

Restoration of Ecological Infrastructure in Rural Areas after Earthquake – A Case Study from Dujiangyan, Sichuan Province

Fei FU

School of Architecture and Design, Southwest Jiao Tong University, Chengdu, Sichuan, 611756, China

Email: 87379260@qq.com

Abstract. After Wenchuan and Lushan earthquake, the experience of Sichuan reconstruction planning is an important sample of agricultural village human settlements safety and regional ecological environment restoration. This paper combines the experience of the reconstruction of Dujiangyan after the Wenchuan earthquake - that is, the concept of sustainable ecological restoration as well as the concept of regional ecological restoration, and the post-disaster recovery study on Ya'an Zhougongshan Chengqing Temple and the surrounding environment after Lushan earthquake, trying to integrate into the process of post - disaster ecological restoration. Through a comprehensive assessment of the thinking on the regional scale issues and the impact of rural ecological infrastructure, we proposed macro-cognitive and multi-level measures of ecological restoration projects in order to provide effective methods to restore regional ecological environment and reconstruct sustainable human settlements in affected areas in the latest Jiuzhaigou earthquake.

1 Introduction

On May 12, 2008, "5.12" earthquake occurred in Sichuan Wenchuan is the Indian plate subduction to Asia. With eastward extrusion along the eastern edge of the plateau of Longmen Mountain, it encountered tenacious blocking under rigid block of Sichuan Bacon. As the energy of tectonic stress accumulated for long, the energy finally released at the region of Longmen Mountain. The affected areas in Wenchuan earthquake were located in Min Mountain-Hengduan Mountain critical areas of biodiversity conservation. The areas area rich in biodiversity and ecological environment is very sensitive. They were important ecological barriers for Yangtze River. The earthquake caused great damage to fragile ecological environment in affected areas, which may do serious harm to the basis of ecosystem. The earthquake mainly made damage from four aspects to the local ecological environment, namely:

1.1 Secondary Disasters

Affected areas were located along upstream of Tuo River. They were in the fault zone, and the geological structure is complex. Also the terrain has large elevation. There are much more loose solid. Landslides and mudslides happen in high incidence. After the earthquake, strong vibration loads led increasingly instability, which induced a great many landslides and other geological disasters. All these exacerbated deformation and failure of geological disasters in existing regions. At the same time, the lake formed by secondary disasters caused a huge risk to the people's lives and property at



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

downstream.

1.2 Forest Ecological Environment

A new round of orogeny and secondary geological disasters generated by the earthquake have caused large areas of landslides, subsidence, etc. Besides, they caused a huge loss of mountain topsoil, vegetation damage, destruction of natural habitat and habitat fragmentation. According to the local forestry department, the infrastructure and equipment of forestry and forest resources have suffered heavy losses.

1.3 Impacts on Biodiversity

Jiuding Mountain is regarded as the habitat, migration, breeding and protected areas to panda, golden monkey, takin and other rare and endangered species. The earthquake caused declines population of these rare species, decrease in distribution area and local extinction, which greatly undermined balance of forest ecosystems and their rich biodiversity. And it seriously threatened the habitat of panda and the pattern of ecological corridors.

1.4 Urban Ecological Environment

After “5·12” earthquake, the city's ecological environment suffered great damage. Industrial and agricultural pollution control facilities, urban and rural centralized drinking water source environmental protection facilities were seriously damaged. And there were serious environmental problems in hazardous waste, pollution treatment and so on. Garbage, sewage as well as a large amount of disinfectants and sterilizing agents used in epidemic will also be a threat to river environment safety and drinking water for the public. All these may result in serious safety risks of water environment.

On May 12, 2008, an 8.0 earthquake on the Richter scale occurred in Wenchuan. Five years later, on 20 April, 2013, a 7.0 earthquake on the Richter scale occurred in Sichuan Province, Lushan County, Ya'an City. After these two earthquakes, the affected areas are facing severe ecological crisis and the crisis are increasingly highlighting, showing the characteristics of a large-scale, a chain and spreading in pieces. An urgent need to resolve on a macroscopic is the environmental problems of the destruction of ecological integrity, the interrupted ecological cycle and water conservation which were caused by the earthquake. However, the current domestic theory and practice of ecological restoration is mainly to discuss the engineering measures in the region's single location or a single ecosystem. These methods cannot solve the systemic ecological restoration problems on a macro-scale. On the other hand, given restoration of damaged natural ecosystem is associated with specific environment and linked to specific geographic space. We require considering embodiments from the relationship between the ecosystem and human ability to control spaces and the point view of sustainability in the ecological restoration. In this paper, we try to put the concept of sustainable ecological restoration and regional ecological disaster restoration ideas into the process of ecological restoration according to experience of ecological infrastructure reconstruction in Dujiangyan agricultural region after Wenchuan earthquake. Through the thoughts on regional scale and comprehensive post-disaster assessment of ecological impact, we propose ecological restoration measures on macro-scale and micro-scale to explore the regional ecological infrastructure restoration after the earthquake and the sustainable development of the safety of rural human settlements.

