Maintenance and development of agro-forestry-pastoral system from the perspective of biodiversity—Taking Zhagana in Diebu County as an example

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Abstract. The issue of sustainable development has a growing impact on rural revitalization and rural planning, which is also the focus of long-term attention in urban-rural transformation. Based on comprehensive analysis of field investigation data in Zhagana area, quantitative data of related factors between resources of various life forms and hidden dangers of rural ecological sustainable development, this paper takes Zhagana in alpine pastoral area as the research object and regards biodiversity and long-term demands for rural sustainable development as the breakthrough point, extracting the ecological advantages associated with the local unique agro-forestry-pastoral system, and exploring the strategic system of maintaining and developing agro-forestry-pastoral system in alpine pastoral area. Additionally, starting from the biodiversity that is highly integrated with the natural environment in rural areas, the construction includes early warning and implementation of rural agro-forestry-pastoral system, detection and later maintenance of rural agriculture, forestry and animal husbandry restoration, and maintenance and remediation of rural ecological sustainable development so as to explore the optimization ways of sustainable development of rural ecology in alpine pastoral areas with low cost, high efficiency, income generation and suitable operation, and conduct public intervention based on natural solutions for rural sustainable development.

1. Introduction
In the growing consumption of rural tourism, the countryside is not simply a local functional space. Villages in alpine pastoral areas are often shrinkage-dominated, which is characterized by large regional differences but a high degree of integration with ecology. With urbanization construction, the local rural social and economic structure is single, and the regional autonomy management is unstable [1]. At the same time, with the working process of urban-rural transformation, these contradictions require further targeted and compound means of governance. On September 25, 2016, the Notice on Promoting Ecological Protection and Restoration of Mountains, Rivers, Forests, Fields and Lakes proposed to implement ecological protection and restoration projects of mountains, rivers, forests, fields and lakes, including the protection of biodiversity. In addition, the 10th important task in the National Ecological Protection and Construction Plan (2013-2020) pointed out that biodiversity should be protected, which not only provides rich dietary and pharmaceutical resources in human daily life, but also is closely related to human living environment. It plays an irreplaceable role in soil erosion.
protection, meteorological guarantee, and ecological balance of mountains, rivers, forests, fields and lakes.

With the increasing development of tourism industry, the output of rural products is excessively dependent on tourism industry, resulting in the gradual imbalance of the local unique agro-forestry-pastoral system. Besides, the traditional transformation path regards the countryside as a modern agricultural production base, or as a space for tourism consumption, or as an industrialized town. However, the consideration of rural biodiversity plays a role in the sustainable development of the ecosystem and serves as a catalyst for the improvement of the social and economic, total population and industrial structure.

The nature-based solutions for Zhagana will be one of the strategic options for diversification, systematization and adaptive ecological restoration of rural governance. With the adaptive development of local agro-forestry-pastoral system, the economic feasibility and biodiversity based on industrial output and population return will gradually improve, which will also promote different levels of market groups and more perfect rural transformation. Under such an adaptive model, the ecological advantages of Zhagana may become clearer compared with the traditional villages in transition [2]. However, the improvement of rural ecology, society, and industry still needs to consider the balance among various benefits.

2. Correlation analysis between ecological sustainable development and biodiversity

2.1. Analysis of hidden trouble and inducement of ecological sustainable development

The factors such as climatic characteristics, infrastructure level, environmental sanitation, seasonal activity types, resident population structure and regional eating habits in the alpine pastoral areas determine the complex system engineering of the rural ecological sustainable development in the alpine pastoral areas, which requires diversified and systematic governance measures [3].

Zhagana is located at the intersection of the alpine steppe zone, the northern temperate steppe zone and the deciduous oak forest zone in the southern warm temperate zone. With the change of altitude and the difference of climate, Zhagana presents rich biological characteristics. For example, winter is long without summer. In addition, spring and autumn are connected. Besides, winter is not cold and summer is hot. And precipitation is abundant and the seasonal distribution is uneven. Additionally, the spring is windy and rainy and the autumn is rainy and overcast. Because of the great difference in the elevation of the terrain, the horizontal difference is large and the vertical change is remarkable [4].

