Reinterpreting change in traditional ecological knowledge

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Much of the previous research on Traditional Ecological Knowledge (herefater TEK) has centred in 1) documenting fading knowledge (eg. Ferguson and Messier 1997; Pieroni *et al.* 2004), 2) understanding the parallel decrease of biological and cultural diversity (Maffi 2005; Harmon and Loh 2010), and 3) assessing the processes and drivers of change that lead to the loss of TEK (Benz *et al.* 2000; Kingsbury 2001; Godoy *et al.* 2005; Gray *et al.* 2008; Turner and Turner 2008). The general argumentative line in those works revolves around lamenting the loss of TEK as indigenous peoples and rural communities modernize and adopt western lifestyles. For example, in the last decade a growing number of studies have reported changes and losses in the medicinal (Begossi *et al.* 2002; Case *et al.* 2005; Lozada *et al.* 2006; Monteiro *et al.* 2006), nutritional (Turner and Turner 2008), and agricultural (Benz *et al.* 2007; Stone 2007; Gómez-Baggethun et al. 2010) knowledge of small-scale societies as they become more integrated in national societies and the market economy.

The idea that TEK systems are capable of adapting both to external changes and internal frictions has been a mainstay of human ecology for some time (e.g. Berkes et al. 2000). Yet, by analyzing change primarily in terms of lost knowledge, the usual research perspective tends to downplay the dynamic nature of TEK systems, and little emphasis is put in understanding particular changes in TEK as an adaptive response to new environmental, social, or economic conditions. Likewise, few researchers have examined how the culprits of the loss of TEK (i.e., modernization, technology, schooling, or integration into the market economy to name the most commonly mentioned factors) actually affect the mechanisms that allow societies to generate, regenerate, transmit, and apply knowledge. In other words, our understanding of how these processes affect the resilience of TEK systems and their capacity to evolve and adapt is still limited.

In this paper, we shift the focus from the analysis of trends in specific bodies of TEK, to the analysis of the factors and conditions that maintain or undermine people's ability to adapt and regenerate TEK in the face of changing environmental and socio-economic conditions. In doing so, we advance our understanding on how factors underlying the loss of TEK affect the mechanisms used by societies to regenerate and transmit such knowledge in the face of global environmental change.

Changes in traditional ecological knowledge systems

Our research is based on two empirical case studies reporting changes in TEK systems. The first case study centers on the Tsimane', a hunter-horticulturalist society in the Bolivian Amazon, which –according to previous published research-, seems to maintain the capacity to generate and apply TEK. The second case study centers on farmers of the Doñana region, in SW Spain, where rural communities have suffered a disruption in the process of intergenerational transmission of TEK as their agricultural systems modernized and integrated the global markets in the mid 20th century.

Case study 1: Traditional ecological knowledge among the Tsimane', Bolivia

A great deal is known about the Tsimane' in general, as they have received ample attention by cultural and physical anthropologists (Chicchon 1992; Ellis 1996; Daillant 2003;

McDade *et al.* 2007; Huanca 2008; Ringhofer 2010). Until the late 1940s, most Tsimane' lived isolated from the outside world. They hunted, fished, gathered wild plants, and practiced slash-and-burn agriculture for subsistence. Their relative isolation ended in the 1950s. Construction of new roads, arrival of missionaries and highland colonist farmers, schooling, and the logging boom, put Tsimane' in contact with Bolivian society, a process that gradually transformed their social and economic system (Chicchon 1992; Godoy *et al.* 2005). These changes brought modern ways of living and a new social environment that gradually encroached upon the Tsimane' and their society. Nowadays some Tsimane' are highly self-sufficient, but others are increasingly adopting market-based economic activities such as cash cropping or the sale of forest products in markets (Vadez *et al.* 2008).

