Did the Little Ice Age Contribute to the Emergence of Rice Terrace Farming in Ifugao, Philippines?

John A. Peterson[1] and Stephen B. Acabado[2]

Abstract The Little Ice Age was a global phenomenon from the late 13th century A.D. that affected the northern Philippines by contributing to more arid conditions, especially in the dry season from December to May. This was more pronounced in the eastern lowlands of Luzon where *Amihan*, or northeastern trade winds, were typically dry. In contrast, the central highlands of Ifugao and the Luzon Cordillera were relatively more humid due to orographic relief even in the dry season. These conditions were caused by periodic volcanism that cooled the northern hemisphere, forcing the Inter-Tropical Convergence Zone further south in the range of 0-5° north latitude, and thereby exposing the northern Philippines in the range of 5-15° north latitude to drier conditions. These conditions may have contributed to the exploration of more humid highland terrain by lowland farmers during the critical sowing period for dry, upland rice that has been documented from as early as 3200 years before present (ybp) in the Cagayan lowlands of Luzon, and that might have then also presented opportunities for the expansion of wet-rice farming after its introduction into the Philippines ca. A.D. 1400-1500. As recent data demonstrates, the rice terraces were not 2,000 year old monumental structures, but were developed around A.D. 1400, and mostly subsequent to Spanish settlement in the lowlands and the emergence of mountain refugium by Ifugao and other highland farmers. Subsequent pressure from the intrusion of Spanish colonialism in the 16th and 17th centuries A.D. led to the florescence of extensive wet-rice farming in the hinterlands remote from Spanish domination.

Keywords Little Ice Age; climate change; terraces; Ifugao

The Little Ice Age spanned 500 years, from the late 13th century to 1800 (Dai and Wigley 2000; Field and Lape 2010; Guoqiang et al. 2002). It was not continuously colder throughout this period, but the first effects were observed in the form of extraordinary and persistent drought during the decades around the turn of the century from A.D. 1290. Tree-ring records from the American Southwest document successive and extreme drought that led to major shifts in settlement (Euler et al. 1979). Major pueblo communities in the highlands were abandoned, reconfigured and centralized in the Rio Grande and other perennial streams (Hall and Peterson 2013). These effects were not continuous, but the onset in the A.D. 1300 era signaled a pattern that would be recurrent over the next half millennium. The next period of extended extreme weather was in the 50-year span from A.D. 1450 to 1500.

In the northern Philippines (Figure 1) there is a paucity of data for paleoclimatic or paleoenvironmental interpretation. A detailed but episodic microfossil core from Lake Paoay (Stevenson et al. 2010) documents changing paleovegetation from as early as 7,000 years ago up until 700 years ago.

Snow et al. (1986) reported the discovery of a single grain of rice fired inside a potsherd. It was identified as a dry, swidden variety of rice dating from the era 3240 +/- 160 years before present (ybp) (SFU-86). This singular discovery is the only record of rice in the Philippines before Spanish reports of the ceremonial use of rice in Cebu in the early 16th century, and then later reports of wet-rice farming in Iloilo and Manila in the late 16th century. The Cebu rice may have been swidden rather than paddy or wet-rice. Robert Fox commented in passing that he doubted there was any wet-rice in the Philippines until shortly before the arrival of the Spanish in the mid- to late 16th century when Legazpi first established a Spanish colonial presence in Cebu, Iloilo, and Manila de Bay (Fox 1970). It is noteworthy that as Spanish patrols pressed northward into Pampanga in the island of Luzon they found no wet-rice farming in the current vast region of wetlands that now support the major rice production area of the Philippines (McLennan 1980). When the Spanish encountered the Ifugao in the early 1700s, there were no mentions of any irrigated rice terracing systems in the region (Scott 1974). It was not until A.D. 1801 that Spanish documents first mentioned the presence of rice terraces in the present town of Kiangan (Antolin 1970). By the mid-19th century, the Spanish were able to penetrate the Ifugao highlands and discovered massive wet-rice terraces in the Cordillera of Luzon (Scott 1974; Figures 2 and 3). E. Arsenio

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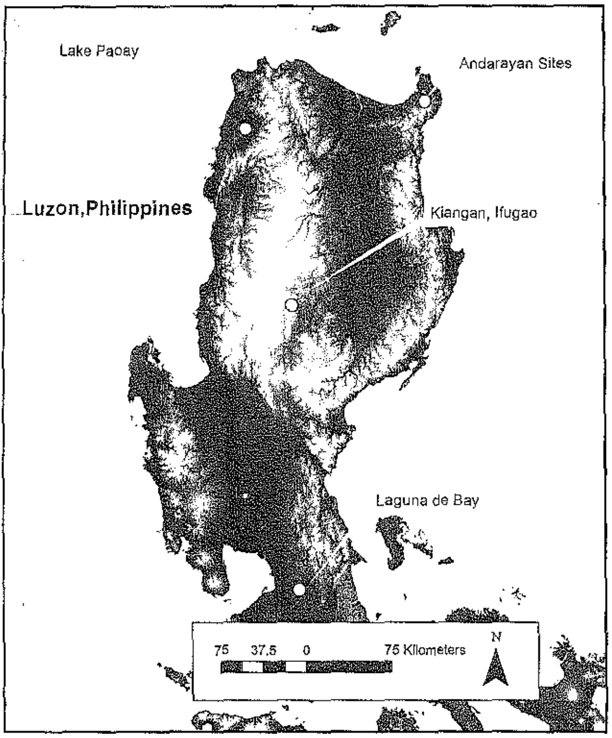


Figure 1. Northern Luzon and places of interest: Lake Paoay, Laguna de Bay; Kiangan, Ifugao; Andarayan Site, Northern Luzon (S. B. Acabado).

