

**Review Article**

The Traditional Knowledge Associated to Biodiversity in an Age of Climate Change

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Abstract: Climate change has largely influenced the biodiversity in the world, as the biodiversity hotspots areas are often also rich in cultural diversity, the local peoples have rich traditional knowledge associated to biodiversity, and these knowledge also provide alternative information about climate variability and climate change based on the experience and practices of biodiversity resource use. This review work examines the researches about traditional knowledge associated to biodiversity in monitoring and adapting to changing climatic conditions in different parts of the globe. We reviewed different reports from both International and Regional Organizations whereby we based our findings from the traditional knowledge and climate change, the traditional knowledge's perception and lastly traditional knowledge's adaption to climate change. In our findings we realized that traditional knowledge associated to biodiversity is not only effective toolbox, but also a process to adopt to the climate change at local level. Lastly this review also demonstrates how local people use their traditional knowledge about the climate to guide their biodiversity resource and its management. The disasters arising from negative impacts of climate change has brought many risks and threats to the indigenous peoples. This paper highlights the importance of integrating the scientific models in conjunction with traditional knowledge system of indigenous peoples. Integrating this traditional knowledge can add a significance value to the development of sustainable climate change mitigation and adaptation strategies that are rich in local content. It was observed that the traditional knowledge and coping strategies can no longer be fully adapted to the intensity and frequency of the present climate change due to unlimited resources and also lack the enough support from both local and international communities' responsible for the climate policies.

Keywords: Climate Change, Biodiversity, Traditional Knowledge, Adaption & Cultural Values

1. Introduction

Climate change has been and is having a negative impact on the environment and livelihood of the people in any society, it has become a hot issue in the world today. Indigenous peoples who are usually considered poor and who depends on natural resources especially in developing countries are particularly vulnerable to the effects of climate change, they are often in a predicament when they are hit severe meteorological and climate phenomenon [1]. Due to historical, social, political and economic reasons, many indigenous peoples have chosen

or forced to live in more remote and harsh environments, and their livelihoods are highly dependent on natural resources, so the impact of climate change on indigenous peoples is more serious than those of other populations [2].

Changes in ecosystems will affect the way of life of indigenous peoples, and climate change will directly and indirectly affect and threaten their survival [3]. For example, variability and extreme weather events such as prolonged drought period, floods, strong destructive winds among others and seasonal climate effects such as the delay of the onset rainy season and prolonged dry season, it will invalidation the

traditional ecological and agricultural calendar of indigenous peoples which may result in agricultural failure and reduction of livestock. At the same time, the shrinking of wildlife resources makes it difficult to collect and hunt, and the epidemic has accelerated the deterioration of human and animal health. However, indigenous peoples are the least responsible for the emergence of man-made climate change, and their carbon footprint and greenhouse gas emissions are negligible compared to the industrial and social urban population [4]. The impact of climate change is a very realistic problem for indigenous peoples, as pointed out in the report of the United Nations High Commissioner for human rights: "The latest evidence shows that the livelihoods and cultures of 370 million indigenous peoples living in North America, Europe, Latin America, Africa, Asia and Oceania have faced the threat of climate change" [5]. For indigenous peoples, such as the marginalization of politics and economy, the invasion of land and resources, the violation of human rights, the discrimination, the abuse of resources and the loss of livelihoods, the impact of climate change has undoubtedly deepened the crisis and made them more vulnerable to the challenges [6].

On the other hand, few cases show that climate change may provide new opportunities for indigenous peoples. The report of the Secretariat of the Convention on biological diversity states that: Economic changes caused by climate change may provide new opportunities for indigenous peoples based on their traditional knowledge. For example, indigenous peoples in the Arctic may have some opportunities to develop some form of sustainable agriculture, while there are some new economic opportunities, such as compensation for sustainable forest management under the framework of carbon trading [7]. However, it should be emphasized that only when the rights framework is clear and safeguards are established, can the real interests and the results of sustainable management be realized [8].

