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Source: *Human Ecology*, DECEMBER 2013, Vol. 41, No. 6 (DECEMBER 2013), pp. 859-870

Published by: Springer

Stable URL: http://www.jstor.com/stable/24015745

Hum Ecol (2013) 41:859–870
DOI 10.1007/s10745-013-9617-5

What Makes Socio-ecological Systems Robust? An Institutional Analysis of the 2,000 Year-Old Ifugao Society

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Published online: 3 October 2013

Abstract Scholars have often puzzled over why ancient socio-ecological systems (SES) have collapsed or survived overtime. This paper examines the case of the 2,000-year old Ifugao SES in the northern Philippines and the contemporary challenges they now face. Five observations can be drawn. First, the Ifugao case does not fit some of the conventional theoretical explanations for the collapse or survival of SES. Second, the Ifugao's primogeniture system of property rights along with the their customary laws and practices have played important roles in maintaining the robustness of their SES through their effects on ecological integrity. Third, the Ifugao SES today is faced with contemporary challenges with varying effects on its robustness: integration into a post-colonial social order, the effects of tourism and agricultural development, migration, urbanization and the introduction of Christianity and mass education. Fourth, despite these changes, it is not a certainty that the Ifugao will shift to a new domain of attraction that cannot support a human population, or that will induce a transition that causes long-term human suffering. Finally, the Ifugao case study adds to our understanding of robust SES.

Keywords Robustness · Resilience · Institutional analysis · Ifugao terraces · Ancient societies · Socioecological systems · Property rights

Introduction

Scholars have puzzled over why ancient socio-ecological systems (SES) have collapsed or survived overtime. Classic examples of collapsed SES include Easter Island, , Henderson Island, the Anasazi in southwestern North America, the Classic Lowland Maya, the Hohokam of Arizona, and the Greenland Norse. In contrast, robust SES include Iceland (1,100 years), Tonga (3,200 years), New Guinea Highlands (7,000 years) as well as the water boards in the Netherlands[1] (Kaijser 2002), the lobster fisheries in Maine (Acheson 2003), the Hatfield Forest (Rackham 1988), as well as farmer organized irrigation systems in Bali (Lansing 1991), the Philippines (Siy 1982) and Spain (Maass and Anderson 1986).

Five competing explanations have been put forward by scholars such as Tainter (1988) and Diamond (2005): Malthusian theory on population growth and resource depletion; political theories postulating violent power struggles; sociological theories postulating class conflict, social dysfunction and mismanagement; chance events or insurmountable natural catastrophes; and finally, complexity theory.

Malthusian and complexity theories come closest to specifying a causal model between explanatory and outcome variables. For instance, the Malthusian model suggests that collapse of ancient societies tended to follow a similar course: population growth forces people to adopt intensified agricultural production and to expand farming from the prime lands onto marginal land. Unsustainable practices lead to environmental damage (deforestation and habitat destruction, soil problems, water management problems, etc.) and thus to food shortages, famines, wars, disease and consequently the loss of all or part of the economic, social, political and cultural complexity of their peak.

Complexity theory, on the other hand, suggests that 1) human societies are problem solving organizations; 2) socio-political systems require energy for their maintenance; 3) increased complexity carries with it increased costs per capita; and 4) investment in socio-political complexity as a problem solving response often reaches a point of declining marginal returns, which limited the capacity of ancient societies to respond sustainably to changes (Tainter 1988).

This paper examines the longevity and robustness of the 2,000 year-old Ifugao SES, a UNESCO World Heritage Site in the northern Philippines. Its focus is on the logic of their institutions, specifically their property and customary laws and enforcement mechanisms and the contemporary challenges

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[1] The regional government bodies charged with managing waterways.

they face. I use the term institutions in the conventional sense referring to formal and informal rules and their enforcement mechanisms (North 1990). I use the term robustness following Carlson and Doyle (2002) as "the maintenance of some desired system characteristics despite fluctuations in the behavior of its component parts or its environment." Anderies *et al.* (2004) provide a slightly nuanced and anthropocentric definition, i.e., an SES is robust if it prevents the ecological systems upon which it relies from moving into a new domain of attraction that cannot support a human population, or that will induce a transition that causes long-term human suffering. Walker and Meyers (2004) referred to robustness of SES in terms of "thresholds" of a system, which they argue is important if we are to advance "sustainability science".

Robustness is a concept closely related to resilience, developed in ecology, which measures the amount of change or disruption that is required to transform the maintenance of a (natural) system from one set of mutually reinforcing processes and structures to a different set of processes and structures (Holling 1973). More recent developments in resilience theory emphasize the concept of adaptive capacity (Gunderson and Holling 2002). Anderies *et al.* (2004), however, argue that while these ideas are useful in a descriptive sense, they are less useful for studying designed systems because it is not clear how adaptive capacity can be designed and at what cost given the uncertainties in a linked socio-ecological system.

In contrast, robustness emphasizes the cost-benefit tradeoffs associated with systems designed to cope with uncertainty in SES. As such, it is a more appropriate concept when trying to understand how SES can deal with disruptions. Carpenter *et al.* (2001), however, note that the SES literature does not clearly define which kinds of system failure should be measured. Anderies *et al.* (2004) suggest that at a minimum, the following questions must be answered in addressing robustness: 1)What is the relevant system? 2) What are the desired system characteristics? 3) When does the collapse of one part of a SES imply that the entire system loses its robustness?

Methodology

Data for this study were drawn from multiple sources including archival and ethnographic research, participant observation, ground truthing, focus group discussions and key informant interviews, census data, secondary sources, aerial and ground photography, as well as participation in an international conference on the Ifugao.

Extensive archival research at the University of the Philippines (Baguio), which has the largest collection of the most authoritative studies on the Ifugao, utilized the pioneering works of anthropologists such as Conklin (1967, 1980) who wrote the seminal Ifugao ethnographic atlas; Barton (1919, 1922) who studied Ifugao customary law in depth and whose work greatly informed this paper; Lambrecht (1967, 1951), Scott (1966, 1975) on the social history of the Ifugao; Beyer (1912, 1955), among others.

