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Secular trends on traditional ecological knowledge: An analysis of different domains of knowledge among Tsimane' men

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Abstract

Empirical research provides contradictory evidence of the loss of traditional ecological knowledge across societies. Researchers have argued that culture, methodological differences, and site-specific conditions are responsible for such contradictory evidences. We advance and test a third explanation: the adaptive nature of traditional ecological knowledge systems. Specifically, we test whether different domains of traditional ecological knowledge experience different secular changes and analyze trends in the context of other changes in livelihoods. We use data collected among 651 Tsimane' men (Bolivian Amazon). Our findings indicate that different domains of knowledge follow different secular trends. Among the domains of knowledge analyzed, medicinal and wild edible knowledge appear as the most vulnerable; canoe building and firewood knowledge seem to remain constant across generations; whereas house building knowledge seems to experience a slight secular increase. Our analysis reflects on the adaptive nature of traditional ecological knowledge, highlighting how changes in this knowledge system respond to the particular needs of a society in a given point of time.

Keywords

acculturation; Bolivian Amazon; ethnobotanical knowledge; Tsimane' indigenous peoples

1. Introduction

In the literature, traditional ecological knowledge (TEK) is defined as the body of knowledge, beliefs, traditions, practices, institutions, and worldviews locally developed and sustained by indigenous and rural communities in interaction with their physical environment (Berkes *et al.* 2000). Given the potential contribution of TEK for conservation

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and natural resource management (e.g., Gadgil *et al.* 1993; Toledo 2002; Berkes & Davidson-Hunt 2006), researchers and policy makers have showed concern about the loss of this body of knowledge as indigenous and rural societies modernize (Godoy *et al.* 2009a; Reyes-García *et al.* 2005; Gomez-Baggethun *et al.* 2010). Much of this research has centered in understanding the parallel decrease of biological and cultural diversity (Maffi 2005) and the processes that lead to the loss of TEK (Turner & Turner 2008; Gray *et al.* 2008; Gomez-Baggethun *et al.* 2010).

Empirical research in different societies, however, provides contradictory evidence on the changes that TEK undergoes (cf. Zent & Maffi, 2010 for a comprehensive revision). Some studies indicate a decrease in stocks of selected domains of TEK, such as traditional medicinal knowledge (Lozada *et al.* 2006; Case *et al.* 2005; Monteiro *et al.* 2006), traditional practices in agriculture and livestock farming (Gomez-Baggethun *et al.* 2010), or traditional wild edible knowledge (Turner & Turner 2008), from which a decline in other domains of knowledge is often extrapolated.

Contrary, some other researchers have registered the persistence of TEK even as societies undergo cultural, economic, and ecological changes (Byg & Balslev 2001; Godoy *et al.* 2009a; Lykke *et al.* 2004). For example, Lykke and colleagues (2004) found no significant differences between the knowledge of useful woody plants hold by older and younger generations of Gourounsi (Burkina Faso). Similarly, in one of the few diachronic studies on the topic comparing data collected in 1968 and in 1999, Zarger and Stepp (2004) report that despite important social changes in the region, there were no significant differences in Tzeltal Mayan children's plant naming abilities.

Researchers have advanced two hypotheses to explain those contradictory findings. First, researchers whose findings deviate from the expected declining trends have argued on the importance of site-specific conditions. For example, Lykke and colleagues (2004) argue that persistence of TEK in the study site can be partially explained by the low floristic diversity in the area that favors quick learning of non-specialist knowledge. Zarger and Stepp (2004) note that the basic subsistence system and routine activities of children had not changed in the 30 year interval between the two studies, which explains children's knowledge persistence.

Second, contradictory findings on secular trends of TEK could also be explained by methodological differences between studies. For example, some studies have measured TEK as agreement between informants (Reyes-García *et al.* 2005) whereas others have measured it by means of a comparison to standard biological knowledge (Zarger & Stepp 2004). Differences regarding sampling strategies, domains of knowledge, or data collection methods seem to account for contradictory findings (Reyes-García *et al.* 2007a; Zent & Maffi 2010).

