

The study and use of traditional knowledge in agroecological contexts

Estudio y uso del conocimiento tradicional en contextos agroecológicos

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ABSTRACT

The importance of researching and maintaining traditional knowledge is a concern within contemporary academic debates and public policies. Scientist of different disciplines have recognized this importance, indicating this is a broader interdisciplinary issue. Specifically, within the field of agroecological science, the concept of traditional knowledge is basic to the analysis of agroecosystems. This essay aims to analyze, within scientific papers, the approaches to traditional knowledge through agroecological studies. First, insights from traditional knowledge studies in socio-ecological systems are presented as a wider view. Secondly, papers that illustrate agroecological approach to traditional knowledge and the usage of participative research methodologies are systematically reviewed to the forward development of five propositions: 1) traditional knowledge dynamics, 2) importance of traditional knowledge and professional's ethics, 3) methodologies used for traditional knowledge gathering, 4) subjects of study in agroecological and traditional knowledge studies and 5) the integration of traditional knowledge with scientific knowledge.

Keywords

traditional knowledge • agroecology • participative methodologies • socio-ecological systems • knowledge integration

La agroecología en perspectiva
de los aspectos socioculturales

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RESUMEN

La importancia de investigar y preservar el conocimiento tradicional es una preocupación dentro de los debates académicos contemporáneos y para los hacedores de políticas públicas. Científicos de diferentes disciplinas han reconocido esta importancia, indicando que este es un tema interdisciplinario más amplio. Específicamente, dentro del campo de la ciencia agroecológica, el concepto de conocimiento tradicional es básico para el análisis de los agroecosistemas. Este ensayo pretende analizar, dentro de los artículos científicos, los enfoques del conocimiento tradicional a través de estudios agroecológicos. En primer lugar, las ideas de los estudios del conocimiento tradicional en sistemas socio ecológicos se presentan como una visión más amplia. En segundo lugar, los artículos que ilustran el enfoque agroecológico del conocimiento tradicional y el uso de metodologías de investigación participativa son revisados sistemáticamente para el desarrollo de cinco proposiciones: 1) dinámica del conocimiento tradicional, 2) importancia del conocimiento tradicional y ética profesional, 3) metodologías utilizadas para la recopilación de conocimiento, 4) temas abordados en estudios de conocimiento agroecológico y tradicional y 5) la integración del conocimiento tradicional con el conocimiento científico.

Palabras clave

conocimiento tradicional • metodologías participativas • agroecología • sistemas socio-ecológicos • integración del conocimiento

INTRODUCTION

Recent studies, especially those that use the methodology of participative investigations with agricultural communities, recognize the importance of traditional knowledge and the local knowledge of stakeholders. In some cases, this is the focus of the studies (51). In other cases it is an element of the participative methodologies in agricultural (or agroecological investigations) and it is used to integrate stakeholders into a larger view. This approach is taken for a several reasons. One is an intention in the academic community to place local actors as active members of the investigation. The purpose here is to accomplish not only an academic result for science but also to provide a management tool for improving communities.

Another possible reason is the concern of traditional knowledge maintenance. Recent reports evidence that it is at risk, increasingly threatened by the spread of globalization (42). Degradation of traditional knowledge is not only a critical concern for scientific knowledge, which could be enriched by it, but is especially a problem as it is a foundation for local management strategies. In diverse locations, these strategies are important for shaping both local livelihoods and the trajectory of local biodiversity (42).

There are several expressions that refer to the concepts studied in this text. Some authors conceive some of these differently than others and grant specific characteristics to each one. 'Indigenous Knowledge' (IK) and 'Traditional Knowledge' (TK) are expressions that describe knowledge specific to a given culture or society (59). For the purposes of this paper, we have decided to clarify and simplify the analyses by treating 'Traditional Knowledge' (TK) as synonymous with related terms (*e.g.* Indigenous Knowledge, Local Knowledge). Various authors (*e.g.* Bali and Kofinas, 2014) have defined these related expressions with the purpose of theoretically clarifying its source and the contexts in which they are used. It is important to note this simplification does not intend to devalue the academic effort in conceptualizing and differentiating these terms.

Another expression suitable for being introduced here is 'Traditional Ecological Knowledge' (TEK). This refers to people's cumulative nonscientific body of knowledge, beliefs, and practices. It describes local ecosystems and their management that has evolved through social learning and adaptive processes handed down through generations by cultural transmission (11, 13, 50). Here, we will treat it as immersed in TK which is a wider umbrella.

Even though the concept of TK is in somewhat amorphous, it is usually linked with the diverse relations between humans and nature. This is a cumulative body of knowledge that includes practices and beliefs that have evolved over time and passed on through the generations by cultural transmission. Hence, Traditional Ecological Knowledge (TEK) is both cumulative and dynamic. It has a base in experience, but an experience that is modified over time by adaptation to change (11). These concepts usually include general notions of interactions between people and the natural world, as well as the environmental connections that happen in specific localities (30).

The agroecological perspective possesses the potential to guide the study of such connections. Evidence affirming this perspective can be found in numerous peasant initiatives requiring them to apply new knowledge and technologies in a coordinated strategy. These initiatives are essentially agroecological science and TK systems (5). It is precisely the agroecological perspective that has the potential to study these complex connections between peasant initiatives, TK, local environments and the general interaction between man and nature.

We sought to answer the question: what are the existing approaches to TK in agroecological studies? The objective in answering this question is to understand the existing linkages between agroecological contexts, TK, and the participative methodologies used in these reported cases.

This essay was written as follows: firstly, literature from socio-ecological system studies and their relationship toward TK or TEK were analyzed. These various perspectives are necessary for understanding the possibilities of TK. This is done in order to draw attention to the contribution these wider visions make in the study of this subject. Afterwards, the available and reported works in indexed journals that relate TK, participative methodologies and agroecological studies were systematically reviewed. We analyzed TK as a study object in the indexed papers, considering not only the agroecological approach but also examining underlying assumptions from a range of perspectives.