Manuel (1994) hypothesized that lowland rice terraces (i.e., Tayabas, Quezon) could have predated the arrival of the Spanish.

Terrace farming in the Ifugao highlands may have developed throughout the Little Ice Age as an effect of the first of range expansion after A.D. 1300 of lowland farmers looking for edaphic opportunities during periods of extensive drought, the later expansion with the introduction of wet-rice varieties ca. A.D. 1400 or 1500, and the successive expansion as a refugium strategy against Spanish settlement in the lowlands. The emergence of the Ifugao rice terraces was thus an effect of the Little Ice Age as well as later Spanish colonial intrusion into northern Luzon.

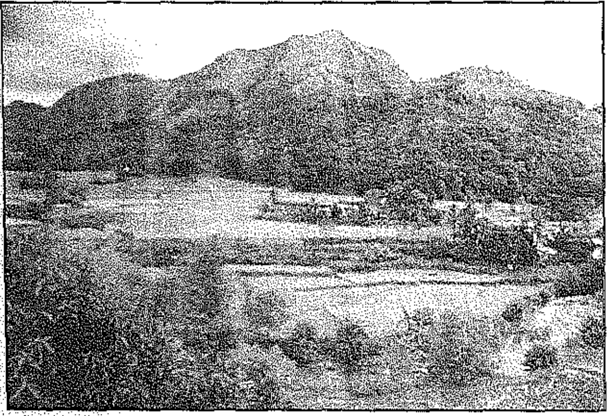


Figure 2. Rice terraces at Kiangan, Ifugao Province, among the earliest (S.B. Acabado, June 2012).

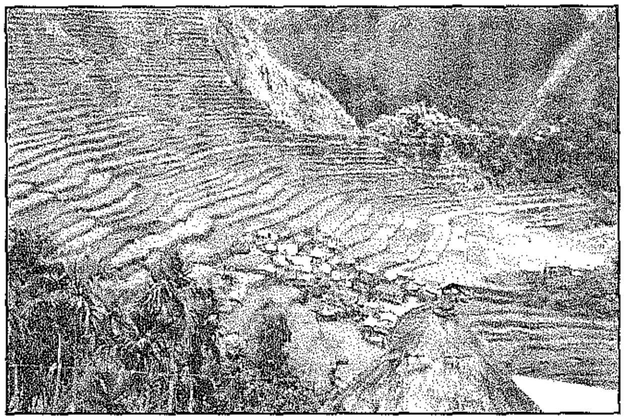


Figure 3. Rice terraces at Batad, Ifugao Province (S. B. Acabado, June 2012).

The Little Ice Age in the Northern Philippines

The extent and effects of the Little Ice Age have been well-documented in the northern hemisphere. Extreme weather events included cold summers and early snowfall in Europe, with shorter growing seasons that often led to years of drought and famine. The high latitudes felt the extremes in greater measure; the degree of change in the tropics was less extreme. The range of temperatures was not as broad, but there were profound effects on rainfall distribution (Figure 4).

The common element in these periods is volcanic activity that was unprecedented before or since. In 1257 Samsara in the Rinjani Mountains of Lomboc in Indonesia exploded with a force 100 times the ferocity of Krakatoa in 1883 and 10 times greater than Tambor in 1809 (Figure 5; Crowley et al. 2008; Lavigne et al. 2013). Multiple volcanic explosions in the mid- to late 14th century and then in the late 15th and 18th centuries suffused the upper atmosphere with hydrogen sulfide particles that reflected solar irradiance. The effect was extended by the accumulating thickness of sea ice during cold years that buffered intervening periods of global warmth. Further, albedo effects from sustained ice coverage also delayed melting and return to warmer climate. These factors contributed to the length and persistence of the Little Ice Age even when the atmosphere was clear of volcanic exhaust (Miller et al. 2012).