The annual average temperature in Zhagana is 6.1°C, 15.9°C in July and -4.1°C in January [5]. Extreme maximum temperature is 33.8°C and extreme minimum temperature is -19.9°C; Frost-free period is about 131 days. The annual sunshine duration is 2262.7h, the annual average precipitation is 634.6mm, and the average relative humidity is 64%. In summer, the maximum values of light, precipitation and temperature appear simultaneously. At the same time, the climate in the pasturing area is cool and the grass is lush, which is conducive to fattening and strengthening livestock. From late autumn to the next spring, the leeward is sunny and there is no thick snow cover, which can effectively prevent cold and shelter from the wind. The livestock can consume body fat to maintain balance (Table 1).

| Climatic Factors                  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average annual |
|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------------|
| Mean monthly temperatures(°C)    | -4.1| -0.9| 3.4 | 8.1 | 11.5| 14.0| 15.9| 15.7| 11.8| 7.3 | 1.4 | -3.4| 6.7            |
| Mean monthly precipitation(mm)   | 1.2 | 3.0 | 15.1| 42.1| 85.5| 89.2| 117.2| 110.4| 97.3 | 52.6| 5.3 | 1.6 | 625.5          |
| Hours of sunshine in each month(h)| 197.2| 178.4| 188.1| 205.3| 199.9| 179.3| 196.9| 198.1| 146.5| 170.0| 189.8| 198.8| 2248.2          |
| Monthly mean wind speed(m/s)     | 1.6 | 2.4 | 2.8 | 2.5 | 2.2 | 2.0 | 1.7 | 1.7 | 1.8 | 1.6 | 1.5 | 1.3 | 1.9            |

Table 1. Table of major climatic factors
The ice period of half a year in the alpine pastoral area makes the villagers’ daily activities have remarkable seasonal differences. According to the survey, continuous ecological destruction in recent years has rapidly weakened the characteristics of local biodiversity resulting in conflicts between ecology and people’s daily life. Viewing from the distribution level of the key studies in Zhagana (Figure 1), the primary meaning of the development of tourism economy industry is the concentration of power and resources, physical space development and economic growth accounting for the maximum. With the intervention of tourism, an “ecological-marginal space” has been created while affecting the local agro-forestry-pastoral system, and this pattern has been continuously compressed. Moreover, with the expansion of the industrial market, the leading tourism industry has become the “general director” of Zhagana, and a large number of construction projects have become the control and command center of Zhagana through the economic flow. Therefore, Zhagana urgently needs to establish an ecological order in line with its own logic.

Figure 1. Key research differences in Zagana’s daily activities

2.2. The ecological advantages of agro-forestry-pastoral system
Based on the method of ecological sensitivity analysis in ecological planning, this paper analyzes the ecological sensitivity of Zhagana’s village and its surrounding environment, defines the adaptability of five types of factors to external disturbances such as development and construction in recent years without coercing or reducing the ecological integrity, and then delimits three types of concerned areas with different scales and levels.

By using the method of factor weighted summation, the importance of each factor in the five factors of elevation, slope, water, vegetation and human settlement to the ecological sensitivity is different. And the weight coefficient of each factor to the ecological sensitivity is determined. Also, the grade evaluation system is established as well. And the comprehensive sensitivity value is superimposed from the single factor ecological sensitivity value, which is the basis for the final delimitation of the regional ecological sensitive area. Based on the superposition of the single factor ecological sensitivity map, several ecological sensitive blocks are obtained. According to the weight coefficient, based on the ecological sensitivity value of each ecological factor, the following formula is used to determine the ecological sensitivity within the distribution area of Zhagana [6].

\[ P_i = \sum_{i=1}^{n} W_i \times B_i \]
Among them (Table 2), \( P_i \) is the total ecological sensitivity value of the block; \( W_i \) is the ecological sensitivity value of the \( i \)th ecological factor; \( B_i \) is the weight coefficient of the \( i \)th ecological factor.

Table 2. Weigh coefficient of ecological factors in Zhagana

| Number | Factor           | Weight |
|--------|------------------|--------|
| 1      | Slope            | 0.3    |
| 2      | Elevation        | 0.1    |
| 3      | Vegetation       | 0.2    |
| 4      | Water            | 0.3    |
| 5      | Human settlements| 0.1    |
| 6      | Total            | 1      |

The ecological impact model reflects the distribution characteristics of ecological sensitivity and species diversity in Zhagarna, which involves not only the water and vegetation in the ecological environment, but also the factors affecting the local elevation, slope, human settlements and rural ecological environment. Through the rural public space and marginal zone with the total value of ecological sensitivity reaching 1-5, which can play an important role in the circulation of agro-forestry-pastoral system (Table 3).

