic islands in the Pacific, archaeologists have uncovered evidence for extensive landscape change resulting from vegetation clearing, soil erosion, and species extinction. Debate continues regarding the role of humans versus climatic factors as the leading cause for these changes, but it is reasonable to assume that human impact on the environment exacerbated in some cases the effects of natural disasters, sometimes resulting in major social disruption. More data are needed to evaluate the degree and main causative agent of environmental change in low coral island settings.

The interlinked topics of 'sustainability' archaeology, historical ecology, and conservation[51] highlight the many challenges faced by contemporary Pacific island communities as they attempt to cope with changing environments, economies, and social values, which more than ever pose a threat to sustainable livelihoods. While the past, as documented through historical ecology, can provide some of the knowledge and tools for sustainable livelihoods, we also need to be critical of the effectiveness of traditional coping strategies under new conditions of growing population, altered land- and seascapes, escalating

---

45 M.S. Allen, "Human Impacts on Pacific Nearshore Ecosystems," in *Pacific Archaeology: Assessments and Prospects*, ed. C. Sand (Nouméa: Département d'Archéologie, Service des Musées et du Patrimoine de Nouvelle Calédonie, 2003).

46 C. Wilson, Kiribati: *State of the Environment Report* (Apia, Samoa: Pacific Environment Programme, 1994;) L.P. Zann, "Traditional Management and Conservation of Fisheries in Kiribati and Tuvalu Atolls," in *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific* , K. Ruddle and R. Johannes (Jakarta: UNESCO/Regional Office for Science and Technology for Southeast Asia, 1985).

47 H. Kaplan and K. Hill, "The Evolutionary Ecology of Food Acquisition', in *Evolutionary Ecology and Human Behavior*, ed. E.A. Smith and B, Winterhalder (New York: Aldine de Gruyter, 1992).

48 M.S. Alvard, "Testing the 'Ecologically Noble Savage' Hypothesis: interspecific Prey Choice by Piro Hunters of Amazonian Peru," *Human Ecology* 21 (1993).

49 C.M. Giovas, "No Pig Atoll: Island Biogeography and the Extirpation of a Polynesian Domesticate," *Asian* Perspectives 45 (2006); F.R. Thomas, "Shellfish Gathering and Conservation on Low Coral Islands: Kiribati Perspectives," *Journal of Island and Coastal Archaeology* 9 (2014).

50 P.V. Kirch, "Oceanic Islands: Microcosms of 'Global Change'," in *The Archaeology of Global Change: the Impact of Humans on their Environment*, ed. C.L. Redman, S.R. James, P.R. Fish, and J.D. Rogers (Washington, D.C.: Smithsonian Books, 2004).

51 S. van der Leeuw and C.L. Redman, "Placing Archaeology at the Center of Socio-Natural Studies," *American Antiquity* 67 (2002); R.L. Lyman and K.P. Cannon, ed. *Zooarchaeology and Conservation Biology* (Salt Lake City: University of Utah Press, 2004); D.L. Hardesty, "Perspectives on Global Change Archaeology," *American Anthropologist* 109 (2007); P.V. Kirch, "Archaeology and Global Change: The Holocene Record," *Annual Review of Environment and Resources* 30 (2005); F.R. Thomas, "The Value of Historical ecology in Planning for Sustainable Livelihoods: Kiribati Case Study," *Journal of Pacific Studies* 32 (2012).

Figure 6

climate-related hazards, and changes in community and individual needs.[52] Surely, adjustments will have to be made to assist in developing long-term ecologically secure approaches to survival. For example, ethnographic data, primarily collected during the first half of the 20th century, confirmed the existence of traditional fishing regulations in the form of taboos with attendant secular and supernatural sanctions, and more recently some rural villages and local councils have limited access to certain fishing grounds.[53] Reviving conservation practices could be quite challenging nowadays in a transformed natural and social environment.[54] Hope remains, however, with approaches that can strengthen the resilience of communities and their ecosystems for both sustainable development and climate change adaptation.[55] The persistence of some conservation practices, albeit on a small scale, is illustrated on outer islands in Kiribati in the form of aquaculture of giant clam and cockle species, representing the live storage of animal meat, in enclosures demarcated by coral cobbles (Figures 6 & 7).

We should moreover look at *culture* as a vital link between past, present, and future. Several low coral communities were successful in achieving sustainability for centuries, and their accomplishments deserve to be recognized and celebrated. Knowledge and practices are dynamic, just as cultures are. Culture on low coral islands and elsewhere in the Pacific islands region is still firmly rooted in community obligations. Kin- and community-related activities can reduce risk and uncertainty. Reciprocity as embodied in the Kiribati concept of *bubuti*, a request that cannot be refused, best exemplifies the close ties between people living in a challenging physical environment. As the anthropologist Tony Whincup remarked 'the integration of people and place' for *I-Kiribati* (the people of Kiribati) has indeed become an imperative of survival.[56] An integrated understanding of land- and seascapes for sustainable livelihoods is strongly

---

[52] F.R. Thomas, "Successes and Failures on Atolls: A Review of Prehistoric Adaptation and Contemporary Lessons," in *Culture and environment: A Fragile Coexistence*, ed. R.W. Jamieson, S. Abonyi, and N.A. Mirau (Calgary: Archaeological Association, University of Calgary, 1993); J. Overton, "A Future in the Past? Seeking Sustainable Agriculture," in *Strategies for Sustainable Development: Experiences from the Pacific*, ed. J. Overton and R. Scheyvens (London: Zed books, 1999); F.R. Beardsley, "Restoration of Traditional Knowledge to Enhance Self-sufficiency," *Micronesian Journal of the Humanities and Social Sciences* 5 (2006); P. Nuttall, A. Newell, B. Prasad, J. Veitayaki, and E. Holland, "A Review of Sustainable Sea-transport for Oceania: Providing Content for Renewable Energy Shipping for the Pacific," *Marine Policy* 43 (2014).