Rainfall in the Tropics was impacted by colder conditions in the northern hemisphere by the effect on the Inter-Tropical Convergence Zone (ITCZ) as shown in Figure 6 (Sachs et al. 2009). This band of rainfall girdles the planet north of the equator. In summer the ITCZ ranges from 10-15° north of the equator; in winter between 5-10° north latitude. It is very responsive to continental climate to the north, so that during extended cold conditions the ITCZ is forced further south between 0-5° latitude. This has been inferred by Oxygen isotope records from corals in the Galapagos and Washington

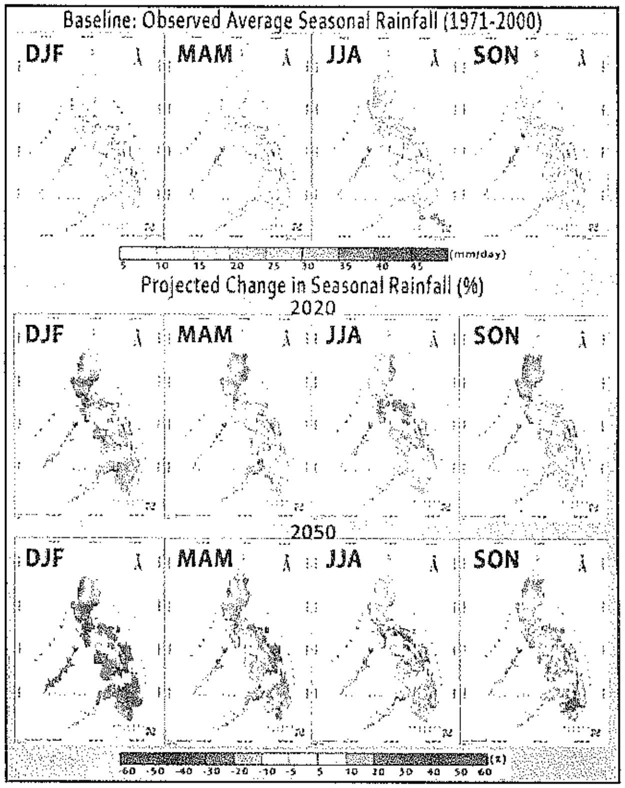


Figure 4. Precipitation patterns in the Philippines with predictions for 2020 and 2050 (adapted from MDG-F 1656 Fact Sheet #1 Philippines).

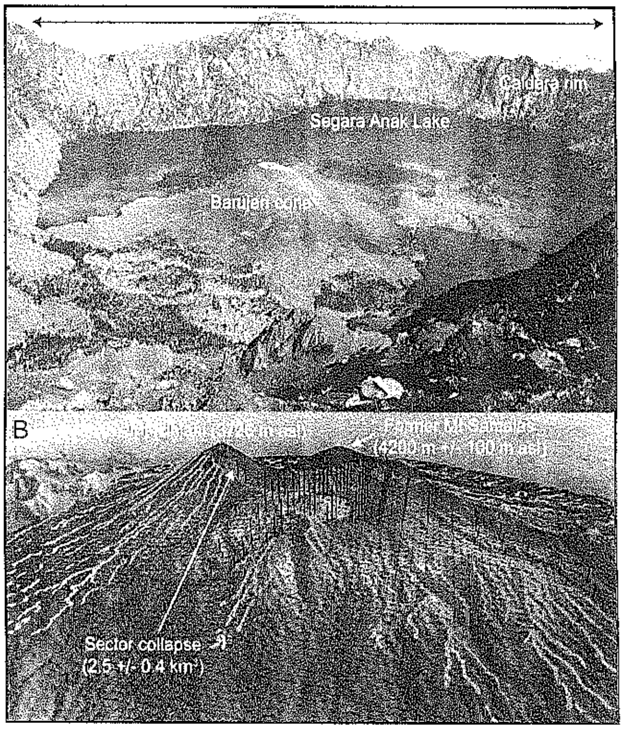


Figure 5. Crater and former Mt. Samalas in Rinjani region, Flores Island, Indonesia (photo A: Zulz, "Gunung Baru" June 26, 2006 via Flickr, Creative Commons License) (adapted from Lavigne et al. 2013:16743).

Islands in the Pacific Ocean, and the periods of southerly forcing match the range of the Little Ice Age, from A.D. 1300 to 1800.

The effect of this forcing on the northern Philippines was profound as it resulted in excessive extended drought and uncertainty in the normal rainfall distribution. Climate in Ifugao Province is usually rainy during the period from December to May but drier from June to August. Even so, it is always wetter throughout the year because of the orographic effect of its high elevation. During the *Amihan* or northeast monsoon from December to May moisture-laden clouds build up and cross the eastern lowlands and the Cagayan Valley, falling as rain in the mountains of the central Cordillera in Ifugao and other provinces in the Cordillera mountains. In the period from June to December the southwest monsoon or *Habagat* would have contributed to drier conditions on the western Ilocos coast, but also to a rain shadow effect on the mountains and the Cagayan Valley to the east. The overall southerly shift of the ITCZ diminished rainfall throughout the year, but especially in what would normally have been a wet winter in northern Luzon.

The effects of the ITCZ are interactive with another cyclical pattern in the Pacific, the ENSO or El Niño Southern Oscillation (Figure 7; Dai and Wigley 2000; Gagan et al. 2004). El Niño conditions have been recurrent every five to seven years in the region. During El Niño periods warm water from the western Pacific piles up in the eastern Pacific, blocking cold upwelling ocean currents off the west coast of Chile and Peru. This leads typically to drought conditions in the western Pacific, and the southeasterly shift of the Asian warm pool of air and water. During La Niña years, the opposite prevails with an expanded Asian warm pool and more equable and wetter climate in the western Pacific.

