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Roles of Traditional Ecological Knowledge for Biodiversity Conservation

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Abstract
Indigenous peoples are actively engaged as partners in biodiversity conservation and biodiversity inhabit local areas. They have a broad knowledge base of the behavior of complex ecological systems in their own localities with a historical continuity of resource-use practices. Management of natural resources in the form of indigenous/ traditional technical knowledge is called "Traditional Ecological Knowledge". Traditional ecological knowledge (TEK) is a cumulative body of knowledge about the relationships living things (including people) have with each other and with their environment, which is handed down across generations through cultural transmission. Traditional ecological knowledge recognized as complementary and equivalent to scientific knowledge has increased its relevance globally. Traditional ecological knowledge is relevant for the maintenance and sustainable use of biodiversity. Maintenance of biodiversity includes the worldview and religious philosophy of indigenous peoples to develop a new environmental ethics and traditional practices of natural resource management tested on-site for many generations. However, sustainable utilization of biodiversity by TEK includes customary use of biological resources in accordance with traditional cultural practices. The roles of TEK for biodiversity conservation is considered at several levels such as traditional knowledge of animals, plants, soils and landscape for the sustainable use of resources; traditional resources management system with an appropriate set of tools, techniques and practices; social institutions or organization for coordination, co-operation, rule-making and rule enforcement and finally, environmental perception and gives meaning to social relations. Moreover, the application and effects of TEK on conservation and ecology are for ethnoecology, population ecology and species interaction and forest management. Beside these roles and integrating of TEK for biodiversity conservation, we recommend that: biodiversity managers and western scientists should be directly connected with knowledge holders and, communication styles should be understood, a foundation of trust to work should be established, and mutual benefits or incentives from knowledge sharing to collaborate biodiversity conservation should identified.
Keywords: Biodiversity, conservation, Indigenous people, Traditional ecological knowledge

Introduction

Indigenous peoples are actively engaged as partners in biodiversity conservation and inhabit areas rich in biodiversity (Weber *et al*., 2000; Kimmerer, 2002). They often possess a broad knowledge base of the behaviour of complex ecological systems in their own localities with a historical continuity of resource-use practices. This knowledge has accumulated through a long series of observations transmitted from generation to generation (Berkes *et al*., 1994). Where indigenous peoples have depended, for long periods of time, on local environments for the provision of a variety of resources, they have developed a stake in conserving, and in enhancing biodiversity. Their practices for the conservation of biodiversity were grounded in a series of rules of thumb which were apparently arrived at through a trial and error process over a long historical time period. This implies that their knowledge base is indefinite and their implementation involves an intimate relationship with the belief system (Gadgil *et al*., 1993).

Indigenous people are also aware of a large variety of uses of biodiversity including medicinal uses, their knowledge of habitat preference, life history, and behaviour relevant to efficient foraging for such resources (Sefi Mekonen *et al*., 2017a). For example the bewildering array of fisheries regulations on mesh size, closed seasons, and quotas that may still prove insufficient to prevent the collapse of fisheries. Compliance is often facilitated through religious belief, ritual, and social conventions (Gadgil *et al*., 1993). The traditional management of natural resources is a form of indigenous technical knowledge (Boonto, 1993). Traditional knowledge tends to emphasize the knowledge based on experiences internal to a particular setting (Van Vlaenderen, 2000). Therefore traditional knowledge is said to be unique to a given culture.

Traditional Ecological Knowledge (TEK) exists all over the world, independent of ethnicity. It is born of long intimacy and attentiveness to a homeland and can arise wherever people are materially and spiritually integrated with their landscape (Kimmerer, 2002). However, TEK is receiving global attention since the United Nations Conference on Environment and Development (UNCED, 1992) (sited in Takako, 2004). It has been recognized as complementary and equivalent to scientific knowledge (Berkes *et al*., 2000; Kimmerer, 2002). TEK is increasingly being sought by academics, agencies, scientists, and policymakers as a potential source of ideas for emerging models of ecosystem management, conservation biology, and ecological restoration. Indeed, the United Nations Convention on Biodiversity calls for recognition, protection, and utilization of TEK

(Kimmerer, 2002).

