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The Impacts of Climate Change on the Traditional Agriculture of Ethnic Minority in China

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Abstract: Climate change is affecting the IPLCs (Indigenous Peoples and Local Communities) around the world, including ethnic minorities in China, especially from agriculture, animal husbandry, hunting and gathering, which are their main source of livelihoods. At the same time, IPLCs have rich traditional knowledge related to climate and its disasters, especially in their livelihoods. This review work examines the research about traditional knowledge associated to livelihood in monitoring and adapting to changing climatic conditions in ethnic minorities in China. Authors reviewed the research papers and monographs on the traditional agricultural livelihood of ethnic minorities in China, and divided different agricultural types on the basis of literature review. At the same time, authors focused on reviewing the traditional knowledge formed by ethnic minorities in the agriculture, especially the traditional knowledge related to weather and climate information. In authors' findings authors realized that ethnic minorities are the practitioners of traditional agricultural practices. Their observation and perception come from real life and may not be "scientific", but they directly reflect the impact of climate change on local livelihoods and contain wisdom to adapt to climate change. Ethnic minorities not only observe and perceive climate change, but also actively adapt to the impact of climate change on traditional livelihoods. In the process of adaptation, traditional knowledge plays a key role. This paper highlights how traditional knowledge can improve understanding of the influence of climate change on livelihood, and provide ideas to develop an equitable and effective plan to adapt the climate change. For the IPLCs, compared with the externally driven adaption options, they are more willing to take the community-based plan, because such plans will enable them to apply their traditional knowledge according to the geographical location and environment of their areas, so that their actions to adapt to climate change will be more effective.

Key words: Adaption, traditional agriculture, climate change, ethnic minorities.

1. Introduction

Global climate change has had an increasingly serious impact on the IPLCs (Indigenous Peoples and Local Communities) around the world, especially in agriculture, animal husbandry, hunting and gathering, which are their traditional livelihoods. At the same time, there is an interactive relationship between climate change and the traditional livelihood of IPLCs.

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Climate affects traditional livelihoods of IPLCs such as farming and animal husbandry. Carbon dioxide, soil and air temperature, rainfall and soil variation will affect the growth and development of crops. For animal husbandry, climate change can lead to changes in pastures, forage and feed, and extreme climate phenomena can affect the health of livestock, such as heat waves that can kill poultry and reduce milk production of cows. Similarly, climate change affects the distribution of livestock pests and diseases [1]. The Saka people in northeast Siberia think the climate is becoming more and more difficult to understand, their harvesting season has changed, and

the feed for horses and cattle is becoming more and more difficult to find [2]. The loss of sea ice has affected the travel, hunting and other livelihood of Inuit people in the Arctic of Canada [3]. Floods, storms and other extreme weather phenomenon have caused great damage to the agricultural production of Bangladeshi people living in the Delta [4]. In summary, climate change has had a serious impact on the traditional livelihoods of IPLCs, most of which are negative.

For a long time, IPLCs' traditional ways of livelihood and their ecosystems, especially forest ecosystems, have played an important role in global climate stability. However, in recent years, with the traditional livelihoods of IPLCs not being properly treated, governments, agricultural companies and large farmers often believe that these traditional livelihoods are of no economic value and hinder economic development, so they force IPLCs to give up traditional livelihoods and change the ecosystem to develop modern agriculture, for example, what happened recently in the Amazon rainforest of Brazil Fire. Forest, grassland and soil can absorb a lot of carbon dioxide, but the area has been greatly reduced and become modern agricultural land. What is more, modern agriculture relies on fossil fuel energy and emits greenhouse gases, which is the second largest source of carbon dioxide emissions after fossil fuel use, accounting for 10%-30% of global carbon dioxide emissions [5]. Therefore, the decline of IPLCs' traditional livelihoods will also affect global climate change.