During the Little Ice Age there was a low frequency of El Niño events, but the northern Philippines remained dry despite the normally wet La Niña conditions. This was because of volcanic activity cooling the northern hemisphere and forcing the ITCZ into a more southerly band (Figure 8). As a result, climate in the western Pacific was controlled by the unusually higher frequency and intensity of volcanic eruptions rather than ENSO events. The A.D. 1300 "event" kicked off a period of climatic stress in the northern Philippines that would have encouraged farmers in the lowlands of either Cagayan or Ilocos to seek out highland opportunities to buffer crop production during the growing season from December to June. The high steep terrain of the Cordillera mountains offered fertile soils, artesian springs for the low rainfall season, and ample rainfall during planting season.

Development of Farming Systems in the Ifugao Highlands

The Andarayan sherd (Snow et al. 1986) with an embedded rice grain is the earliest and the only discovery of

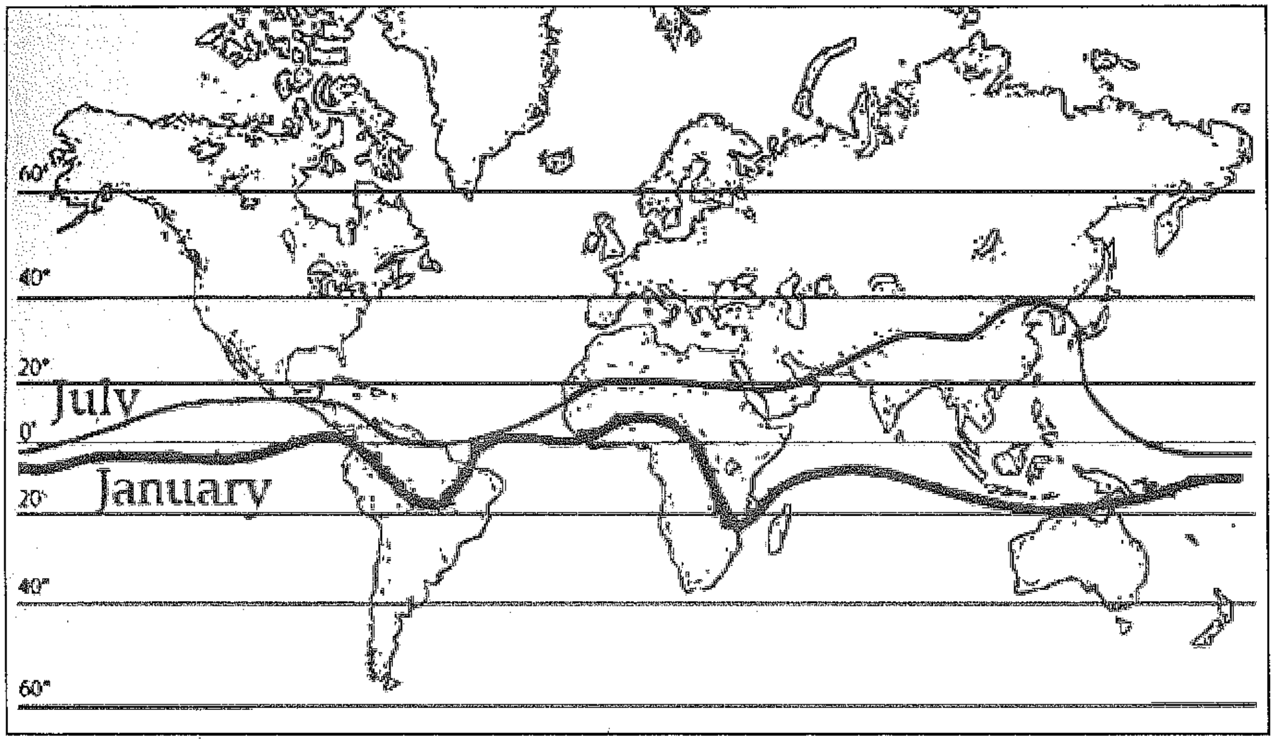


Figure 6. Northern hemisphere summer position of the Inter-Tropical Convergence Zone (ITCZ) (adapted from Expedition USF 2010).