There is ample evidence of TEK and practices involved in enhancing biodiversity at the landscape level. There is species diversity management in some traditional aquaculture systems. Unlike many contemporary single-species, high-input, high-throughput aquaculture systems, many of the ancient fish-rearing systems elsewhere make use of a mix of species, taking advantage of the ecological characteristics of each, and making full use of waste recycled to provide food (Folke and Kautsky, 1989 and 1992). New directions in applied biology that have direct parallels and precedents in TEK include ecosystem management, medicine, pharmacology, agro ecology, wildlife, fisheries, and animal behavior and biological research is moving to explore these approaches (Kimmerer, 2002; Sefi Mekonen *et al*., 2017b). There have been many attempts that target the preservation of TEK as a record of useful plants and animals (Takako, 2004).

In spite of the recent attention by the international communities, TEK has been diminishing worldwide. How and what sort of traditional ecological knowledge can contribute to conserving biodiversity also have not been sufficiently discussed so far. Also, indigenous peoples' roles in biodiversity conservation have been underestimated (Takako, 2004). On the other hand, acknowledgment or understanding of traditional ecological knowledge is rare in the scientific community (Kimmerer, 2000). These are very important factors to be considered in a policy making context for conserving biodiversity. In spite of these, the main aim of this paper is to present the case that exposure to TEK has a legitimate role in the conservation of the biodiversity for biologists, environmental scientists, and natural resource managers.

Definition of traditional ecological knowledge

The concept of traditional ecological knowledge (TEK) comes up frequently in certain segments of environmental and natural resources science and policy literatures (Houde, 2007). There is no generally accepted definition of traditional ecological knowledge. Some definitions see TEK as a basic body of knowledge. This basic body of knowledge is usually defined as having been gathered across generations: "Traditional knowledge refers to the knowledge and know-how accumulated across generations, and renewed by each new generation, which guide human societies in their innumerable interactions with their surrounding environment" (Nakashima *et al*., 2012).

TEK is broadly defined as cumulative bodies of indigenous knowledge about the relationships living things (including people) have with each other and with their environment, which is handed down across generations through cultural transmission. Traditional ecological knowledge is a more or less integrated system of knowledge, practices, and beliefs. It is dynamic and evolves as people build on their experiences and observations, experiment, interact with other knowledge systems, and adapt to changing environmental conditions over time. TEK is grounded in place, and is most often found among societies that have engaged in natural resource use in a particular place over a long period, such as indigenous or traditional peoples (Berkes, 1999).

TEK is a rational and reliable knowledge that has been developed through generations of intimate contact by native peoples with their lands (Mauro and Hardison, 2000). It is held by peoples in relatively non technological societies with direct dependence upon local resources (Kimmerer, 2002). It is applied by combining the knowledge and skills that are a product of a person's cultural history and learning, and expressing them in the context of prevailing environmental circumstances currently affecting resource use and management (Charnley *et al*., 2008).

As defined by Berkes (2008:7), TEK encompasses (1) factual knowledge about ecological components and processes, (2) knowledge put into practices of environmental use, and (3) the cultural values, ethics, and philosophies that define human relationships within the natural world. To various degrees, all these TEK "categories" have contributed to environmental research and management by improving baseline data on species and ecological processes (Gagnon and Berteaux, 2009), by providing insights that can be used to develop alternative resource management systems or by renewing conservation ethics (Berkes, 2008).

Integration between Traditional and Scientific Ecological Knowledge

There are many similarities between TEK and scientific ecological knowledge (SEK), since both:-derive from the same source: systematic observations of nature, attempts to make sense of the world, to render it comprehensible to the human mind, they are based on observations and on generalizations deriving from those observations (Berkes *et al*., 1994), knowledge systems yield detailed empirical information of natural phenomena and relationships among ecosystem components, and both have predictive power, and intellectual traditions, observations are interpreted within a particular cultural context. Therefore, TEK is being recognized as having equal status with scientific knowledge (UNEP, 1998) and has been termed the "intellectual twin to science" (Kimmerer, 2002).