In China, there are 53 officially recognized ethnic minorities, most of them are distributed in complex, diverse and fragile natural environment and ecosystem, so the traditional livelihood of ethnic minorities is more significantly affected by climate change and its disasters. Like the IPLCs around the world, climate change and extreme climate disasters pose a serious threat to the traditional livelihood of ethnic minorities, and bring great risks and challenges. At the same time, ethnic minorities have rich traditional knowledge related to climate and its disasters. Tujia people living in Wuling mountain area of Hunan, Hubei, Chongqing and Guizhou Province have three kinds of agricultural proverbs: solar term type, seasonal type and phenology type [6]. In the process of coping with mountain climate, Dong people in Hubei Province, constantly improve their understanding of climate change, adjust their farming and lifestyle, and create relevant folk culture [7]. In recent years, climate change has also had an impact on the traditional knowledge. The traditional livelihood of Bai people living in Dali area of Yunnan Province is farming. The Bai people have rich traditional knowledge of calendar and astronomical cognition. The changes of lunar calendar and solar terms brought about by climate change make the Bai people's traditional knowledge no longer accurate or even invalid [8].

The traditional livelihoods of ethnic minorities are diverse, mainly including agriculture and nomadism, as well as hunting, fishing and gathering. In the past 30 years, nomadism and hunting have been abandoned due to the policy of herdsmen settlement and the law of hunting prohibition formulated and implemented by the state. Ethnic minorities who used to make their living mainly by nomadism and hunting have turned to agriculture.

Therefore, in the above context, this paper chooses agriculture as the representative of traditional livelihood, discusses the impact of climate change on the livelihood of ethnic minorities in China, and studies show traditional knowledge can cope with the risks and challenges brought by climate change.

2. Material and Methods

Authors reviewed the research papers and monographs on the traditional agricultural livelihood of ethnic minorities in China, but there are few researches in this field, the relevant literature is limited, so authors also conduct field research. And authors divided different agricultural types on the basis of literature review. At the same time, authors

focused on reviewing the traditional knowledge formed by ethnic minorities in the agriculture, especially the traditional knowledge related to weather and climate. On the basis of literature review, authors have also carried out field investigation on some cases, such as agro-pastoralism of Tibetan, shifting agriculture of Wa and Jino peoples, etc..

3. Procedure for Selecting the Best Model

Through literature review and field research, our research hypothesis is: first, in the context of climate change, whether the traditional livelihood of ethnic minorities has changed; second, in ethnic minority communities, whether local strategies and solutions based on traditional knowledge can be formed to adapt to climate change.

4. Applications

4.1 Traditional Types of Agriculture

Ethnic minorities have a long history in agriculture. At the same time, due to different living environment and ecosystem, ethnic minorities have formed different types of agriculture. This paper divides the traditional agriculture of ethnic minorities into five types (Table 1).

4.2 Shifting Agriculture

According to historical documents, shifting agriculture has a long history in China, and used to be the main livelihood for many ethnic groups. Today, shifting agriculture is only common among the mountain ethnic groups in Yunnan Province, WA, Jingpo, Bulang, Jinuo and Dulong ethnic groups are engaged in or part of shifting agriculture [8].

In Yunnan Province, there are two main environmental reasons for the survival of shifting agriculture: First of all, at present, the area of shifting agriculture is subtropical and tropical, with warm or hot climate, controlled by southeast and southwest monsoon zone, adequate rainfall and abundant forest biological resources. Such geographical and climatic environment provides a good ecological basis for the local people to engage in shifting agriculture. Secondly, the areas practicing shifting agriculture are mostly mountainous areas, with small basins and river valleys. The mountainous terrain is complex and steep, so it is difficult to build irrigation system. In the same area, the temperature difference is large, the temperature is low in high mountains, and the water is cold [9]. Therefore, it is difficult to cultivate paddy field in these places, and only shifting agriculture can be practiced.

4.3 Terraced Agriculture

Terraced agriculture is mainly distributed in Yunnan, Guangxi, Guizhou, Sichuan and other provinces in Southwest China, and also in Hunan, Zhejiang and other provinces. The ethnic minorities mainly engaged in terraced agriculture include Hani, Miao, Yao, Zhuang, She and Dong. Among them, Hani in Yunnan has the largest scale of terraced agriculture, and is also the most famous, which is rated as the world cultural heritage by UNESCO (United Nations Educational, Scientific and Cultural Organization).

Table 1 Traditional types of agriculture.