Fieldwork was undertaken from May to October 2008. A team of research assistants in the municipalities and districts of Banaue, Batad, Asipulo, Hengyon and Mayaoyao, Ifugao Province, northern Philippines, conducted surveys and focus group discussion among indigenous knowledge experts, *mumbaki* (village priests), members of the non-governmental organization (NGO) Save the Ifugao Terraces Movement, and officials of the Department of Agriculture and Provincial Planning and Development Office, which keeps statistical records on the rice terraces. The aerial photography by Conklin and Javellana (2008) was invaluable in providing a visualization of the conditions of the rice terraces.

Findings and Discussion

The Ifugao SES is found in the Ifugao Province of Cordillera mountainous region of northern Philippines. There are 14 mountain ranges in the province with an average elevation of 1,600 m above sea level. The Ifugao ethnic group is actually composed of several indigenous sub-groups, namely, the Banaue, Bunhran, Mayayao, Halipan, Hapao, and Kiangang. In the dialect, the word *Ipu-gaw* means "inhabitants of the earth" and it should be noted that Ifugao society is not homogenous and there are variations in the practices among the subgroups. What binds them together is that Ifugao society, which has been around for about 2,000 years, essentially revolves around their main source of livelihood, the rice terraces, which were declared in 1995 a UNESCO World Heritage Site:

> For over 2,000 years, the high rice fields of Ifugao have followed the contours of the mountains. The fruit of knowledge passed on from one generation to the next, of sacred traditions and a delicate social balance, they helped form a delicate landscape of great beauty that expresses conquered and conserved harmony between the humankind and the environment.

The age of the terraces actually vary from place to place. Based on a series of radio carbon dating by the University of Georgia Center for Applied Isotope Studies, some terraces have been dated to the sixteenth century, others as early as the seventh to eleventh century (Maher 1973). Ancient Ifugao families tended to live in small, dispersed and isolated hamlets of one to several dozen households (165–360 individuals per square kilometer of cultivable area) located in agriculturally developed property.

The terraces occupy an area of 4,000 km^2 in mountainous slopes as steep as 70° and at altitudes up to 5,000 ft. Terrace embankments stretch some 20,000 km, of which 7,000 km are stonewalled (Conklin 1980) (Appendix 1; Fig. 1).

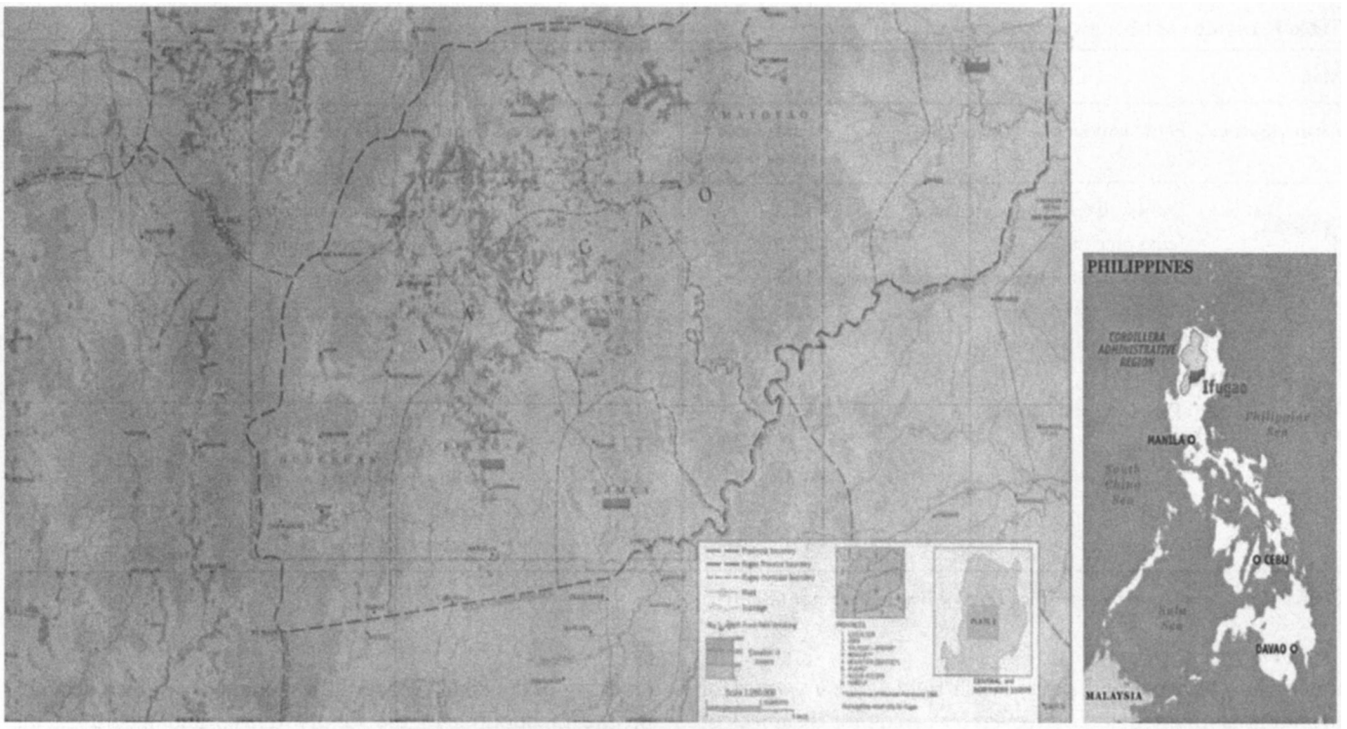

Fig. 1 Geographical distribution of settlements with rice terraces (blue) and partially urbanized towns (orange). Source: Conklin (1980). Philippine Map: http://indigenousissuestoday.blogspot.sg/2008/02/ifugao-indigenous-peoples-of.html

Operating and maintaining the terraces is a complex feat of structural and hydraulic engineering that requires constant repair, extension, restructuring and dynamic recycling of resources while trying to surmount a variety of uncertainties and shocks, including 1) unpredictable earthquakes of varying magnitudes, the Philippines being earthquake prone, which often damage streams that feed the terraces and lead to their collapse; 2) frequent landslides due to monsoons and cloudbursts (the Philippines averages 26 typhoons a year; 3) numerous pests and diseases associated with farming and 4) inherent conflicts over scarce resources such land, water and forests. The ability of Ifugao farmers to build, operate and maintain this complex SES in the face of these persistent shocks and uncertainties for the last 2,000 years is what distinguishes them from other ethnic groups in the Philippines and elsewhere.