However, there are some notable differences between the two kinds of knowledge. Western scientific knowledge tends to be driven by theoretical models and hypothesis testing, and generated using the scientific

method; not necessarily utilitarian; often generalizable and not always local; generated by research institutions; and documented and widely disseminated in written form (Charnley *et al*., 2008). TEK tend to be driven by a desire for utilitarian information that will help people survive and maintain a natural resource-based livelihood; generated through practical experience with the natural world in the course of everyday life; locally based and specific; and transmitted orally or through demonstration (Ellen and Harris, 2000).

According to Berkes et al., (1994), in particular, TEK differs from scientific knowledge as follows:

- Restricted geographical scale of observations;
- Reliance mainly on qualitative (rather than quantitative) information
- Lack of a built-in drive to accumulate more facts;
- Slower speed in the accumulation of facts;
- More reliance on trial-and-error, rather than on systematic experimentation;
- Limited scope for the verification of predictions;
- Lack of interest in general principles on theory- building

The Relevance of TEK for Biodiversity Conservation

Indigenous peoples use natural resources in a sustainable manner, and protect specific sites or species as sacred objects. The linkage between biological and cultural diversity, or areas of indigenous peoples' territories and of high biodiversity, has become good grounds for indigenous peoples' participation in biodiversity conservation (Takako, 2004). Three key features may be used to characterize indigenous biodiversity management. These are; (1) The indigenous social organization that controls the access to natural resources within the community (Luoga, 2000), (2) The customary norms and procedure for control, acquisition, maintenance and transfer for natural resources (Boonto, 1993); and (3) The indigenous utilization techniques for conserving and preserving resources (Boonto, 1993, Luoga, 2000).

Much of the world's biodiversity resources has been inhabited and managed by indigenous peoples (Takako, 2004). Also the potential for TEK to contribute to biodiversity conservation has been widely recognized. For example, at an international level, Article 8(j) of the United Nations Convention on Biological Diversity states that the knowledge and practices of indigenous and local communities that are relevant for the conservation and sustainable use of biodiversity should be respected, preserved, and applied (Charnley *et al*., 2008).

According to Takako (2004), TEK has been receiving global attention since the UNCED in 1992 and increased its relevance due to several factors: Firstly, the ethical imperatives of conserving cultural diversity. Secondly, traditional ecological knowledge contributes to a sustainable development. For example, community based industrial development using Non Wood Forest Products (NWFP) make forest utilization more economically, culturally and environmentally sustainable, "both because they extend the range of forest benefits and because gathering and processing activities can be managed by communities near the forest resource, with a greater portion of the end-product revenues returning to those who manage the resource." Third, traditional ecological knowledge can be viewed as the means that enabled indigenous peoples to interact with their natural environment in a sustainable manner.

Numerous resource use and management practices based on TEK contribute to conservation either intentionally or unintentionally (Anderson, 2005; Berkes *et al*., 1994, 2000). TEK is important for a number of practical reasons, many of them highly relevant to biodiversity conservation. According to IUCN (1986) programme adapted (cited in Berkes*et al*., 1994), TEK for biodiversity conservation:

- TEK offers new biological knowledge and ecological insights;
- Some TEK systems provides models for sustainable resources management;
- TEK is relevant for protected areas and conservation education;
- The use of TEK is crucial for development planning;
- TEK may be used in environmental assessment

How TEK Maintain and Sustain Biodiversity?