From this wider view, it is possible to deduce five principal linkages in agroecological approaches in the 11 papers selected in the systematic review presented in the results.

MATERIALS AND METHODS

The methodological strategy used has both of qualitative and quantitative nature. First, insights from traditional knowledge studies in socio-ecological systems are brought to discussion to achieved a wider view. Secondly, a systematic review is developed where papers that illustrate agroecological approach to traditional knowledge and the usage of participative research methodologies are analyzed.

Using the socio-ecological systems approach to study traditional knowledge

The starting point in our analyses will be to look at several conclusions by diverse authors and scientists. These conclusions point toward Agroecology as a whole-systems approach to agriculture and food system development, an approach based on TK (34). As such, it must be viewed as immersed in social-ecological systems. We will look at what these authors have to say about the relation between TEK, social and ecological resilience, and how these interactions effect socio-ecological systems.

Resilience, as defined by Berkes *et al.* (2000), is understood as the capacity to recover after disturbance, absorb stress, internalize it, and transcend it. To be resilient, rural societies must have the ability to buffer disturbances with agro-ecological methods adopted from and disseminated through self-organization and collective action (57). Berkes *et al.* (2000) analyze the role of TEK in ecological resilience by monitoring the responses to and management of ecosystem processes. Resilience was found to be related to traditional or local practices of ecosystem management. This can be viewed from various categories, such as multiple species management, resource rotation, succession management, landscape patchiness management, and others. These practices, identified and listed by Berkes *et al.* (2000), are consistent with agroecological principles as well.

Such strategies to enhance ecological resilience are essential, not just to the natural surroundings, but also to social resilience. Defined by Nicholls and Altieri (2012), social resilience is the ability of groups or communities to adapt to external social, political, or environmental stresses. Both resiliencies would imply social mechanisms (50). These mechanisms were also identified by Berkes *et al.* (2000). They include items such as: adaptations for the generation, accumulation, and transmission of knowledge; local institutions and rules for social regulation; internalization of traditional practices; and development of cultural values. Some authors found the use of TEK contributed to an increase in survival chances by traditional communities by offering an understanding on how to adapt to changes in complex systems (*e.g.* Gómez-Baggethun, *et al.* 2013). These authors argued through case studies in Africa, Asia, America and Europe, that one of the main ways which TEK contributes to building resilience in socio-ecological systems is by promoting bio-cultural diversity.

Bohensky and Maru (2011) also posited two relevant premises of resilience theory in the reviewed literature. These concern knowledge integration and social-ecological system resilience. The first one is TK (the authors used the expression 'Indigenous Knowledge') can enhance resilience of social-ecological systems because it has the ability to deal with complexity and uncertainty. This is due to its being an accumulation of experience, learning, and adaptation developed through intergenerational transmission. The second is combining of knowledge systems can enhance resilience of social-ecological systems. This is the case despite the many academic doubts whether TK or TEK can be brought into the realm of science. Most studies appraise resilience in a theoretical level rather than a more practical one.

Social-ecological resilience, according to Bohensky and Maru (2011) will depend on, among other things, adaptive learning which requires maintaining the web of relationships of people and places. In this way, the experience of change and successful adaptations can be captured. And through community debate and decision-making processes these changes can be embedded in the culture (12, 27). Folke (2014) also states principles for building adaptive capacity in socio-ecological systems: learning to live with change and uncertainty, nurturing diversity for reorganization and renewal, combining different types of knowledge for learning, and creating opportunity for self-organization. In this way TEK and shared systems of beliefs may facilitate collective responses to crises and may contribute to the long term maintenance of resilience in social-ecological systems (35).

Efforts in integrating TEK in land and resource management and also in decision making, in the search for socio-ecological resilience, are not new. According to Ellis (2005) this issue has been prominent in the academic discourse for about 20 years. There are evidences published about processes that don't incorporate TEK in decision-making, studding the influence of contextual factors in the adoption of unsustainable agricultural models (15). Because of its connection with environmental sustainability and social improvements, there is a tendency of analyzing, systemizing, and incorporating TEK into environmental decision making processes. This usually happens in two directions: the "top-down" approach, which includes methods based on the recognition of TEK by institutions of authority that leads to the development of rules for the use of this knowledge. The other direction is "bottom up" where the capacity of aboriginal people to bring traditional knowledge to influence policies, procedures of governance, and changes in regulation is recognized (31). According to the author they are not mutually exclusive.

Knowledge of resource and ecosystem dynamics and management practices exists among communities that interact with ecosystems (32). It has become important to understand and combine it with other knowledge systems in matters of improving management and governance of complex adaptive systems. Folke (2014) lists some objectives suggested by studies of this combinations: promotion of participatory processes, creation of new information, improving use of existing knowledge, developing indicators of change and resilience for monitoring ecosystem dynamics, and developing social responses for dealing with uncertainty and change, to mention a few. Biodiversity for conservation is another example of an issue included in these several existing studies (36, 50). However, this is not identified as a practice. Rather it is a consequence of many traditional management systems.

The importance of understanding and promoting diverse cultural foundations of resource management and restoration and the potential of combining different knowledge systems in the context of social–ecological systems, is highlighted by diverse authors (32, 50, 58). Four mechanisms through which TEK could result in positive adaptation in community-based conservation contexts are: indigenous people elaboration of knowledge about ecosystems by testing it iteratively; transmission and guarding of knowledge at the local level; the relation between interpretation of ecosystem change and traditional ceremonies which contributes to cultural internalization of conservation rules; and such rules being the basis of flexible decision making.

An example of the last mechanism mentioned is from Ghimire, McKey *et al.* (2004) who point to the heterogeneity and complexity of TEK in relation to its practical and institutional context in the management of Himalayan medicinal plants. Another example of the way in which TEK strengthens community resilience was reported by E Gómez-Baggethun *et al.* (2013) using case studies about global environmental change.