2. Related Concepts on Regional Ecological Restoration

Region: region is a concept of scale. The purpose of thinking and solving problems with regional vision is to emphasize the association, integrity and collaboration intensive nature between things, especially in landscape orientation.

Ecology^[1]: in general, the ecological concept consists of three levels: (1) natural ecology, means the relationship between propagation and their habitats. (2) multiple ecology, means the relationship among nature, society and economy under the joint action of natural succession and human

development. (3) philosophy ecology, represents the harmony between things and the concept of sustainable development.

Ecological engineering principles and ecological restoration: in 1962, H.T. Odum^[2] in America first used the Ecological Engineering. It was defined as "in order to control the ecosystem, human controls the environment by the application of energy from nature as an auxiliary energy". Then they applied it to ecological restoration project. The principle involves five aspects. They are material recycling principle, species diversity principle, coordination and balance principle, integrity principle, system science and engineering principles.

The concept of regional ecological infrastructure restoration: society for ecological restoration(1995) defined ecological restoration as^[3] "process to help repair and manage integrity of native ecosystem". The ecological integrity includes the critical range of biodiversity, the structure and processes of ecosystem, regional and historical content, sustainable social practice and so on.

3. Impact on Ecological Living Environment in Affected Areas Caused by Earthquake

Earthquake made great damage to fragile ecological environment and it may seriously damage the basis of ecosystem in affected areas. The affected areas in Wenchuan Earthquake lie in critical areas for biodiversity conservation in Min Mountain -Hengduan Mountain where the ecological environment is sensitive and rich in biodiversity. And it is an important ecological barrier to Yangtze River^[4]. Wenchuan earthquake made damage to local ecological environment mainly in three aspects. On one hand, the earthquake caused landslides, mudslides and other secondary geological environmental disasters. The earthquake generated a new round of orogeny and secondary geological disasters which has resulted in large area of mountain landslides, subsidence, quake lake and so on. It also caused a huge loss of topsoil, vegetation damage, destruction of natural habitats and propagation habitat fragmentation. On the other hand, the earthquake destroyed the balance of ecosystems in agricultural areas, resulting in the decline in ecological function, and formed the hidden dangers in soil and groundwater.

As to Ya'an region, it occurred strong earthquake in the surrounding neighborhood frequently. The rainy areas in major affected areas by earthquake in Ya'an were also severely affected. I ever participated in the restoration activities on the assessment of Chengqing Temple in Zhougong Mountain. Zhougong Mountain is a provincial forest park and it ranked along Zhougong River in Ya'an.

4. Eco-environment Restoration Measures of Agricultural Regions Based on Ecological Infrastructure Security Pattern after the Earthquake

4.1 Timely Assessment of Disaster

In prophase stage of investigation and analysis, we need to quantitatively and qualitatively identify the types of influence, strength, advantages and disadvantages, and then propose countermeasures, including suggestions for other decision-making authority(for example, we can propose the government for economic policy adjustments or propose land use planning to make concessions on the natural ecosystem maintenance) as well as coordination with the interests of all parties and the methods on how to develop ecological restoration programs(such as the use of different restoration methods, intensity and costs bringing a different environmental ,economic and public interest).

4.2 Farmlands in Agricultural Areas ----Water Nets Restoration Project Based on Material Recycling Principle and Regional Species Diversity Principle.

Soil erosion causes surface ecological degradation through rainfall, rainfall, flood erosion and surface erosion. On one hand, soil erosion makes damage to soil with the splash, sheet loss, gully erosion, badlands erosion and spall, diarrhea slip, avalanches, landslides, sinkholes, mudslides and other accompanying gravity erosion. All these cause soil loss, texture degradation, fertility reducing leading to land degradation. On the other hand, vegetation became bare because of erosion during the process

of soil erosion. Meanwhile, in the process of land degradation, the moisture, nutrient storage and transport processes will change with the land barren. The soil gets worse and soil environment is increasingly becoming arid and barren. Vegetation structure and composition retrograde succession, resulting in degradation of vegetation. Then the process of soil erosion is a process of ecosystem degradation.