Here we advance and test a third, complementary, explanation. We argue that contradictory findings in trends of TEK might be due to the adaptive nature of this knowledge system. TEK is composed by a number of distinct cultural *domains* of associated meanings and practices (Reyes-García *et al.* 2005), each of which might follow a different trend. Researchers have highlighted that, as other types of knowledge, TEK is inherently dynamic, and constantly faces continuous changes encompassing a complex mix of replication, loss, addition, and transformation (Gómez-Baggethun & Reyes-García 2013). Because TEK is the basis for decision-making in many areas of daily living, changes on TEK systems should be closely linked to changes on livelihoods (Berkes *et al.* 2001; Ross 2002).

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The idea that changes on different domains of TEK should parallel changes on the livelihood activities to which they relate, although not previously tested in a systematic way, finds support in previous studies. For example, Nabhan (1998) reports that Tohono O'odham children, in the southwestern U.S., could only name a small fraction of the plant and animal species that their grandparents could. Contrary, Rosenberg (1998) finds no significant difference in the lexical recognition of culturally salient and ecologically representative animal species of young and elders Seri of Sonora (Mexico). In an analysis of those works, Zent and Maffi (2010) argue that those differences may be attributable to the fact that O'odham youth no longer participate regularly in collecting expeditions and other subsistence activities, while the Seri youth are still actively involved in the traditional activities.

In this paper we provide an empirical test to the idea that trends in different domains of TEK parallel other social changes that might affect each of those domains differently. For the empirical analysis we use data collected among the Tsimane'.

2. The Tsimane' and changes in their livelihood

The Tsimane' are an indigenous society of foragers and farmers living in the Bolivian Amazon. Unofficial estimates ciphers the Tsimane' population close to 10 000 people settled in approximately 125 villages. Most Tsimane' live in small villages with about 25 households, each containing an average of six people (Godoy et al. 2009b). Until the late 1940s, the Tsimane' mostly lived like a pre-contact Amazonian society, isolated from the outside world by the thick blanket of rainforest. They hunted, fished, gathered wild plants, and practiced slash-and-burn agriculture. Their relative isolation ended in the 1950s, when the country's development brought them into closer contact with mainstream society. The construction of new roads, along with the arrival of missionaries and highland colonist farmers, added to the logging boom, put the Tsimane' in contact with other segments of the Bolivian society, a process that gradually transformed their social and economic system (Chicchon 1992; Godoy *et al.* 2005).

The Tsimane' continue to be a fairly autarkic society (Vadez *et al.* 2008), with monetary earnings accounting for only about 32% of Tsimane' total income (Godoy *et al.* 2007). However, there is variation in the dependence on different types of economic activities across households: some Tsimane' continue to be highly self-sufficient while others are increasingly dependent on cash cropping and employment in logging camps, cattle ranches, and the homesteads of colonist farmers (Vadez *et al.* 2008). Some Tsimane' also sell forest products, such as thatch palm, to obtain cash (Vadez *et al.* 2004). Reliance on different sources of income (subsistence versus cash) affects the way in which the Tsimane' distribute their time and their consumption patterns, possibly also affecting the distribution of TEK. For example, we have found that the Tsimane' typically use the cash obtained through labor to buy local market goods (Godoy *et al.* 2007), many of which are substitutes for locally made products.

Contact with the mainstream society has also affected Tsimane' health system. Nowadays, the Tsimane' continue to use medicinal plants and traditional healers, but Tsimane' are also increasingly using pharmaceutical products and hospital services (Calvet-Mir *et al.* 2008) which might result in changes in traditional medicinal knowledge.

Results from previous research analyzing how those changes in the social system affect Tsimane' overall levels of TEK are inconclusive (Reyes-García *et al.* 2007a; Reyes-García *et al.* 2005). Some analyses suggested a loss of TEK (Reyes-García et al. 2007b; Reyes-Garcia *et al.* 2013) whereas some others suggested maintenance of TEK (Godoy *et al.*

2009a). We propose that a closer analysis to secular trends with respect to different domains of TEK might help clarify those contradictory findings.