Types	Ethnic minorities	Location (province)	Climate condition	Altitude (m)
Shifting agriculture	Wa, Jinuo, Jingpo, Bulang, Dulong	Yunnan	Warm, humid	1,200-2,000
Terraced agriculture	Hani, Miao, Yao, Zhuang, She, Dong	Yunnan, Guizhou, Guangxi, Zhejiang	Warm, temperature difference changes greatly	120-3,000
Paddy field agriculture	Dai, Dong	Yunnan, Guizhou, Guangxi	Sweltering, humid	80-600
Oasis agriculture	Uygur	Xijiang	Sweltering, dry	30-1,200
Agro-pastoralism	Tibetan	Yunnan, Sichuan, Tibet, Qinghai, Gansu	Cold, temperature difference changes greatly	1,900-4,000

For Hani, terraced agriculture is closely related to the local environment. This is a subtropical monsoon climate area, but due to the large altitude difference, the vertical climate change is obvious. The valley area is extremely hot and dry, while the mountain area has low temperature and more precipitation. Hani people live in a mountainous area with an altitude of 1,400-2,000 m [10]. The climate is mild and the rainfall is abundant. The vegetation is between deciduous broad-leaved forest and evergreen broad-leaved forest, which is very suitable for rice planting [11]. Therefore, Hani people in Yunnan Province have formed the most centralized and largest terrace agriculture in China.

4.4 Paddy Field Agriculture

Ethnic minorities living in basins and river valleys at low altitudes are engaged in paddy field farming, such as Dong, Dai, etc.. Most of these ethnic groups are located in Southwest China, especially in Guangxi, Guizhou and Yunnan. A large numbers of glutinous rice varieties have been preserved in the paddy fields of ethnic minorities, forming a rich agricultural biodiversity.

The area that can be engaged in paddy field agriculture is between 100 m and 600 m above sea level, with flat terrain, abundant rainfall, crisscross rivers, hot and humid temperature, which have the environmental basis for rice planting. While planting rice, Dong people in Guizhou also raise fish and ducks in paddy fields. This "rice-fish-duck" symbiotic system is not a single farming, but a compound livelihood system based on paddy field agriculture [12, 13]. In China, this unique composite livelihood system has been selected as agricultural cultural heritage.

4.5 Oasis Agriculture

Oasis agriculture is mainly distributed in the south of Xinjiang. According to the investigation of archaeological sites, more than 4,000 years ago, human beings carried out agricultural production in this area. In the Han Dynasty more than 2,000 years ago, based on oasis agriculture, local people formed many small city states [14, 15]. Today, Uygur people continue to engage in oasis agriculture here.

The oasis agriculture of Uygur is mainly distributed between 30 m and 1,200 m above sea level, from mountain basin to alluvial plain. Because of the great difference in altitude, the complex terrain, and the great difference in climate change in various regions, different farming systems are formed and a variety of crop species are cultivated. The main crops are wheat, barley, corn, rice, chestnut, sorghum, soybean, and millet [16, 17]. Oasis agriculture is closely related to the local topography and rivers. After the melting of glaciers and snow on the snow mountain, countless rivers formed, and the rivers flowed down to the desert area at the foot of the mountain, after encountering the dry and high temperature desert, the water is gradually absorbed and evaporated, and finally the river gradually disappears and forms an oasis in the desert, which is the basis of oasis agriculture.

4.6 Agro-Pastoralism

Agro-pastoralism is important to Tibetan people in North-West Yunnan, Eastern Himalayas in China, as a way of livelihood, and also biodiversity resource management and culture to them. Relating to the system of agro-pastoralism, agriculture and herding are mutually dependent on each other. Firstly, both agriculture and herding are important livelihood to Tibetan people. They provide basic and necessary food to local people. Secondly, while herding livestock provides necessary manure for crops, crop straw also provides important fodder to livestock. Additionally, after harvest farmland can become grazing land for herding during winter season [18].

Tibetan people mainly raise yak, cattle yak, yellow cattle and goat for animal husbandry. Usually they herd animals according to different seasons and physical locations, and classify the herding into three

types: summer grazing land (summer alpine pasture), spring-autumn interim grazing land, and winter grazing land. In Tibetan language, local people call summer grazing land as "Ru La", which means grassland covered by snow. Its altitude is around 4,000 m and refers to alpine meadow. At the same time, local people call spring-autumn interim grazing land as "Ru Mei", which means grassland locating at middle altitude. Its altitude is around 3,000 m and refers to meadow and sloping land. Finally, they call winter grazing land as "Ru Bo", which means grassland locating nearby villagers' houses. Its altitude is around 2,000 m and refers to sloping land nearby the village. While villagers herd yak at alpine pasture and goats at winter grazing land respectively, they will herd cattle yak and yellow cattle regularly among three grazing lands. Every year during March and April villagers will change the grazing land for cattle yak and yellow cattle from winter grazing land to spring interim grazing land. From May to July, they will herd them at summer alpine pasture. During August they will herd at autumn interim grazing land, and from September to February they will herd cattle yak and yellow cattle at winter grazing land [19].

