Landscape Planning and Design Expression of Tibetan Village in Vulnerable Ecological Areas

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Abstract. Tibet is a fragile ecological area of compound erosion in Qinghai-Tibet Plateau, and Nyingchi City is in southeast Qinghai-Tibet Plateau, and is a typical valley land with fragile ecology. In this paper, via the survey on village landscape of Zhangmai Village, Nyingchi City, the problems of Tibetan village landscape are analyzed from the perspective of landscape architecture in vulnerable ecological zone. Based on the idea of ecological restoration, landscape transformation of Tibetan village is firstly conducted from ecological landscape planning and design level, such as waterscape, green space, vegetation distribution and pavement, and landscape design model of Tibetan village is constructed, which aims to explore the protection and inheritance of Tibetan village landscape.

1. Introduction

Seen from national level, Tibet is a fragile ecological area of compound erosion in Qinghai-Tibet Plateau, and its ecological vulnerabilities are as below: it has high altitude, high drop and alpine climate; vertical zoning of vegetation is obvious, and transverse vegetation coverage is less; frost, wind and water erosion, desertification and other natural disasters frequently occur, and surface soil erosion is serious, and ecological vulnerability is outstanding.

At present, ecological restoration research in fragile ecological zone of plateau that generally indicates screening dominant species of vegetation based on habitat environment or using technical support based on site environment, and corresponding vegetation restoration countermeasures under different eco-environment are proposed[1-3]. There is a lack of small-scale village landscape planning, which takes vulnerable ecological area as research objective.

In the Strategic Plan for Rural Revitalization (2018-2022), it is clearly proposed that countryside is regional complex with natural, social and economic characteristics, has multiple functions such as production, life, ecology, culture and so on, and mutually promotes and exists with town, which commonly constitutes main space of human activity[4]. According to the Strategic Plan for Rural Revitalization (2018-2022), the building of beautiful countryside could not only remain at the level of vegetation restoration, but also combine landscape ecology, landscape architecture and regional
ecology for planning research. Nyingchi City is in the valley of the Niyang River. Although there is sufficient rainfall, ecological landscape is single due to the barren soil layer and lack of rational planning, and it lacks adequate protection efforts and measures. Meanwhile, it lacks rational water system planning in the mountain, which is easy to cause drought, water and soil erosion and other natural disasters. In this paper, planning and design of village landscape in Zhangmai Village are conducted by combining ecological restoration idea, “sponge city”, “rainwater garden” and other multidimensional design concept. Moreover, landscape planning and ecological restoration of plateau “beautiful village” are explored under the strategy background of rural revitalization.

2. General situation of research zone and investigation of settlement space

2.1 General situation of research zone
Nyingchi is located in the southeast of Tibet and the lower reaches of the Yangtze River (92°09'E~98°47'E, 26°52'N~30°0'N). It covers an area of 117000 km², which is an open horseshoe shape of area. Total regional climate is abundant heat and rainfall, and annual rainfall in whole region is between 298 and 2200 mm, while annual average sunshine hours is 2202 h. Frost free period is 180-360d, and annual average temperature is between 7 and 18℃ [5]. Zhangmai Village is taken as planning site, and it is at 7 km from west Bayi Town, Bayi District, Nyingchi City, Tibet, with 33.6 hm² of farmland and 16.7 hm² of vegetation plantation area, which is mainly composed of sandy soil and no obvious landscape characteristics.

2.2 Spatial form and layout of village.
Topography and geomorphology in Nyingchi are dominated by mountain and valley, which is precipitous and is not suitable for living. Therefore, traditional village is generally in a sheltered area surrounded by mountains, mountain area close to valley or some flat valley. Its site selection mainly considers direction, water source, soil texture, wind direction and velocity, vegetation, solar radiation and terrain. Spatial form of Zhangmai Village is random type [6], and it is built by local materials and terrain. Main bases of settlement site selection contain direction, water source, soil texture, wind direction and velocity, vegetation, solar radiation and terrain [7], and architectural composition of the settlement is loose and free.

2.3 Problems

2.3.1 Arbitrariness of settlement space.
Zhangmai Village is built on the mountain, and spatial form of its settlement is random. Dwellings are mostly in east side of the village, which is too close and difficult to form excellent landscape feature. Because of monsoon erosion from easterly and southerly, and lack of vegetation protection at east and south sides of the village, geomorphology is susceptible to wind erosion.