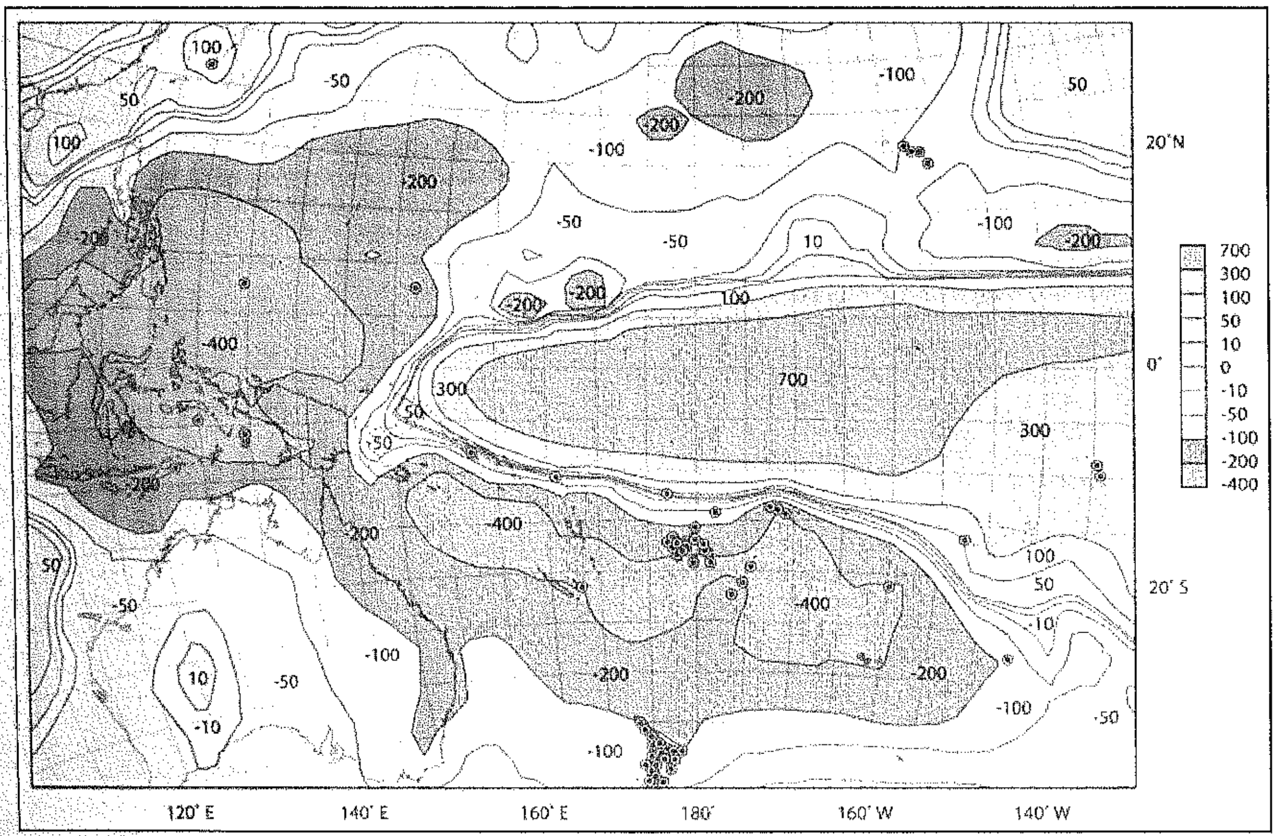
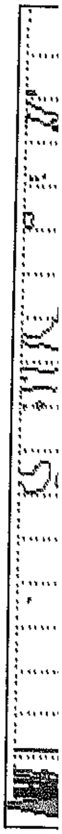


Figure 7. Precipitation patterns in the western Pacific during El Nino events (adapted from Dai and Wigley 2000, reproduced in Field and Lape 2010:118).



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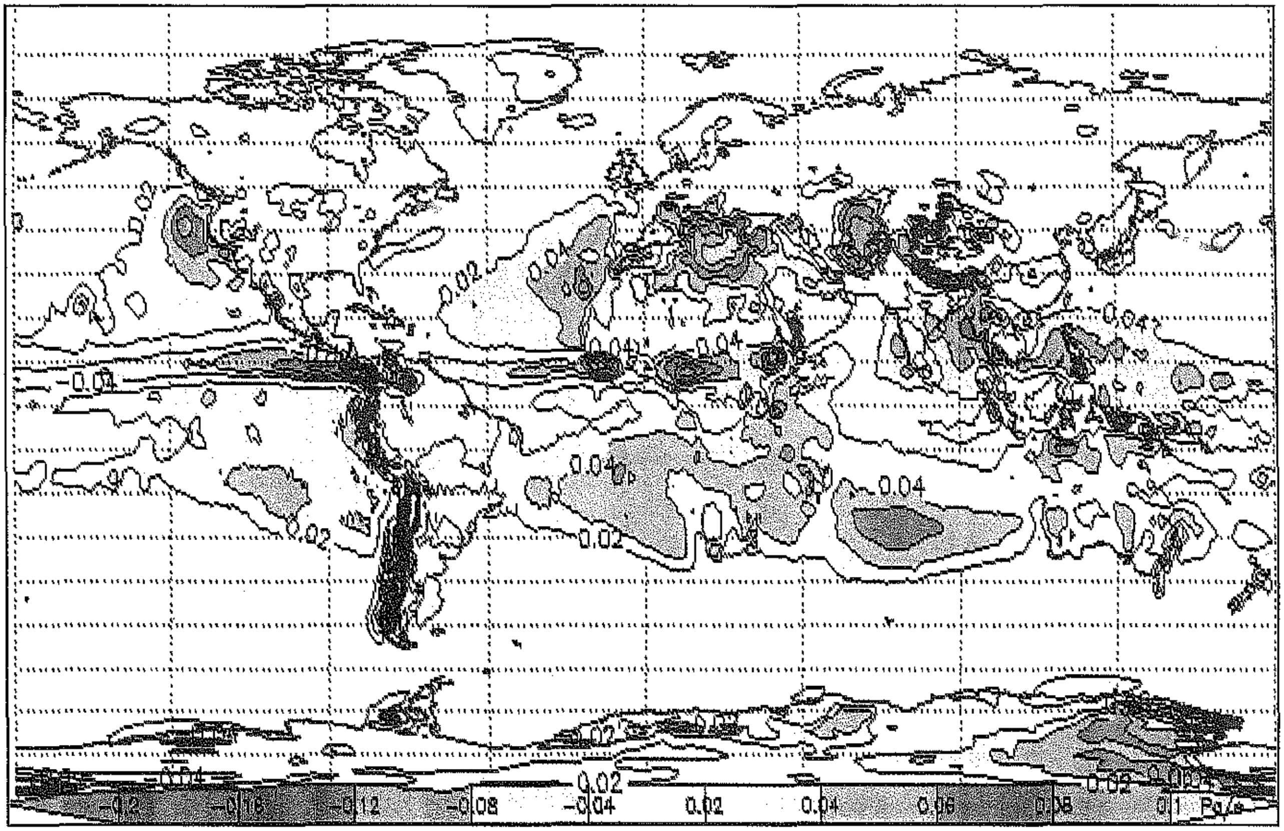