4.7 Traditional Knowledge of Agriculture

Different forms of agriculture are closely related to the local environment, including climate. Climate conditions are also one of the important reasons for the formation of different forms of agriculture. On the contrary, through long-term practice, ethnic minorities have formed traditional knowledge related to agriculture, especially traditional knowledge of water, forest, weather and climate.

4.8 Phenological Calendar of Shifting Agriculture

Like all agriculture, shifting agriculture is closely related to climate, and more dependent on seasonal and climate change. Most of the ethnic minorities engaged in shifting agriculture in Southwest China have no writing, few written records of climate and phenology, and no written calendar. Phenological calendar is the division of seasons, which defines the seasonal rhythm of shifting agriculture in a year, and forms a series of farming etiquette. For example, in the phenological calendar of shifting agriculture, the most important thing is to control the time of cutting trees, burning land and sowing, thus forming the relevant farming etiquette [20]. Therefore, for these ethnic minorities, the production process of shifting agriculture is determined by the phenological calendar of the specified season, and the cycle and change of phenological calendar are marked by farming etiquette.

4.9 Customary Law of Terraced Agriculture

The most remarkable feature of terraced agriculture is to make full and effective use of water resources by using the stereoscopic climate, landform and the natural environment characteristics of "how high the mountain is, how high the water is". Water resources are the foundation of terrace agriculture. Therefore, the ethnic minorities have formed the customary law of water resource management, which has become an important part of their traditional knowledge [21, 22]. For example, in the terrace agriculture of Hani people, there are very strict water resource management customary laws. These customary laws include the distribution of water resources, the protection of water forest, and the punishment of water stealing and the maintenance of irrigation channels [23]. Under the constraints of customary law, the ecosystem on which terraced agriculture depends has been protected, especially the forest and water resources; on the contrary, a good ecosystem also enhances the flexibility of terraced agriculture to cope with climate change and its disasters. For example, from 2009 to 2012, Yunnan province suffered a serious drought in succession, and agriculture suffered a huge blow and loss, only the Hani terraced agriculture was not affected.

4.10 Technology of Paddy Field Agriculture

In paddy field agriculture, ethnic minorities have formed the traditional technology of changing and adjusting local climate. When Dong people is engaged in paddy field agriculture, because the irrigation water for paddy field in high altitude area mostly comes from underground well water and spring water, the water temperature is relatively low. In order to improve the water temperature, Dong people often build a ditch from the water source to guide the well water or spring water to flow around the paddy field along the ditch, and then flows into the paddy field. In addition to the construction of ditches, the Dong people will set aside a special paddy field for well water or spring water to flow through before entering the paddy field for rice planting [24-26]. After the long-distance circular flow of well water or spring water from the underground through ditches and special paddy fields, the water temperature will be improved when it finally flows into the paddy field through the sun and the surface temperature, which is conducive to the growth of rice [27]. Other ethnic minorities have similar traditional technologies, because many paddy fields are located in the plateau area, the altitude difference is large, and the surrounding forest is covered, in order to engage in paddy field agriculture in such an environment, it is necessary to overcome the adverse climate environment such as short sunshine, low water temperature and temperature, cold dew, etc. In the face of these unfavorable factors, during the long-term process of engaging in paddy field agriculture, ethnic minorities have formed the traditional technology that can adapt to the local climate and environment actively through the accumulation of generations of experience and knowledge.

4.11 Water Conservancy Project of Oasis Agriculture

Because it is located in the desert area, the most important thing for oasis agriculture is to ensure that there are sufficient water resources for irrigation. In this context, the Uygur people invented the Karez water conservancy project through the accumulation of generations of experience and traditional knowledge. Karez is divided into two parts: underground channel and over ground channel, and the underground channel is the main part. The maximum length of the underground trench can reach 14 km, and the minimum length is about 3 km. There is a vertical well every 10 to 30 m, which is directly connected to the ground by the underground trench, the deepest vertical well is 60 to 80 m. The underground channel rises gradually, and finally it is exposed to the ground and becomes the over ground channel [28, 29]. According to the earliest written records, Karez has a history of 180 years and is a great innovation and invention of Uygur traditional knowledge. As a water conservancy project, Karez has a strict management system, including its own maintenance and distribution of water resources. Karez is of great significance to oasis agriculture in water shortage area, and it is the guarantee of sustainable development of local agriculture [30, 31].