2.3.2 Worse aesthetic effect of landscape.
The east side of Zhangmai Village close to Nyingchi-Lhasa Road is mostly crushed stone and soil slope, with worse landscape effect, and landslide is easy to occur in rainy season. At the same position, there is stone wall with special Tibetan ornaments, and architectural form is beautiful, but the volume is small, which is difficult to form whole rural landscape effect.

2.3.3 Poor road landscape visuality
The main and secondary roads in Zhangmai Village are all cement pavements, without drainage facilities. Drainage is difficult, and it is easy to form ponding in rainy season. The distribution of primary and secondary roads is chaotic, and main road is not wide enough. Moreover, landscape effect at two sides of main road is bad, and herbaceous flower is mostly planted to form flower bed, which accounts for the width of some main road. Traffic lane is not graded, and traffic of people, bicycles,
small cars and big cars is chaotic. Garbage truck to the back mountain often passes through the village, which could not only damage village road but also cause landscape pollution.

2.3.4 Insufficient water improvement degree.
Zhangmai Village has a river formed by alpine meltwater, which flows from south village to public activity area in east village. The water area only flows through greenhouse area built by villagers, and water resources only flow through ground surface, causing the loss and waste of water resources. There is also a cement canal through whole village, 20-30 cm deep, without covering device. Landscape effect is not good, and it does not correspond with waterscape design of rainwater garden under sponge city.

2.3.5 Single vegetation landscape level.
Landscape level of Zhangmai Village is too single, and arbors are mostly native tree species, with worse landscape effect. Arbors contain *Populus alba, Salix alba, Quercus semecarpifolia, Amygdalus mira, Morus mongolica, Malus baccata*; shrubs are mostly *Ligustrum compactum, Rubus biflorus Buch.-Ham. ex Smith, Sorbaria sorbifolia*; herbs are *Cosmos bipinnata, Tagetes erecta, Dahlia pinnata, Fagopyrum esculentum, Sambucus williamsii*; endemic gramineous plant is *Fargesia setosa*.

2.3.6 Bad flood discharge and water retention capacity of village.
Relative altitude of Zhangmai Village is higher than urban landscape of Nyingchi City. Due to certain drop, rainwater flows down along ridge in rainy season, and water rising speed of pavement is too quick. Rainwater could not be timely absorbed, which is easy to cause flood disaster on school and village at lower reaches.

3. Case study of landscape planning in Zhangmai Village

3.1 Analysis of related concepts

3.1.1 “Sponge city”.
Sponge city indicates that the city could have good “elasticity” in adapting to environmental change and responding to natural disasters like sponge. It could absorb, store, penetrate and purify water in rainfall process, and the stored water could be “released” and used when needed[6]. Using principles of ecology, way of landscape architecture, and key techniques of “penetration, storage, purifying, use and drainage”, comprehensive target dominant by urban waterlogging and stormwater management is realized, which also contains ecological flood control, water purification, groundwater recharge, ecological restoration, conservation and restoration of biological habitats, park green space construction and regulation of urban microclimate. Under the premise of ensuring urban drainage and waterlogging prevention safety, it could realize accumulation, penetration and purifying of rainwater in urban region to the most extent, and promote use of rainwater resources and eco-environment protection[6].

3.1.2 “Rainwater garden”.
Rainwater garden is low-impact development facility, and belongs to biologic detention facility in the Technical Guide for Sponge City Construction-Construction of Low-impact Development Rainwater System (Trial). “In the lower region, it is the facility of penetrating and purifying runoff rainfall via plant, soil and microorganism system”[7].

3.1.3 “Ecological rehabilitation”.
Ecological rehabilitation indicates that the interfered and destroyed land is restored to the condition before damage according to land use plan, and certain productivity could be guaranteed. Meanwhile, it is harmonious with surrounding landscape patch, and environmental pollution problem is solved[8].
3.2 Construction of index system for landscape transformation of Zhangmai Village based on design concept of rainwater garden

“Rainwater garden” has two kinds of types: control rain and flood runoff; decline pollution. Meanwhile, common urban rain and flood management manners contain rainwater garden, concave green space, shallow furrow of vegetation, ecological tree pool, vegetation filter belt and permeable pavement[9]. In this paper, index system of stereoscopic landscape transformation in Zhangmai Village is made according to beach land type of fragile ecological region in Nyingchi City (Table 1).