Indigenous groups offer this alternative knowledge and perspectives based on their own locally developed practices of resource use (13). Such empirical experiences and the theoretical bases mentioned suggest that despite the tendency of worldwide TEK erosion (36), it persists in valuable cases. Moreover, not only does it persist but it has also been shown by the cited authors that it is basic for traditional communities in attaining socio-ecological resilience. Papers from some study cases link agroecology specifically with TK or TEK. These studies were reviewed and afterwards five links were analyzed.

Systematic review

A systematic review was made about TEK, agroecology and participative research methods. The research and selection were made by the adaptation of the Cochran Manual for medical systematic reviews proposed by PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) (43). The search path used in the databases is shown:

(traditional knowledge OR native knowledge OR local knowledge OR indigenous knowledge OR community knowledge) AND (agroecology OR sustainable agriculture OR organic agriculture OR biological agriculture OR ecological agriculture OR healthy agriculture OR organic production OR multifaceted agriculture OR sustaining agriculture OR multifunctional agriculture OR urban agriculture OR conservation agriculture) AND (participatory research methods OR participatory research OR participatory methods OR community-based participatory research)

Date ranges: until August 2015

The databases were chosen for being interdisciplinary and with wide information cover. The choice finally yielded a result of 11 articles viable for analyzing in order to answer the objective question (figure 1, page 342).

Data

The information collected from each one of the 11 papers was organized as shown in table 1.

After the review of the chosen papers was made, five aspects were specifically analyzed from these literature: 1) traditional knowledge dynamics, 2) importance of traditional knowledge and professional's ethics, 3) methodologies used for Traditional Knowledge gathering, 4) subjects of study in agroecological and traditional knowledge studies and 5) the integration of traditional knowledge with scientific knowledge.

Table 1. Information gathered from the selected papers.

Tabla 1. Información obtenida de los artículos seleccionados.

Title	Authors	TEK approach	Participative research methods used	Agroecology approaches	Location of the research	Content	Journal/year
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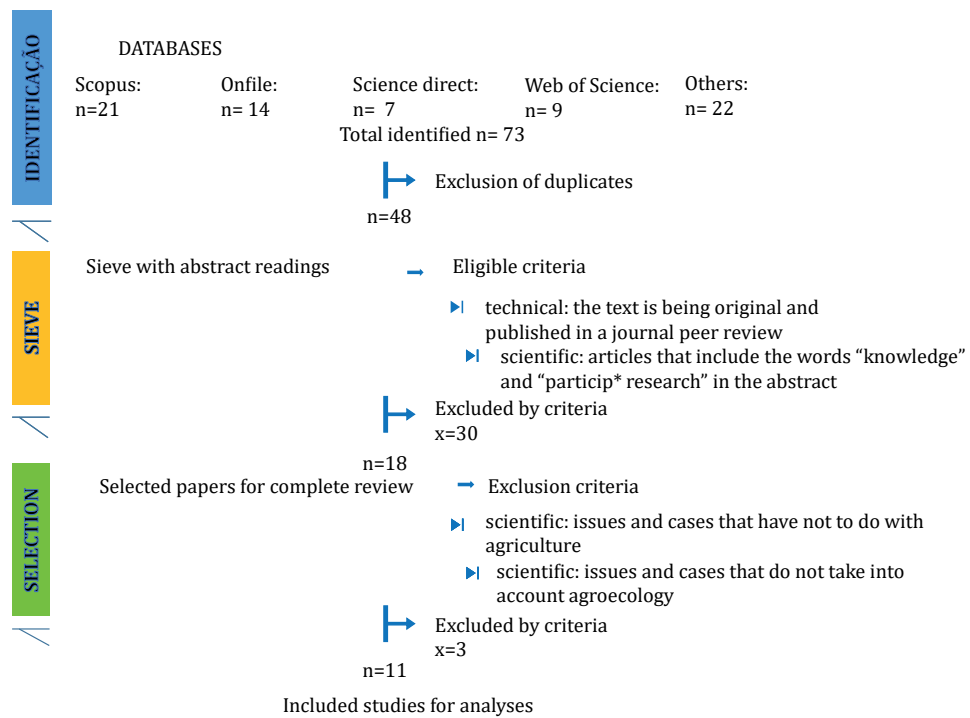


Figure 1. Selection steps in the systematic review.

Figura 1. Pasos para la selección de artículos.

RESULTS

Traditional knowledge dynamics

The study of TEK began with the study of species identifications and classification. Later it dealt with people's understandings of ecological processes and their relationships with the environment (11). According to Berkes, Colding, and Folke (2000), the analysis of many TEK systems show the following components: local observational knowledge of species and environmental phenomena, people's practices in the way they carry out their resource use activities, and finally a component of belief that deals with how people relate to ecosystems. This means TEK is a knowledge-practice-belief complex (11). In the studied papers, some of these components are immersed in the agroecological analyses.

The component of observation and experimentation is structural for the development of TK about adaptation strategies for facing agricultural systems constrains. TEK's transmission implies a dynamic nature that is never static. This can be corroborated in the literature analyzed. According to Dahlberg (1994) the interaction with local biota in ancient practices, shaped socio-ecological systems in landscapes of food production. Observation lead to the knowledge of how to raise particular plants and allowed the evolution of agrobiodiversity in particular geographical areas (26). Species developed by communities over long-term periods converse with environmental dynamics and cultivation practices resulting in a base of knowledge (4).

There is a clear tendency in these papers to find additional social components of TEK transmission that are consistent with the nature of agroecological studies. TEK is commonly conceived as inheritable from generation to generation. As such, it is a form of evolutionary ideas and practices that have been cost energy independent (52). Actually, what gives potential and strength to local knowledge as a tool for conserving natural resources and agroecological knowledge is experience. It is experience through times and generations of confronting diverse situations coupled with the fact of farmers living in complex ecosystems that demanded a wider understand of biological processes that has resulted in this knowledge (6).