[53] R.E. Johannes and B. Yeeting, "I-Kiribati Knowledge and Management of Tarawa's Lagoon Resources," *Atoll Research Bulletin* 489 (2001).

[54] F.R. Thomas, "Remodeling Marine Tenure on the Atolls: A Case Study from Western Kiribati, Micronesia," *Human Ecology* 29 (2001).

[55] D. Storey and S. Hunter, "Kiribati: An Environmental 'Perfect Storm', "*Australian Geographer* 41 (2010).

[56] T. Whincup, "*Te Wa:* The Traditional Canoe of Kiribati," http://www.spasifikmag.com/freetravelarticletewaphotoessay/ (accessed on 2 November 2010).

Figure 7

linked to a *sense of place*. Historical ecology has often documented the transformation of *place*, whose custodians today, the local communities, will need to take on an increasingly active role to manage their biocultural world successfully.

ACKNOWLEDGEMENTS

Many individuals and organizations have assisted in my research over the years. Space precludes a comprehensive listing. Special thanks to informants and host families in the Marshall Islands and Kiribati for their hospitality and sharing their knowledge of the environment, harvesting techniques, and social practices. I am grateful to the Republic of the Marshall Islands Historic Preservation and my colleagues Josepha Maddison and Fred Langmoir. In ongoing research on historical ecology in Kiribati, I acknowledge the support of Tekautu Ioane and Natan Itonga of the Kiribati National Cultural Centre and Museum, and Mary Rokonadravu and Ann Tarte of the Oceania Centre for Arts, Culture & Pacific Studies, University of the South Pacific, for editorial assistance. This paper is an expanded version of a presentation at the 2011 Annual Meeting of the American Society for Environmental History held in Phoenix, Arizona. Am I grateful to Paul Hirt, John McNeill, and an anonymous reviewer for comments.

SAŽETAK

Niski koraljni otoci u Pacifiku često se doživljavaju kao marginalna staništa za naseljavanje ljudi. Ovakav stav dolazi zbog malih i fragmentiranih komadića kopna, otočića sa siromašnim tlom, nedostatkom trajne površinske vode za piće i ekstremne izloženosti poplavama od olujnih valova, a u novije vrijeme i dizanja razine oceana zbog globalnog zatopljenja. Atoli i niski, ravni grebeni otočnih državica Kiribati i Maršalovo otočje imaju povijest nekih od najranijih naseljavanja ljudi istočne Mikronezije. Održivost u posljednjih dvije tisuće godina bila je vjerojatno posljedica relativno slabe gustoće stanovništva, ekstraktivnih tehnologija malog utjecaja i učinkovitog korištenja ograničenih resursa, kao i primjena ciljanih ali i nenamjernih postupaka zaštite prirode.

Economic- and Ecohistory
Ekonomska i ekohistorija

Journal for Economic History and Environmental History
Časopis za gospodarsku povijest i povijest okoliša

History and Sustainability
Povijest i održivost

Editors / *urednici*
Hrvoje Petrić, University of Zagreb
Paul Hirt, Arizona State University

Volume XI / Number 11
Zagreb - Samobor 2015
ISSN 1845-5867
UDK 33 + 9 + 504.3

***Publishers* / Nakladnici:**
Društvo za hrvatsku ekonomsku povijest i ekohistoriju
Society for Croatian Economic History and Environmental History
Ivana Lučića 3, HR - 10000 Zagreb
tel.: +385/1/4092-148, fax: +385/1/4092-879
sites.google.com/site/ekoekohist/

Izdavačka kuća Meridijani
p.p. 132, 10430 Samobor
tel.: 01/33-62-367, faks: 01/33-60-321
e-mail: meridijani@meridijani.com
www.meridijani.com

ISSN 1849-0190 (Online)
ISSN 1845-5867 (Tisak)

***Print by* / Tisak:**
Bogadigrafika, Koprivnica 2015.

***Mailing adresses* / Adresa uredništva:**
Hrvoje Petrić (editor/urednik)
Odsjek za povijest, Filozofski fakultet
Ivana Lučića 3, HR-10000 Zagreb
e-mail: hrvoje.petric@ffzg.hr
ili Vinka Vošickog 5, HR-48000 Koprivnica

***Print supported by Ministry of science, education and sport of Republic of Croatia and Koprivnica-Križevci county* / Tiskano uz potporu Ministarstva znanosti, obrazovanja i športa RH i Koprivničko-križevačke županije**

***Cover* / Na naslovnici:**
Brus Sluice

Ekonomsku i ekohistoriju referiraju:
CAB Abstracts
HISTORICAL ABSTRACTS, ABC CLIO Library, Santa Barbara, California, USA
AMERICA: HISTORY AND LIFE, Washington, USA
JOURNAL OF ECONOMIC LITERATURE (JEL), Pittsburgh, USA
CENTRAL AND EASTERN ONLINE LIBRARY, Frankfurt am Main, Deutschland
ECONLIT - AMERICAN ECONOMIC ASSOCIATION, Nashville, USA