| Target layer | Criteria layer | Index layer |
|--------------|----------------|-------------|
| Water landscape | Design of water storage system | Positive impact of ponding on road surface |
| Green landscape | Expression design of landscape appreciation | |
| Road landscape | Permeation treatment of pavement | Road function division |
| Ecological restoration of underlying surface | Language expression of traditional culture |
| Residential landscape | Style embodiment of traditional residential buildings | Decoration embodiment of traditional residential buildings |
| Plant landscape | Selection of local tree species | Selection of landscape tree species |
| | Expression of land landscape level | |

3.3 Transformation elements of important landscape node in Zhangmai Village based on rainwater garden under the idea of sponge city

3.3.1 Waterscape transformation.

Constructed wetland has the effects of absorption, interception, filtration, redox, subsidence, transformation and microbial decomposition on water body[7], and could enrich species diversity, regulate environmental climate, and beautify eco-environment. According to terrain of Zhangmai Village and advantage of stream formation by alpine meltwater, natural water source could combine with rain and flood storage system in sponge city, which increases landscape effect and stabilizes system balance of rainwater garden. By setting landscape pool in northeast side of the village and water storage system under the pool, water could be pumped from underground pipeline to upper stream to form landscape again in arid season of stream when guaranteeing landscape effect (Fig.1).

When concentrated rainfall appears in the planning region, drainage facilities could be set on dwelling roof, and water could flow to ground surface by drainage pipe. Via natural slope of ground surface, rainwater flows into ecological wetland close to house (blue water area in Fig.1). Due to permeability of permeable pavement, water is absorbed by permeable pavement when rainfall occurs. When rainfall is too large, surface runoff flows into ecological tree pool or biologic depressions due to slope effect. Under excessive rainfall, rainwater flows in filter belt of plant layer in square and parking area, thereby making pavement ponding reduce.
3.3.2 Green landscape transformation.

(1) It belongs to plateau temperate humid and semi humid monsoon climate in Zhangmai Village, and whole green rate is lower. To prevent water and soil erosion by southeaster, it could increase green area in whole region, especially set wind barrier at southeast side. In south side of design region, large-area flower sea is set. To convenient for viewing, four large viewing and floating plank roads are set. Garden road could be set in flower sea, which could be used for viewing in flower sea and make managers timely maintain landscape of flower sea (Fig.2).

(2) Small scale-Concave green space and “rainwater garden” design.

Combining with local actual situation, the transformation of concave green space and ecological tree pool considers that local residents plant flower and lawn around the house, and uses the form of lawn+flower bed+road+ecological tree pool. Open design is conducted at the interface between road and lawn, flower bed, road and ecological tree pool, to treat rainwater runoff from road surface. Continuous interface is used on curb, and soil of plantation pool is concave. Common plantation shrubs contain *Photinia × fraseri* Dress and *Buxus megistophylla*, while cobblestone is paved on the exposed surface. For the road with low shading requirements and needing the highlight of building facade, arbor should not be planted in green belt, and it could be designed into rainwater garden with high ornamental quality (Fig.3). Local shrub and herb could be planted, such as *Cosmos bipinnata*+*Photinia × fraseri* Dress[^10].

(3) Design of ecological tree pool
According to regional characteristics and environment in Nyingchi City, three kinds of tree pool types suitable for the region are designed. The combination of hard and soft treatment could not only protect tree root but also maintain water, which could constitute whole landscape with concave green space and “rainwater garden”. Common plants of ecological tree pool are mostly coleus plant and shape viewing plant, such as *Salix babylonica*, *Acer palmatum*, *Ligustrum vicaryi*, *Magnolia grandiflora*, *Prunus Cerasifera*, and *Cerasus serrulata* (Fig.4).

![Fig.3 Schematic diagram of concave green space and rainwater garden design](image)

**Fig.3** Schematic diagram of concave green space and rainwater garden design

**Fig.4 Transformation and design of ecological tree pool**

3.3.3 Road updating and transformation in Zhangmai Village.
Original arbitrary spatial layout pattern of dwelling in the village is combed, making that architectural distribution is more even in whole village, and it is favorable for developing the tertiary industry. Two new class-one roads are set, in which main road far from the village at north is used for large vehicle, which not only reduces road damage in the village but also makes traffic more regular. Pedestrian way uses permeable pavement form, and main materials are permeable brick, permeable concrete and granite (Fig.5).

