Research on Planning and Design of Mountain Villas Based on Geographic Information System

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Abstract. With the rapid development of economy, transportation, and culture, people are increasingly eager to return to nature and enrich humanity. As a bridge between nature and humanity, mountain villas are ingeniously integrated with mountains, vegetation, and architecture, forming a new pattern of mutual penetration and mutual construction of architecture and nature, which has become a new trend in the development of modern architectural patterns. This article takes a mountainous area in Shandong Province, China as an example, uses geographic information system to analyze the spatial structure of mountain villas, and conducts planning and design based on the local status quo, which provides the necessary scientific basis for the planning and design of mountain villas.

1. Research Background
The rapid development of cities and the rapid increase of urbanization rate have led to higher and higher urban density. Urban residential buildings and living environment have become problems that must be faced in urban development\cite{1}. At the same time, with the improvement of people's quality of life, people have begun to yearn to return to nature and regain their own way of life, but it has become unrealistic to build villas in high-density cities. However, the good ecological environment in the area where the mountain villas are located can satisfy people's desire for nature\cite{2}. At the same time, China is a typical mountainous country. In the land area, the mountainous area accounts for about 70\% of the total area, far exceeding the plain area. Therefore, the construction of villas in mountainous areas can rationally allocate and optimize various resources in mountainous areas, and solve the problem of urban construction land shortage. It can be seen that it is a very meaningful subject to plan and design in combination with the original landform features of the mountain, and build a mountain villa that is in harmony with the natural environment.

2. Analysis of Safety Factors of Mountain Villas
In the complex mountainous terrain, planning and constructing a qualified villa building should consider many influencing factors, among which height and slope as safety factors directly affect people's living experience. Based on the actual situation of the selected area, this paper selects a mountainous area in Shandong Province, China for elevation and slope analysis.

2.1. Elevation Analysis
In the process of planning the mountain villa area, the location of the villa should not be too high or
too low, because too high a height will cause people to have altitude sickness. Scientific research shows that the incidence of altitude sickness is related to the speed of tourists’ ascent, altitude, and residence time. As a long-term residence for people, villas must fully consider the impact of altitude on the human body in the planning and design process. The location of the villa should not be too low. If the altitude of the villa is too low, it will not be able to reflect the advantages of mountain conditions, which not only affects the viewing effect, but also fails to achieve the purpose of rational use of mountain resources.

![Figure 1. Elevation Analysis (Source: Self-drawn)](image)

Figure 1 shows a mountainous area in Shandong Province of my country. In order to explore whether the area is suitable for villa construction, GIS software was used to conduct an elevation analysis of the area. It is not difficult to see from the figure that the altitude of this area is about 590-600 meters, so it is more suitable to construct villas in this area, which not only ensures the health of the residents, but also obtains a good visual landscape experience.

2.2. Slope Analysis

In the mountainous conditions with complex terrain, the slope will not only affect the difficulty, cost and stability of the construction of the villa project, but to a certain extent, it is also the main factor affecting the mountain ecological environment and landscape stability[3]. The slope factor in mountainous areas is often related to the location and traffic of the villa. When choosing the location of the villa construction, you cannot choose steep mountains. Keep the slope within 30°. If it is steep, a lot of vegetation will be destroyed, which will increase the overall cost of the project[4]. When the road traffic construction in the mountain villa area is carried out, the slope of the road needs to be controlled below 8%, and the original slope and height of the base should be combined to grasp the alignment of the road, ensure road accessibility and maximize cost savings.
Figure 2 is the slope analysis diagram of the same area, we can see the data analyzed by GIS software. The gentle slope in the range of 0°-5° in the picture is a very ideal choice for other wall construction land, because the other wall construction here will not be restricted by the terrain. In the middle slope between 5°-15°, you need to pay attention to the combination of the trend of the building and the topography in the construction, and the layout of the building is subject to certain restrictions. The slope larger than 15° is not only restricted by the topography of the layout and design of the building, but also increases the amount of work.

3. Planning and Design Principles of Mountain Villas

3.1. Respect the Natural Ecological Environment
In the process of planning and designing mountain villas, the most important thing is to protect the ecological environment. A complete ecosystem can ensure that the overall layout of the villa is integrated with the natural environment to achieve a coordinated and beautiful effect.

3.2. Reasonable Development in Combination with Resources
As complex topography will affect the design of mountain villas, local resources should be investigated and evaluated during the planning and design process, and resource characteristics should be highlighted during development, and planning and design should be carried out rationally.

3.3. Reflect Local Cultural Characteristics
In recent years, the number of construction projects in mountainous villas in our country has been increasing, but we often blindly learn from successful cases while ignoring our own unique regional culture. Therefore, the design concept should be updated when designing to fully reflect the local humanistic and cultural characteristics.
4. Planning and Design of Mountain Villas

4.1. Outdoor Planning and Design
The outdoor courtyard of the mountain villa can expand the range of activities of the residents and promote the contact between man and nature. The outdoor courtyard area of mountain villas should not be too large due to the topography or topography. Therefore, the space layout of the courtyard should be carefully planned and designed. As shown in Figure 3, if the villa is built on one side, the outdoor open space can be relatively concentrated, which is convenient for greening and beautification. In the courtyard, turf and flowers can be planted, and the means of dividing and organizing space can be made full use of trees, pools, flower walls, etc. according to different positions. The outdoor space and the indoor space are connected to each other to form a unified whole.

![Figure 3. Outdoor planning (Source: Self-drawn)](image)

4.2. Interior Space Design
In order to save land, mountain villas should use two or three more floors. In the interior space layout, the living room, dining room, kitchen and living room are usually arranged on the ground floor. On the upper floor, the main bedroom and reading room are often arranged[5]. Toilets are generally arranged in layers according to the size and standard of the villa. When the indoor rooms are arranged in layers, in addition to meeting the functional requirements, the horizontal traffic area of each floor can also be greatly reduced. And when arranging rooms such as living room, kitchen, etc., due to the difference of the size of the villa and the living habits of the occupants, the size and shape of the villa vary greatly. For bedrooms, study rooms and other rooms, it is generally considered to be arranged in a better-oriented area. Therefore, when arranging rooms with different shapes, areas and functions, we must fully consider their influence and carry out a reasonable interior space design.

5. Epilogue
The design of mountain villas must not only focus on the impact of terrain on the villa, but also make a reasonable layout of indoor and outdoor spaces, so that the building and the mountain environment can be organically combined to provide residents with a comfortable living experience.
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