

# The Correlation of Geo-Ecological Environment and Mountain Urban 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 urban planning is facing more severe challenges. Therefore, this article bases on the correlation research of geo-ecological environment and mountain urban planning, and re-examines mountain urban planning from the perspective of geo-ecological, 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-ecological and mountain urban planning, analysis the status and dynamics of present mountain urban planning.

## 1. Introduction

China is a mountainous country, 69 percent of our country is mountainous environment, which has the characteristics of the absolute number of mountainous towns, the large population and the potential development. In the process of high speed urbanization in china, mountain city is also gradually taking on this responsibility. 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 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. 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, 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.[2] 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.[3] In recent years the WenChuan earthquake, YaAn earthquake and the secondary disasters of The Three Gorges Reservoir area make mountain cities geological ecological environment changes and its negative impact on urban development becoming a focus, having urgent exploration of planning strategy to deal with the geological ecological environment changes. 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.

## **2. Geo-ecological environment and mountain urban planning**

### *2.1. Mountainous cities are frequent zone of geo-ecological environment 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. 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. According to the survey in six towns of Jiangyou City after the great earthquake, 98% buildings show varying degrees of damages (Table 1), and thus the whole city has to be rebuilt. For instance, Jiangyou City is located in northwest Sichuan Basin, upper and middle reaches of Fujiang River, and Longmenshan fault zone (a large scale nappe structure belt). Influenced by the north-south Minjiang River fault structure zone, Longmenshan fault zone is of strong seismic activities and low-frequency, and among strong earthquake ( $M \geq 7.0$ ) regions in history. There have been more than 50 earthquakes in Weizhou, Maozhou and Wenchuan, since the earthquake of Yinping and Guangwu (now Qingchuan) was recorded in A.D. 278. Jiangyou City is one of the earthquake prone areas in Sichuan Province because the city is traversed by Longmenshan fault zone from northeast to southwest, and according to investigation of 6 large affected towns in Jiangyou, it is severely affected during 2008 Wenchuan Earthquake (Table 2).

**Table 1.** The questionnaire of damage to buildings of six affected towns in Jiangyou

Name/Town	Pre-disaster (1000 m <sup>2</sup> )	Collapsed buildings		Damage Building		Light damage building	
		Acreage	Population	Acreage	Population	Acreage	Population
Dakang	140.54	23.35	3979	108.94	15752	8.24	1105
Jiuling	30.0628	8.6051	288	20.279	3004	/	/
zhangming town	101.6883	19.558	650	63.737	3005	12.809	313
liuhe	24.9445	20.668	3683	5.724	588	/	/
Fangshui	102.91	23.9	4092	49.22	8119	29.82	2090
Tongxing	78.3602	32.769	7801	36.9367	7589	6.0275	484
Total/1000 m <sup>2</sup>	478.5058	128.8501	20493	284.8367	38057	56.8965	3992
Damage building acreage 470.5833; affect population 62542							

Data source: Table statistics is derived from the 2009 annual report of Jiangyou.

**Table 2.** Investigation of 6 large affected towns in Jiangyou

NameTown	Affected population	Number of village	Earthquake damage				
				All the damage	lots of damage	parts damage	no damage
Dakang	20862	13	Quantity	2	7	4	0
Fangshui	14301	10	Quantity	0	0	10	0
Jiuling	14736	12	Quantity	0	7	5	0
Liuhe	4681	8	Quantity	8	0	0	0
Tongxing	13004	9	Quantity	7	2	0	0
Pengming	11554	2	Qquantity	0	4	7	1
total	79138	64	--	17	20	26	1

Data source: Table statistics is derived from the 2009 annual report of Jiangyou.

## 2.2. Limitations of mountain urban planning responses on geo-ecological environment 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, and undeveloped coping mechanism for geological hazards. Thus, Geo-ecological changes in mountainous cities and towns are difficult to detect. Generally, mountainous cities process tendency may be predicted through the regularity of adjustment of urban industrial structure, urban development system, urban spatial layout and urban problems. However, mountain urban planning due to geo-ecological changes is difficult. 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.

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

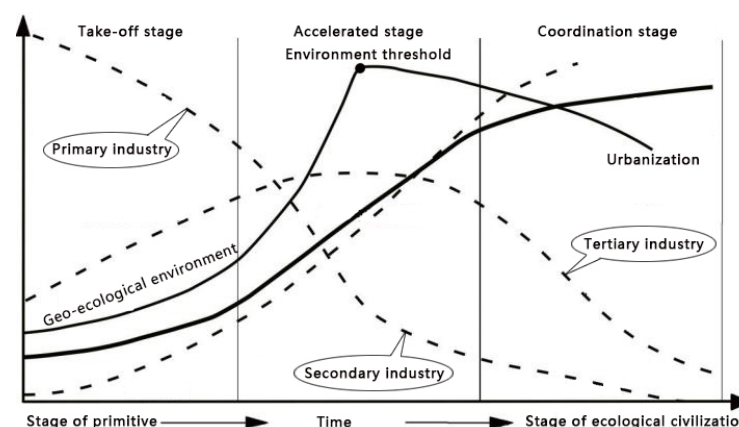
Before the birth of human civilization, those follow the law of nature on earth. The five layers has stabled relying on each other, biology compete with evolving each other while also enjoying the joy of origin society. Human as an important member of nature reconstruct geo-ecological environment with their wisdom, having disrupted the balance of the earth. "Industrial Revolution" made "the rule" that evolved inherent balance for tens billions years destructing. In the 1952s, the London Smog event killed more than 12,000 people. From 1955 to 1972, cadmium waste polluted rivers and rice in Japan causing hundreds of casualties. And Smog Event of Maas River, Minamata disease events, Elnino

phenomenon, and species extinction, small to landslide, debris flow, heat island, soil and water loss, the phenomenon had caused a big stir. The geologists, ecologists joined together, which made it necessary to solve the huge problem of social geo-ecological environment at that time, the scholars also gradually turned to begin research interaction between people and geo-ecological environment.