TEK and knowledge transmission are also explained as dynamic processes immersed in specific networks where they are enriched and transformed. Network studies that map sources of knowledge in a certain community and explain its complexity support this contention (6). The role and leadership of different actors in the network is also analyzed in means of knowledge transmission. It was noticed how very few farmers acted as sources of knowledge. This could be due to knowledge hierarchies in the communities or even by a lack of belief in the legitimacy of farmer's knowledge and its supposed opposition to scientific knowledge. The first is also assumed to be akin to common sense, which is viewed as closed and nonsystematic knowledge. By this judgment, expert knowledge tends to be privileged over farmers' knowledge in agricultural practices (2). These assumptions of TEK lead to understanding it as immersed in unequal social relations that conflict with its production and interpretation.

One of the studies discusses this matter of power involved in social knowledge dynamics, showing how it has affected knowledge vision for both professionals and farmers. This vision of knowledge sees it as more like a commodity rather than a relationship. It affects the way it has been delivered, contributing to the "top Down" model (25) as already highlighted in the previous section. This same study reports alternative views where there were attempts to defend a more horizontal construction of knowledge and learning as an adaptive and iterative process, *e.g.* Roth (2004). This model documents innovations in TEK resulting from careful experimentation through experience and systematic observation. These efforts of constructing more horizontal studies and looking at their results in terms of benefits obtained by communities and by scientists, are a clear tendency in agroecological studies. It is not just confined to the reports analyzed here.

Importance of traditional knowledge and professional ethics

The reasons these two issues are discussed in the same section responds to the question of the pertinence of "rescuing" TK by scientists. This question is generally answered with arguments about its importance. That way, authors indirectly state the dilemma of intervening or not intervening in TK processes in the communities.

The importance of TK, specifically TEK, lies in its being a source of ideas for understanding local environments in a creative and grounded way (11). McCarter *et al.* (2014) cite from diverse authors other various reasons: It represents detailed ecological information, strengthens management strategies, raises adaptive capacity to environmental variability, and its active support can improve people-centered resource governance approaches. The analyzed studies enrich this list with more specific possible applications.

Another issue these studies point to is how TK's base is at risk. However, the social and ecological changes that have put TK at risk are also generating increased interest in this kind of knowledge (42). Several arguments backup the idea that risk is a problem to be solved.

One goal of its preservation, it is suggested, is the enhancement of the quality of life of traditional communities that produce and conserve that knowledge (52). For that matter, the same author assumes that unless professionals take it into account, they will not be able to offer sustainable bases to traditional agricultural communities.

Several other works that we analyzed also gave attention to the researcher's role in evaluating and transforming science's path toward the production of knowledge about agriculture. In addition, the institutional role of universities is also questioned. In general, they have not shown enough concern for the community's social processes and knowledge. Universities are charged with the responsibility of working with local knowledge without displacing it, and providing a useful contribution to agroecology science. This responsibility would include paying more attention to the particularities and idiosyncrasies of farmers' land instead of applying recipes and formulas that generalize production systems. This way it would be feasible to understand the micro-scale variations within farmer environments (24).

One of the most cited reasons for rescuing and studying TK dynamics is the need to find a more sustainable agriculture to counteract the negative environmental impacts of monoculture, chemical fertilizers and pesticides. Ecological designs of agroecosystems demand knowledge of how biology can regulate itself. Not only will this knowledge allow more innovative answers, but more successful social projects can be achieved with greater social acceptance (41).

Another big issue found in the study of TK is the urgent need for conservation, a need to which TK can contribute. Efforts in this matter demand new alliances among actors like “conservation biologists, agroecologists, agronomists, farmers, indigenous peoples, rural social movements, foresters, social scientists, and land managers” (22) for the achievement of an interdisciplinary approach able to construct efficient landscape, biodiversity conservation and sustainable livelihood policies.

According to Barthel, *et al.* (2013) few studies have analyzed the methods, opportunities, and challenges of maintaining and revitalize TK systems. Nevertheless, the authors tend to recommend it (10, 42). The papers analyzed suggest this as well, but their focus is a search for TK instead of its maintenance and revitalization.

It is important to cite other valuable reasons why TK is clearly needed. Although not mentioned in agroecological approaches to TK in the studies analyzed, it is actually inherently related to agroecological science. TK in a substantial number of traditional societies maintains a high level of human health, sustains natural resources in good condition (in most of the cases), and offers a diverse set of institutional solutions for ecological sustainability (10).

The list of reasons of TEK importance grows: conservation of rare species, protected areas and ecological processes (13); development planning and environmental assessment (12); designing adaptation strategies to change (*e.g.* climate change) based on experimentation and knowledge coproduction (14, 16); maintenance of qualities of traditional food systems that support traditional communities (37).

Methodologies used for Traditional Knowledge gathering

All the studies analyzed use qualitative approaches, specifically participation methodologies. Some of them use quantitative methodologies as well. According to Singh and Sureja (2008) the qualitative approach is the most appropriate in the case of studying traditional knowledge systems and natural resources.

It is important to clarify that participatory methodologies was adopted here as a generalist concept which can be found in literature under a number of titles as: Participatory Research approaches, Farmer-back-to-Farmer, Farmer-First, People Centered Agriculture Improvement, Rapid Rural Appraisal, Agroecosystem Analysis, farmer participatory strategies, and others (29).

Most of the studies aimed at finding TK through participative methodologies. For this matter, personal interviews were always a starting point and choosing the interviewees was an essential part of the process. This choice was made according to the study scope, time available for the research, chain referrals and information gathered from previously contacted community organizations. The existence of these community based farmer organizations can greatly facilitate scientist's participation in the research (29).

Different knowledge gathering methodologies are reported as being taken into account. These include things such as interactions with peasants, analytical interviews, semi-structured interviews, free list questionnaires, multi-stakeholders' approach, and schools foundations for knowledge interchange between farmers and professionals (38). The last one is for the purpose of making agricultural knowledge more horizontal rather than top-down (41).

One methodology used was having the farmers classify different factors such as soil, crop rotations, combinations, and others. The most common classification was of soil, and they were positively correlated with topographical features or fertility characteristics (54). Generally, those classifications are correlated with some biological or chemical aspect.