4.12 Resource Utilization Mode of Agro-Pastoralism

In the agro-pastoralism, Tibetan people mainly raise yak, cattle yak, yellow cattle and goat for animal husbandry. Usually they herd animals according to different seasons and locations, and classify the pastureland into three types: summer grazing land (summer alpine pasture), spring-autumn interim grazing land, and winter grazing land. In Tibetan language, local people call summer pastureland as “Ru La”, which means grassland covered by snow. Its altitude is around 4,000 m and refers to alpine meadow. At the same time, local people call spring-autumn interim pastureland as “Ru Mei”, which means grassland locating at middle altitude. Its altitude is around 3,000 m and refers to meadow and sloping land. Finally, they call winter pastureland as “Ru Bo”, which means grassland locating nearby villagers’ houses. Its altitude is around 2,000 m and

refers to sloping land nearby the village. While villagers herd yak at alpine pasture and goats at winter pastureland respectively, they will herd cattle yak and yellow cattle regularly among three pasturelands. Every year during March and April villagers they will change the pastureland for cattle yak and yellow cattle from winter pastureland to spring interim pastureland. From May to July, they will herd them at summer alpine pastureland. During August they will herd at autumn interim pastureland, and from September to February they will herd cattle yak and yellow cattle at winter pastureland [32]. Through the utilization of different pasturelands, animal husbandry adapts to the local climate and seasonal changes, and uses and protects the forage resources most effectively.

5. Discussion

At present, there are many academic researches on the impact of climate change on agriculture, including traditional agriculture of ethnic minorities, which rely on data, models and formulas to draw relatively objective and scientific conclusions. However, for the traditional agriculture of ethnic minorities, their traditional knowledge, especially their perception of climate change, has not been given due attention.

Ethnic minorities are the practitioners of traditional agriculture. Their observation and perception come from real life and may not be "scientific", but they directly reflect the impact of climate change on local livelihoods and contain wisdom to adapt to climate change.

5.1 Local Perceptions on Impact of Climate Change to Agriculture

When climate change has an impact on traditional livelihoods, ethnic minorities have their own observation and perception of these impacts. The perception of ethnic minorities on climate change is multi-faceted, which is not only limited to the climate field, but also includes the phenology of natural environment and livelihood, that is to say, the observation of climate and phenology change forms the perception of ethnic minorities on climate change. So, this perception mainly includes two aspects: climate and phenology. Taking the temperature rise as an example, in addition to intuitively feeling it, ethnic minorities also observed the temperature rise from the change of glaciers, the increase of crop diseases and insect pests and other natural environment and livelihood changes. For climate instability, in addition to direct experience, ethnic minorities also observed this kind of unstable climate phenomenon from the changes of climate disasters such as avalanches, lunar calendar and crop growth cycle.

Local perceptions on impact of climate factors on agriculture include temperature rise, climate instability and extreme weather disasters. Based on their traditional livelihoods, most of the perceptions of ethnic minorities on the impact of climate change are negative, and climate change has brought threats and challenges to their agriculture.

For Dai People's paddy field agriculture, due to the rising temperature and the accompanying drought, the output of some traditional rice varieties that are not resistant to high temperature and drought has decreased, so that they are gradually eliminated by local farmers in the process of seed selection, which is the loss of agricultural biodiversity. The increase of temperature has affected the Tibetan animal husbandry. The early maturity of forage, the decrease of forage yield at high altitude, the degradation of pasture, the increase of diseases and insect pests and other phenomena make the livestock breeding face more challenges.

Climate instability makes the Jino people's farming calendar invalid, and changes the whole process of shifting agriculture production process and farming etiquette. At the same time, unstable precipitation also affects the growth of crops, making the grain harvest reduced. For Hani people's terraced agriculture, climate instability not only brings some challenges to water supply resources, but also leads to the increase

of crop diseases and insect pests, and sudden cooling also leads to crop freezing in high altitude areas.