The Tsimane' have provided an interesting case for the study of TEK, and the findings of previous research have often challenged hypotheses and expectations. Some findings of previous research are of interest for the sake of our discussion here. Our first finding in the study of Tsimane' TEK relates to the returns provided by this body of knowledge. In this research, we have found that individual levels of TEK are associated with effective habitat management proxied by the conservation of crop diversity (Reyes-Garcia *et al.* 2008b) and with the reduction of the area of old-growth forest cleared for slash-and-burn agriculture (Reyes-Garcia *et al.* 2007b). We have also found a positive association between individual levels of TEK and nutritional status (Reyes-Garcia *et al.* 2008a) and offspring's health (McDade *et al.* 2007).

Our second finding relates to the lack of consistent evidence for secular loss of TEK. Analyzing cross-sectional data from Tsimane' adults, Godoy *et al.* (2009) found no evidence of secular loss of knowledge since the 1920's. Differently, the analysis of panel data does seems to suggest a net decrease in the report of plant uses (Reyes-Garcia et al., in press). A more fine-grain analysis by domain of knowledge is able to reconciliate those to findings, as it seems that different domains of plant knowledge follow different secular trends. For example, the Tsimane' seem to be losing knowledge related to wild edible and medicinal plants, although they seem to be generating new knowledge on the domain of plants used for house building. Increasing sedentarization pushes the Tsimane' to build larger and more durable houses and they seem to be generating new knowledge on it based on their TEK system (Reyes-Garcia et al., in press b).

Our third finding on Tsimane' TEK relates to its association with exposure to the market economy and schooling. First, we have found that people who live more isolated from the market economy share more TEK than people who live in villages closer to towns (Reyes-Garcia *et al.* 2005). We have also found that among the Tsimane' only market related activities that take people out of their environment and cultural context have a negative effect on their TEK, whereas market related activities that allow people to continue in their environmental and cultural context do not seem to have a negative effect on it (Reyes-Garcia *et al.* 2007a), highlighting the importance of contextual social transmission of knowledge.

We have conducted a similar analysis looking at the association between TEK and another typically culprit for its loss: schooling. Although we found that schooling bears the expected negative association with TEK, the magnitude of the association was surprisingly low, challenging results of previous research in similar contexts (Benz *et al.* 2000; Sternberg *et al.* 2001). Formal schooling was introduced in the area several decades ago by Protestant missionaries. Missionaries provided a partially contextualized school curriculum (i.e., in Tsimane' language, using examples from the local environment, with Tsimane' teachers) that did not seem to interfere with the transmission of TEK as much as other types of schooling do (Reyes-Garcia *et al.* 2010).

In sum, our previous research among the Tsimane' documents different patterns of secular change: some domains of knowledge are decreasing, some remain stable, and some are increasing.

Case study 2: Traditional ecological knowledge among farmers of Doñana, Spain

We proceed now to examine our research on changes in TEK among farmers of the Doñana natural areas (south-western Spain) as affected by processes of market integration and acculturation. Until about the middle 20th century, Doñana maintained a semi-autarchic and subsistence-oriented economy with strong dependence on local ecosystem services (Ojeda 1987). Failures to adapt severe drought and other environmental extremes typically resulted in economic crises and famines (Flores 2005; Gómez-Baggethun *et al.* 2010). A variety of locally-evolved adaptation practices (eg. mobility, pooling, diversification, storage, rationing) and rituals (eg. rogation ceremonies) formed part of the communities' mechanisms to cope with environmental variability and change (Gómez-Baggethun *et al.* 2012).

Since the early 19th century, enclosure of common lands and other institutional changes that followed liberal revolutions in Spain paved the way for modernization, development of productive forces, and market integration (Naredo 2004), but TEK kept playing an important role in resource mangement by local farmers (Ojeda 1987). In the 1960s, exogenously driven development and conservation policies radically transformed resource systems in Doñana, resulting in an abroup decline of associated bodies of TEK (Estevez and Rosell 1989). In our previous research, we found that intergenerational decline in TEK (proxied through a sample of adaptive practices to cope with disturbance and change) was most acute in agricultural knowledge, finding a decline of about 40% between the old and young age classes, but less pronounced for traditional livestock farming, which declined by 16.5% between the old and middle age classes and by 5.65% between the middle and young age classes (Gómez-Baggethun *et al.* 2010).