Although indigenous peoples have been greatly affected by climate change, they remain marginalized in academic, policy and public discussions on climate change until recently [9]. In the high level meetings and reports, there is little mention of indigenous peoples, even if they are referred to as only the victims of no hope in the process of climate change, that they are unable to cope with the impact, and that there are very few areas and ethnic groups mentioned [10].

Fortunately, in recent years, the international community has been increasing its attention on this issue, whether it is in the areas of humanitarian, development and finance, as well as international non-governmental environmental organizations, and the relevant international conventions and reports have also begun to address and involve indigenous peoples and climate change. Such as the Convention on biological diversity (CBD) and the United Nations Framework Convention on climate change (UNFCCC). Other United Nations agencies and intergovernmental organizations, such as the United Nations Development Agency (UNDP), the United Nations Development Organization (UNDOG), the United Nations High Level Committee on human rights

(UNOHCHR), the United Nations University Advanced Research Institute (UNU-IAS), the United Nations Educational, scientific and Cultural Organization (UNESCO), the international organization for migration (IOM) and the world bank, have begun to recognize that climate change has a destabilizing effect on indigenous peoples, the importance of discussing the issue with indigenous peoples and to support their capacity-building. The relationship between climate change and indigenous peoples is expounded in relevant conventions, conferences and research reports.

The international ecological protection organization is increasingly aware that, in the long term, the protection of biodiversity is closely linked to the social and cultural values and practices, and the right to live with the safety and dignity of the peoples of all countries. In this context, indigenous peoples should be focused. So the international non-governmental environmental organizations are increasingly concerned about the special vulnerability of indigenous peoples and their role in mitigation and adaptation to climate change, at the same time, the practice of assisting indigenous peoples in coping with climate change. For example, the work of the World Conservation Union (IUCN) and the Conservation International (CI) is particularly focused on the sharing of fair benefits under the mechanism of greenhouse gas emissions (REDD) resulting from deforestation and forest degradation, and land rights of the poor communities, including gender considerations within the framework of UNFCCC. Through indigenous peoples' projects, CI supports indigenous peoples in biodiversity conservation and climate change issues in areas such as participation, policy making and implementation of projects.

The core relationship between climate change and indigenous peoples is traditional knowledge. The Tenth Conference of the parties to the Convention on biological diversity, convened in October 2010, in its resolution thirty-third, specifically proposed the relationship between biodiversity and climate change, especially the possible impact of climate change on traditional knowledge. Traditional knowledge is not only the basis for indigenous peoples to cope with climate change, but also related to the sustainability of the natural resources management and livelihood development of indigenous peoples, the continuity of society and the inheritance of traditional cultural values. One of the important issues in the discussion of indigenous peoples and climate change is that the traditional knowledge and practical experience of indigenous peoples may play an active role in the design and implementation of policies to mitigate and adapt to climate change. However, because of the great impact of climate change and the constraints of the social and political structure, it is not conducive to the ability of indigenous peoples to adapt to climate change. Therefore, there is an urgent need to support indigenous peoples through legal, political, technological, financial and other means. The report of the International Conference on indigenous peoples and climate change which was held in Copenhagen in February 2008, summarizes the concerns of indigenous peoples that the International experts often seem to overlook

the basic rights and interests of this peoples and often ignore the valuable potential contribution based on the traditional knowledge, innovation and practice in the global search for solutions and strategies for climate change [2]. So far, there are few references to indigenous peoples' contingency strategies based on traditional knowledge in the relevant literature on climate change. However, their contributions must not be underestimated. First of all, they are most vulnerable to the negative impacts of climate change, thus accumulating to some adaptive experience. In addition to that, based on their traditional knowledge and related technology and methods, they have realized their strong creativity in interpreting and responding to climate change [6].