3. Methods

To study secular trends in different domains of TEK, we worked in coordination with researchers from the Tsimane' Amazonian Panel Study (TAPS, http://www.tsimane.org/) during the years 2008 and 2009. We collected data in 69 of the approximately 125 Tsimane' villages through individual-level interviews lasting about one hour/person. Four Tsimane' who have worked with TAPS from its inception served as translators. Written consent to carry out our study was provided by the *Gran Consejo Tsimane'* and informed oral consent was obtained from all communities and individuals participating in the study.

3.1. Questionnaire design

We estimated TEK with a test designed to quantify individual knowledge of wild plants uses following a two step procedure. Since cultural domains are ideally supposed to correspond to emic semantic constructs that have psychological reality for native actors, on the first step, we assessed the cultural validity of the different domains to be included in the questionnaire. We first conducted free-listing with 50 informants to obtain a list of useful plants (Reyes-García *et al.* 2006). We randomly selected 46 plants from the list and took pictures of all of them. We then asked a sample of adults (n=30) in two villages at different distance to the market town to sort the pictures in piles according to their main use. Informants were told that they could do as many or as few piles as they considered, but that they could only put each picture in one of the piles. Thus each informant sorted pictures in a different number of piles, and each pile had a different number of plants in it. After Pile Sorting, we asked informants to tell us about the reasons for piling plants together. We used the Pile Sort procedure in the ANTHROPAC software to analyze pile sort data (Borgatti 1994). The procedure aggregates data across respondents, yielding an item-by-item matrix (in our case plant-by-plant) indicating the degree of similarity between items; or, in other words, the proportion of times across informants that two items were sorted in the same pile. To identify cluster of items that, according to informants' responses, are cognitively close, we submitted the aggregated similarity matrix to the Non-metric Multidimensional Scaling (NMDS) procedure, which allows for visualization and intuitive interpretation of the degree of proximity between items.

The second step included the actual design of the questionnaire. We used the map obtained with NMDS (Figure 1) and the explanations provided by informants after pile sorting to identify domains plant uses that seemed to be culturally valid: medicinal, wild edible, firewood, canoe building, and house building. Then, we returned to the list of useful plants and randomly selected 20 plants, which do not necessarily overlap with the plants used in pile sorting. Once we had identified the domains of knowledge and the plants, we generated a matrix of plants (rows) by uses (columns) that we used during our interviews.

3.2. Sample

We used a recent census (Reyes-García *et al.* 2012) to select villages with different levels of distance from a main road or market town (excluding villages in the Sécure River because of their remoteness). In communities with 10 or less households we surveyed all the households; in communities with 11 to 40 households we randomly selected 10 households from a list provided by the highest-ranking authority, and in communities larger than 40 households we randomly selected 25% of the households. Data were collected among men from different households. We limited data collection to men for practical reasons: men were already being interviewed as a part of the larger research project and interviewing women would have difficult the logistics of the research design. Since men and women typically hold different TEK, by excluding women we probably reduced variation in our data. Since several authors have suggested that the accumulation of TEK likely peaks in the late teens and remains relatively constant during adulthood (Zarger 2002; Hunn, 2002), we restricted our analysis to people aged 20 or older. The final sample consists of 651 Tsimane' men.

3.3. Measure of Traditional Ecological Knowledge

We measured individual levels of TEK evaluating responses to the questionnaire of useful plants. Specifically, for each plant in our list, we asked every informant whether the plant could be used for each of the five categories identified (wild edible, medicinal, firewood, canoe building, and house building). We counted various uses within one domain (e.g., several medicinal uses of a plant) as one.

3.4. Age and Cohort

Participants were asked to estimate their age in years. As many adults did not know their exact age, they guessed, introducing random measurement error in the age variable. We used the year of the survey and the participants' self-reported age to create dummy variables for three generations: Elder (people born in 1949 or before), Mature (people born between 1969 and 1950) and Young (people born in 1970 or after). Such variables took the value of 1 if the person was born in the indicated generation and 0 otherwise.