Aiming at the characteristics of areas with soil erosion and ecological degradation, we propose ecological restoration measures as follows:

Control soil erosion and achieve stability of the substrate surface in ecosystem. The substrate surface is the presence carrier of ecosystem development. If the substrate surface is unstable, the ecosystem will not be sustained to be in succession and develop.

According to site conditions to classify recovery zones, we focus on controlling soil erosion occurring with high intensity in hilly areas. Before the earthquake, area which is more than 25 degrees slope in the city accounts for about 35%. Some are more than 45 degrees in slope. After the earthquake, the types of slope are more complex. We can curb soil erosion which caused by hillside through dorsal groove, ridge, side culvert, retaining walls and other engineering measures. We should restore vegetation and soil to ensure a certain degree of vegetation cover and soil fertility. The restoration of natural ecosystem is largely based on vegetation restoration. Therefore, it is the main content of ecological restoration which is based on artificial means to restore the vegetation in the short term. Natural recovery process of vegetation typically enter the adaptability of species and soil fertility slowly accumulate and structure slowly improve.

To increase the species composition and biodiversity. To achieve restoration of biological communities and improve ecosystem productivity and self-sustainment capabilities. Ecological restoration and regional economic develop harmoniously. Utilize agriculture, forestry and recreation in the surrounding area and recovery area to promote local economic development and to drive nature-economy-society system running as quickly as possible.

4.3 Planning Strategies for Safe Use based on the Principles of Coordination and Balance in Site Building.

Component GIS technology can be used to build digital elevation models and hydrological analysis model of construction area threatened by erosion and other geological disasters to model simulation area of landslides and other natural hillside areas in geological disaster-prone areas. And it can make analysis and evaluation effectively on the correlation of its terrain slope and convergence factor. With the slope of the terrain, we can evaluate the impact of topography. The degree of change is represented by slope and slopes are grouped according to grading standards: gently is $<15^\circ$; gently slope is $15^\circ\sim25^\circ$; cliffy slope is $25^\circ\sim35^\circ$; steep slope is $35^\circ\sim45^\circ$; very steep slope is $>45^\circ$. After the model simulated analysis in Hongkou landslide zone, we propose influencing factors associated with disaster include the slope factor and the bus cumulative distribution factors. In the areas where slope is more than 500 and changes greatly, the ecological environment is more fragile and is easy to appear landslides and other geological disasters. The results^[5] highlighted the geological disasters along hillside should be simulated and evaluated of digital elevation models of ecological security pattern. The traditional two-dimensional urban planning should be turned into three-dimensional. And we should strengthen the control measures, build sites of ecological protection, constitute safety control measures, develop and control mountain river landscape and pay attention to tourism management, safety and disaster prevention.

4.4 Contributions on Urban Blue-green Grid based on Agricultural Villages' Regional Holistic Principles, System Science and Engineering Principles-----Taking Dujiangyan as an Example

Agricultural ecological conservation of protected area should conduct a comprehensive scientific investigation on wildlife resources and ecosystem status within the region. Fully grasp the ecosystem situation of the agricultural irrigation areas to make plans for the recovery and development and then protect the regional biodiversity effectively.

Construction of green net plant communities: the restoration of zonal native vegetation is dominated to areas. Establishing a reasonable community structure, improving soil conservation and water conservation, enhancing functions of forest landscape ecology can make it the proliferation and protective barriers of regional environmental features. Combined with the green plants to maintain oxygen balance, retaining solid demand slope and landscape needs, we can develop green layout and configure in the minimum requirements. As to different geographical conditions, we take measures of closing hillsides to facilitate afforestation, artificial promoting natural regeneration, artificial planting and other measures to gradually restore the ecological environment[6]. Specific measures are as follows:

①Plantation recovery methods: close forest and stand improvement. In order to promote the rapid succession of forest, we can stand improvement to communities in the early stages of succession or to plantations. Also, we can introduce dominant species, keystone species of vegetation zones to accelerate the speed of anterograde succession. Improve woodland setting conditions to improve achieving the succession. Plant pioneer species in relatively poor location of local ecological environment to promote the growth of other plants to make it into native forest as soon as possible to achieve a rapid recovery of local forest.