Various works also map knowledge flows (where the TK of farmers came from). It is observed and related that knowledge is affected by factors like gender, age, leadership and others (6). Geographic Information System (GIS) is a tool that helps researchers understand how local and scientific knowledge is linked spatially. It was reported to have been used in three of the case studies (18, 24, 41). This methodology seems to give a good basis for analyzing traditional knowledge dynamics, described in the previous section.

Another cited benefit of participatory evaluation is the capacity of explaining discrepancies between suitability prognoses provided by the method and actual land use. This revealed some big differences between farmer and expert land suitability assessment (24).

Application of participatory research action to the field of agroecology is another benefit to this approach. Diverse cases were taken from previous studies of the community-based participatory approach and applied in action-oriented research all over the world (25).

According to the studies in general, participation-based research can provide additional possibilities for agroecology where it can assume a cultural and political dimension. Specifically, it allows the co-production of new cross-cultural knowledge. This is a basic aspect of the agroecological approach due to its interdisciplinary nature (25).

Other tools brought by diverse disciplines or areas, like those studying socio-ecological systems, can enrich agroecological studies and the study of TK. These other tools and methodologies, not found in the studies analyzed are: effective documentation of TK that provides long-term baseline information about the past and contemporary social and ecological conditions (13); future scenarios and theater performance to communicate scientific knowledge to communities (16); oral history interviews (20); directed work with elders (28); creation of databases with historical archives of communities (35); making collaborative field projects and analytical workshops (23); participant observation and focus group discussions (46).

Gathering TK presents an inherent requirement for academic investigation due to its interdisciplinary nature. Specifically, this is the need to integrate methodologies from different disciplines. Given the tendency of specialization in our occidental view of knowledge, the use of social science methods to gather biological data becomes a difficult task. Additionally, Bali and Kofinas (2014) point out some other difficulties at reaching TEK like the fact that it is passed on as an oral tradition in stories attached to people and events over generations. Also contemporary local knowledge is usually shared as stories describing personal experiences. These personal experiences are often not contextualized in scientific interpretations. These authors used participatory videography, in which the community creates its own film in the attempt of facing those difficulties.

Subjects of study in agroecological and traditional knowledge studies

Most of the studies report farmer's methods of production, crop combinations and fertility. They asked farmers to evaluate these aspects. Gender is a particular aspect that was reported in some studies, but it wasn't a factor considered by farmers (52).

As mentioned, soil was repeatedly a factor studied in TK in the papers analyzed. Other important and repetitive aspects described were farmers' adaptive practices for cropping systems, perception of farmers about climate variability and collective water management, biodynamic agricultural adaptations, adaptive practices for disease and pest management, and others. Climate and soil TK were found to be consistent with recorded climate and soil data from the regions studied.

Indigenous pest management knowledge is site-specific and should be the basis for developing integrated pest management (IPM) techniques (1). Other results of studying TK are suggestive of alternatives to modern technology. This points to designing agricultural models less dependent on western science and its outputs and is more community based (9). According to Toledo (2013), it is also important to mention examinations of biodiversity based on TEK: the correlation between biological richness and cultural diversity on geopolitical and biogeographic terms; importance of indigenous communities in biomass appropriation; the overlap between indigenous territories and the world's remaining areas of high biodiversity; and the importance of indigenous views, knowledge, and practices in biodiversity conservation, as already highlighted in a previous section.

It could be said that special attention has been paid to economic/traditional crop varieties, but not as much attention has been paid in searching for plants and animals that have food value, or medicinal plants, etc. harvested from the wild. Some other socio-ecological uses found in TEK and gathered in studies (besides the studies analyzed) are: forest use practices (20); composition and management of historical species (21); traditional monitoring methods for sustainable customary wildlife harvests (44); providing historical and contemporary baseline information, suggestions of stewardship techniques, improved conservation planning and practice, resolution of management disputes; interrelation between all of the above and marine ecology (55); ecological restoration information (59); socio-ecological manipulation of biodiversity for coping with uncertainties in the environment and global change; control of soil water regimes and hydrology; soil fertility management through soil biological processes; and for efficient organic residue management. And finally TEK as a socio-ecological tool integrates ethical, cultural, spiritual, and religious belief systems that focus on sacred elements for communities (47).

Integration of Traditional Knowledge with Scientific Knowledge

First of all, in any scientific study which aims understanding TK there is an imperative need for contextualization. Fortunately, Reid *et al.* (2006) assure us that this need is receiving more attention with time. Other imperative needs of scientists are the capacity to determine the pertinence of intervening, incorporating or integrating scientific knowledge in the loci studied (16), as already highlighted in a previous section.

In the papers reviewed, we observed that TK and scientific knowledge are often compared. Both share the same objects of knowledge but differ in methodologies and, according to the papers, also differ in values. This means that both types of knowledge present different priorities and interests. *E.g.* scientific methods use a deductive approach which doesn't always achieve a satisfactory prediction of land productivity (24).

One of the papers reported a study concerning the kinds of educational training needed if professionals are to succeed in incorporating sustainability knowledge in agricultural faculties. Specifically, integrating TK with technical knowledge was one of the needs found (3). That necessity goes both ways.

Yet, TK and community skills of crop management, agronomic manipulations, and natural resource management are not fully appreciated and recognized by some researchers (54), especially in agronomical disciplines.

Another deficiency pointed out by looking at the non-integration of knowledge, is the lack of a reference for the guidance of traditional communities that are trying to adopt new technologies or new management practices. Professionals have the advantage of dominating standardized and systematic methods for assessing new technologies. On the other hand, it often happens that the assumptions used in expert evaluations aren't feasible. In this matter, farmers' knowledge has the advantage of possibly understanding better the variations of various phenomena (*e.g.* climate) as they are in direct and constant contact with the environment (24). This means that farmers' own production and transmission of knowledge gains some empirical legitimacy due to their constant experience and use of land systems on a day to day basis.

Lyon (2011) explains how scientific knowledge is limited by temporal and spatial constraints in its application. In contrast, TK doesn't seek a static solution but looks for adaptability. The scientific community tends to seek knowledge that can be generalized. Nevertheless, conventional knowledge and TK systems could complement each other (60).