Ifugao Institutions

The Ifugao SES appears to be a good example of a robust SES. I speculate that this robustness is due in large part to the logic of the Ifugao institutional structures, particularly their customary laws and a primogeniture system of property rights reinforced by credible and low cost enforcement mechanisms. These customary laws and practices evolved from a polycentric constitutional order, which in turn evolved from and was finely adapted to local ecological conditions. I refer to this as the ecological and institutional grafting hypothesis (see also Barton 1919; Keesing 1962; Conklin 1967; Scott 1982; Lambrecht 1967). I also argue that conventional theories, for example political conflict, Malthusian theories, social theories and insurmountable catastrophes, cannot adequately explain the persistence of the Ifugao SES.

Principles of Customary Law

The Ifugaos have established several principles of customary law, primarily collective responsibility. Not only the individual who commits an act but also his kin in proportion to the nearness of their kinship are held responsible. This applies not only to crimes but to debts and civil injuries as well. The second principle is collective procedure by and between families. These principles are derived from Ifugao bilateral kinship, which is the primary legal and social unit, i.e., an individual's responsibility to his kin takes precedence over self-interest.

Ifugao collectivism and bilateral kinship have their economic basis in the need to mobilize substantial amounts of labor to construct, operate and maintain their terraces and their mountain ecology:

> To terrace 1 ha of mountain slope would require 10,000 cubic meters of excavation, filling and masonry. Thus, the Ifugao rice terraces alone, which cover an area of 4,000 mile^2, would require 103.6 million cubic meters of earthworks using bare hands and crude tools. (Beyer 1964)

According to Beyer (1964), during the long off-season, men channel and impound vast amounts of water and invest

Table 1 Division of labor and specialization

Male			Female		
Farm sequence	Farm activities	Farm labor (person-days/ha)	Farm sequence	Farm activities	Farm labor (person-days/ha)
2	Stonewall/terrace maintenance	12.5	1	Seedbed prep/sowing/maintenance	7.7
3	Land preparation	27.3	4	Transplanting/ replanting	42.2
5	Irrigation canal repair and maintenance	11.3	6	Cleaning / weeding	20.3
7	Fertilizer application	1.7	7	Fertilizer application	0.3
8	Pest control (male child)	5.1	8	Pest control	3.1
			9	Harvesting	40
10	Threshing and hauling	8.3	11	Seed selection	0.8
13	Storing	3.1	12	Drying	7
14	Milling/powdering	4.7	14	Milling/powdering	3.9
	Total	74		Total	125.3
	Percent (%)	37		Percent (%)	63

Source: Provincial Agriculture Office (PAO), Ifugao Province (2008)

much labor to repair and expand their fields. Stream water for irrigation is diverted and conveyed by canals for distances of up to 6 km with water networks totaling 130 km in just one hamlet. Women provide 63 % of the labor required for the whole rice cycle while men are generally responsible for tasks that require more strength and effort such as land preparation, terrace /stonewall and canal maintenance, as well as guarding against water theft, among others (Table 1).

Altogether, it is estimated that 1 ha of highland pond field rice requires a minimum of 630 days of farm labor per year (PAO 2008). When terraces and waterworks are under heavy repair or construction, the annual labor requirement may rise to over 1,000 days of farm labor per year. Farm labor is provided by group effort (*ubbu*) among neighbors and families/clans. Men do the site preparations including irrigation ditch and terrace maintenance while women help in the weeding, pest control and harvesting. Another group, the *baddang*, helps in constructing and maintaining the terraced walls and canals. Others act as monitors for the canals checking on a daily basis for clogging or damage and to guard against diversion of water to other canals.

Principles of Property Law

The Ifugao have developed an elaborate system of property and personal law that operates independently of government. Ifugao property law is based on the principle of primogeniture rights, i.e., the first-born acquires the right to inherit the entire or a substantial part of property of his parents while younger siblings would have to develop or acquire their own properties. The logic of this is as follows: First, for the rice terraces to function properly and sustainably overtime, they need sufficient year round water supply to prevent the drying and cracking of the soil. Year round water supply in turn depends on the functioning of the family forests and woodlots, the *muyongs*, which are located above the upper most part of the rice terraces. The *muyongs* are maintained as forest cover for the watersheds that supply the irrigation water of the terraces as well as sources of fuel-wood, timber and food.

Second, in order to maintain the integrity of *muyongs* they are inherited in their entirety and cannot be subdivided into smaller areas, which would threaten the sustainability of the terraces. This is the equivalent of vertical integration in the theory of the firm (Williamson 1985). Primogeniture rights are reinforced by rules requiring perpetual tenure over rice and forestland. If an owner abandons a rice field for any period of time, and another farmer cultivates the field without objections from the true owner and makes the land productive again, the latter has the right to use the field for the same number of years that it was abandoned. Moreover, properties cannot be pawned to another party for an amount higher than the original pawn price. This rule ensures the prompt return of the field to the original owner as soon as he is able to redeem the pawned property, which prevents land speculation and is likewise equitable.

Furthermore, farmer interviews reveal that there is no such thing as absentee landlords and that very little land is controlled by non-Ifugao. Ifugao land tenure and usage have been tightly managed and integrated culturally. Absentee landlords and non-Ifugao landowners would present problems for maintaining the watersheds and pond fields on which farmers further down-stream are dependent for the functioning of their fields. Deterioration of the terraces and watersheds in the upper slopes of the mountain would impact water management downstream and could result in soil erosion damaging pond fields.