1. Stage of primitive: 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, and 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 flexible 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, and 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. (Figure 1).



**Figure 1.** The analysis of correlation between urbanization and geo-ecological environment

### 3. The main factors of geo-ecology affects mountain urban 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 mountainous urban decline,

especially involving urban safety, urban land layout and location factors, etc. With the analytic hierarchy process (AHP), literature statistics and expert weight index method, analyze the correlation index of geo-ecological main factors and urban construction(table 3), according with the relevant size selecting geological structure, landform, hydrology, soil and climate conditions of five factors.

**Table 3.** Geo-ecological factors and mountain cities on the number of related literature index

The correlation between geo-ecological factors and mountainous cities							
Factors	Mountainous cities (unit/paper)			Correlation			Rank
	Cnki	Wanfang	Elsevier	AHP	Statistics	Correlation	
Geological structure	1032	101	3456	0.083	0.033	0.058	8
topography	4236	885	3957	0.154	0.062	0.108	4
hydrology	13892	2302	7776	0.109	0.142	0.126	3
soil	2249	492	7774	0.049	0.059	0.054	9
resource distribution	11051	58	10155	0.033	0.053	0.043	10
plant	4256	658	9042	0.058	0.068	0.063	7
animal	1227	491	5972	0.015	0.040	0.027	12
climate	5130	553	8998	0.079	0.079	0.079	5
building	29523	2161	11653	0.122	0.192	0.147	1
large-scale project	4314	974	7340	0.072	0.072	0.072	6
road	16834	1421	9802	0.137	0.137	0.137	2
pollutant emission	2593	502	4303	0.042	0.042	0.042	11

Data sources: Cnki, Wangfang data, Elsevier data

### 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 [4]. 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 urban 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(streams, ponds, etc.) gradually disappearing. Urban construction has broken original ecological balance, making the ability fighting against disasters (strong storm, flood, etc.) 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, and 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. Such as urban system planning in kaixian chongqing, analyze the a variety of factors of farmland, geological disasters, water conservation, vegetation, geomorphology, slope, elevation, etc, and form the distribution of construction land and non-construction land, to urban planning reasonably comply with geo-ecological status quo, and deal with the special landform conditions of mountain city.

### 3.4. *Climate*

Climate is the most active factor in the natural elements of mountain cities, with urban construction, architecture layout, and 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.[5]

Wuhan called china's traditional "furnace cities", the problem of urban heat island is very prominent." The overall planning of Wuhan city calculated the probability about the main wind direction by applying computational fluid dynamics (CFD) and GIS to analyze the influence of the peripheral wetland to urban areas, forming the ecological sensitivity evaluation to determine the scope of the ventilation and ecological corridor, making the highest temperature of summer average down nearly 1 °C in Wuhan city, effectively reduced the heat island problem [6].

### 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. Different population size, economic structure, environmental characteristics (such as garbage disposal rate, sewage treatment rate, etc.) 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.[7] 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.

## 4. **Conclusion**

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. Planners should be closely combined with the national strategic target of ecological civilization and the urban development, focus 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. In view of the current researching situation of geo-ecology in China, there are many problems that need to be taken seriously: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;to promote technology application in urban planning, use the new method and technology to promote urban planning management standardization;to 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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### References

- [1] Carl TROLL,B. Landscape ecology (geoecology) and biogeocenology — A terminological study. *Revue de Geologie, Géophysique et Géographie, série de Géographie*, 1970 vol. 14, 9–18.
- [2] Trofimov,V,T. Ecological geology—A novel branch of geological sciences. *Earth Science Frontiers*, 2001(01), 27-35.
- [3] Trofimov ,V,T., Andreeva,T,V. Ecological geological systems and their types, position in the ecosystems structure and tasks of the investigation. *Earth Science Frontiers*, 2010, 17(02), 425-438.
- [4] Panzera, G., Lombardo, F., Sicali,S., D'Amico,S. Surface geology and morphologic effects on seismic site response: The study case of Lampedusa, Italy. *Physics and Chemistry of the Earth, Parts A/B/C*, 2017(Apr), 98, 62-72.
- [5] Claire,L., Walsh, Richard,J., Dawson, Jim,W., Hall, Stuart,L., Barr, Michael Batty, Abigail,L., Bristow, Sebastian Carney, Athanasios,S., Dagoumas, Alistair,C., Ford, Colin Harpham, Miles,R., Tight, Helen Watters, Alberto,M., Zanni. Assessment of climate change mitigation and adaptation in cities. *Proceedings of the Institution of Civil Engineers - Urban Design and Planning*, 2011(Jun), 164, Issue 2,75–84.
- [6] ZENG Suiping.,TIAN Jian. Research on microclimatic characteristics of mountainous cities and strategy to mitigate the heat island effect. *Architectural Journal*, 2013(S2), 106-109.(China)
- [7] ZHOU Qilong. Study on relationship between soil erosion and shallow landslides in the loess gully region. *Lanzhou Univeristy*, 2013.(China)