We identified three main drivers behind the loss of TEK: market integration, conservation policies, and acculturation. First, market integration in the 1960s was accompanied by fast mechanization and intensification of resource systems. Many farmers abandoned traditional agriculture –mainly consisting of vines, olive groves, and cereal- and engaged in new and agricultural systems demanding large inputs of energy, machinery, fertilizers, and pesticides (González-Arteaga 1993). New crops (e.g. strawberry) adopted in this period required management techniques that were unfamiliar to local farmers (Corominas 1995).

Second, top-down implementation of the Doñana National Park in 1969 with a 'fortress conservation' approach excluded local resource users largely from ecosystem management in the protected areas. Consequently, scientific knowledge progressively substituted TEK (Gómez-Baggethun *et al.* 2010).

Third, we found links between mechanization and acculturation processes. Historically, local beliefs had played a central role in representing and responding to environmental change (Gómez-Baggethun et al. 2012). At least since the 15th century the locals organized rogation ceremonies to claim for protection against environmental hazards such as droughts, pests, and floods (Flores 2005). By promoting community cohesion and representing the causes of hardship as external from socio-economic relations, rogations reduced the chance of social disruption, thereby enhancing the resilience of the community during crises (Gómez-Baggethun *et al.* 2012).

In the 20th century, scientific knowledge provided a way to rationalize the understanding of environmental extremes and technology allowed for responses to disturbances against which

locals had felt powerless in the past. For example, the possibility of pumping underground water through imported technology alleviated (but also masked) the impacts of drought (González-Arteaga 1993). In 1956 rogation ceremonies were regularized so as to be held every seven years thereby losing their coupling to environmental hazards and thus their historical role in representing and managing shocks collectively. In sum, our research documents a secular loss of TEK associated to processes of market integration, conservation policies, and acculturation.

Comparison and interpretation of research findings

The two case studies presented above show that TEK systems hold by small-scale societies can respond very differently to the exposure to globalization forces. What explains that while some TEK systems manage to adapt and regenerate others fail to do so? A comparative analysis of our findings shed some light over this question.

On the one hand, our previous research suggests that, for the Tsimane', TEK 1) continues to be at the basis of livelihood, and it is associated to different health, economic, and environmental outcomes, 2) shows dissimilar secular trends across different domains of knowledge and occupations, and 3) is only partially affected by the processes of exposure to the market economy and schooling. Those results are interesting because they challenge the assumption that TEK should irremediably fade as indigenous people increase their interactions with national societies and the market economy. But, what does explain those findings? In the 1950s the Tsimane' started experimenting profound societal and economic changes. But despite those deep changes around and within their society, the Tsimane' still continue to greatly depend on the forest around their villages for their livelihood. Nowadays, most Tsimane' are only partially more reliant on products generated outside their own society than they were some decades ago. Furthermore, the social and environmental context that allow for the maintenance and production of TEK still remains in place. For example, Tsimane' mostly have social interactions with other Tsimane', and exogamy is extremely unusual (Daillant, 2003).

Because the Tsimane' continue to rely on their TEK for their livelihood, albeit in a changing condition, and because the cultural and environmental contexts in which this knowledge is produced remains, it is not surprising that we do find signs of adaptation on Tsimane' TEK system: particular bodies of knowledge that are being less used (i.e. wild edibles) is decreasing, knowledge in some other domains (i.e., house building) might be increasing (Reyes-Garcia et al. in press b). The finding suggests that the ability of the system to generate new knowledge remains as the social and environmental circumstances in which Tsimane' live change, even if knowledge in certain domains is lost.