3.5. Analysis

To assign a score of knowledge to each informant, we followed a two steps procedure. First, we elaborated an answer-key to our questionnaire. To do so, we only considered as correct those plant uses that had been mentioned by at least 15% of the people who reportedly knew the plant. Following this criterion, we produced a plant-by-domain matrix in which each cell took the value of 1 if the use of the plant was mentioned by 15% or more of the respondents and 0 otherwise. In the second step, we compared individual matrices of responses to the generated answer-key, assigning one point to each positive match. Thus, our overall measure of TEK consists of the sum of all positive matches between an informant's response and the generated answer-key. Measures for each of the five domains of knowledge consist of the sum of positive matches in a given domain of knowledge.

We analyzed data using bivariate and multivariate analysis. We first used Spearman correlations and Cronbach's alpha to test the relation between the individual scores for the five domains of knowledge, and a One Way analysis of variance (ANOVA) to test differences across groups. Second, to analyze secular changes in the five domains of knowledge, we ran a multiple regression model. Since our outcome variable -the person's score in a domain of knowledge- is discrete, we ran a series of Poisson regressions. Explanatory variables in the model include two dummy variables for generation, using the category *Elders* as a reference category, a variable to capture the level of education of the informant, and a set of village dummies to control for village fixed-effect. For the statistical analyses, we used STATA 10 for Windows.

4. Results

4.1. Description of five domains of knowledge of plant use

The NMDS generate the map in Fig. 1 (stress=0.09). The visual inspection of Figure 1 shows that plants used as medicinal, wild edibles, firewood, canoe building, and house building appear relatively clustered together. From our ethnographic work we also know that

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the Tsimane' have specific words to refer to each of these categories, further confirming their cultural appropriateness. For example, in Tsimane' language the word *piñidye'* refers to traditional medicines and the word *piñidyedyes* is used to refer to plants that can be used for medicine. Similarly, the word *säcsedyes* is used to refer to edible plants, the word *tsidyes* to denote to plants that can be used as firewood, the word *covambadyes* to refer to plants that can be used to dig out canoes, and the word *aca'dyes* to consign plants that can be used for house building. This is not true for other domains cognitively recognized in other cultures. For example, we have not been able to identify a word for plants that are useful to make crafts or tools, rather the Tsimane' have specific words depending on the tool being designated.

The generated answer-key suggests that three of the plants in our list can not be used in any of the categories of use, nine plants only had uses corresponding to one of the categories, seven plants had uses corresponding to two of the categories, and one plant had uses in three of the five categories (Table 1). Five of the plants in our questionnaire could be used for house building, seven could be used as firewood, five had medicinal uses, seven were edible, and only two could be used to dugout canoes. Thus, our answer-key yielded a total of 26 culturally-correct uses of the 20 selected plants across the five domains of knowledge.

With the exception of traditional house building knowledge, scores in the other four domains of knowledge analyzed bore a positive and statistically significant correlation with each other (Table 2). Within-subject, pair-wise Spearman correlations of the four related domains of knowledge ranged between $\rho=0.21$ ($p<.001$) for the association between traditional wild edible knowledge and traditional medicinal knowledge $\rho=0.49$ ($p<.001$) for the association between traditional firewood knowledge and traditional canoe building knowledge. The five variables that measure knowledge in different domains were weakly inter-correlated with a Cronbach's alpha of $\alpha=0.50$. The alpha coefficient increased to 0.55 when excluding the score of traditional house building knowledge.

4.2. Secular changes in five domains of knowledge: Descriptive analysis

From a possible range of 0 to 26 culturally-correct answers, the average Tsimane' men had a score of 13.5 (S.D.=3.73) (Table 3). One person did not have any positive match with the answer-key, and another had the maximum number of matches. Results also suggest a slight secular decrease in overall TEK; however the decrease was not statistically significant in ANOVA, nor uniform in the descriptive inspection of the specific domains of knowledge. Thus, we found a lower average score of traditional wild edible knowledge for the young generation comparing with the mature and elders ($p< 0.01$) and medicinal knowledge for the mature generation comparing with the elders ($p<0.1$). However, there were not statistically significant differences between generations for the domains of traditional firewood and canoe building knowledge. The average score of traditional house building knowledge was higher for the young generation than for the mature and elder ($p<0.05$).