Table 3. Three-point levels in the ecologically sensitive area of Zhagana

| Ecologically sensitive area | Distribution area                                                                 |
|-----------------------------|------------------------------------------------------------------------------------|
| Ecological high sensitive area: 3.5-5 | At the foot of Guanggai Mountain, the surrounding farmland, the edge of the village, the natural stream and its ecological corridor in the north, and the core protected area patch of the traditional village |
| Ecological intermediate sensitive area:1-3.5 | Farmland matrix, village public space, village patch in the construction control zone, road control green corridor |
| Ecological low sensitive area:0.5-1 | Village construction zone, far from the mountain |

2.3. Translating agro-forestry-pastoral system of biodiversity

The research data (including remote sensing images of Zhagana, interview records, traditional village reports, construction guidelines, etc.) obtained from rural planning in alpine pastoral areas are coded with qualitative analysis method. Through three processes of open coding, selective coding and spindle coding, quantitative classification and linkage form a collection of coding nodes such as climate change mitigation and adaptation, natural disaster risk reduction, economic and social development, residents’ health, food security, water resources security environmental degradation and biodiversity loss [7]. There is a logical relationship between the coding nodes in the same data source, according to which the relationship among agroforestry, agropastoral and forest can be mined to realize the translation of rural biodiversity and agro-forestry-pastoral system (Table 4).

Table 4. Agro-forestry-pastoral system linked to biodiversity development needs

| Ecological impact model | Name                          | Reference point | Development needs linkages for biodiversity |
|-------------------------|-------------------------------|-----------------|---------------------------------------------|
| Human settlement        | Settlement factor protection  | 453             | Natural demand / Requirement of society    |
|                         | Vegetative factor development | 394             |                                             |


3. Nature-based Solutions (NBS) for ecological sustainable development needs

Nature-based Solutions (NBS) proposed by the International Union for Conservation of Nature (IUCN) refers to specific solutions that can simultaneously carry out biodiversity conservation and adaptive system management and restoration in these two areas. The ecological sensitivity usually evaluated in the field of rural ecological protection is to maintain the local ecological environment as the main goal and intrinsic value, while NBS takes the maintenance of ecology and society as the primary purpose. There are some overlaps in ecological science and regulation principles, but they are quite different in endogenous driving view. In practical application, NBS can be used as part of the mitigation hierarchy to minimize the negative factors on local biodiversity by means of avoidance, subduction, reconstruction and biodiversity neutralization.

The restoration of agro-forestry-pastoral system in Zhagagna region is to cope with social pressure, adapt to climate change and mitigate the negative impacts of transformation industries on local residents, which is a targeted approach in line with ‘Nature-based Solutions’ [8]. The maintenance of agro-forestry-pastoral system aims to assist the restoration of degraded, damaged or destroyed ecosystems. Artificial intervention in the countryside is aimed only at the restoration of natural or semi-natural ecological environment, rather than imposing a standard or template. In other words, nature-based restoration puts the local ecosystem on a recovery track and enables it to develop sustainably and adaptively, and assists the regeneration or evolution of the species it contains. The ultimate goal of the restoration of agro-forestry-pastoral system in Zhagana is to restore the local ecological cycle system to a natural balance in the process of rural transformation, including flora, fauna and abiotic components.

Rural biological diversity and reasonable allocation of resource contribute to the sustainable development of high quality rural ecology. The “Circle Model” of NBS-oriented agro-forestry-pastoral system and seven social challenges are as follows [9]. There are interaction mechanisms among climate change mitigation and adaptation, natural disaster risk reduction, economic and social development, human health, food security, water resources security, and environmental degradation and biodiversity loss. Combined with the actual situation of rural ecological sustainable development, as well as the ecological environment, micro-climate environment, built environment and residential environment related to biodiversity, this paper studies the needs of circle-stratification development from social model, agricultural model method for specific problems, forest model construction method, adaptive management based on nomadic model, mainstreaming monitoring and sustainable maintenance of ecosystem, etc. (Figure 2).
4. Ecological sustainable development models of agro-forestry-pastoral system

The restoration of agro-forestry-pastoral system in alpine pastoral areas is not only limited to species hybridity and community dynamics, but also needs to take into account the benign adaptive management of rural society. At the same time, this paper analyzes the species composition to be restored and the change of healthy and livable demand and draws support from four reference standards of ecological restoration proposed by the International Society for Ecological Restoration: Planning and Design; Implementation; Monitoring, Recording, Evaluation and Reporting. In the later stage, maintenance and rational utilization of the natural three-dimensional agro-forestry-pastoral system will constitutes the sustainable development among traditional nomadic culture, farming culture and forest culture [10].

The agro-forestry-pastoral system in alpine pastoral area is the basis of connecting nature and reconstructing man and nature. With ecological nature as the carrier of space, human’s living activities and construction activities all take place in it. People’s demands for different resource elements in rural biodiversity are actually great opportunities for local development, as well as contradiction and pressure that ecological development must face and deal with.