Regarding using GIS as a tool for TEK studies, Bryan (2009) calls attention to existing colonizing tendencies inherent in the standardization of cartographic and digital technologies used to map indigenous territories and knowledge. The author argues that indigenous mapping should search for an alternative to the colonial geographical understanding of the world. That task would be possible only by "negotiating" limits of both kinds of knowledge.

The invitation from these studies is to attend to the need for integration of both forms of knowledge. To this end, it is essential to develop a language in which farmers and land resource professionals can understand each other. Cools *et al.* (2003) reported studies on linking local and scientific soil knowledge in Nigeria, in Peru, and in New Mexico, but little work has been done in West Asia and North Africa. All these studies make an attempt to link both farmer and expert knowledge (24).

According to Leitgeb *et al.* (2014) in studies about Cuba it was concluded that the government's commitment to social participation in knowledge development is a basic prerequisite. This kind of commitment is need to facilitate effective integration of farmers' experiments and innovation.

Literature in socio-ecological systems and TK offer wide analyses contributing an important component in the integration of both kinds of knowledge. Not all these contributions can be cited in this text, but the characteristics, similarities and complementarity between TK and scientific knowledge can be identified as useful tools for agroecological science to face the challenge of integrating both.

CONCLUSIONS

Traditional knowledge is a multidisciplinary matter that is now being studied by varied disciplines through various methodologies. Here, agroecological approaches to TK were searched, and the wider linkages between this discipline and the concept of TK were analyzed.

Understanding TK transmission in agroecological studies is a useful tool for accompanying socio-ecological processes that happen in the agroecosystem. The nature of its transmission can be understood from socio-ecological theories and the concept of resilience.

Agroecological science by adopting TK as objects of study, has inherently built a theoretical and ethical position of “rescuing” TK for the clear purposes of enriching its sources and enhancing resilience. Authors analyzed in this text have lighted the construction of a theoretical framework that vision this objective.

Participative methodologies showed potential to answer questions demanded of research by providing a tool that assures a method sufficiently extensive in scope to be incorporated into any trans-disciplinary science. This does not assume that other nature methodologies could not be used, indeed it would be necessary to inquire for methodological strategies in the Social and Human sciences such as anthropology and sociology to know better the production and reproduction of TK. Suggestions were given of other applicable methodologies for enriching agroecological analyses.

Integration of knowledge and the preservation of TK sources in traditional communities is a dual demand of researchers and practitioners. As the field has advanced in the study of this area it has become clear there is a broader demand for society and academia to give this area greater attention and priority, especially thanks to the risk of losing TK sources in traditional communities threatened with disappearance.

Agroecology has the theoretical and practical bases for giving shape to TK research. The analyzed studies demonstrate the importance of this kind of knowledge for actual agroecological projects, biodiversity and social cohesion.

REFERENCES

1. Abate, T.; Van Huis, A.; Ampofo, J. K.; Van Huis, A. 2000. Pest management strategies in traditional agriculture: an african perspective. *Annual Review of Entomology*. 45: 631.
2. Agrawal, A. 2002. Indigenous knowledge and the politics of classification. *International Social Science Journal*. 54(173): 287-98.
3. Alibaygi, A.; Pouya, M. 2011. Needs assessment of senior agricultural students regarding sustainability knowledge. *African Journal of Agricultural Research*. 6(31): 6542-46.
4. Altieri, M. A.; Masera, O. 1993. Sustainable rural development in latin america: building from the bottom-up. *ecological economics*. 7(2): 93-121. Available in: <http://www.sciencedirect.com/science/article/pii/092180099390049C>.
5. Altieri, M. A.; Toledo, V. M. 2011. The agroecological revolution in latin america: rescuing nature, ensuring food sovereignty and empowering peasants. *The Journal of Peasant Studies* 38(3): 587-612.
6. Arora, S. 2012. Farmers’ participation in knowledge circulation and the promotion of agroecological methods in South India. *Journal of Sustainable Agriculture*. 36(2): 207-35. Available in: <http://www.tandfonline.com/doi/abs/10.1080/10440046.2011.620231> (November 14, 2014).
7. Bali, A.; Kofinas, G. P. 2014. Voices of the caribou people: a participatory videography method to document and share local knowledge from the North American human-rangifer systems. *Ecological Economics* 19(2).
8. Barthel, S.; Crumley, C. L.; Svedin, U. 2013. Biocultural refugia: combating the erosion of diversity in landscapes of food production. *Ecology and Society*. 18(4). Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84884913034&partnerID=40&md5=1725bee0490e6e62dfd91270a678aee>.
9. Bebbington, A. 2001. Indigenous knowledge and technology. In ed. Neil J Smelser Paul B B T-International Encyclopedia of the Social & Behavioral Sciences Baltes. Oxford: Pergamon. 7289-92. Available in: <http://www.sciencedirect.com/science/article/pii/B0080430767041838>.
10. Becker, C. D.; Ghimire, K. 2003. Synergy Between traditional ecological knowledge and conservation science supports forest preservation in Ecuador. *Conservation Ecology*. 8(1): 1. Available in: <http://www.consecol.org/vol8/iss1/art1>.
11. Berkes, F. 2012. *Sacred Ecology*. 3rd ed. ed. Routledge. Nova York.