![Fig.5 Road updating and transformation in Zhangmai Village](image)

**Fig.5 Road updating and transformation in Zhangmai Village**

3.3.4 Landscape renovation of folk houses.
Tibetan residential landscape is an indispensable part of village landscape. When creating village landscape of “rainwater garden”, it should sufficiently consider important value of residential landscape. When constructing whole landscape, it should sufficiently consider whole layout and function use of residential landscape (Fig.6). Soil retaining wall could be set on crushed rock and soil slope in east village, which could increase landscape effect and prevent debris flow. In design process, Tibetan stone masonry wall at east side should be properly prolonged, and stone debris resources (granular—diameter 30 cm) could be used to make Tibetan architecture to increase landscape effect. Stone is made into rhombus and inlaid in walls, which could not only block soil but also have aesthetic effect (Fig.7).

![Fig.6 Landscape renovation of folk houses](image)

**Fig.6 Landscape renovation of folk houses**
3.4 Plant configuration at main nodes

Plant configuration sufficiently considers vernacular feature, hierarchical feature, seasonal color, and species diversity (which could decline disease and pest control of single plant). Via plant screening, some plants highlighting local features of Nyingchi City are selected in some landscape nodes, and main collocation pattern is arbor+shrub+herb\textsuperscript{[11]}. Plant configuration is shown as Table 4, and landscape effect is shown as Fig.8-9.
Table 2. Plant configuration at main nodes

| Main nodes          | Arbor                          | Shrub                               | Herb                                      |
|---------------------|-------------------------------|-------------------------------------|-------------------------------------------|
| Class-one primary road | Toxicodendron insignis + Alangium alpinum + Abies forrestii + Abies georgei + Larix griffithii + Pinus armandii + Pinus densata + Pinus wallichiana + Cupressus torulosa + Platycladus orientalis + Juniperus chinensis + Taxus yunnanensis + Populus mainlingensis + Populus alba + Salix alba + Quercus aquifolioides |
|                     | Paeonia ludlowii              | + Berberis                          | Polygonum polystachyum + Aconitum monghoense + Delphinium kamaonense + Cardamine macrophylla + Thlaspi andersonii + Astilbe chinensis (Maxim.) Franch. et Sav. + Aruncus sylvester + Astragalus tumbatica + Primula Alpicola + Primula asarifolia + P. sinoplantaginea var. Fengxiangiana + Salvia castanea + Salvia sikkimensis + Pedicularis longiflora |
| Class-two road and branch | Ulmus microcarpa + Morus mongolica Schneid. var. diabolica Koidz. + Acer campbellii + Acer palmatum + Rhamnus xizangensis + Rhamnus henryi + Litsea cubeba (Lour.) Pers. + Zanthoxylum motuoense + Sorbus vilmorini + Malus baccata + Cerasus rufa + Magnolia Wall + Viburnum cotinifolium + Lonicera myrtillus + Viburnum obtusifolium + Viburnum himalaica Hook.f.et Thorns. ex Clark. + Lonicera webbiana + Lonicera japonica + Salvia sikkimensis + P. sinoplantaginea var. Fengxiangiana + Salvia castanea + Salvia sikkimensis + Pedicularis longiflora + Aphananthera microphylla + Viburnum obtusifolium + Viburnum huiquense + Viburnum thunbergii + Lonicera japonica + Lonicera japonica + Salvia sikkimensis + Pedicularis longiflora |
4. Conclusion

In this paper, design idea of “rainwater garden” is tried to be applied in the transformation of Tibetan village landscape planning in fragile ecological regions based on the idea of ecological restoration and sponge city, and the extracted landscape transformation means is different from vegetation restoration means in large-scale fragile ecological regions. The landscape planning is dominated by node. Via the transformation, past rainwater drainage feature in Zhangmai Village has been fully updated. Via waterscape reconstruction, small-scale concave green space design and “rainwater garden” design, ecological tree pool design, road updating and transformation, landscape renovation of folk houses and plant configuration of main nodes, it makes land have better elasticity in adapting to environmental change and natural disasters. In the planning, it further optimizes water storage, penetration, purifying and use links, and solves the problems of water pollution and road ponding, and the constructed index system of stereo village landscape transformation is conducive to landscape planning and transformation of different types of sites in “beautiful village”.

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