Indigenous peoples account for only 4% of the world's population, but most of the biodiversity rich regions of the world are owned, lived and managed by them: they account for only 22% of the global land area [11]. Indigenous peoples are rich in biodiversity and cultural diversity, but they are also often vulnerable to climate change. But at the same time, the vast majority of them are in the pre-industrial society, relying mainly on agricultural products for their survival, closely related to the natural environment, the most direct and sensitive affected by climate change, so the traditional knowledge about climate change is also rich and diverse.

2. Methodology

We reviewed academic papers and online resources for definitions of traditional knowledge associated to biodiversity in the context of climate change. We also reviewed the reports of International and Regional Organizations (UNDP, UNEP, UNFCCC, EU, APN, ILO, IIPFCC etc.) about the traditional knowledge as an agent for local community in the process of climate change adaption. In addition to that, we used the references from these articles and reports obtained by this method to check for additional relevant material. Selected areas were chosen as examples to demonstrate the role and value of traditional knowledge in climate change adaption, which was supported by reviewing the relevant literature for each.

2.1. Traditional Knowledge and Climate Change

Nowadays, human society is facing more and more pressure in many fields such as environmental natural resources and development. With the emergence of climate change, food security, the disappearance of biodiversity resources and environmental degradation are happening now and again. In order to solve these problem through the use of modern scientific and technical knowledge for the health and sustainable development of human society, peoples have also put their eyes on the "traditional knowledge". Traditional knowledge has been paid more and more attention in practice, the use this traditional knowledge will close the gap of the scientific and technical knowledge so that to achieve the environmental protection, the use of biodiversity resources, natural resources management and livelihood sustainable development and other purposes.

Traditional knowledge has different terms according to different focuses and different application backgrounds. In terms of practical technology, it is referred to "knowledge", such as Traditional Knowledge, Traditional Ecological Knowledge, Indigenous Knowledge and Local Knowledge; focusing on cultural aspects, it is so-called Indigenous Heritage and Intangible.

Some scholars define the traditional knowledge from the owner and value, it is considered that traditional knowledge is collectively owned by indigenous or local communities under the influence of society and environment. And Traditional knowledge is a knowledge, innovation, and practice closely related to traditional resources and territory, local economy, genes, species and ecosystem diversity, cultural and spiritual values, and traditional laws [12]. Some believe that traditional knowledge is a process, rather than a content, which should be studied. Scholars have wasted too much time in debating science and traditional knowledge, and should carry out dialogue and cooperation between science and traditional knowledge [13].

The impact of climate change is not only reflected in natural phenomena, such as temperature change, precipitation, sea level rise and extreme climate, but also in the ecological, social and economic aspects. Similarly, how people respond to the impact of climate change is not only related to climate change itself, but also to the ecological, social and economic environment in which they are located [14]. The adaptability of people to climate change depends on many factors, including all kinds of effective resources in environmental change [13]. Therefore, climate change is like a "social ecosystem". In this system, factors from different fields interact on different spatial and temporal scales [16]. If we rely solely on Natural Science, the social ecosystem cannot be fully understood [17]. It is not only because these systems are rather complex and have great uncertainties that it is impossible to build enough through models [18]. And this social ecosystem is intricate with people's preferences and decisions.

In this context, traditional knowledge can enhance people's understanding of climate change and its impacts. Compared with the empirical science that is outside the system and does not give its influence, and adopts to maintain a neutral observer, the observation of the local people is formed in the local culture and social environment, and has a very important influence on the change of the local environment [19]. In addition, the observation of locals often comes from their environment, practice and experience, which is precisely what is lacking in scientific research and models [20]. And traditional knowledge is a kind of technology, and based on this technology, it can find solutions to the impact of climate change. This technology will help human society to respond more fully to the changes that are happening and coming soon, thus achieving sustainable development [9]. Therefore, local traditional knowledge can make a valuable contribution to better understanding the calamities of the climate change, and can provide local information that is often ignored by science in order to amend the empirical research on climate change.