The extreme climate disasters caused by the climate instability such as heavy rainfall and continuous high temperature bring great risks to traditional agriculture. For Wa people, floods caused by heavy rainfall will completely destroy the shifting agriculture's fields on the hillside. As in history, the continuous drought will severely hit the Uyghur oasis agriculture, not only reducing its output, but also making it wasteful. However, heavy snowfall, drought, debris flow, landslide and other disasters will also cause huge losses to Tibetan Alpine agriculture.

But at the same time, with the rise of temperature, ethnic minorities also feel some positive and beneficial effects. For example, for oasis agriculture, Uighur farmers have observed that due to the climate warming and the increase of precipitation they have improved the advantages of agricultural climate resources in some regions, making the sowing date of crops earlier, the autumn frost period later, the total growth period longer, and the yield per unit area increased, which is conducive to agricultural production to a certain extent. For agro-pastoralism, Tibetan farmers have observed that due to the rising temperature, they can now grow some crops that were previously unable to survive due to the cold climate.

Ethnic minorities believe that the perception of climate change is causal. These perceptions cannot be divided into temperature, rainfall, natural environment and livelihood independently, but are related to each other. It can also be said that one perception leads to another perception. For example, the change of snow and glaciers causes the instability and abnormality of water flow in rivers, which in turn directly leads to the change of crop yield, quality and growth environment while the rising temperature provides a hotbed for the invasion and reproduction of some alien organisms, which in turn directly leads to the frequent occurrence of livestock diseases and the emergence of new diseases.

The observation and perception related to climate change of ethnic minorities include sound, vision, touch and smell, etc., so as to obtain current and future information about clouds, temperature, humidity, wind, rain and other weather. Ethnic minorities usually use the culture, belief and experience related to weather or climate to explain such perceptual information, which plays an important role in arranging the time of agricultural activities and coping with the threat of extreme weather.

The observation and perception of climate change by ethnic minorities are closely related to their living environment. Ethnic minorities often observe climate change based on the surrounding environment. Traditional livelihoods show that even in a small geographical area, the perception differences brought by climate change to local ethnic minorities may be very large, which is caused by the differences in three-dimensional climate and geographical environment, as well as the differences in age, gender and family planning activities. The observation of climate change by ethnic minorities is often closely related to their gender, age, livelihood activities and living environment. Different factors will lead to different perceptions of climate change. For example, for long-term climate change, older people have more perception, knowledge and experience than younger people. However, for extreme weather disasters, there is no correlation with age, because even the relatively young respondents between 30 and 40 years old perceive and observe such phenomena as the instability of climate change, the change range of climate deviating from the normal year and the frequency of extreme weather disasters.

Gender is also an important factor affecting the observation and perception of climate change by ethnic minorities. For example, in Dai people's paddy field agriculture, men and women have different roles and responsibilities, resulting in different observation and perception of climate change. In the agro-pastoralism of Tibetan peoples, women tend to

be more sensitive to the climate change in villages and nearby villages, because they mainly live in villages and engage in production activities near villages while some men need to live and graze in different alpine pastures because they are engaged in animal husbandry, so they are more familiar with the phenomenon of climate change in high-altitude areas.

To sum up, the observation and perception of climate change by ethnic minorities, influenced by gender, age, livelihood activities and living environment, has formed the diversity of observation and perception of climate change by people in the same region. The advantage of this diversity is that it can provide local climate change information that is not concerned by global climate change models.

5.2 Traditional Knowledge and Climate Change Adaption

Ethnic minorities not only observe and perceive climate change, but also actively adapt to the impact of climate change on traditional livelihoods. In the process of adaptation, traditional knowledge plays a key role. In order to better understand how the traditional knowledge of ethnic minorities adapts to climate change, this paper divides the traditional knowledge related to agriculture into the following three categories:

The knowledge for traditional use of agricultural bio-species and genetic resources;

Traditional technical innovations for bio-resource use and traditional practices for farming and living styles;

Traditional cultures such as customary laws and community protocols that are related to agriculture.