The primogeniture system of property rights is central to maintaining kinship as the primary basis for social relations among traditional Ifugao,[2] who practice bilateral consanguineal kinship resulting from marriage, economic circumstances, neighborhood and propinquity (Conklin 1980). Finally, primogeniture inheritance provides a mechanism for balancing power among competing interests. As Barton (1919) notes:

> It is preferable for the Ifugaos that a family has at least a powerful member around whom the kin may rally and to whom they may look for aid than to have the family property split into insignificant parcels that would affect little the property of all. The unity of the family is primodial and must be preserved at all times and at all cost.

Customary Law Enforcement and Rituals

Customary law enforcement among the traditional Ifugao relies mainly on religious norms and taboos rather that courts or judicial decisions. Religion and law appear conjointly in matters of importance such as transfer of property, payment of large fines and peace making.

Field interviews reveal the importance of norms or taboos in mitigating conflicts in the allocation of scarce resources such as water. These norms follow the established principle "first in time, first in line." For example, in opening of new rice fields, traditional Ifugao law provides that if all the land below a spring is a common land, i.e., without a landowner, the farmer who makes the first rice field below the water source is entitled to all the water needed for his rice field. The owner may sell the surplus water to whom he pleases and the water rights sold are in perpetuity. Thus: farmer A has a rice field in which there is a spring and sells water to farmer B whose field is at a considerable distance from A's. Farmer C has a field immediately below A's, which he purchases and unites it with his own. Land ownership in this case does not involve automatic water rights. Farmer C would have to buy the water rights from farmer B.

Elaborate rules on water allocation can also be found among those governing irrigation canals. As the field interviews reveal, constructors of irrigation canals may sell their interest in the ditch and the ditch shared with others becomes an equal burden as to upkeep on all the owners. The constructors of the irrigation ditch who have sold part of the water from their ditch must share the water in time of water scarcity in proportion to the respective areas of the rice fields.

The complex operation and maintenance of the rice terraces over time requires a well functioning social order that can easily adapt to the various risks and uncertainties associated with farming in particular and the challenge of survival in the mountain ecosystem of the Ifugao. Traditional Ifugao frequently employ rituals and seek the protection and assistance of deities, but these practices may vary geographically and possibly also over time.

The traditional Ifugao pantheon of deities rivals that of India, with as many as 1,500 deities in various ranks from gods, to demons, monsters, imps and spirits dwelling in trees, stones, mountains, and rivers in addition to the omnipresent ancestor spirits (Barton 1919). Deities are invoked to explain catastrophes such as typhoons, earthquakes, pests and crop diseases, and provide traditional Ifugao with some form of reassurance to the uncertainties of life in general and of rice farming in particular. Today, not all Ifugao subscribe to these beliefs—notably those who have converted to Christianity. Rituals and invocation of deities are accompanied by oral chants—*hud hud*—that can last for 3 to 4 days. In 2000, UNESCO recognized the Ifugao *hud hud* as one the 19 oral traditions in the world with intangible value.

For those who continue to practice rituals, reverence and worship of their deities instills a deep sense of respect for the environment, which in turn guides their behavior in relation to nature. In social relations, reverence for deities serves to strengthen taboos, rules of propriety, and the sense of collective responsibility and reinforces the effects of conjoined law and religion. It must be noted that today, among the younger generation of Ifugao, the essence of these rituals is gradually being eroded as a result of their formal education, options to move away, and the introduction of Christianity (see below).

In addition to worship of deities, socialization among traditional Ifugao takes the form of rituals, festivals, collective work and dense kinship networks, all of which serve as mechanisms to ensure the transmission of indigenous knowledge, social capital and values from one generation to the next and hence help ensure the robustness of the SES. . Conklin (1980) recorded 37 types of rituals in a small hamlet of Bayninan with 50 inhabitants from 11 households, which were held every month for an average of 16 days with some lasting 26 days. In all, during the year 1962–1963 at least 191 days were spent for rituals in this hamlet (Fig. 2).

During the sowing and planting period (December to February), when the seedlings are ready for transplanting the Ifugao conduct the *loh-wang* ritual. Rice wine is served and two chickens are killed to feed the workers. When the transplanting is completed, the *asi apoy* ritual is observed giving the workers at least 3 days to rest, drink and socialize. After the rice fields have been planted, farmers celebrate in their own homes *(olpi)*, which serves as a thanksgiving for the work done in the rice fields. This is also the time when they ask *Kabuniyan* (god) to spiritually protect their rice plants for a successful harvest. A month after the *olpi* ritual, the ceremony is repeated (*hagophop*) specifically by those who can

[2] By traditional Ifugao, I refer to those who continue to practice and subscribe to the ancient Ifugao belief system in contrast to the contemporary Christianized Ifugaos.

afford a second celebration. As soon as the rice plants in the field change color from green to purple-yellow, the *Hanglag* or *Mamague* ritual is observed and the farmer announces to all the rice goddesses that the harvest season is fast approaching.

During harvesting (July–August), Ifugaos practice the *tungo* ritual in their respective houses or granaries. The people call the goddesses of rice to come down and ask their favors to make the harvest fruitful and abundant and to guard the fields from evil spirits. Two days before this ritual, the leader of the community will announce the day of the holiday after harvest for the thanksgiving ritual to *Kabuniyan* for a successful harvest.

Contemporary Challenges

The contemporary Ifugao SES is faced with challenges of varying degrees of severity as a result of its integration with the local economy and the national political and legal system (Barton 1946; Beyer 1955; Scott 1966; Dulawan 1979; Conklin 1980; Bulayo 1998; UNESCO 2008). This section briefly traces this process of integration from the colonial era to the post-colonial period and describes the contemporary challenges and their implications for the Ifugao SES.

During the Spanish era (1500s to 1896), historical records show that the Ifugao were never effectively colonized owing to the remoteness of their mountain ranges. During the American colonial era (1897–1946), Protestant missionaries brought Christianity and English language education to Ifugao settlements. This had little immediate impact on the Ifugao SES but would subsequently lay the foundations for the gradual erosion of the use of rituals by younger generations, at least in settlements where Christianity has taken root. During the Japanese occupation (1941–1945), the population of the province significantly dwindled as a result of casualties and emigration due to disruption in farming livelihoods.