TEK is considered best in biodiversity conservation efforts for different reasons. Firstly, for example, local people spend a great deal of time in biodiversity resources observing, experiencing, experimenting, working, and tinkering. In the process, they learn things that could be of value to western scientists and other conservationist; they are a potential source of experimental, anecdotal, and/or observational data on ecosystems. Another reason from the observation is that commercial biodiversity production on private industrial and public lands based on western science, belief, and value systems have emphasized the production of a small number of commercially valuable species on short rotations in plantations using even-age management techniques, with negative effects on the structure, composition, and function of forest ecosystems (Carey, 2006, Wilson and Puettmann, 2007). Biodiversity management for a diversity of products, uses, and values is more likely to maintain biodiversity than biodiversity management for commercial production based on short rotations and a small number of species (Carey, 2006; Carnus *et al*., 2006).

TEK can be a source of new biological insights and potential models for conservation and sustainable

utilization. According to Takako, (2004), the relevance of traditional ecological knowledge are for the maintenance of biodiversity, and for the sustainable use of its components. The maintenance of biodiversity includes the worldview and religious philosophy of indigenous peoples, as lessons to develop a new environmental ethics based on human-nature reciprocity and deep moral, in contrast to modern environmental ethics out of regret of human domination over nature. Secondly, traditional practices of natural resource management tested on-site for many generations are regarded as an alternative for modern resource management. The sustainable utilization of biodiversity includes indigenous knowledge on using NWFP. There are some "customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements." Also, traditional ecological knowledge related to the utilization of medicinal plants and animals has become an important pinpointing factor in the conduct of bioprospecting today.

TEK may be considered at several levels. Firstly, there is the local TEK of animals, plants, soils and landscape, all such knowledge has obvious survival value but may not be sufficient by itself for the sustainable use of resources. Secondly, there is the traditional resources management system, which uses local environmental knowledge and also includes an appropriate set of tools, techniques and practices. Thirdly, such traditional systems of management require appropriate social institutions. For a group of interdependent hunters, fishers or agriculturists to function effectively, there has to be a social organization for coordination, co-operation, rile-making and rule enforcement. Lastly, the world view which shapes the environmental perception and gives meaning to social relations may be considered a fourth level of traditional knowledge (Berkes *et al*., 1994).

Many practices used by indigenous people serve to manage species diversity, create habitat heterogeneity on the landscape scale, and manage intensity of use, thereby enhancing the diversity of biological resources available. Examples from diverse geographical areas show that there are a number of ways in which indigenous practice may enhance biodiversity. The overall productivity of agricultural systems may be increased by making full use of the available temporal and spatial opportunities for growing a diversity of crops. Intercropping, multiple cropping, agroforestry, shifting cultivation, and integrated farming systems are all traditional approaches that help maintain biodiversity (Berkes *et al*., 1994).

Habitat management by traditional agriculturalists and agro foresters is relatively well known. More controversial is habitat management by hunter-gatherers. Another widely used traditional practice is that of rotation of harvesting pressure, which would similarly contribute to landscape heterogeneity. The principle of rotation in agriculture is well known: land is periodically fallowed or "rested", and often planted with species that help restore soil fertility. Less well known is the use of rotation for grazing lands and for hunting and fishing grounds. In semiarid regions such as the fringe of Sahel, plant productivity is seasonal and follows the rains. Many of the larger herbivores have adapted to this pattern by migrating seasonally, and the migrations of traditional herding peoples also follow the same adaptation (Gadgil*et al*., 1993).

The contribution of TEK for subsistence, conservation and sustainable use of biodiversity, is the generation of indicators (Heink and Kowarik, 2010). In general, indicators should be useful to diagnose an environmental situation, to evaluate the condition or state of the environment or to provide early signals of change. Therefore, should include attributes that would inform the structure, function and composition of ecological systems (Dale and Beyeler, 2001).

Internationally there are successful experiences around the participatory generation of indicators in the conservation, management and evaluation of action research for agriculture, the quality of water bodies, local coastal management and environmental degradation. According to Munis de Medeiros *et al*. (2011), the indicators are related to the volume of wood consumption, indices of diversity and equity. This point out that the use of wood energy facilitates the use of greater importance and recommends to specify which species are the highest quality fuel, taking into account the preference of consumers, ecological information in plants, forest seral stage, and post-disturbance regenerative capacity. It is believed that linking culture with nature through traditional ecological knowledge could be useful for decision-making in the development of policies, plans and development programs (García-Moya *et al*., 2012).

