Disaster Prevention Route Planning of Fenglin Ancient Village Based on Space Syntax Analysis

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Abstract. The channel of a disaster prevention (hereinafter referred to as DP) system for traditional villages are roads and alleys (hereinafter referred to as RA) whose accessibility decides DP efficiency and route. This paper aims to illustrate how potential the RA of Fenglin Ancient Village (hereinafter referred to as FAV) are as DP channel and define insecure area by looking into accessibility layout which is produced by analysis on 2 indexes of space syntax (integration and choice). The result shows that the RA of FAV enjoy a high value of integration (1.059), with the middle area being most prominent. The average choice value is 1161.57, which reveals their low potential as passage. In accordance with the research result, the DP route map is planned, and strategy optimization is put forward.

Key Words: Space Syntax, Traditional Alley; Accessibility.

1. Introduction
The ancient villages at the Nanxi River Basin of Zhejiang Province is a complete pedigree that testifies the evolvement of Chinese agriculture. It is endowed with significance on such aspects as history, art and economy.[1] The traditional RA in the villages possess a clear spatial connection and conversion, which is a rare treasure for digging out ecological DP measures of the villages of southern Zhejiang. At present, the focus of rural DP planning is how should traditional villages endeavor to enhance efficiency by constructing an expedite three-dimensional DP network. Some scholars contend that RA, as the channel of the DP system [2], is the skeleton and support of the spatial structure of village, and that we should analyse their spatial characteristics in a quantitative and qualitative manner [3-5], before we provide theoretical support for the plan and design of channel of rural DP system and go further to help conserve and upgrade RA [6-8]. A combination of space syntax and software Depthmap is being widely used to research into this topic. [9-10] In this method, accessibility, proximity and maximum capacity are evaluated to screen out the optimum DP route [11]. This paper applies space syntax to sort out the spatial characteristics of the RA in FAV, and identify the most optimized lifeline channels, hoping to provide a reference for DP planning of the traditional villages of Nanxi River Basin.
2. Overview

Founded in the early Tang Dynasty, FAV had been the economic, political, educational and cultural center of Nanxi River basin.

Bearing the nickname of “the Best village around Nanxi River” and “Another Wenzhou (commercial center of China’s south-eastern coast)”, in 2000, FAV was awarded famous historical and cultural town in Zhejiang Province.

FAV fully considered ecological DP when it selected site, planned water conservancy project and designed landscape. It is one of the few villages that conserves a fairly complete traditional RA system. In order of rank, the 33 roads were classified as main road (3), sub-main road (4) and alley (26), each carrying its historical name (Figure 1).

![Figure 1. The RA system of FAV](image)

3. Research Method

Depthmap is applied to study two indexes (integration and choice) of axis map of RA in the village. The research process consists of 3 steps: (1) Use AutoCAD to draw the map of the RA, and save it as DXF; (2) Import the map into the Deathmap and draw an axial map and VGA map; (3) obtain data on integration and choice through syntactic calculation and go further to produce an analysis model.

3.1. Integration

Integration refers to the number of topological steps that a node in a space needs to take to reach a space along the axis. It reflects the agglomeration between the space and other spaces, and can be used to illustrate the level of accessibility [12]. A high integration value represents high degree of agglomeration, hence good topological accessibility; hence fewer obstacles between channels, which means that the potential as DP channel is high [13]. By referring to a large volume of literatures that compare and analyze the maximum, minimum and average integration value, it is spotted that the integration of RA is high and accessibility is good when its average value exceeds 1; and accessibility is low when the value is less than 1 [14].

\[
I_i = \frac{(MD_i - 1)(n - 1)}{n \log_2 \left( \frac{n}{3} \right) + 1}
\]

MDi stands for Mean Depth of node i, n stands for the sum of nodes

3.2. Choice

Choice denotes the times the shortest topological path appears in a space. It expresses how potential a space is in attracting elements to come, and is often applied to illustrate its potential as passage [15-16]. A higher degree of choice equals to higher potential to attract elements to travel through; hence it expresses stronger passability, and good agglomeration; it shows higher potential of a space as a passage, and vice versa [13].
4. The Morphological Characteristics of FAV

4.1. An Analysis on the Integration of RA

Capitalizing on the data segmentation of Depthmap and marking average integration value as benchmark, an integration map (Figure 2) is obtained. It is found that the integration value of FAV range from 0.627 to 1.813. North-south RA enjoys higher accessibility than their counterpart, as seen from Laixun Road and Jiefu Alley, which is attributed to fewer RA on the eastern area that results in dead ends and reduces connection with other RA. Shengzhimen Road, the main road on the east-west axis, holds the maximum integration (1.813). Being more than 5,00 meters, the road links the east of FAV to the west, is home to commercial activities and public service. Its role in the internal transportation is extremely important, which is consistent with output of quantitative analysis. The winding and reclusive alleys at the northwestern corner bear the minimum l integration value (0.669).

