Research Thinking on Geo-ecology and Mountain City Planning*

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ABSTRACT

As a special area with the complex geological structure, mountain city is more prone to geological disasters. Due to air pollution, ground subsidence, serious water pollution, earthquakes and floods geo-ecological environment problems have become increasingly serious, mountain city planning is facing more severe challenges. Therefore, this article based on the related research of geo-ecology, re-examines mountain city planning from the perspective of urban geological ecology, coordinates the relationship between the human and nature by geo-ecological thinking, raises the questions which urban planning need to pay attention. And advocates creating an integrated system of geo-ecology and urban planning, analysis the status and dynamics of present mountain city planning.

1. Introduction

China is a mountainous country, mountain city accounting for half. Since the 1950s, the rapid urbanization process in the world has brought about the rapid development of economy and society, but also brought many negative effects to the geo-ecological (geological and ecological) environment of the cities. The number of geo-ecological disasters caused by urban construction straight upward, and attained peak at the beginning of the 21st century (FIG.1). With the development of economy, China also faces geo-ecological problems. In 2011, the *China environment development report* pointed out that geo-ecological environment problems became an impossible burden: water shortages, ground subsidence, traffic jams, air pollution, solid waste pollution, soil erosion, heat island effect had severed more serious impact to vulnerable ecosystem. In recent years, geo-ecological environment deterioration caused by geological structure and human engineering activities has been gradually revealed. The fog haze, earthquake, flood, landslide, debris flow, collapse has become the most serious natural disasters in the process of urban development, the geo-ecological environment problems have gradually become an important factors restricting the sustainable development of cities

Accompanying with the development of city, geological ecology emerged. The concept of "geological ecology" is derived from landscape ecology proposed by German geographer Carl Troll in 1939, and he then expanded the concept and proposed "geo-ecology" in 1968. [1] "Geo-ecological" within geo-ecology scope refers to the organic integrity formed by ecological environment, geological environment and human social and economic environment interactions. It focuses on the interaction between human behavior, ecological environment and geological environment, which is closely related with urban planning. Therefore, urban planning must be fully aware of the importance of geo-ecological environment, especially facing all kinds of present disasters problems, and it is more urgent to incorporate the consideration of geo-ecology into urban planning.

Fig 1 Natural geological and ecological disasters caused by man-made technology from 1900 to 2014 (Data source: <http://www.emdat.be/>)

1 Geo-ecology

Geo-ecology is a complex interdisciplinary environmental science which gradually formed on the basis of geological science, geography, ecology and environmental science, research on the earth movement and human activities affecting geological entity changes. In terms of current research, geo-ecology mainly has focused on the aspects of basic theory of geo-ecological environment, geo-ecological environment investigation, evaluation and prediction, geo-ecological environment informatization, rehabilitation and management, etc. Geological research and practice originates in the West, during which Britain, America, Russia and other developed countries started their geo-ecological environment evaluations based on geo-ecological investigations in the 1980s, established river basin and geological disaster survey investigation project, and resulted in the national large and medium scale geological map, provided the basis scientific evidence for the development of mineral resources and geological environment protection. Especially Russia step ahead to geo-ecological environment survey, completed a large series scale ecological geological map [2]. Gradually, scientists all over the globe have taken the solution to environmental problems and hazards as one of geosciences expanding directions, since the Geological Environment Declarations were put forward in the 26th International Geological Congress in 1980, which greatly accelerated the development of geo-ecology. [3] Later in 1995, United States Geological Survey (USGS) carried out the ecological system project, and focused on the environmental effect of geo-ecological environment resources and development. In the year of 1997, Russia and America held the international "geo-ecology" conference and "geo-ecology concept" seminar respectively. Lin (1999) [4] believes that geo-ecology should mainly study the impact of man-made geological process in human living environment, and takes urban ecological environment as the prototype to introduce geo-ecology to environmental pollution control practices. In 2001, Russian natural resources ministry enacted the geo-ecological requirements, and compiled a series of the 1:40 00000 geo-ecological map, including ecological hydrology map, ecological engineering map, artificial pollution figure. Lu (2003) [5] puts forward elements, classifications and main research directions of geo-ecological changes. In 2008, with "Climate Change Brings to the Geologists of Vibration and Impact" as the theme of The 33rd Annual International Geological Congress held in Norway Oslo, human's interaction with the earth has become an extremely concerned topic of ecological studies. [6] Trofimov (2010) [7], academician of Russian Academy of Sciences,

elaborates the type of geo-ecological system and its status in ecological system framework, which specifies the research object. Under the painstaking study of many scholars, the related concepts, objects and scope of geo-ecology became more clear, research content are more in-depth, and close to the actual applications.