Traditional knowledge about climate change is very important, because this knowledge reflects the local people's understanding of the impact of climate change, traditional knowledge is based on local environmental conditions and phenomena, and cannot be simulated and evaluated by scientific models [21]. In addition to that, traditional knowledge affects local people's decision to respond to climate change at two levels: First, the possibility of taking measures and secondly, taking different adaptation measures for short-term and long-term impacts [22]. Therefore, traditional knowledge should be taken into consideration in the process of understanding, adaptation and mitigation of climate change and its impacts.

At the same time, the ultimate impact of climate change lies on the culture of indigenous peoples. Changes in traditional knowledge directly affect the continuity of culture and the rights of indigenous peoples [23]. To the indigenous people, Climate change is a cultural issue, because as climate change worsens, more and more intimate relationships between people and the environment will gradually vanish, and these relationships are an important part of the world's cultural diversity.

For indigenous peoples, climate change is not a coming or future event, but a critical reality that they are trying to understand, communicate and respond to. The impact of climate change is not only the adaptation and resilience of indigenous peoples, but also it leads to the migration of human beings, animal and endangered of some species of certain plants populations. By the way, there is a close relationship between the indigenous peoples and the natural environment, which not only forms the basic and rich worldviews of the indigenous peoples, but also includes their management and maintenance of the local natural environment. So such migration, both current and future, means the loss of the close relationship between indigenous peoples and the natural environment. In many cases, migration will lead to the loss of animal and plant totems, including the mythological and phonological symbols of indigenous peoples, and even the core parts of their culture.

The existence of human beings runs through the time and space of social development, and the communication of society is accomplished through the words, language and symbols of human beings, then people need to address the extent to which climate change will change these spaces, symbols and positions [24]. Climate change will lead to a large loss of traditional knowledge, worldviews and cosmos of the indigenous peoples, also their interaction with the environment, which are the core of culture. Therefore, we need to pay much attention to the impact of climate change on culture.

2.2. Traditional Knowledge's Perception

Although climate models can make the macro scenes of climate change and estimate the different trends and consequences of human future development, this model cannot provide accurate information for regional climate change. In recent years, more and more people have realized

that the traditional knowledge of indigenous peoples is the precious source of this information. From Polar Regions to Highlands, Islands to deserts, rainforests to mountains, the indigenous peoples of these regions have noticed the phenomenon of climate change. The perception on climate change of indigenous peoples is an important part of their traditional knowledge.

Indigenous peoples are mainly aware of climate change from temperature, rain and snow, season and phenology, strong and devastating winds, huge waves and strong storms, annual climate, melting of glaciers and reduction of snow covers, ice, drying of rivers and lakes, and disappearing of some species [2]. The perception of climate change by indigenous peoples living in Northeastern Siberia includes more warm winter with snowfall and more cold summer with more rain [25]. The Inuit people inhabited by the Arctic region of Canada have observed the great disappearance of sea ice [26]. The mountain inhabitants of the Swiss Alps see the glacier disappear year after year [27]. In Bangladesh, the perception of climate change of the peoples living in the delta area includes changes in sea level and floods [28]. The Native American in the Columbia valley of the Northwest of the United States observe climate change from the changes of main species and ecological environment in the rivers of Columbia [29]. People living on the Pacific islands have observed changes in climate from rising sea levels and island inundation [30]. Peasants living in the Andes of Peru recognize climate change through water scarcity and rapid melting of glaciers [31]. In the South Pacific island countries, people's perception of climate change includes sea level rise, sea area expansion, subsurface temperature, sea water acid, coral whitening, coastal erosion, heavy rainfall, seasonal rainfall, extreme climate disaster and drought [32]. In Botswana, people have observed natural phenomena such as water shortage, uncertainty of seasonal changes, and they do not fully agree with climate warming, because some areas are getting colder [33]. In Yunnan province of China, the Tibetans' perceptions of climate change include extreme temperatures, snowfall, glacial atrophy, rainfall and snowfall, and snow disasters [2]. These are very similar to the local knowledge and local interpretations of climate change of the mountain peoples in Himalaya, northwest India [34].