5.3 The Knowledge for Traditional Use of Agricultural Bio-Species and Genetic Resources

Ethnic minorities adapt to climate change by planting a variety of crops and selecting different varieties. In the agro-pastoralism, cattle are the main livestock for animal husbandry and grazing, while highland barley is the main crop for traditional farming. The knowledge for traditional use of cattle and barley species assists local Tibetans adapt to climate change. As for the classification of local cattle breeds, scientific terms mainly include *Bos mutus* and *Bos taurua*, in English, they are called yak, oxen and cattle yak; however, the appellation of cattle in local traditional languages is far more than scientific appellation and English appellation, with a total of more than ten appellations, reflecting that the classification system of cattle by local people is very complex, and these classification standards contain climate related ones' traditional knowledge: some cattle adapt to cold, some to drought, some to heat, some to humidity and so on; also for the appellation of highland barley in the traditional language, as well as the knowledge hidden behind. Similar to the appellation of cattle, the appellation of highland barley in the local language is very rich and complex, far more than the scientific appellation of *Hordeum vulgare* Linn. var. nudum Hook. f., or the English appellation of Hulless barley. The appellation of different highland barley also contains traditional knowledge related to climate: some highland barley adapts to cold; some adapts to drought; some adapts to heat while others adapts to humidity and so on. So, when climate change such as drought and high temperature occurs, local Tibetans will choose to breed cattle and highland barley according to the characteristics of different varieties to adapt to the impact of climate change.

For Dai people's paddy field agriculture, with the increase of temperature, the temperature of paddy soil and water is also increasing, so when Dai chooses rice varieties, they are more and more inclined to choose those varieties that are resistant to high temperature. For the shifting agriculture, in order to cope with the long-term drought, Wa people will choose more drought resistant varieties when they choose to plant upland rice. For terrace agriculture in high altitude areas, in order to cope with the climate instability such

as strong cooling and rainstorm, Hani and Dong people will also choose cold resistant rice varieties to grow. For the Uygur oasis agriculture, due to the increasing rainfall in recent years, the selection of crop varieties has gradually changed, and the original drought tolerant varieties have gradually been replaced by the varieties adapted to the new climate environment [13].

5.4 Traditional Technical Innovations for Bio-Resource Use and Traditional Practices for Farming and Living Styles

Traditional knowledge is also an innovative process. In order to adapt to climate change, ethnic minorities have adopted a series of agricultural technical innovations. These traditional technical innovations include: staggered seed crop planting, mixed cropping, crop rotation practices, soil fertility improvement practices and soils tillage practices etc.

5.5 Staggered Seed Crop Planting

For agro-pastoralism and terraced agriculture, because the cultivated land is distributed in the mountains with different altitude, shady and sunny slopes, dry land and wetland, so the climate borders of each piece of land are different, and Tibetan and Hani peoples often adopt the staggered seed crop planting. On the one hand, it adapts to the microclimate environment of different plots, on the other hand, it reduces the risk of crop planting due to the instability of rainfall and drought.

For example, Tibetan farmers will first cultivate low altitude land, then medium altitude land, and finally high-altitude land, so as to reduce the risk of drought at low altitude, flood at medium altitude, snow and cold wave at high altitude. At the same altitude, the land on the sunny slope is cultivated, followed by the land on the shady slope; on the same slope, and finally the wet land and dry land. Such staggered seed crop planting can maximize the use of sunlight, temperature and water resources, while reducing the risk of rainfall instability.

5.6 Mixed Cropping

Mixed cropping is a common way of shifting agriculture. Farmers of Wa, Jino and other ethnic groups often plant two or three or more crops in the same farmland. The basis of mixed planting is the division of land types and the utilization of different types of land. After the classification of land types, different crops are planted according to the specific geographical and climatic environment of different plots.

At the same time, due to the change of altitude and slope, there is also a difference in temperature in different areas of the same plot. There are differences in thickness, fertility and barrenness between steep and flat areas. Therefore, different crops or different varieties of the same crops are mixed in a small plot. For example, Jino people will plant different varieties of early rice, middle rice and late rice in the same plot, and then beans, sorghum and vegetables etc.

The mixed planting of different plots enables the different varieties of upland rice and different crops to be cultivated on the plots with suitable climate and environment, and the yield can be increased; the mixed planting in the same plot can avoid the situation of no harvest when suffering from extreme weather disaster, and reduce the livelihood risk brought by climate change.