(1) The research content

Geo-ecology research includes the lithosphere, hydrosphere, atmosphere, and biosphere compound environment, and their interactions and the change rule with the human activities. Lithosphere includes the development and evolution of strata, structure, landform, (rivers, mountains, plains, etc.), mineral resources and the internal and external dynamic geological phenomena; Water and atmosphere include climate elements, such as rainfall, temperature, humidity, wind, sunshine radiation, freeze-thaw, surface water, underground water body, water circulation, etc. The biosphere includes the distribution and evolution of natural animals, plants and microbes, and the ecological balance and restriction rule. Its elements are involved in various layers, including human and related activities such as engineering activities, agricultural activities, etc.

(2) The features

a Long-term stability: geo-ecological environment is the earth forming for billions of years, the main feature is not easy changing in larger spatial and persistent time scale;

b Continuous action: geo-ecological changes have continuous action from the the time of impact on the city, the correlative question will have a lasting impact on mankind.

c Response delaying: from the point of its performance, it has the corresponding reaction to the external influence of outside world. However, this is a complicated system, one of its internal factors effect, mankind enabled to realize the changes which is result in correlation factor need to experience a period of time , making the reaction is lagging behind.

d Pervasiveness of the influence: Geo-ecological environment destruction mainly by the destruction of the vegetation, soil erosion and desertification in the agricultural civilization, the contemporary urban geo-ecological environment problems involved rocks, atmosphere, water, resources, biological and other fields, also affects people's travel and life ,the construction and development of the city.

e Vulnerability of self-healing: geo-ecological environment is relatively stable system with strong ability to repair itself. However, due to the interference of human factors and the destruction of the geological ecosystem by urban construction, its self-healing ability is also destroyed.

f Dynamic chain reaction: geo-ecological environment is a complex system, involving dynamic structure and multidimensional information, the multiple factors constitute the "chain" structure, a factor's change can trigger correlative factor's change, as the earthquake could trigger tsunami;he tsunami could cause flooding,and may lead to disease later.

g Artificially: human effects was also seen as part of the geological processes, the man-made geological process as the artificial denudation, handling, stacking, shape the terrain and other human geological activities.

2 Geo-ecological and mountain city planning

2.1 Mountainous cities are frequent zone of geo-ecological changes

China is a mountainous country with changeable climate, intense geological tectonic activities, and 56% population live in 69% mountainous regions. In these large-scale mountainous cities and towns, geological disasters frequently happened with great loss in history. Landslide record can be dated back to Han Dynasty in A.D. 100. Most disasters mentioned by *Notes on Book of Waterways*, *Continuation of Historiography of Han Dynasty*, *General Investigation* and other *chorography* resulted in large numbers of casualties. Historical data not only provides references for geo-ecological changes research, but also proves the fact that frequent geo-ecological changes in mountainous regions lead to severe geological disasters in history.

Geo-ecological changes in mountainous areas are fragile, and thus mountainous geological disasters are in various types with distinct features. Landslide, debris flow, collapse, ground fissure, surface erosion, land subsidence, karst collapse, immersion and earthquake are the

commonly seen disasters, of which landslide and debris flow are most widely distributed with the highest frequency, accounting for 80% of total mountain disasters. Environmental elements in the same geographical range have correlations, and may stimulate the triggered connected effect among geological disasters. Thus, geological disasters in mountainous areas are usually group-occurring, with high frequency, concentrated sweeping scale, difficult predictability, strong destructive power and other features, and meanwhile, the temporal distribution is an irregular periodicity with strong connection to human activities.

2.2 limitations of mountain city planning responses on geo-ecological changes

Although mountainous cities and towns enjoy the unique advantage in urban development owing to beautiful natural scenery, various urban form, relatively safe natural defense and multi-national fusion,their development is always affected by geo-ecological environment change due to complex geological structure, frequent geological activities, undeveloped coping mechanism for geological hazards. Thus, the decline of mountainous cities and towns is rapid but difficult to recover. Geo-ecological changes in mountainous cities and towns are difficult to detect. Generally, urban decline tendency may be predicted through the regularity of adjustment of urban industrial structure, urban development system, urban spatial layout and urban problems. However, urban decline phenomenon due to geo-ecological changes is different. Although the geo-ecological change is a slow process with certain omen and regularity, the accumulation of geological forces by nature is invisible. Thus, it is impossible for current technology to precisely predict natural changes, and it is passive for mountainous cities and towns with frequent geo-ecological changes to avoid the geo-ecological changes.The development of mountainous cities and towns always contradicts ecological environmental protection.