4.1. Early warning and implementation based on agro-forestry-pastoral system

The planning and early warning for the complex system with complementary advantages mainly includes the determination of village ecological environment assessment; Determination of the internal and external boundaries of the village; Determination of the identification of external ecosystem and its condition; Determination of the identifiable boundary of internal and external ecosystem by means of entity symbol and visual conflict, which contributes to meet the evaluation procedures of improving air quality, population density, evaluating ecological sensitivity ownership and maintenance responsibility analysis of stakeholders under specific circumstances.

In the implementation of the regulation stage, the scale and grade of the restoration project should be reasonably adjusted to ensure that it will not cause damage to the surrounding environment and daily life and further change the living form [11]. Effectively continue the three-dimensional layout presented by the traditional natural landscape in rural areas, establish a schedule of repair which constantly changes with the change of seasons and classify herdsmen of different professions in detail.
All layouts and maintenance are carried out in a natural process and in a mode that preserves nature and enhances the potential for assisted restoration.

4.2. Monitoring and post-maintenance based on agro-forestry-pastoral restoration

With the continuous update of network information technology, the efficiency of this monitoring link has been significantly improved in China. However, compared with developed countries, this method is still in the preliminary stage of development, which needs to be strengthened in the aspects of monitoring personnel, equipment, funds and mechanisms. It is necessary to build a wide distribution and appropriate scale of online automatic monitoring among rural villages in different dimensions. It is an efficiency driven adaptive system, which focuses on the automation and electronization of monitoring and maintenance. Internet + links the whole scene of each village with people so as to realize the smooth implementation of measures and self-adaptive smooth management and evaluation without the constraints of physical environment.

Responsible teams in relevant regions of each village group are reserved for later maintenance. And index evaluation and progress record are made according to the previous three links so as to ensure that the restoration status within the scope of each region will not shrink or stagnate the cycle. Meanwhile, continuous guidance is required to prevent the degradation of the reference ecological system. Finally, the report will be summarized and communicated regularly.

4.3. Maintenance and improvement based on ecological sustainable development

Combining the unique agro-forestry-pastoral system, species types, industrial structure, village composition and ethnic culture of the alpine pastoral area, the progressive natural cycle of “agro-forestry-pastoral-industry-environment” in the biodiversity sequence of Zhagana is excavated and developed. Based on the original local activities, the spontaneous ecological environment renovation and restoration is an endogenous trend, so that the diversity of rural species can be transformed into exploitable resources of agro-forestry-pastoral system. With the aid of rural ecological technology, and on the premise of continuing the traditional ecological pattern of the countryside, the quantitative threshold of the “ecological” agro-forestry-pastoral complex genes is used as a reference for the evaluation of rural biodiversity. It is necessary to identify authentic rural ecological resources of peripheral climate change mitigation and adaptation, natural disaster risk reduction, economic and social development, human health, food security, water security, and environmental degradation and biodiversity loss. Artificial intervention in rural areas can only help restore the natural or semi-natural ecosystem by extracting the genes of the rural agro-forestry-pastoral system, so as to activate the new economic growth point in rural areas and mobilize the enthusiasm of villagers to protect and improve the rural ecological environment and restore the ecological cycle[15].

The identification, excavation, development and reuse of rural biodiversity resources and the promotion and guidance of rural seasonal lifestyle can be used as effective ways to restore and continue the agro-forestry-pastoral system, which aims to promote the rural ecological sustainable benign operation of “promoting industry with space, supporting culture with industry and moistening space with culture”.

5. Conclusion and Recommendation

At present, the role of biodiversity in rural transformation and development is mainly reflected in the remodeling of ecological functions. However, the realization of sustainable development in rural areas depends on the establishment of a self-benign development cycle mechanism, which requires both top-level design at the national level and the active exploration of local practice. Among them, it includes developing the economic vitality of rural areas, exploring the public service and infrastructure configuration mode suitable for the actual development of rural areas, promoting the two-way communication between urban and rural areas, increasing the supply of public policy in rural areas and promoting the innovation of urban-rural dual system.
With the economy in Zhagana, the villagers have new demands for life. Rural industry changes to tourism and other diversified industries. There are unbalanced income and the traditional industry output is insufficient. Moreover, a large number of natural and cultural heritages gathered in rural areas face great challenges of development and protection. In the alpine pastoral areas with similar contradictions, the rural revitalization during the transition period is likely to turn into an extreme situation that villages with ethnic minority characteristics become regions driven by tourism industry rather than homes suitable for work and living. These problems lead to the shift of emphasis in the process of urban-rural transformation. Therefore, in addition to maintaining and developing the agro-forestry-pastoral system, Nature-based Solutions of Zhagana should also pay attention to the problems of improving the human living environment and public facilities, and build a new village with the integration of “production, life and ecology”, which is the real rural revitalization.

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