Figure 8. Interactive effects of Inter-Tropical Convergence Zone (ITCZ) and El Niño Southern Oscillation (ENSO) (adapted from Connelley 2006).

early rice in the Philippines. It has been identified as a dry, swidden rice that would have been low-yielding but likely very important as a ritual or ceremonial food (Fox 1970). Dry swidden rice continued to be grown even long after wet-rice was introduced into the region, and there is a contemporary tradition of farming dry rice even in the Ifugao highlands (Scott 1974). In more arid regions of the Philippines or where the terrain is unsuitable for rice terrace or paddy construction, dry rice is grown instead. Wet-rice production also requires considerable investment in construction and maintenance, and is typically a form of landesque capital that supports different forms of social organization than the less-organized village social structures associated with swidden farming (Acabado 2009, 2012a, 2012b).

Rice farming was not likely the sole or most productive practice for agricultural resources. Agro-forestry cropping of banana, breadfruit, coconut, and other trees, along with swidden farming of yams and millet or *dawa*, as well as wetland farming of taro and other aroids and sugarcane are crops reported from microfossil studies (Acabado et al. 2012; Peterson 2005); or in the ethnohistoric (Alcina 2002; Scott 1974) and ethnographic literature (Conklin 1967, 1980; Eder 1982). In the Ifugao highlands yams were reported as a significant crop grown in swidden terrain outside the rice terraces, and taro is reported in the upper reaches of the terrace systems. These crops complemented rice production within a broad spectrum resource production system of the Ifugao. Also, these crops may have been historically significant sources of subsistence than rice. Rice was produced more as a social resource contributing to the emergence and maintenance of systems of elite organization (Acabado 2012a).

The development of terraces and water control features for other wetland crops appears to have predated rice production in the Ifugao highlands, as supported by paleoenvironmental sampling and radiocarbon dating in the agricultural fields in Kiangan, Ifugao Province, which also show that taro was grown in the Ifugao terraces as early as A.D. 1300 (Figure 9; Acabado et al. 2012). Following the introduction of wet-rice varieties around the 14th century, these rice varieties could have easily adapted to conditions in the mountains and the terrain that was already managed for taro pondfields. Rice epidermal fragments as well as phytoliths were found in deposits dating as late as A.D. 1700-1800; phytoliths were found in lower deposits which may date around A.D. 1400-1500 (Acabado et al. 2012). Although it is not clear from these archaeological profiles when rice was introduced, it appears that rice was rapidly integrated into the terrace systems which considerably raised the energy produced in the Ifugao mountains (Acabado et al. 2012).