2.3 The correlation between geo-ecological environment and mountain city planning

1. Stage of breeding :The geo-ecological environment dominates the construction of mountain cities. In the early days, the natural ecological system was balanced,and the urban construction interfered geo-ecological environment minimally. In order to survive, human beings chose the height that had rich water resources, fertile land to live on, from the original cave to timber frame, built half a cave to the settlement, the initial settlement construction without planning, the building principle is following the natural geo-ecological environment. Geo-ecological environment has played a huge role for the location, layout, form, construction method, Yangshao culture, the Yellow River, the Yangtze river basin, Mongolia along the Great Wall settlement civilization has an obvious tendency of "environment choice". The temple building used topography flexibl planning in ancient Greece, the temple as the center of composition, considering the external vision changes ;The city of Athens was also spontaneously formed without axis. The site of the ancient capital of china had more consideration for water resources and terrain, political, military defense and transportation.

2. Stage of urbanization:Urban planning ignores the importance of geo-ecological environment. As human beings obviously alienate from the natural systems in the socialization production, industrial technology replaced the traditional system of primary agricultural technology, humans began to reform , conquest and plunder nature. Town one-sidedly pursued economic efficiency, consumed a large amount of non-renewable resources, all kinds of environmental pollution and ecological problems rapidly spread, broke the friendly situation. The disorderly "expansion" and "expansion" of urban construction ignored the geo-ecological environment, and occupied a lot of ecological land in the suburbs. The residential area and industrial area are mixed layout, a lot of waste gas, waste water, household garbage and industrial garbage polluted environment,and urban geological disasters have been increasing frequency.

3. Stage of ecological civilization: The various disasters caused by the geo-ecological environment destruction have attracted the whole society's attention, the research on ecological environment and geological environment has gradually entered a multi-dimensional development era. More and more architects, economists, ecologists and sociologists pay attention to the ecological environment and geological environment of mountain cities. The philosophy of "Rural City", "Green Heart City" and "Eco-city" bring new thinking, methods and practical goals for city planners.

3 The main factors of geo-ecology affects mountain city planning

Geo-ecological affects mountainous urban involving many

factors. Based on geo-ecological factors of classification, select major factors which plays an important role to mountain city planning, especially involving urban safety, urban land layout and location factors (table1). With the analytic hierarchy process, literature statistics and expert weight index method, analyze the correlation index of geo-ecological main factors and urban construction, according with the relevant size selecting geological structure, landform, hydrology, soil and climate conditions of five factors.

Tab 1 Geo-ecological factors and mountain cities on the number of related literature index(data sources : Cnki 、Wangfang data 、Elsevier data)

The correlation between geo-ecological factors and mountainous cities					
Factors	Mountainous cities(unit : paper)			Correlation	
	Cnki	Wanfang data	Elsevier	Correlation	Rank
Geological structure	1032	101	3456	0.058	8
topography	4236	885	3957	0.108	4
hydrology	13892	2302	7776	0.126	3
soil	2249	492	7774	0.054	9
resource distribution	11051	58	10155	0.043	10
plant	4256	658	9042	0.063	7
animal	1227	491	5972	0.027	12
climate	5130	553	8998	0.079	5
building	29523	2161	11653	0.147	1
large-scale project	4314	974	7340	0.072	6
road	16834	1421	9802	0.137	2
pollutant emission	2593	502	4303	0.042	11

3.1 Geological structure

Geological structure refers to various tectonic deformations that occur under the external dynamic effect of rocks, including folds, faults, joints, cleavage and other structures. Mountain cities compared to plain and hilly region, the structure and lithology are more complex, its geological body is easier to form a fracture, directly affects the stability and mechanical properties of rock and soil mass, induced landslides, leakage of reservoir, dam foundation seepage, earthquake and other geological disasters [8].Therefore, before planning for a mountainous areas, must analyze the region tectonic position and properties , find out the nonstable zone and potential geological disasters spots to form geological reference map for mountain cities planning.