As mentioned in the previous text, a road or alley with integration value surpassing 1 possesses high accessibility. As far as integration concerned, there are 104 roads or alleys in FAV that can be incorporated into DP route, which are mainly distributed in the central area along Shengjimen road, Jiefu Alley, Laixun Road, Zhenqian Road, Daonan Road, etc. These east-west roads can support huge human flow and are placed with protected historic sites and traditional buildings. They are the focus of the village DP strategy.

4.2. Choice of RA

There is often a positive correlation between choice and number of attracted target. A lower choice value means fewer attractive elements. Based on automatic segmentation of Depthmap, using the average value as screening criteria, we finally obtain the axial map on accessibility (Figure 3). It turns out that there is a positive relation between choice and integration. The amount of axis that pride itself on choice value higher than 1161.57 is 60, 26.7% of the gross axis, which displays that elements that attracts tourist to FAV are meagre. Shengzhimen Road and Jiefu Alley, the core conservative zone that possesses 7 of the 8 county-level cultural relics the village has to offer, boasts high level of choice. In consequence, Jiefu Alley, Shengzhimen Road, Zhenqian Road, Daonan Road, Puting Road, Fengling Road, Laixun Road and Ciqian Alley should be taken as part of DP route.
5. DP Plan about the RA of FAV

5.1. Plan DP Unit and Distribute Evacuation Site Proportionally
The evacuation sites in FAV are mainly comprised of ancestral halls, churches, primary and secondary school playgrounds, green spaces, which carry simple functions and can only serve as temporary evacuation site (half a day after a disaster) and emergent shelter. In conformity with the stipulation that a person occupies an area no less than 1.0 square meter, a DP Unit Plan is drawn based on a comprehensive understanding on the area of evacuation site and population of the unit. Xu’s Ancestral Hall, Cathedral, Fenglin primary school, Yanling Memorial temple, Yuanyi Memorial Temple and Yuanyu Memorial Temple are set to be town-level evacuation site to address east-west DP. Another 5 grid-level evacuation sites are also established in Shifen Temple, Xiaoshanlaosifang Temple, the Old Residence of Dingchao XU, Sanguan Pavilion, in an effort to refine unit layout.

5.2. DP Channel Capacity and DP Route
Studies have shown that speed of evacuation is closely related to area of channel and human flow. It is advised to keep flow density at 0.85-1.2p/㎡ and flow speed 0.85-1.2m/s. [2] Therefore, when formulating an DP route, a comprehensive consideration must be given over the number of escapees and the capacity of passage. For example, if the total amount of FAV resident is controlled to be within 7,600, assuming the flow speed to be 0.85m/s, the evacuation radius should be less than 255 meters if only 5 minutes is allowed for the process. In conclusion, in order to achieve full-coverage DP network, the capacity of DP site and evacuation direction should be planned congruent with population distribution.

5.3. Reinforce Lifeline Route Connection and Optimize DP Channel system
Psychological researches reveal that people is most likely to choose the most familiar entrances and exits and escape routes nearby when a disaster occurs. So it is very important to construct a three-dimensional DP RA network with high recognition. At present, there are many dead-end roads and obstructed ends in the DP route. In order to improve integration and connectivity of the roads and strengthen the horizontal connection, it is recommended to demolish and remove some residential buildings that have collapsed due to fire to connect Fengling road and Dazhai Alley, Guangyue Road, Shangwu Alley, Sanhe Alley and other obstructed roads. This effort will help add DP channels such as
Baimentai Alley and Shijie Alley, shorten the evacuation distance, and improve the cohesion and capacity of RA in FAV (Figure 4).

![Figure 4. DP Route Map](image)

### 6. Conclusion

Comparing the maximum, minimum and average value of accessibility and choice by means of space syntax, and employing average value as criteria to screen out DP route, it is found that (1) average integration value (1.059) exceeding 1, the RA of FAV carries good accessibility, with the middle area (Shengzhimen Road) being most prominent; (2) average choice value is 1161.572 (higher value dispersed on middle and marginal area), which is far less than its maximum value of 12615. Therefore, there is low potential to deploy those RA as passage. From the perspective of DP planning, a three-dimensional evacuation system is devised where evacuation site and passage capacity were rationally arranged so as to divert flow of people quickly and improve evacuation efficiency when a disaster occurs.

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