4.3. Secular changes in five domains of knowledge: Multivariate analysis

The results of the multiple regressions of the overall TEK scores against dummies for generation do not show a secular decline in overall TEK (Table 4). The two dummies for generation have negative coefficients, suggesting that mature and young people had lower levels of TEK than elders, however the results are not statistically significant at the 10% level.

We ran the same model for each of the five domains of knowledge analyzed, and found three different patterns. First, we found statistically significant evidence of secular loss of knowledge in only two of the domains of knowledge analyzed: medicinal and wild edibles.

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Traditional wild edible and medicinal knowledge was lower among the *mature* and *young* generations than among the *elders.* Poisson regressions model the log of the expected count variable (the knowledge score) as a function of the predictor variable (generation of birth), so the coefficient of the *young* generation for the model with traditional wild edibles knowledge can be interpreted as follows: the difference in the logs of expected counts is expected to be 0.067 units lower for the young generation compared to elders, while holding the other variables constant in the model ($p<0.001$). A test of joint significance suggests that the two generations are jointly significant in their association with traditional wild edible knowledge. Second, we did not find any trend in the association between the domains of traditional firewood and canoe building knowledge and cohort. Last, we find a positive association between the variables that capture the cohort of a person and the variable that measure traditional house building knowledge. A test of joint significance suggests that the two cohorts are jointly significant in their association with knowledge of plants that can be use in house building. The finding is in line with the lack of association between this and other domains of knowledge found in the descriptive analysis (Table 2) and suggest that traditional knowledge is not being lost in this particular domain.

Previous research on secular trends on TEK has fitted an age-cohort multiple regression model that considers a) the effect of aging on the acquisition of knowledge (age effect), and b) the effect of unique historical periods in which a group's common experiences are embedded (cohort effect) (Godoy *et al.* 2009a; Gomez-Baggethun *et al.* 2010). In analysis not shown, we followed this model for the five domains of knowledge considered. When including a variable for age in the model, the variables for generation loss statistical significance, and the association between age and TEK was not statistically significant either.

5. Discussion

Our findings on secular trends on different domains of TEK for the Tsimane' men indicate that not all the domains of plant knowledge follow the same trends. We find that the most vulnerable domains of knowledge are those related to wild edible and medicinal plants. Traditional canoe building and firewood knowledge do not seem to experience any particular trend, whereas the domain of traditional house building knowledge seems to experience a slight increase over the period analyzed. We devote the discussion to explain those different secular trends in the light of the changes that Tsimane' livelihoods have experienced over the last decades.

Our data suggest that the Tsimane' experience a declining secular loss of traditional medicinal and wild edible knowledge, and that this trend is especially acute among the *young* generation (born 1970 or after). Our work in the area suggests that, probably because of their relative isolation, Tsimane' were able to partially maintain their cultural identity until some decades ago. But more recently the Tsimane' have been increasingly exposed to Western biomedical technology (i.e. pharmaceuticals, vaccinations, health clinics, paramedics, physicians, and hospitals), so nowadays they seem to be accepting its use even if in combination with their own traditional medicinal plant knowledge (Calvet-Mir *et al.* 2008; Byron 2003). While partial, the adoption of Western biomedicine probably explains the secular decline of traditional medicinal knowledge among the Tsimane'. Researchers have highlighted that changes in local cosmovisions and the stigmatization of indigenous cultures might also play a role in explaining loss of traditional medicinal knowledge (Vandebroek *et al.* 2004; Case *et al.* 2005). For example, among the Dusun of northern Borneo, young people consciously avoid learning traditional medicine because they believe that traditional medicine connect them to the primitive lifestyle of their parents that they are seeking to overcome (Voeks & Nyawa, 2001). Similarly, stigmatization has been used to explain the loss of knowledge of edible plants in certain contexts. Thus, among tribal and nontribal groups of Western Ghats (India) the knowledge and consumption of wild food plants seem to be declining because of the social stigma attached to these low-status food types (Cruz-García 2006).