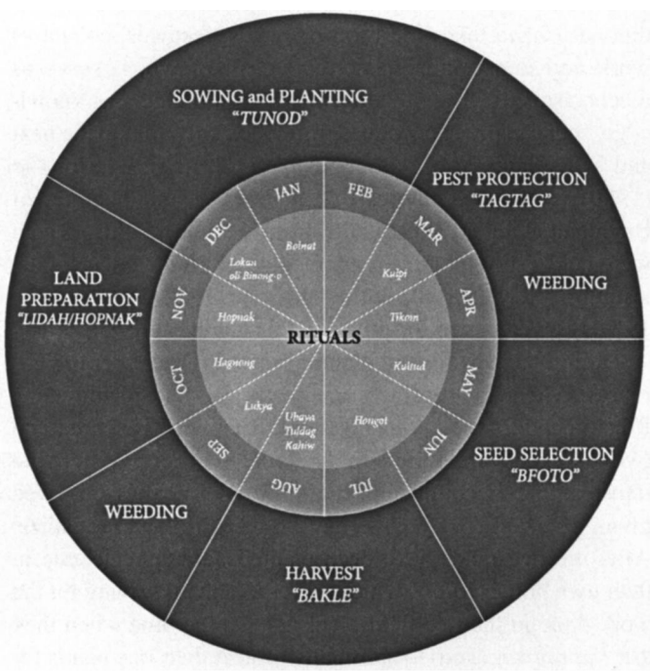

Fig. 2 Cropping calendar and associated rituals (Source: Guimbatan 2003)

During the post-colonial era, several developments have had important implications for the Ifugao SES. The first, in 1973, was the declaration of the Ifugao rice terraces as a national landmark. The declaration sought to develop the province as a tourism destination as well as to conserve the terraces, and opened the area for development, including roads linking various municipalities and other provinces in the region, an airport in the adjoining province of Nueva Vizcaya, communication facilities, hotels, banks, schools, and agricultural development. Today, the Banaue rice terraces, one of the five clusters of the Ifugao terraces—Kiangan, Central Mayaoyao, Hungduan, Batad and Banaue—has become a major tourist destination attracting some 60,000 visitors a year (Appendix Fig. 8).

The second major development, the1987 Philippine Constitution, gave significant political autonomy to the Cordillera Region, including Ifugao province, with the aim of respecting and strengthening indigenous institutions. A more specific law—the Indigenous People's Rights Act—was passed in 1997, which strengthened the claims of indigenous peoples to their ancestral domains. This law stipulates, among other clauses, that indigenous property laws will have precedence over national land laws. This in effect helped to strengthen the Ifugao's native land laws and their customary enforcement mechanisms. The third major development was the UNESCO recognition of the Ifugao rice terraces in 1995 as a World Heritage Site, which saw a significant increase in tourism and the pressure it brought to some of the terrace clusters particularly in Banaue.

Urbanization, Education, and Tourism

Four of the 11 municipalities in Ifugao province are now partially urbanized (with a population of at least 10,000 individuals), but account for only 10 % of the population. However, of these four, only two (Kiangan and Banaue) have significant terrace clusters. The majority of settlements with rice terraces are still villages located in relatively remote rural areas (Fig. 1). Population density is generally low at 69 individuals per square kilometer as of 2007 compared to 60 in 1995 (National Census 1995, 2007).

Banaue, a partially urbanized municipality, has seen its population increase by 37 % to 23,800 since 1990 due to migration from nearby towns and provinces. Tourism based livelihoods are a strong attraction, with the town drawing some 85 % of tourists visiting the province. During the 1990s, some 60,000 tourists visited Banaue and its surrounding attractions annually. This figure has now risen to 180,000, putting considerable pressure on the terraces.

Tourism has both positive and negative impacts on the rice terraces. On the positive side, tourism related livelihoods and

revenues sustain the local economy and provide strong incentives for locals to sustain the rice terraces. This is particularly the case for the Banaue-Batad terrace cluster, which is a favorite tourist destination. Some of these terraces, especially in Banaue, have been converted to residential and commercial land use (Appendix Fig. 8), but this use is not robust in the sense defined by Anderies *et al.* (2004) (see above).

On the other hand, a new kind of dynamics is emerging in some Ifugao settlements as a result of integration with the market economy. These include increased opportunities for employment both overseas and in other areas of the Philippines, migration pressures, labor shortages and rising costs, urbanization and the consequent erosion of customary law and practice of rituals due to the introduction of Christianity and integration into the market economy (Conklin 1980). The customary property laws that have sustained the integrity of the terraces (i.e., the primogeniture system of property rights) are also under stress due to labor shortages. Mechanisms, such as rituals, to transmit indigenous knowledge are also slowly disappearing due to high costs, loss of interest by the younger generation and because rituals are considered taboo by the Christian converts. The net effect is a steady loss of the indigenous knowledge that is crucial for the robustness of the Ifugao SES.

Exit Options: Migration and Alternative Livelihoods

The introduction of roads, mass education, media and tourism has created a number of exit options for the Ifugao. In the last decade, out migration to adjacent provinces, cities and overseas have increased in large part because of rising levels of education for younger Ifugao and because rice farming is not as profitable as other livelihood options. Census data (2007) showed that about 35 % of Ifugao obtained at least a high school diploma and another 41 % had received some primary schooling. The literacy rate is at 78 % (NCSO 2007).

In a 1998 survey in Bulayo municipality overseas employment emerged as one of the main sources of livelihoods for the Ifugao, followed by driving motor vehicles for hire, working as hired labor in nearby provinces, wood carving and weaving to supply the tourist industry (Table 2). The trend towards overseas employment increased from 570 individuals in 1990 to an estimated 4,500 in 2010.

The overall effect of these exit options is increasingly evident. In 1980, based on census data (NCSO 2012) only 2.5 % of total arable lands in the province were reported idle compared with 11.5 % in 2002. No recent estimates are available as the national census is still underway but it is likely that this figure will be in excess of 20 % given the high rate of literacy amongst the Ifugao, which gives them exit options for non-farming jobs in urban areas.