12. Berkes, F.; Folke, C.; Gadgil, M. 1995. Traditional ecological knowledge, biodiversity, resilience and sustainability. *Biodiversity conservation: Problems and Policies*, eds. Charles Perrings. Kluwer Academic Publishers. 281-99.
13. Berkes, F.; Colding, J.; Folke, C. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*. 10(5): 1251. Available in: <http://www.jstor.org/stable/2641280?origin=crossref>.
14. Berkes, F.; Jolly, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian Western arctic community. *Conservation ecology*. 5(2): 18. Available in: <http://www.consecol.org/vol5/iss2/art18>.
15. Blandi, M. L.; Rigotto, R. M.; Sarandón, S. J. 2018. Influencia de factores contextuales en la adopción de modelos de agricultura insustentables. La incorporación del invernáculo en agricultores platenses. *Revista de la Facultad de Ciencias Agrarias*. Universidad Nacional de Cuyo. Mendoza. Argentina. 50(1): 203-216.
16. Bohensky, E. L.; Maru, Y. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on 'Integration'? *Ecology and Society*. 16(4): 6. Available in: <http://dx.doi.org/10.5751/ES-04342-160406>.
17. Boillat, S.; Berkes, F. 2013. Perception and interpretation of climate change among quechua farmers of bolivia: indigenous knowledge as a resource for adaptive. *Ecology and society*. 18(4).
18. Brunner, A. C.; Park, S. J.; Ruecker, G. R.; Vlek, P. L. G. 2008. Erosion modelling approach to simulate the effect of land management options on soil loss by considering catenary soil development and farmers perception. *Land Degradation & Development*. 19(6): 623-35.
19. Bryan, J. 2009. Where would we be without them? knowledge, space and power in indigenous politics. 41(1): 24-32. Available in: *Futures*. <http://www.sciencedirect.com/science/article/pii/S0016328708001110>.
20. Bürgi, M.; Gimmi, U.; Stuber, M. 2013. Assessing traditional knowledge on forest uses to understand forest ecosystem dynamics. *Forest Ecology and Management*. 289: 115-22. Available in: <http://linkinghub.elsevier.com/retrieve/pii/S0378112712006093> (October 2, 2014).
21. Celentano, D.; Celentano, D.; Rousseau, G.; Engel, V.; Façanha, C.; de Oliveira, E.; Gomes de Moura, E. 2014. Perceptions of environmental change and use of traditional knowledge to plan riparian forest restoration with relocated communities in Alcântara, Eastern Amazon. *Journal of ethnobiology and ethnomedicine*. 10(1): 11. <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4120938&tool=pmcentrez&rendertype=abstract> (November 14, 2014).
22. Chazdon, R. L.; Chazdon, R.; Harvey, C.; Komar, O.; Griffith, D.; Ferguson, B.; Martinez-Ramoz, M.; Morales, H.; Nigh, R.; Soto-Pinto, L.; Van Breugel, M.; Philpott, S. 2009. Beyond Reserves: A Research Agenda for Conserving Biodiversity in Human-Modified Tropical Landscapes. *Biotropica*. 41(2): 142-53. Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-61549121006&partnerID=40&md5=188b03d7bb8b4da4808315aa7fb5694f>.
23. Consulting, H.; River, E.; Huntington, H. P. 2000. Using traditional ecological knowledge in science: methods and applications. *ecological applications*. 10(5): 1270-74.
24. Cools, N. E. De Pauw; Deckers, J. 2003. Towards an integration of conventional land evaluation methods and farmers' soil suitability assessment: a case study in Northwestern Syria. *Agriculture, Ecosystems & Environment*. 95(1): 327-42.
25. Cuéllar-Padilla, M.; Calle-Collado, A. 2011. Can we find solutions with people? Participatory action research with small organic producers in Andalusia. *Journal of Rural Studies*. 27(4): 372-83. Available in: <http://www.sciencedirect.com/science/article/pii/S0743016711000805> (August 18, 2014).
26. Dahlberg, K. A. 1994. A transition from agriculture to regenerative food systems. *Futures*. 26(2): 170-79.
27. Davidson-hunt, I.; Berkes, F. 2003. Learning as you journey: anishinaabe perception of social-ecological environments and adaptive learning. *Conservation Ecology*. 8(1): 5. Available in: <http://www.consecol.org/vol8/iss1/art5>.
28. Davidson-hunt, I.; Idrobo, J.; Pengelly, R.; Sylvester, O. 2013. Anishinaabe adaptation to environmental change in northwestern ontario: a case study in knowledge coproduction for nontimber forest products. *Ecology and Society*. 18(4).
29. Dlott, J.; Altieri, M.; Masumoto, M. 1994. Exploring the theory and practice of participatory research in us sustainable agriculture: a case study in insect pest management. *Journal of the Agriculture, Food, and Human Values Society*. 11(2): 126-39.
30. Drew, J. A. 2005. Use of traditional ecological knowledge in marine conservation. *Conservation Biology*. 19(4): 1286-93.
31. Ellis, S. C. 2005. Meaningful consideration? a review of traditional knowledge in environmental decision making. 58(1): 66-77. Available in: <http://www.jstor.org/stable/40512668> (December 1, 2014).
32. Folke, C. 2014. Traditional knowledge in social-ecological systems. *Ecology and Society*. 9(3): 7. Available in: <http://www.ecologyandsociety.org/vol9/iss3/art7/>.
33. Ghimire, S. K.; McKey, D.; Aumeeruddy-Thomas, Y. 2004. Heterogeneity in ethnoecological knowledge and management of medicinal plants in the Himalayas of Nepal: implications for Conservation. *Ecology and Society*. 9(3): 6.