Climate change also has an impact on the traditional livelihoods and related knowledge of indigenous peoples. The indigenous peoples in Northeastern Siberia believe that the climate is becoming more and more difficult to understand and the harvest season has changed. The feed for horses and cattle is becoming increasingly difficult to find [25]. The massive disappearance of sea ice has affected the Inuit people's travel, hunting and other livelihoods in the Arctic region of Canada [26]. In the northwest of Yunnan province of China, agro-pastoralist is the traditional livelihood of local Tibetans. The perception of the climate and phenology occupies an important position in the traditional Tibetan knowledge. Changes in the farming calendar caused by climate change have affected Tibetan traditional livelihoods [35].

2.3. Traditional Knowledge's Adaption

Indigenous peoples not only observe climate change, but also actively adapt to this change. Different indigenous peoples have different observations on climate change, so the ways they use to mitigate the negative effects of climate change and the ability to adapt to climate change are different [23]. As climate change becomes more and more obvious, indigenous peoples all over the world adapt to and respond to this change based on their traditional knowledge.

The adaptation of traditional knowledge to climate change includes the following aspects: diversity of resources, variety and innovation of crop varieties, adjustment of time of livelihood activities, changes in production technology, change of production position, change of life style, exchange among communities, resource management, etc.

People living on the Pacific Islands have begun to use traditional environmental knowledge to adapt to the effects of climate change. These Island residents try not to build houses in low-lying areas, and start to add four pillars to the new house to keep it away from the ground, [36]. Indigenous peoples in Botswana respond to climate change through diversification of their livelihoods, water resources management techniques and mutual assistance between communities [33]. In Inner Mongolia, China, Mongolian herdsman adopt flexible migration to maximize the use of environmental resources in the most suitable climate season, it not only promoted the cyclic utilization of grassland, but also developed animal husbandry. It includes coping with climate change in different time and space, selecting livestock to adapt to climate change and coping with extreme climate. Traditional knowledge is also an innovative process. In Yunnan province of China, the Tibetans adapt to climate change through the diversity and innovation of their livelihoods, including Tibetan medicine planting and ecotourism [37].

Indigenous peoples' traditional knowledge also can play an important role in reducing climate risks and coping with climate crises. The practice and traditional knowledge that the indigenous peoples have accumulated over the generations to deal with the risk crisis of environment and climate change is an important basis for the formulation of climate change adaptation strategies. The traditional knowledge of adaptation to climate change includes informal education in daily life, prevention and preparation of disasters, seasonal migration, and diversity of livelihoods, community collective response, product exchange and traditional technology. Informal education refers to inheriting the traditional knowledge of resources and environmental management through stories, songs, proverbs and poetry. The prevention and preparation of disasters refers to the various activities and measures taken to respond effectively to climate risk, including buildings adapted to the mountain environment, the storage of grain, the safe preservation of seeds, early warning, the spread of disaster information, and the temporary evacuation of people and property from dangerous areas.

3. Results and Discussion

3.1. Traditional Knowledge Related to Climate and Climate Change

Indigenous peoples are familiar but also inexperienced to climate change: they are familiar with climate change because they live in complex and changeable climatic conditions for generations, thus forming rich and diverse traditional knowledge; they are unfamiliar with climate change because the instability of climate change and the risk of extreme climate disasters are intensifying and improving over the past thirty years, and it also made indigenous peoples' traditional knowledge of climate fail and change.

But this does not reduce the value of traditional knowledge, because traditional knowledge is not only a knowledge based on climate change phenomena formed by local people, but also a process of understanding and forming such knowledge. Therefore, in addition to the original accumulation, traditional knowledge has strong vitality and adaptability in the process of constantly updating, innovating and developing. In addition, traditional knowledge is not inconsistent with meteorological change data and models, on the contrary, the two can complement and combine each other to form a more comprehensive and detailed understanding of climate change and extreme climate disasters, especially for a certain local and specific region.