Challenges to Rice Farming

The integration and urbanization of some Ifugao towns such as Banaue has led to particular challenges to rice farming. For instance, an entomological study in 2005 shows that Banaue suffers significantly from a host of pests and diseases compared with rural and less accessible rice terraces, such as those in the Hungduan District. For example, 90 % of farmers in Banaue report that earthworms pose a major problem to their farms compared with only 53 % in Hungduan. Farmers in Banaue also report that the earthworms have become resistant to pesticides and the problem has worsened over time. Ground observations reveal that more terraces are crumbling in Banaue compared with Hungduan, and the cost of maintaining them has become more and more expensive because of the need for hired labor. Labor costs in terraced farming range from 75 to 88 % (Provincial Agriculture Office (PAO) 2007).

Three out of four farmers in Banaue also report that golden apple snails have become a major pest in rice farming compared with only 21 % in Hungduan (PAO 2007). US Peace Corps Volunteers introduced the apple snails, with government encouragement, in the 1980s as a source of protein for farmers in mountainous areas. Since then, the snails have become a major rice pest. In addition, urbanization has led to the growth of rat colonies in Banaue, and 84 % of farmers report that rats have become a major pest in rice farming compared with only 60 % in Hungduan.

Furthermore, in the 1980s in an effort to modernize rice farming in Ifugao, the government promoted the use of high yielding rice and vegetable varieties that are heavily dependent on fertilizers and chemicals for pest control and do not require year round inundation. Absence of inundation promoted the growth of large earthworms (*Polypheretima elongata*) that bore into the soil creating tunnels through which water passes and thereby weaken the terraces. Changes in cropping have also increased the incidence of pests, especially rats (*Ratus tanezumi*) (PAO 2007).

Likewise, in the last three decades, chemical farming has intensified in the terraces along with the introduction of modern rice varieties during the green revolution of the 1970s and 1980s. This was followed up with two major agricultural development projects in the region in the 1990s—the Cordillera Highland

Table 2 Sources of livelihood, Nanulditan, Ifugao (1998), $n=90$

Livelihood activity	Frequency	%
Overseas employment	42	23 %
Tricycle driving	38	21 %
Farming out of the province	30	17 %
Wood carving	27	15 %
Weaving	21	12 %
Cash cropping	15	8 %
Hog raising	8	4 %
Poultry raising	4	2 %

Source: Bulayo (1998)

Agriculture and Resource Management Project funded by the European Union and the Highland Agricultural Development Project funded by the Asian Development Bank. Both projects sought to improve the income of Ifugao farmers by introducing "modern" methods of farming as well as providing credit, technical assistance, farm-to-market roads, post-harvest facilities, among other incentives. These projects also introduced Ifugao farmers to more intensive use of fertilizers and chemicals as well as to diversify into high value crops (Bulayo 1998).

Chemical farming has a particularly corrosive effect on the rice terraces. Soils saturated with chemicals tend to loosen, dry up and crack easily and thus are more prone to erosion and therefore require more maintenance, incurring increased labor costs. Heavy rains accelerate the collapse of these dried up terraces (Appendix Figs. 6 and 7). This problem particularly affects newly built terraces, but not so much the old terraces that were built with organic materials as well as those built with stone walls (Butler 2007).

The response of contemporary Ifugao farmers to the difficult challenges of rice farming is becoming evident in the shift in land use patterns as documented by the Bureau of Agricultural Statistics (2012). For instance, in the 1980s, only 4.3 % of total arable land was devoted to permanent crops. By 2002, this has grown to 13.2 %. More tellingly, the proportion of arable land devoted to rice farming has declined from 23,000 ha in the 1980s to 17,000 ha in 2007, while that devoted to corn (which requires less labor and water) has increased to 22,900 ha (2007) from 10,000 in the 1990s. This shift in land use patterns could possibly be explained by labor shortages and preference for higher value crops such as corn and permanent crops such as fruit trees. This shift to higher value crops in turn could have been driven by the need for higher incomes to finance secondary and tertiary education for younger Ifugao who go to urban areas to study.

Change in Primogeniture Rights and Rituals

Today, in many contemporary Ifugao families, the primogeniture system of land inheritance is also undergoing change. For instance, younger siblings usually inherit some of their parents' property although less than the first-born child. This practice is likely to continue among contemporary families, leading to further fragmentation of field ponds making rice farming less viable and attractive for the younger generations. This shift to semi-ultimogeniture is usually due to the fact that it is a way to attract and keep at least one sibling (the youngest) at home to take care of the parents (Save the Ifugao Terraces 2007).

Likewise, reliance on rituals to strengthen social capital and facilitate labor exchange is gradually being eroded because of costs, the loss of interest by the younger, formally educated generation and because of the influence of Christianity (Bulayo 1998). For instance, the *hud hud*, the tradition of oral chant accompanying the harvest season is gradually being eroded as the younger generation lose interest and rely on formal education. The effect over time has been that indigenous knowledge required to build, operate and maintain the Ifugao SES is slowly being lost from one generation to the next (Save the Ifugao Terraces 2007). This could also possibly account for the significant shift in land use patterns i.e., the increase in the proportion of arable but idle lands and significant shift to corn farming, which does not require ritual inputs unlike rice farming.

Conclusion and Speculation

I have addressed the longevity and robustness of the Ifugao SES by focusing on the logic of their institutions and the contemporary challenges they now face. Five conclusions can be drawn. First, the Ifugao case provides an empirical account to refute some of the conventional theoretical explanations for the collapse of SES. First, the political hypothesis speculates that societies collapse if there is a power vacuum (Tainter 1988). Historically, Ifugao society did not face this problem because it did not have a central government. Even when it was eventually incorporated into the Philippine nation state in the mid-twentieth century, the effective control of the centralized government over the Ifugao society was rather weak. Second, Marxists—for instance Gray (2008) and Woods (2009)—speculate that class conflicts led to the demise of ancient societies. This was not the case either since there is no distinct class stratification among Ifugao although rank and status are regarded as important. Third, the Ifugao have managed to overcome significant setbacks, such as frequent earthquakes, typhoons, pestilence and conflicts over resource allocation overtime and thus the catastrophic shock hypothesis do not apply. Fourth, the complexity hypothesis does not apply because the Ifugao SES is not as complex as defined by Tainter (1988). Finally, the Malthusian hypothesis likewise does not apply as Ifugao population density has remained relatively small (60 individuals per square kilometer) and is stable over time, growing at a rate of 1.3 % in the last three decades.