②Restoration and protection of natural forests

The protection of natural forests play an important role. On the one hand, it is the gene pool of dominant species. On the other hand, it can be restored to provide a model for the plantation. The protection of natural forests is mainly reflected in the following aspects: first, protect biodiversity of forest ecosystem. Protecting the genes, species, populations, various plant and animal resources in ecosystem and landscape aesthetic resources prevent its degradation and avoid the collapse of basic ecological processes. Secondly, maintain the productivity of forest ecosystems to maintain the natural ecological processes as far as possible. Thirdly, the protection of forest protection. Prevent further soil erosion and soil loss and ensure natural disturbances and human activities can not lead to unacceptable damage of forest ecosystem functioning. Fourthly, maintain the health and vitality of forest ecosystem. Prevent unbalanced development of ecosystem because of interference caused by human(tourism development, research, rural areas or settlements, etc.) in the post-disaster reconstruction project implementation. Reduce environmental pollution, so that the forest ecosystem carry capacity to take a self-protection and self-adjustment function.

Farmlands in irrigation areas---blue water network system planning of water nets^[7]: water as an important element of the region, first we should ensure a minimum capacity of water and secondly ensure maximum carrying capacity.

Hydrological modeling can control flood risks. Combining fluctuation of water in irrigation areas and the green land of flooding river can bring a rich and dynamic environment of the landscape and also play a role in flood retention. In building layout and traffic flow line, we should fully consider the impact of fluctuations in floodplains. By simulating the model assessment, controlling building land, we can create wetlands and other water conservation landscape environment.

Rainwater collection and organization of drainage management, promote the concept of sustainable eco-friendly. Rainwater collection and sustainable drainage technology management have developed for many years in developed countries in Europe and achieved good ecological and landscape benefits. Rainwater converges through drains. Part of it filtered into the ground to keep the balance of the amount of groundwater and maintain regional hydrological cycle to effectively prevent the occurrence of geological disasters. On the other hand, according to water conservation research, part of the rainwater and canals of original drains play very important roles in flood protection. Therefore, the preservation of ditches and organizing forms of restoration, while strengthening planning and design measures of regional ecological filter strips, swales, wetlands, filter drains, perforated pipes, flooring and other infiltration facilities to achieve sustainable storm water management structure.

5. Summary

After the Wenchuan earthquake, the whole community are exploring the issue of reconstruction. After

nine years' construction, Jiuzhaigou earthquake reminded ecological research scholars, regional environmental sustainability of human settlements are urgent. Especially, ecological restoration of the affected areas is a long and difficult process. It includes some urgent problems, such as eco-control problems and disaster prevention and mitigation which directly relate to the health and survival of tens of thousands of victims. Developing scientific and rational recovery plan is also urgent. How to use the accumulation of past research experience in qualitative and quantitative model analysis results for today's urgency and efforts to make large-scale ecological restoration of the affected areas to their original level are questions worth thinking and acting.

Acknowledgements

The content of this paper is based on a project funded Science and Technology Bureau of Chengdu science and technology Huimin technology research and development project "based on GIS platform agricultural village Ecological Infrastructure Research"(2015-HM01-00356-SF);The key research base of Social Science in Sichuan -- Sichuan circular economy research center -- "recreation mode based on farmland water network pattern ecological protection mechanism"(XHJJ-1522)

Brief introduction of the author

Fu Fei (1982-) , Ph. D., associate professor, master tutor, School of architecture and design, Southwest Jiao Tong University. Research field: eco city design, email:fufei2000@163.com

References

- [1] Yang Pei Feng. The research on the theory and approach of urban and rural spatial eco-planning[M]. Bei Jing: Science Press, 2005
- [2] Mitsch, W. J. , 1989, Ecological engineering: An introduction to Ecotechnology, Wiley. , New York.
- [3] Li Hong Yuan, Ju Mei Ting. Principles and practice of ecological restoration [M]. Bei Jing: Chemical Industry Press, 2005
- [4] Ecological restoration and reconstruction planning after earthquake in Mianzhu [EB] . <http://www.mz.gov.cn/>, 2008
- [5] Fu Fei, Dong Liang, Zhang Jian. A Post Disaster Safety Analysis of Construction Site of Scenic Region[J]. Journal of Southwest Jiaotong University, 2012
- [6] Plan for restoration and reconstruction of ecological environment in Mianzhu after "5. 12" earthquake [EB]. <http://www.mz.gov.cn/>, 2008
- [7] Fei Fu. A STUDY OF ECOLOGICALLY ORIENTED PLANNING FOR RIVER LANDSCAPE[D]. Southwest Jiaotong University, 2011, 9