A similar explanation is probably true for traditional wild edible knowledge. The bulk of the Tsimane' traditional diet was made up of freshwater fish, hunted game, gathered forest fruits and locally cultivated starches (plantains, rice, manioc) (Zycherman 2011). Over the last decade, however, Tsimane' diet has seen the increase of agricultural products, and the introduction of purchased food (including beef, sugar, pasta, salt, lard, vegetable oil, and white flour/bread) (Zycherman 2011). Research conducted by TAPS has documented diet shifts. Thus, between 2002 and 2006 the value of food purchased in the market increased by 6.35% per year (Godoy *et al.* 2009b). Similarly, an increased focus on cash crops, such as rice and maize, has influenced what is planted in horticultural fields (Vadez *et al.* 2008), and therefore most probably what is consumed in the household. Therefore, recent changes in Tsimane' lifestyle (with the intensification of agriculture and the introduction of purchased food), might well explain the secular decline in traditional knowledge of wild edibles.

Two of the domains of traditional knowledge examined remain constant across generations: canoe building and firewood, are those with overall lower scores. A closer look at the data reveals that those are the two domains of knowledge with lower number of responses. Thus, 47.8% of respondents did not mention any plant from our list that could be used to build a canoe and 48.2% did not mention any plant that could be used as firewood. So, it is possible that our questionnaire did not capture enough variation in those domains of knowledge to pick up existing secular trends. But it is also possible that knowledge on useful plants in those domains have not changed in the recent past. As other Amazonian societies, Tsimane' communities were traditionally settled next to rivers, and their main way of transport has traditionally been the use of canoes dugout from locally available trees. The arrival of colonist farmers and logging companies to the Tsimane' area during the 1970's was accompanied by the construction of roads, a change that to some extend affected Tsimane' traditional settlement pattern. For instance, while 62 % of the villages in our sample are settled on the edges of a navigable river, 38% are settled on interdepartmental roads or on roads opened by logging companies. Despite those changes in settlement pattern, canoes continue to be an essential element in Tsimane' livelihood, or at least they are common enough to the extent that our questions could not capture variation. A similar argument explains the lack of changes in the domain of knowledge related to plants used as firewood. Although some species are more appreciated as firewood than others, the Tsimane' report using almost any tree as firewood. This finding is common to other indigenous groups (Prance *et al.* 1987) and has not changed in the recent decades, as all Tsimane' households interviewed continue to depend on firewood for cooking.

Last, we find that traditional house building knowledge has experienced a slight increase. We think that changes in the settlement patterns mentioned before may also help explain this trend. Until recently, the Tsimane' were semi-nomadic and lacked a system of individual land or resource tenure (Reyes-García *et al.* in press). Because of frequent mobility in search of a resource base (shifting agriculture, or the search of a new hunting of fishing area), Tsimane' traditional housing structures were simple and constructed to last short periods of time (or a maximum of about three years). Tsimane' traditional houses had a palm leaves roof and a single wall on the windward side, while the other three sides remained exposed. An additional shelter was constructed next to this main shelter to keep the cooking fire away from the sleeping area and the rain. Sedentarization and the acquisition of modern goods have changed housing structures. More and more Tsimane' are beginning to build larger houses and to enclose them with a bamboo-like plant used as fencing material. Some even

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add doors with locks, which in interviews were justified as a measure to safeguard valuables (Byron, 2003). Thus, for the case of traditional knowledge of plants that can be used to build houses, it is possible that changes in the social system are resulting in an increase, rather than a decrease of knowledge in this domain.