Effects of Traditional Ecological Knowledge Practices on Ecology

The World Conservation Union (IUCN) recognizes the practical significance of TEK to contemporary sciences such as ecology, conservation biology, pharmaceutical botany, forestry, and fish and wildlife sciences. An IUCN report (IUCN,1986) lists the following arenas in which TEK can prove useful to science and environmental applications: new biological insights, resource management, conservation education, reserve design and management, development planning, environmental assessment, and commodity development (Kimmerer, 2002). TEK also has strong potential for informing the science of ecological restoration (Kimmerer, 2000; Kimmerer, 2002). Ford (2001) suggests that TEK plays a vital role in ecological monitoring by providing early warning signs of ecosystem change.

The scope of traditional ecological knowledge includes detailed empirical knowledge of population biology,

resource assessment and monitoring, successional dynamics, patterns of fluctuation in climate and resources, species interactions, ethnotaxonomy, sustainable harvesting, and adaptive management and manipulation of disturbance regimes (Berkes 1999; Kimmerer, 2002). As traditional knowledge overlaps significantly with the content of a mainstream course in ecology or conservation biology, the effects of TEK on ecology are categories in this review into: ethnoecology; population ecology and species interaction, forest management practices for a wide range of species and for timber production.

Ethnoecology

Ethnoecology explore which plants and animals indigenous peoples used prehistorically, historically, and today, and for what purposes; people's knowledge about the natural history of these species; native names for species; descriptions of the plants and animals used and the habitats in which they occur; how they were prepared; and beliefs, rituals, stories, and songs associated with each species (Marles *et al*. 2000; Minnis 2004).

One important purpose of ethnoecological research is to document what species were used and how by indigenous peoples. Ethnoecological information provides a window into the cultural heritage, classification systems, and identity of indigenous peoples. It has also been used to explore the potential for developing commercial uses of plants, a possible economic development and diversification strategy for indigenous communities. With regard to biodiversity conservation, ethnoecological information reveals which species were and are important to indigenous peoples, and their role in supporting different cultural practices. This information can be used to identify what species should be protected and restored to facilitate the continuation of these practices (Charnley *et al*., 2008).

Population ecology and species interaction

Traditional ecological knowledge is not restricted to the biology of subsistence activities but includes detailed observations of population ecology and species interactions, which arise from long-term association with a particular flora and fauna. These kinds of observations can be extremely valuable in validating scientific hypotheses and suggesting new research directions. TEK has been shown to provide accurate and reliable species information, and therefore effective management (Kimmerer, 2002).

Knowledge of species interactions may be documented in sources unfamiliar to scientists, but valid nonetheless. Indigenous languages can encode significant information concerning species interactions. Nabhan (2000) suggests that biological information embedded in indigenous languages may be valuable in conservation biology. Songs, poems, and stories that exist in the oral tradition may be of great value in validating and expanding scientific understanding. The scientific richness of the oral tradition forces scientists to confront assumptions concerning the validity of this traditional information, which has typically been marginalized by scientists. The wealth of ecological information in native languages, many of which are nearly extinct, supports the link between conservation of biodiversity and conservation of cultural diversity (Kimmerer, 2002; Maffi, 2005).

Forest management practices

The third relevance of TEK relating to biodiversity conservation characterizes how indigenous people managed natural resources in prehistoric and historical times. Moreover, some assert that biodiversity was dependent on active environmental management by indigenous peoples, and has declined locally with the disappearance of indigenous management practices (Anderson 2005, Charnley *et al*., 2008). For example, fire was an environmental management tool commonly used by indigenous peoples in California and the Pacific Northwest in the past, although not all tribes used fire and not all environments were shaped by it (Charnley *et al*., 2008). There is substantial historical and ethnographic evidence that prescribed fire was widespread in historical and prehistoric times, but there is little physical evidence of past anthropogenic fire (Lepofsky 2004). Burning disrupted forest succession and reduced the dominance of coniferous forests, maintaining open habitat where desirable food plants grew (Kimmerer and Lake 2001). It also created a mosaic of habitat patches in different successional stages, which increased food security by enhancing the diversity of resources, and creating a buffer against fluctuations in the abundance of individual species.