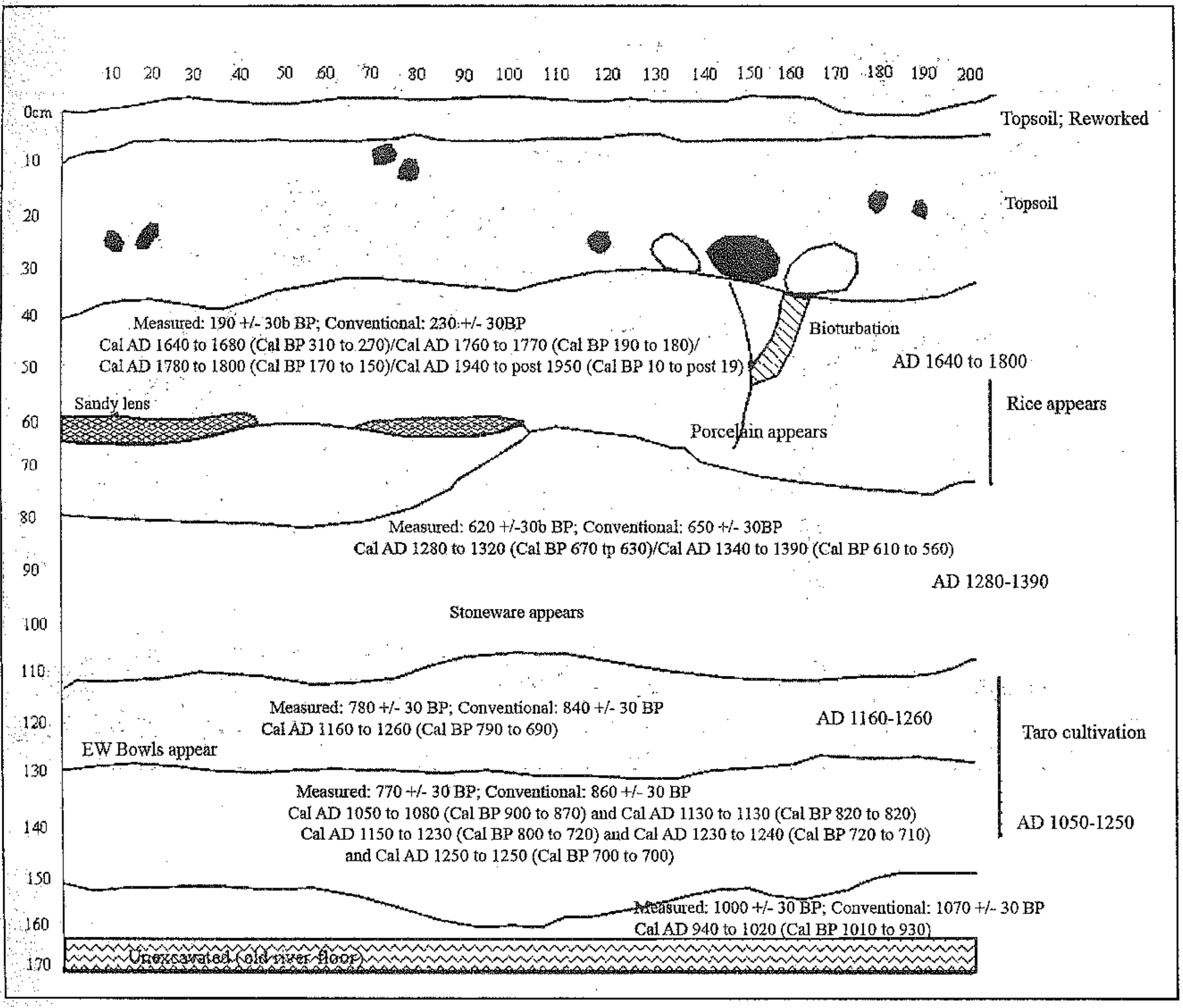

Figure 9. Profile with radiocarbon ages and results of paleoenvironmental assays (adapted from Acabado et al. 2012:18, Figure 14).

Climate modeling for northern Luzon circa A.D. 1300-1800 provides a key to understanding Cordilleran farming as an adaptive strategy for lowland peoples. Awareness of edaphic and soil opportunities in the Cordillera among lowlanders would have provided them an appealing alternative farming site during dry years in the Cagayan Valley. Reduced stream flow as well as intermittent rain in the region may have limited agricultural production. Stream resources favored taro pondfields at the margin of the Cagayan Valley where primary streams issued onto the valley floor; intermittent rainfall might have limited germination and seedset at critical periods for the annual growth cycle of upland or dry-field rice.

The Introduction of Wet-Rice Varieties and Practices in the Philippines

The period or place of the introduction of wet-rice varieties and associated agricultural practices in the Philippines is unknown. Wet-rice agriculture does not appear to have been practiced in the vast interior of Luzon or the Cagayan Valley during the early Spanish colonial period. Instead, Spanish observers reported rice as commonly used in rituals in Cebu, and that rice was more abundantly produced in Panay and Manila. The latter two areas are reported to have been sites for wet-rice production when the earliest Spanish arrived in the Philippines in the 16th century. However, wet-rice farming in Ifugao was not reported by the Spanish until the early 18th century.

It is possible that the earliest wet-rice varieties and practices were introduced by Islamic traders and pilots who were visiting the region in the late 14th century. Entrepots or trading centers were already established in Manila de Bay by the Brunei Sultanate, and also in Butuan (Gunn 2011:72). The latter may have been an established trading center as early as A.D. 1000 through contact with Islamic traders, thus, wet-rice may have been introduced there earlier than in Cebu or Luzon. Nonetheless, there is no evidence for its introduction anywhere in the Philippines.