Tsimane' relation with and dependence on the environment, despite changes associated to their integration to the market economy, helps explain adaptation and change of their TEK. Because the Tsimane' continue to use the environment around them for their subsistence, they still seem to retain the ability to generate, transmit, and discard knowledge according to the particular needs of their society. Thus, the Tsimane case study reflects how the adaptive capacity of TEK is maintained when it remains in people's control.

On the other hand, our in Doñana research suggests that TEK 1) is no longer at the basis of livelihood as it has been progressively replaced by scientific and technical knowledge 2) shows dissimilar secular trends across different domains of knowledge, and 3) has been affected by mechanization and exposure to the market economy.

What may have been the processual factors that precluded the adjustment? We advance two explanations to address this question. The first hypothesis relates to what may be

characterized as a decoupling between the industrial mode of agricultural production adopted in Doñana and the advantages that TEK systems can offer in the short term. Differently from the Tsimane', who sell products that they kept producing in 'traditional ways', TEK-driven resource systems in Doñana since the 1970s could no longer secure productivity and profit margins required to compete in the international market. Comparative advantages of TEK-driven resource systems such as their low impacts on soils, water, and biodiversity (and thereby their capacity to maintain long term ecological reslience) became less important in the emerging mode of production, where profits depends to a large extent on the ability to externalize environmental impacts from production costs (Naredo, 1987). Similarily, the ability of TEK-driven resource systems to adapt in the face of environmental variability (Berkes *et al.* 2000) became less important as human-made capital buffered its direct impact on production. For example, as we noted in a previous research 'the use of pesticides and fertilizers discouraged traditional practices to prevent pest outbreaks and oxygenate the soil, and the possibility of pumping underground water discouraged the selection of drought-adapted species and diversification of crops to buffer droughts' (Gómez-Baggethun *et al.* 2010: 727).

Adoption of modern technologies in scientifically rationalized production systems reduced the reliance of local farmers on TEK, turning them more dependent on exogenously produced technology and technical expertise and knowledge.

Our second explanationrelates to the barriers set by conservation policies implemented in Doñana to customary ways of applying TEK. Differently from the Tsimane', who kept sovereignity over land and access rights to resources, in Doñana, enclosures and banning of traditional management practices for conservation purposes (e.g. use of fire) prevented local communities to continue experimenting with their TEK in the protected areas, a prerequisite to keep the adaptive nature of living TEK systems.

In sum our results supports the hypothesis that industrialization of agriculture and conservation policies excluding local farmers from management favoured a process of deskilling that precluded TEK from adjusting to the new socio-economic juncture.

Reinterpreting change in traditional ecological knowledge

Traditional knowledge is declining in many parts of the world due to complex and multifaceted reasons (Gómez-Baggethun 2009), including the compounding influences of land use change, integration to market economy, acculturation, and more generally, industrialization and globalization forces (Turner and Turner 2008; Harmon and Loh 2010). Scholar's efforts have focused in documenting the loss of TEK systems and not in understanding the processes that drive those changes and their effects in the society's capacity to generate, apply, and transmit knowledge to maintain living TEK systems.

We -scientists concerned with TEK systems and other bio-cultural diversity components- often fall in the temptation of putting the emphasis on the most noble features of small-scale societies such as their capacity to harmonize livelihood with biodiversity conservation (Gadgil *et al.* 1993), reciprocity-based economies (Mauss 1954), tendency to minimize working time through institutionalized frugality (Sahlins 1972), absence of bureaucracies (Zerzan 1994), communitary control of technologies (Ilich 1973), and collective action (Ostrom 1990). This literature has played a fundamental role in highlighting virtues of small-scale societies that have been sistematically obscured by mainstream academic thinking since the Enlightment. Probably because of the emphasis of the anthropological literature on the remarkable aspects of TEK, changes within these bodies of knowledge often tend to be automatically perceived as negative. The fundamental problem implicit in this perspective is a tendency to advocate TEK and related lifestyles in frozen forms.