Other techniques they used to enhance desirable plant species included planting or broadcasting seeds; transplanting bulbs and other propagules, shrubs, and small trees to make them more abundant and accessible; modifying soils and digging to enhance the growth of root vegetables; removing undesirable plants that competed with valued plants; selective harvesting; pruning or coppicing berry bushes and other shrubs to enhance their productivity and to encourage certain patterns of growth; pruning trees and shrubs near desired plants to reduce competition; rotating harvesting locations; and diverting water for irrigation and to reduce erosion (Anderson 2005: Deur and Turner 2005).

The third category of literature regarding forest management by focuses on historical and contemporary timber management practices. Forest growth is enhanced by controlling density, generally with the use of a chainsaw or brushsaw to reduce competition from undesirable vegetation. Commercial thinning programs are

limited, in part because of uneven-age management, and in part because of a focus on regeneration harvest of slow-growing, old-growth stands. There is a move toward ecosystem management, with a shift from commodity production to maintaining ecological processes and functions (Charnley *et al*., 2008).

Regeneration following logging activities has been effective in most places, although some areas are under-stocked or no- stocked owing to regeneration failures. Harvest in coastal forests has simplified the structure and composition of stands, with clear cutting eliminating older trees, large snags, down logs, and large woody debris in watercourses. Road systems developed to support timber harvesting and other forest management actions have had a major impact on water quality, causing stream sedimentation and negatively affecting fish populations. There has been a simplification of stand structure and loss of species resulting from even-age harvest practices, and old-growth forest habitat has been lost from some landscapes, with negative ecological effects. Fire suppression and past forest management practices have resulted in overstocked stands and insect epidemics (Charnley *et al*., 2008).

Conclusion and Forward Recommendations

Indigenous peoples are one of the important actors in biodiversity conservation, and conservationists began to pay attention to contents of their respective cultures as an outgrowth of human-nature interactions, which are so called traditional ecological knowledge. Traditional ecological knowledge is a cumulative body of knowledge about the relationships living things has with each other and with their environment, which is handed down across generations through cultural transmission. There is increasing recognition that the use and application of traditional knowledge and indigenous natural resource management systems provide effective strategies for the conservation of biological diversity and the sustainable use of natural resources.

Despite TEK is important for a number of practical reasons, many of them relevant to biodiversity conservation such as TEK offers new biological knowledge and ecological insights, provides models for sustainable resources management, relevant for protected areas and conservation education, crucial for development planning and used in environmental assessment. TEK is considered best in biodiversity conservation efforts due to: local people spend a great deal of time in biodiversity resources observing, experiencing, experimenting, working, and tinkering; and commercial biodiversity production on private industrial and public lands based on western science, belief, and value systems.

Moreover, the relevant of TEK are for the maintenance and sustainable use of biodiversity at several levels i.e. TEK of animals, plants, soils and landscape, traditional resources management system and appropriate social institutions and environmental perception. As TEK wide scope, it pertinent for detailed empirical knowledge of population biology, ethnoecology, resource assessment and monitoring, succession dynamics, species interactions, ethnotaxonomy, sustainable harvesting, and adaptive management and manipulation of disturbance regimes. In light of these roles and integrating of TEK for biodiversity conservation, for its successfully efforts further we recommended that: the knowledge holders should be directly engaged with biodiversity managers and western scientists in which interaction and knowledge sharing occur, communication styles of the knowledge holders should be understand, a foundation of trust to work from should established, and mutual benefits from knowledge sharing that create an incentive to collaborate for biodiversity conservation should identify.

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