Second, I found that the Ifugao primogeniture system of property rights along with the their customary laws and practices have played important roles in maintaining the robustness of their SES over the past 2,000 years. The primogeniture system helped ensure the integrity of the ancient Ifugao SES by ensuring the vertical integration of the watersheds and the rice fields and avoiding their fragmentation. Their customary laws and practices in turn helped ensure self-regulation (and hence low transaction costs) as evidenced by the absence of centralized executive, legislative and judicial units of government until they were integrated into the Philippine nation-state in the mid-twentieth century. In this sense, the ancient Ifugao SES meets Carlson and Doyle's (2002) definition of robustness (i.e., the maintenance of some desired system characteristics, in this case ecological integrity, despite fluctuations in

the behavior of its component parts or its environment, in this case typhoons, earthquakes, pests and social conflicts).

Third, the Ifugao SES today is faced with contemporary challenges with varying effects on its robustness. These include integration into a post-colonial social order, the effects of tourism and agricultural development, migration, urbanization and the introduction of Christianity and mass education. Of these challenges, perhaps the effect of outmigration and gradual loss of indigenous knowledge and interest from the younger generation pose the most serious challenges in the short to medium term. For instance, the effect of outmigration from rural areas can be seen in terms of the proportion of arable lands now lying idle for extended periods of time. Moreover, the effects of the gradual loss of indigenous knowledge as well as the introduction of government programs on agricultural "modernization" can be seen in changes in land use over time. For instance, this is evident in the significant shift to corn farming and permanent crops (fruit trees), which do not require significant inputs (labor, water, rituals etc.) compared to traditional rice farming.

Fourth, despite these changes, the collapse of the Ifugao SES is not a certainty. It is likely possible that some rice pond fields will shift to different crops (such as corn, permanent crops or higher value crops) and that labor will be imported from outside of the settlements and paid in cash rather than through the traditional practice of labor exchange. The shift to towards crops such as corn and permanent crops or cash crops that do not depend heavily on water would affect the logic of the primogeniture system of inheritance rights that has ensured the ecological integrity of the Ifugao SES. This could evolve into a various forms of land and water rights, as is already slowly happening in many households where younger siblings increasingly inherit some of their parents' property although less than the first-born child.

Finally, the Ifugao case is useful in partly answering the question posed by Anderies *et al.* (2004) on the usefulness of the concept of adaptive efficiency, which has become a core concept in the study of resilience theory. They argued that this concept is useful in a descriptive sense but less useful in studying designed systems because it is not clear how it can be designed and at what cost given the uncertainties in a linked SES. This case study has shown how the institutions supporting the Ifugao SES have been designed and what their associated costs have been in terms of the construction, operation and maintenance of the rice terraces given the fluctuations and uncertainties in the behavior of its component parts. Future research should address the emerging patterns of institutions (or lack thereof) that the Ifugao employ in response to the contemporary challenges they face and whether or not the Ifugao SES would remain robust.

Acknowledgments This study was funded by US NSF Grant BCS-0527744 through the Center for the Study of Institutional Diversity, Arizona State University. I thank Elinor Ostrom and Marty Anderies for their encouragement, helpful comments and funding support. The usual caveats apply.

Appendix 1

Fig. 3 Batad Rice Terraces, Banaue, Ifugao. Altogether, the Ifugao rice terraces cover an area nearly 4,000 km^2 in steep mountainous slopes of as high as 70°, with more than 20,000 km of terraced bunds, 7,000 km of which are stone walled. Note the well protected forest and watershed above the terraces. Maintaining these forests requires the design of a primogeniture system of property rights and low transaction costs. The need to maintain ecological integrity with the rice terraces has led to the emergence and longevity of the primogeniture system of property rights. Note also the relatively small and stable population of the village, which led to the emergence of a polycentric social order that did not depend upon a centralized form of government until their integration into the Philippine nation state. A small, stable and isolated population linked by consanguinity or kinship ties led to the emergence of commonly shared religious beliefs conjoined with law, norms and taboos and reinforced by dense social networks. Photo by Conklin and Javellana (2008)

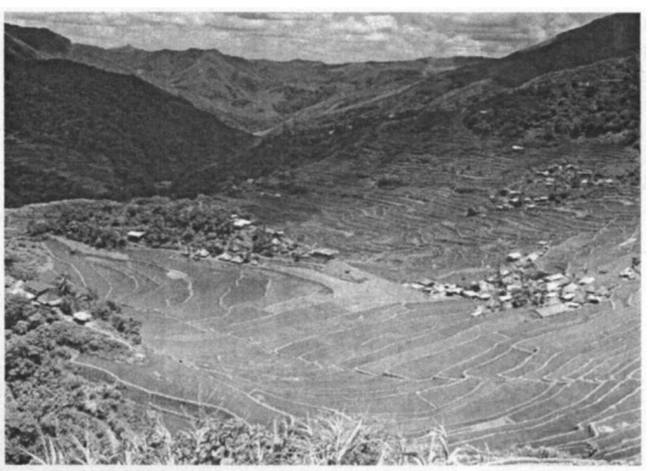

Fig. 4 Another view of the Batad Rice terraces cluster (Source: UNESCO 2008)