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Emphasis is put on the TEK that is lost with change while little attention is devoted to analyze how lost knowledge is often replaced by new knowledge. Put it differently, exclusive focus on the loss of knowledge obscures the equally important question on how TEK adapts and rejuvenate when faced with environmental and socio-economic change, especially when communities conserve autonomy and control over the process of producing and regenerating knowledge.

Over the broad course of human history, particular elements of TEK change and eventually disappear as cultures evolve and adapt to new conditions (Boyd and Richerson 2005). But the analytical approach that pictures traditional lifestyles in a frozen form often fails to acknowledge that specififc TEK components related to given sets of pre-existing conditions may no longer meet the daily needs of rural and indigenous communities faced with rapidly changing environmental and socio-economic conditions. Evolution and change in TEK, with knowledge being lost, transformed, and generated, in many cases simply reflect the adaptive nature of TEK. This gives basis for the prediction that the rate of change of any cultural trait should be higher for societies that face rapid environmental or social changes than for societies that evolve in relatively stable environments. It is just predictable that once they get exposed to globalization forces, bodies of TEK remaining in indigenous, peasant, and other types of semi-autarkic societies are bound to either change and adapt (e.g. through hybridization) or disappear. Strategies to protect biological and cultural diversity that strive to maintain traditional societies and related knowledge systems as they were in the past are bound to fail (Kurin 2004). Implementation of successful strategies to protect biological and cultural diversity should strive to advance the understanding of how TEK systems evolve, transform, and adapt in order not to perish.

Our message should not be misinterpreted as uncritical acceptance of global change as a neutral process. Major drivers of global change including modernization, economic growth, technological development, and commodification of new environmental and social domains are institutionalized processes shaped by asymetric class and power relations (Polanyi 1957; Ellul 1964; Naredo, 1987; Gorz 1994, Gómez-Baggethun and Ruiz-Pérez 2011). Efforts aimed at resisting these processes are, to the view of the authors, both legitimate and necessary strategies in the quest to prevent small-scale societies and associated knowledge systems to be subsumed by Western globalization. Yet, an exclusive focus on mitigation strategies with no acknowledgement of the fundamental adaptation component required to maintain living TEK systems can easily fall in the narcissist temptation of the lost battles.

Conclusion

A stronger analytical focus on the dynamic nature of TEK helps moving the spotlight from the specific bodies of knowledge lost or produced under TEK systems to the societies's capacity to regenerate and apply knowledge. That is, the fact that a concrete piece of knowledge is lost or kept by a society is not as important as whether the society retains the ability to generate, transform, transmit, and apply knowledge. It is the capacity to generate and apply knowledge what enables actions and adjustments in response to current and future changes, and therefore it is the capacity to generate and apply knowledge –and not the knowledge itself- what contributes to increase the resilience of a socio-ecological system (Berkes *et al.* 2003).

Researchers concerned with TEK should strive to understand the mechanisms underlying the capacity of these systems to adapt to the accelerating rates of economic, socio-cultural, and environmental change brought by globalization forces. Such quest involves broadening the analytical focus from the understanding of how specific bodies of knowledge are lost, to address in more depth how new knowledge emerges in response to change. In this light, a

critical task for the research agenda in TEK is identifying and understanding the factors underlying the capacity of indigenous and rural communities to keep their capacity to generate and regenerate TEK. This research is an attempt to address this formally acknowledged, yet under-explored, question.

Mantaining TEK's capacity to regenerate over time requires that conditions that allow to continue developing, testing, and updating knowledge are met. While location and context as broadly construed are important factors that show the need for further inquiry, our research suggests that maintaining conditions for TEK regeneration requires holding sufficient levels of sovereignity over land, ecological means of production, technology, and knowledge systems at the basis of livelihoods.

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