Our results, however, need to be taken with caution for at least two reasons. First, results from our robustness test suggest that the statistical significance of our findings decreases when introducing a variable for age in the model. Second, our sample might be biased. For example, if people with lower levels of TEK suffer from worse mortality and morbidity than people with higher levels of knowledge, then older cohorts might display higher levels of knowledge because of selectivity bias. On the contrary, selectivity bias in the sample can occur if young people with lower traditional knowledge migrated to urban centers. Since we do not have information from people outside the sample, we can not test the real effect of selectivity bias, but the topic should be addressed in future research.

Conclusion

Berlin (1992) and Atran (1987) made the insightful point that native peoples know more about species that are easy to observe, large, social, colorful, abundant, noisy, and diurnal. Bentley and Rodriguez (2001) added that native peoples know more about species perceived as important –whether useful or harmful. The work presented here continues this tradition of analyzing how elements of the natural world (plants in our case) coupled with the usefulness of those elements for a particular society in a particular point of time help explain the interactions of people with those species. Results from our study suggest that different domains of knowledge experience different trends as a result of other changes experienced by the indigenous groups. The finding, to us, reflects on the adaptive nature of this type of knowledge, as well as on the different social factors that affect unevenly this type of knowledge, that is generated, transmitted, or loss according to the particular needs of a society in a given point of time. The type of analysis presented here also help researchers and policy makers to identify which types of knowledge are most vulnerable to the process of socio-economic changes that indigenous societies face nowadays.

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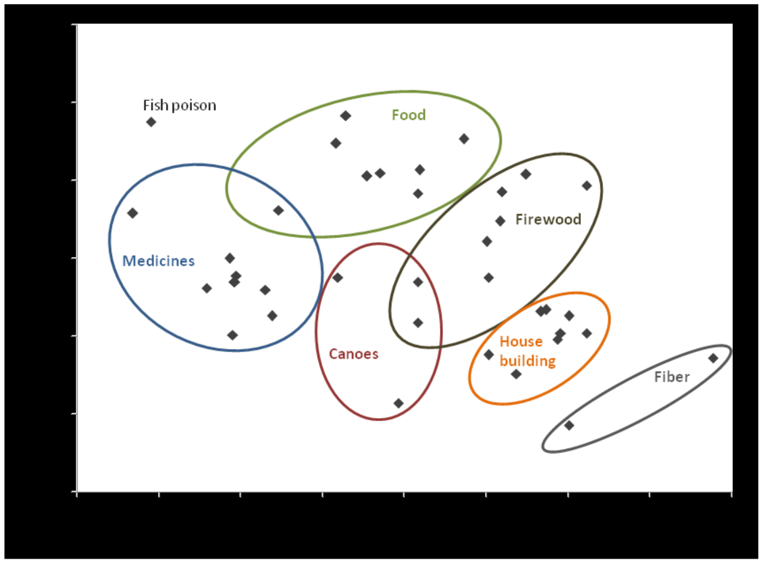

Figure 1.
Non-metric multidimensional scaling plot showing proximity of 43 plants as determined by pile sorting conducted by 30 informants. Stress=0.09. Clusters as interpreted by authors based on visual interpretation of the figure and ethnographic information.

Table 1

Answer-key for the five domains of knowledge studied (n=651)

Tsimane' name	Scientific Name	Food	Medicine	Firewood	Canoe	House building	Total uses
Ashaba	*Poulsenia armata*	1	0	1	0	0	2
Bätin	*Syagrus sancona*	0	1	0	0	0	1
Cajtafa	*Geonoma deversa*	0	0	0	0	1	1
Chip	*Sida rhombifolia*	0	0	0	0	0	0
Cojma	*Dipteryx odorata*	1	0	1	0	1	3
Conojfoto	*Hura crepitans*	0	0	1	1	0	2
Cucush	*Mimosa sp.*	0	1	0	0	0	1
Dveij	*Sterculia apetala*	0	1	0	0	0	1
Jajru	*Oenocarpus bataua*	1	0	0	0	0	1
Na'fa	*Tetragastris altissima*	1	0	1	0	0	2
Oba	*Chorisia speciosa*	0	0	0	1	0	1
Paya	*Heliconia sp.*	0	0	0	0	0	0
Shepi	*Gallesia integrifolia*	0	1	0	0	0	1
Shuru	*Gynerium sagittatum*	0	0	0	0	1	1
Simuri	*Himatanthus sucuuba*	0	0	0	0	0	0
Sima	*Ficus sp.*	0	0	1	0	1	2
Tsocoi	*Rheedia acuminata*	1	0	1	0	0	2
Tutyi	*Xylopia sp.*	0	0	1	0	1	2
Tyi'	*Genipa americana*	1	1	0	0	0	2
Väij	*Bactris gasipaes*	1	0	0	0	0	1
Plants reported as useful		5	7	7	2	5	26