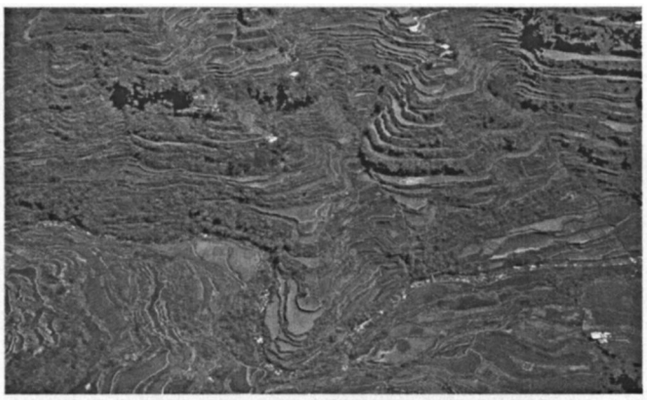

Fig. 5 Another view of the terraces in Banawol District, Ifugao. Note the finely curved terraced bunds following the contours of the mountainside. In places where there is no ample supply of stones, the terraces are built with earthen materials. In places where there is abundant stones from the riverbeds, terraces are built with stones. Some 7,000 km of these type of terraces are found in Ifugao. Photo by Conklin and Javellana (2008)

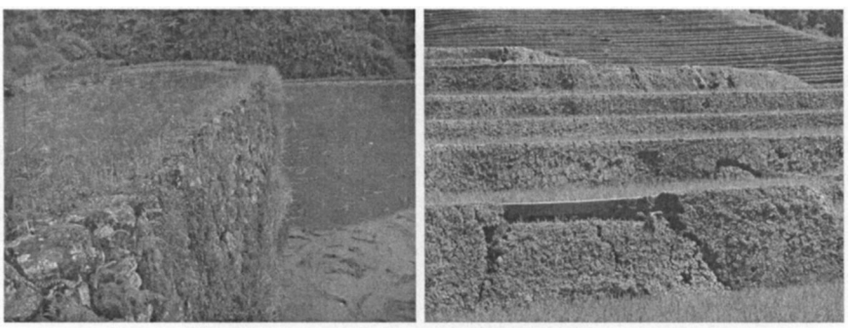

Fig. 6 Left photo, a closer look at the stonewalled terraces in Central Mayaoyao. The sturdy stone walled terraces have made it possible for the terraces to last for a long time. There are an estimated 7,000 km of these stone walled terraces in Ifugao. In contrast, newly built earthen terraces (right) are brittle and requires constant repair. There are some 13,000 km of these type of terraces (below). Photo by Dustin Butler (2008)

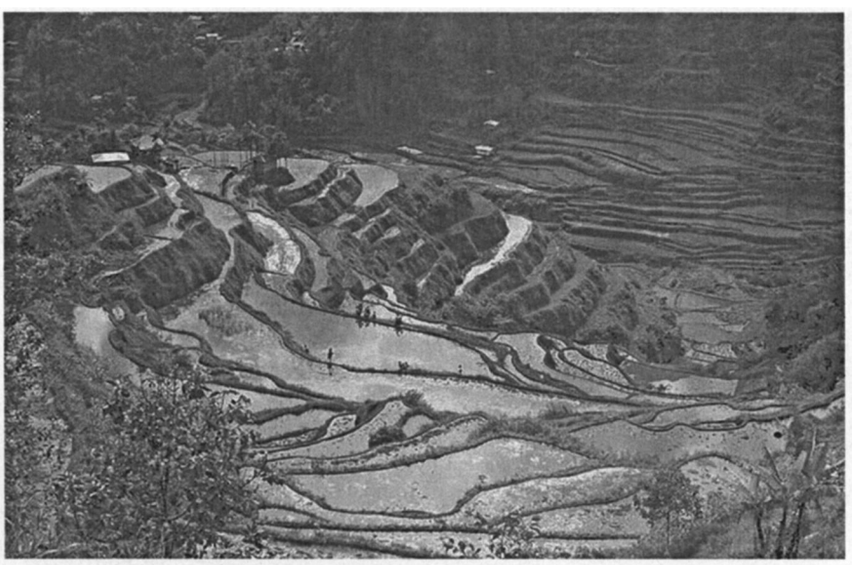

Fig. 7 A close up shot of the rice terraces in Banaue, Ifugao. Note the height of the ponds relative to the height of the farmers. Operating and maintaining the rice terraces require considerable skills in structural and hydraulic engineering. Photo by John Rawlinson (2006)

Fig. 8 Increased connectivity through roads and tourism has led to the partial urbanization of the rice terraces in Banaue, Ifugao province. Some terraces have been converted for a different land use but this has not necessarily led to the collapse of the Ifugao SES. The system just shifted into a different mode of production, from farming to tourism services and commerce. Photo by Conklin and Javellana (2008)

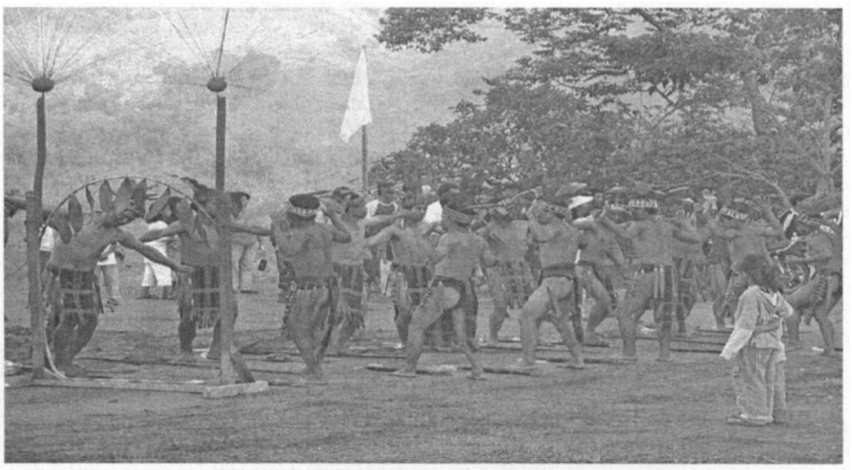

Fig. 9 In the past, the Ifugaos spend some 192 days a year to practice more than 37 types of rituals, and worship more than 1,500 deities covering all aspects of life from birth to death and afterlife. Rituals serve as mechanisms to transfer knowledge and promote socialization, while deities serve to constrain behavior, both of which lower transaction costs. Ritual practices have significantly declined in recent years due to high costs and loss of interest by the younger generation who have been exposed to formal education and the internet. Photo by Dustin Butler (2008)

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