At present, the scientific models and measurements of climate change are developing and becoming more detailed and accurate. However, models and other scientific instruments are not enough to fully understand or solve complex problems such as climate change. Because climate change is not a purely physical or environmental issue, but it also affects economic, social, cultural and spiritual aspects. Traditional knowledge is based on the culture of indigenous peoples and the local natural environment, this knowledge system is of great significance to the study of climate change and extreme climate phenomena in local areas. Although it cannot replace scientific measurement and model, it is a necessary supplement. Traditional knowledge can observe how climate change is presented in local areas, and how to deal with the problems and challenges arising from such changes. Traditional knowledge can complement the areas that may be neglected in the scientific research of climate change, and help to formulate new hypotheses and research questions. Traditional knowledge affects the way of indigenous peoples cope with climate change, these ways are often effective choices according to local conditions. The livelihoods of indigenous peoples often depend heavily on factors such as climate, environment and natural resources. Climate change and extreme climate catastrophes not only change the environment, but also change resources, these changes have and will bring more and more risks and threats to the livelihood, and the adaptation strategy based on traditional knowledge can improve the safety of livelihood to a certain extent.

3.2. Traditional Knowledge and Adaptation to Climate Change

In the face of the challenges of climate change and extreme climate disasters, the most direct, effective and minimum cost adaptation methods and strategies adopted by indigenous peoples are often based on their traditional knowledge. Like environment and natural resources, traditional knowledge is also a resource that indigenous peoples can rely on to enhance their resilience to climate change and extreme climate disasters.

Today, however, many indigenous peoples have felt the limitations of traditional knowledge adapting to climate change as it is pointed out as follows:

First, because of the variability of climate, only their traditional knowledge and coping strategies can no longer be fully adapted to the intensity and frequency of the present climate change, and the method of forecasting the weather and climate based on traditional knowledge has become more and more inaccurate.

Secondly, the adaptation methods based on traditional knowledge are often derived from community discussion, observation and daily life, rather than a formal, long-term and planned process, so it is difficult to record and disseminate these practical experiences.

Third, in the process of adapting to climate change, because they are often limited by resources and ability, they can only participate in direct and emergency short-term adaptation strategies, but they need a more active and preventive long term adaptation strategy.

Fourth, indigenous peoples often lack the support of relevant climate policies, initiatives, technology and funds to cope with climate change, while many legal and institutional obstacles impede their response to climate change and possible solutions.

4. Conclusion

There are two key points in the research of traditional knowledge and climate change: First, traditional knowledge is not a static and closed system, but a dynamic and developing process of change and innovation. In this process, we can integrate other cultures, including scientific knowledge, and create a new culture; secondly, science and traditional knowledge are not antagonistic. The future human social development should be based on the integration and innovation of multiculturalism, so as to find the way of human sustainable development.

With the frequent occurrence of climate change and extreme climate disasters, as well as the rapid development of politics, economy and society, it is unrealistic for indigenous peoples to rely solely on traditional knowledge to adapt to climate change. It is necessary to seek policy and scientific support and assistance. At present, whether it is international or national, the policy of coping with climate change is always a macro decision and top-down train of thought. In indigenous peoples' communities, such policies need to be combined with

local specific conditions and circumstances to achieve effective implementation and positive results. The traditional knowledge of indigenous peoples can become a platform for "landing" of macro climate policy and become a useful and necessary supplement in the implementation process.

The traditional knowledge of indigenous peoples is a complex and relatively loose aggregate in a sense, because the living environment, age, occupation and gender of knowledge owners are different, therefore, even in the same area or even the same village, the traditional knowledge of indigenous peoples is different. Therefore, in the process of adapting to climate change, indigenous peoples should not only pay attention to the characteristics and potential of traditional knowledge themselves, but also to combine traditional knowledge with climate policies, modern science and technology to enhance the effectiveness of adaptation strategies. The integrated adaptation strategy based on the development and innovation of traditional knowledge can make indigenous peoples better adapt to climate change.

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