Notes: 1 means that the referred use of the plant was mentioned by >15% of the informants who knew the plant, and 0 that it was mentioned by <=15%.

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Table 2

Spearman correlations between scores of five domains of knowledge among Tsimane' adults (n=651).

	Food	Firewood	Canoe	House
Medicine	0.21***	0.21***	0.27***	0.09**
Food		0.33***	0.25***	−0.003
Firewood			0.49***	0.09*
Canoe				0.07*

Note:

*** significant at the ≤1% level.

** significant at the ≤5% level.

* significant at the 10% level.

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Table 3

Average score in the traditional ecological knowledge questionnaire by birth period (born 1920-1990) and domain of knowledge (n=651 Tsimane' adult men; Years 2008-2009).

	Elder **(n = 112)**		***Mature*** **(n = 207)**		***Young*** **(n = 332)**		**Total (n = 651)**	
	Mean	***S.D.***	***Mean***	***S.D.***	***Mean***	***S.D.***	***Mean***	***S.D.***
Food (0 to 7)	5.71	0.87	5.57	1.01	5.24 [a] (elder,mature)	1.23	5.43	1.13
Medicine (0 to 5)	2.91	1.17	2.60 [c] (elder)	1.31	2.66	1.13	2.68	1.20
Firewood (0 to 7)	1.71	2.09	1.71	2.11	1.51	1.92	1.61	2.01
Canoe (0 to 2)	0.72	0.75	0.71	0.77	0.72	0.78	0.72	0.77
House building (0 to 5)	2.84	0.85	3.11 [b] (elder)	0.94	3.08 [c] (elder)	0.99	3.05	0.96
Total (0 to 26)	13.89	3.61	13.70	3.72	13.20	3.77	13.48	3.73

Note:

[a] indicates a statistically significant difference (p<0.01) between the selected generation and the generation marked in the superscript in a One way Analysis of Variance.

[b] indicates a statistically significant difference (p<0.05) between the selected generation and the generation marked in the superscript in a One way Analysis of Variance.

[c] indicates a statistically significant difference (p<0.10) between the selected generation and the generation marked in the superscript in a One way Analysis of Variance.

Table 4

Results of Poisson regressions of five domains of traditional ecological knowledge (outcome variable) against birth cohort variables among Tsimane' adults (n=651). Years 2008-2009.

	Food	***Medicine***	***Firewood***	***Canoe***	***House building***	***Total***
Age-group of reference: ***Elder***						
Mature	−0.014 (0.023)	−0.090* (0.056)	0.008 (0.135)	0.042 (0.096)	0.074** (0.031)	−0.005 (0.028)
Young	−0.067*** (0.020)	−0.091** (0.046)	−0.005 (0.126)	0.096 (0.085)	0.077** (0.033)	−0.024 (0.027)
Education	−0.004 (0.003)	0.011 (0.006)	−0.011 (0.018)	−0.007 (0.014)	0.008* (0.004)	0.001 (0.003)
Joint: Mature & Young	12.38 (0.002)	4.08 (0.13)	0.03 (0.97)	1.62 (0.45)	6.30 (0.04)	1.43 (0.49)

Robust standard errors in parenthesis. All regressions include village dummies to control for village fixed-effects. 'Joint' = F statistics of joint statistical significance for age groups (significance level in parenthesis).

*** significant at the ≤1% level.

** significant at the ≤5% level.

* significant at the 10% level.