34. Gliessman, S. 1992. Agroecology in the tropics: achieving a balance between land use and preservation. *Environmental Management*. 16(6): 681–89. Available in: <http://dx.doi.org/10.1007/BF02645658>.
35. Gómez-Baggethun, E.; Reyes-García, V.; Olsson, P.; Montes, C. 2012. Traditional ecological knowledge and community resilience to environmental extremes: a case study in Doñana, SW Spain. *Global Environmental Change*. 22(3): 640–50. Available in: <http://linkinghub.elsevier.com/retrieve/pii/S0959378012000246> (July 9, 2014).
36. Gómez-Baggethun, E.; Corbera, E.; Reyes-García, V. 2013. Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and Society*. 18(4).
37. Kuhnlein, H. V.; Receveur, O. 1996. Dietary change and traditional food systems of indigenous peoples. *Annual review of nutrition*. 16: 417.
38. Leitgeb, F.; Funes-Monzote, F. R.; Kummer, S.; Vogl, C. R. 2011. Contribution of farmers' experiments and innovations to Cuba's agricultural innovation system. *renewable agriculture and food systems*. 26(4): 354–67. Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-80855163596&partnerID=40&md5=0fccb29ec6fc24d957f033618d85932e>.
39. Leitgeb, F.; Kummer, S.; Funes-Monzote, F. R.; Vogl, C. R. 2014. Farmers' experiments in Cuba. *Renewable Agriculture and Food Systems*. 29(1): 48–64. Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84897852425&partnerID=40&md5=c549174211ce35a677f8452152380c8>.
40. Lyon, A.; Bell, M. M.; Gratton, C.; Jackson, R. 2011. Farming without a Recipe: Wisconsin Graziers and new directions for Agricultural Science. *Journal of Rural Studies*. 27(4): 384–93. Available in: <http://www.sciencedirect.com/science/article/pii/S074301671100026X> (September 10, 2014).
41. Malézieux, E. 2012. Designing cropping systems from nature. *Agronomy for Sustainable development*. 32(1): 15–29. Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84857857787&partnerID=40&md5=caa39395c301cc048799c031068f217b>.
42. McCarter, J.; Gavin, M.; Bareleo, S.; Love, M. 2014. The Challenges of maintaining indigenous ecological knowledge. *Ecology and Society*. 19(3). Available in: <http://www.ecologyandsociety.org/vol19/iss3/art39/>.
43. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PloS Medicine*. 6(7). Available in: <http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.1000097>.
44. Moller, H.; Berkes, F.; Lyver, P. O.; Kislalioglu, M. 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. *Ecology and Society*. 9(3): 2. Available in: <http://www.ecologyandsociety.org/vol9/iss3/art2>.
45. Nicholls, C. I.; Altieri, M. A. 2012. Agro-ecological approaches to enhance resilience. *Farming Matters* (June): 14–17.
46. Oteros-Rozas, E.; Ontillera-Sánchez, R.; Sanosa, P.; Gómez Baggethun, E.; Reyes García, V.; González, J. 2013. Traditional Ecological Knowledge among Transhumant Pastoralists in Mediterranean Spain. *Ecology and Society*. 18(3). Available in: <http://www.ecologyandsociety.org/vol18/iss3/art33/>.
47. Ramakrishnan, P. S. 2001. Ethnobiology. In ed. Neil J Smelser Paul B B T - International Encyclopedia of the Social & Behavioral Sciences Baltes. Oxford: Pergamon, 4846–52. Available in: <http://www.sciencedirect.com/science/article/pii/B0080430767041796>.
48. Reid, W.; Berkes, F.; Wilbanks, T.; Capistrano, D. 2006. Bridging scales and knowledge systems concepts and applications in ecosystem assessment. Washington, D. C. USA: Millennium Ecosystem Assessment. <http://www.unep.org/maweb/en/Bridging.aspx>.
49. Roth, R. 2004. Spatial organization of environmental knowledge: conservation conflicts in the inhabited forest of Northern. *Ecology and Society*. 9(3): 5. Available in: <http://www.ecologyandsociety.org/vol9/iss3/art5>.
50. Ruiz-Mallen, I.; Corbera, E. 2013. Community-based conservation and traditional ecological knowledge: implications for social-ecological resilience. *Ecology and Society*. 18(4): 12.
51. Sánchez-Toledano, B. I.; Kallas, Z.; Gil, J. M. 2017. Importancia de los objetivos sociales, ambientales y económicos de los agricultores en la adopción de maíz mejorado en Chiapas, México. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*. 49(2): 269–287.
52. Singh, R. K.; Sureja, A. K. 2008. Indigenous knowledge and sustainable agricultural resources management under rainfed agro-ecosystem. *Indian Journal of Traditional Knowledge. Tradit. Knowl.* 7(4): 642–54.
53. Singh, R. K.; Kumar, S.; Jat, H.; Singh, A.; Raju, R.; Sharma, D. 2014a. Adaptation in rice-wheat based sodic agroecosystems: a case study on climate resilient farmers' practices. *Indian Journal of Traditional Knowledge. Tradit. Knowl.* 13(2): 377–89.
54. Singh, R. K.; Singh, A.; Pandey, C. B. 2014b. Agro-biodiversity in rice-wheat-based agroecosystems of Eastern Uttar Pradesh, India: implications for conservation and sustainable management. *International Journal of Sustainable Development and World Ecology*. 21(1): 46–59. Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84896715786&partnerID=40&md5=ca2758853dd6d676acea9b27fe8a81ad>.

55. Thornton, T. F.; Scheer, A. M. 2012. Collaborative engagement of local and traditional knowledge and science in marine environments: a review. *Ecology and Society*. 17(3): 8.
56. Toledo, V. M. 2013. Indigenous peoples and biodiversity. In ed. Simon A B T-Encyclopedia of Biodiversity (Second Edition) Levin. Waltham: Academic Press. 269-78. Available in: <http://www.sciencedirect.com/science/article/pii/B9780123847195002999>.
57. Tompkins, E. L.; Adger, N. 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*. 9(2): 10. Available in: <http://www.ecologyandsociety.org/vol9/iss2/art10/>.
58. Turner, N. J.; Boelscher Ignace, M.; Ignace, R. 2000. Traditional ecological knowledge and Wisdom of Aboriginal Peoples in British Columbia. *Ecological Applications*. 10(5): 1275-87.
59. Upreti, Y.; Bergeron, Y.; Doyon, F.; Boucher, J. 2012. Contribution of traditional knowledge to ecological restoration: practices and applications. *Ecoscience*. 19(3): 225-37. Available in: <http://www.bioone.org/doi/abs/10.2980/19-3-3530> (November 13, 2014).
60. Wanzala, W. 2012. A survey of the management of livestock ticks and other aspects of animal ethno health in Bukusu Community, Western Kenya. *Livestock Research for Rural Development*. 24(10). Available in: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84867447739&partnerID=40&md5=fe924346b94ac55352561c01b1f7b8aa>.
61. Warren, D. M.; Rajasekaran, B. 1993. Putting local knowledge to good use. *International Agricultural Development*. 13(4): 8-10.