However, if wet-rice varieties and practices were introduced in Luzon, it would have followed the expansion of Islamic trading from the Brunei Sultanate and the establishment of Islamic trading centers. Islamic expansion followed a different trajectory than European colonization with its hierarchical and extractive character. Islamic expansion in Southeast and Island Southeast Asian regions accommodated local cultures and social organizations, and encouraged a horizontal flow of power and resources that supported and commingled with existing power and kinship structures. In fact, the Islamic practice of polygamy may have promoted the spread of Islamic culture and religion as well as the emergence of expansive trading networks. Its effectiveness is evident in the adoption of social terms such as *datu* and *rajah* as expressions of prestige and status that the Spanish erroneously recognized as denoting chiefdoms or hierarchical social organization. The meaning of these terms should, however, be contextualized within the systems of horizontal power flow epitomized by Islamic economic and evangelical expansion from the 14th century onward in Island Southeast Asia. Trade centers associated with the Brunei Sultanate facilitated down-the-line trading in the region and expansive networks for commodity exchange as well as Muslim religion (Majul 1973; Saleeby 1908). Islamic coastal trading centers may have been the nodes of exchange for agricultural crops as well as the organizational structures to develop complex cropping practices such as wet-rice paddy farming. In the Ifugao highlands, in contrast, wet-rice may have been introduced into a pre-adapted terrace setting that had been developed for other wetland crops such as taro, but that could rapidly have been converted to wet-rice production.

Wet-Rice and Upland Farming as a Response to the Little Ice Age and Historical Contingency

Adaptive strategies for edaphic averaging may have been practiced by highlanders before the advent of lowland peoples, or alternatively taro pondfield farming might have been expanded as a transhumant or relocation strategy during the arid periods of the year and during extended drought cycles. The evidence from Kiangan suggests that taro farming was the primary practice in wetland soils in Ifugao as early as A.D. 1300 when pondfield structures and arable fields appear to have been first constructed in the Kiangan area of the Ifugao Highlands. Evidence for wet-rice farming appears sometime before the 16th century as demonstrated by the discovery of epidermal fragments and rice phytoliths in deposits between the two dated periods. The introduction of wet-rice into pre-adapted pondfield terrain, therefore, may have occurred after the introduction of the variety by Islamic traders around the late 14th century. Other varieties may have been introduced later by lowlanders who migrated into the region as a form of resistance to the Spanish intrusion of the Luzon lowlands, as Keesing (1962) proposed based on his interpretation of Spanish ethnohistoric documents. The phenomenon had also been occasioned by the emergence of social organization that favored formation of an elite corporate group bound by kinship and perpetuated by landesque capital in the form of the terrace systems. The product of the rice terraces however was not necessarily for subsistence; it is also for the production of rice wine, an important beverage for ceremonial occasions for the Ifugao. Rice production might have evolved as signifiers of power relations and social capital that had to be subsidized by other cultigens such as yams and taro as well as agro-forestry in communal forests in the uplands around the terrace systems. Furthermore, carabao feasts further cemented social power and relations and contributed to the maintenance and florescence of the rice terraces.

Figure 10. Rice before harvest, Kiangan terraces, Ifugao Province (S.B. Acabado, June 2012).

The Little Ice Age contributed to the emergence of agricultural practices in the Ifugao highlands in complex and myriad ways, from providing highland opportunities that might have lured lowlanders during periods of stressful drought, especially during critical planting times in December to May. Dry rice farming in the uplands might have been more amenable during these periods because orographic uplift in the highlands contributed to more rainfall in that terrain even during extreme drought in the region. Artesian spring water provided another crucial buffer for wetland farming in the highlands so that taro and other wetland crops could have been grown there even when the lowlands were stressed, and surface water as well as rainfall was limited. Dry rice and yams, taro, and agro-forestry resources were more favorably produced in the highlands during periods of drought. Furthermore, the emergence of water control and pondfields for taro were pre-adapted agricultural fields for the later introduction of wet-rice varieties and terrace farming practices following their advent in the Philippines ca. A.D. 1400 (Figure 10).

In itself, these adaptations appear to have enabled the expansion of farming systems and population growth in the highlands, but the additional pressure of Spanish settlement and colonization of the lowlands may have led to migration into the highlands, serving as a refugia that the Spanish did not discover until the early 18th century. That stream of immigrants may have occasioned a cementing of social patterns as well as providing the critical mass of population that led to an even greater expansion and development of terrace systems in the region.

It could be argued that the expansion of western European exploration from the late 15th into the 18th century was also an effect of the Little Ice Age (Fagan 2000, 2004) that contributed to the evolution of social systems, farming practices and migration into the Ifugao highlands. In addition, the trajectory of historical change in the region conforms to the episodic effects of colder and drier climate as influenced by the southern shift of the ITCZ toward the equator. This in turn was the effect of intensive and long-term volcanism that shifted climate trends toward colder and drier conditions despite a global warming pattern that was already emerging from atmospheric accumulation of greenhouse gases.

Future predictions for climate change in northern Philippines are toward drier and warmer conditions with more extreme weather events ranging from droughts to typhoons. However, the effect of shifting ITCZ patterns might be anti-correlational to this as the ITCZ shifts more northward with more precipitation in areas located within 5-10° north latitude from December to May, and as far north as 10-15° north latitude from June to November. Rather than ENSO dominating the climate of the Philippines, the ITCZ might produce higher annual and seasonal rainfall. On the other hand, another period of intensive volcanism could reverse these trends and offset the progressive effects of global warming that are now pronounced and dramatic in many regions of the planet. The effects of changing climate will be profound in the Philippines, especially considering the current population of 100 million in contrast to the dispersed and low density population during the Little Ice Age.

Acknowledgments

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