3.2 Hydrology

Hydrology refers to water resources and water culture in china, which has a unique status for mountain cities. Water is an important resource for the formation of early human settlement and the present riverside residential areas; On the national scale, the south-to-north water diversion project; small to a stream designed in the park, the hydrology has affected all aspects of mountain cities. At the same time, a lot of urban construction is changing the hydrological conditions of mountain city, the surface of natural runoff and rain flood catchment way is changed, making some natural water gradually disappearing. Urban construction has broken original ecological balance, making the ability fighting against disasters gradually degraded, new disasters also is producing, waterlogging, subsidence, water pollution caused the economic loss and human disaster,etc. Therefore, mountain city planning from the national strategy, city site selection, function layout, architectural space, and then to some basic engineering construction should consider the hydrology.

3.3 topography

Topography can be divided into hilly, mountain, plain, plateau and basin five types, the main factors are climate, lithology and human activities. Because of the larger slope of the mountain city there are many gullies and more surface instability factors, the landslide is easily formed. In addition, man-made urban construction activities of railway, terraced fields, highway, surrounding lake field, mining have great influence on the development of mountainous terrain. Therefore, the complex topography

conditions of mountain cities has put forward higher requirements for urban planning.

3.4 Climate

Climate is the most active factor in the natural elements of mountain cities, with urban construction, architecture layout, material closely linked, there are mainly five effects: cloudy, heat island, dry island, wet, the rain island. The factors that influence the mountain climate are mainly atmospheric circulation, urban latitude, altitude, mountain direction, mountain form, terrain, hydrology, geology and the characteristics of underlying surface. City as an important platform to adapt climate changes, scientific and rational planning is an important implement to mitigate and adapt climate change, plays an important role in reducing greenhouse gas emissions, slowing climate changes and improving the urban adaptation ability.[9]

3.5 Soil

Soil is a loose layer that can be used for plant growth and the basic material basis for human survival. Different soil types have different characteristics in nutrient, water content, density, bearing capacity and shape different landscape patterns on the surface. In Karst area, the soil and vegetation are the sensitive elements in mountain ecological environment. Different population size, economic structure, environmental characteristics can cause soil bearing capacity different. The deterioration of soil has a certain superposition effect on the occurrence of geol-ecological disasters, soil erosion and the decrease of water storage capacity have superposition effect on the landslide. Zhou Qilong used SHALSTAB model and GeoWEPP model respectively simulate the regional stability and soil erosion in Huachi Gansu province, and using SPSS statistical analysis software couple with landslide distribution and the simulation results.[10] Landslides and soil erosion have certain positive correlation, came to the conclusion where soil erosion is relatively weak in the formation stability and soil erosion is serious in the unstable strata , indicating that the area of landslide occurrence is also the area with serious soil erosion in the loess gully region. In addition, the change of soil bearing capacity results in the decrease of productivity in the town. Soil erosion has effect on soil fertility and land productivity that is the negative effect of soil fertility factors causing soil organic matter reducing, and lead to productivity decline.

4. Conclusions

Urban planning as the important means that control urban land use, urban space form, and organize urban traffic achieves the harmonious between human and nature, complies with the unique spatial pattern and model of development of the mountain cities as well as region geo-ecological environment. Geo-ecology is from the point of view of geology, ecology, urban activity system to study, putting it into the mountainous urban planning to establish integrated system. Planners should be closely combined with the national strategic target of ecological civilization and the urban development, focusing on hotspot issues of urban planning and urban geo-ecological, and plan to do a more comprehensive and more in-depth thinking to the long-term development of mountain cities. Strengthen academic research and the exchange of information technology to promote the sustainable development of city. In view of the current reseraching situation of geo-ecology in China, there are many problems that need to be taken seriously:

- 1.To popularize regional geo-ecological planning, closely combine the capacity load of natural ecology and geological ecosystem, and meet the ecological background and the region ecological reserves.
- 2.Promoting technology application in urban planning, use the new method and technology to promote urban planning management standardization. Using geophysical prospecting, skyline technology, remote sensing technology and GIS technology service geological disciplines and analysis the present stage of the urban planning, to improve the construction quality and efficiency of mountain cities planning.
- 3.Strengthen geo-ecological environment database involving urban development, urban land use, urban space form, urban traffic database establishing. And establish special urban planning database through a lot of topographic map information, meteorological data, hydrological data, geological and seismic data, the urban historical data, a variety of ecological social space data information and planning management information, unified storage the departments data and analysis the actual circumstances, to provide quantitative positioning and auxiliary decision-making information resources analysis for urban planning.

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