5.7 Crop Rotation and Soil Fertility Improvement Practices

In Blang people's shifting agriculture, the rotation of gramineae and solanaceae is often adopted. Specifically, there are three forms: cotton and upland rice rotation, cotton, upland rice and corn rotation, or cotton, upland rice, coix and corn rotation. Cotton, as a heat loving crop, has the advantages of drought tolerance, barren tolerance, strong resistance to disease and insects, deepening the mature soil, soil and water conservation, especially its large amount of

leaves, which can greatly improve the organic matter content of the soil.

Climate change and instability bring uncertain risks to farmland, such as too much water brought by heavy rainfall and insufficient water brought by continuous drought. The effective way to deal with these two risks is to improve the organic content of farmland soil. Soil organic matter stabilizes the soil structure and makes the soil absorb more water without causing soil erosion. During the long-term drought period, soil organic matter can also improve the water absorption capacity of the soil, which can enhance the ability of soil to contain water.

5.8 Traditional Cultures Such as Customary Laws and Community Protocols That Are Related to Agriculture

In addition to knowledge and technical innovations, the traditional knowledge of agriculture also contains customary law for use of water resources as well as management of watershed, which includes methods to prepare the anticipated hazards and reduce the risk of climate change. The ethnic minorities have developed a variety of customary laws and strategies to use the water resources in agriculture and to cope with the water risk which is affected by the climate change, such as water source sanctifying, watershed conserving, water resource sharing and water disaster resisting.

When the continuous drought comes, without rainfall, the amount of water in the river is also decreasing, and it brings a threat to agriculture. In this case, ethnic minorities will use customary law of water resource sharing to cope with drought. There are two forms of customary law: one exists between different ethnic groups, and the other exists in the same ethnic group.

In Yunnan, the residential pattern of mountain ethnic minorities is based on different altitudes: from 100 m to 1,000 m above sea level, the river valley and basin areas are mainly inhabited by the Dai people engaged in paddy field agriculture; from 1,000 m to 2,000 m above sea level, the semi-mountain areas are mainly inhabited by the Hani people engaged in terraced field agriculture; from 1,500 m above sea level, the mountainous areas are mainly inhabited by the Wa, Jinuo and Bulang people engaged in shifting agriculture; the plateau area with an altitude of more than 2,000 m is mainly inhabited by Tibetans engaged in agro-pastoralism.

When different ethnic groups live in the upper and lower reaches of the same small watershed, such as the Dai people in the lower reaches, the Bulang people in the middle reaches, and the Jino people in the upper reaches, during the drought, the ethnic groups will formulate common customary laws to reasonably and fairly distribute agricultural irrigation water, avoiding conflicts caused by water shortage.

When residents of a small watershed live in the same ethnic minority, such as Tibetans, customary laws will be formed within the same ethnic group to distribute water resources reasonably. At this time, for one village, a collective meeting of villagers will be held inside the village to discuss how to allocate water resources. The Tibetan village is divided into two parts according to their geographical position, the customary law arranges farmers who live in the upper part of the village to irrigate farmland in the morning and farmers in the lower part of the village in the afternoon. For several villages, village meetings are also required to arrange the use of water resources, so that the upstream and downstream villages can take turns and make fair use of water resources. The customary law of water resource sharing avoids the conflict of water use during drought and makes the most efficient use of water resources.

Traditional culture including customary law alleviates the shortage of water resources caused by the continuous drought, and enhances the resilience of ethnic minorities to adapt to climate change.

6. Conclusions

Climate change is affecting the IPLCs around the

world, including ethnic minorities in China. At present, at both the international and national levels, the relevant policies and activities on climate change adaption often follow the top-down model, and are introduced to IPLCs' areas by external resources such as government departments and scientific research institutions. Many of these adaptation policies and development strategies do not take into account the traditional knowledge of IPLCs, lack the concept of adapting to local conditions and the participation of local people, so the effect of these policies and initiatives is not effective.

In the process of adapting to climate change, the traditional culture, technology and knowledge of IPLCs can play an active role. The traditional knowledge can improve understanding of the influence of climate change on livelihood, and provide ideas to develop an equitable and effective plan to adapt to the climate change. For the IPLCs, compared with the externally driven adaption options, they are more willing to take the community-based plan, because such a plan will enable them to apply their traditional knowledge according to the geographical location and environment of their areas, so that their actions to adapt to climate change will be more effective.

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