Influences of the Natural Environment on Traditional Settlement Patterns:
A Case Study of Hakka Traditional Settlements in Eastern Guangdong Province

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Abstract
This study surveyed 89 traditional Hakka settlements in Dabu County, eastern Guangdong Province, China. The influences of the natural environment on settlement patterns were investigated via spatial and statistical analysis. Natural factors such as terrain, rivers and sunlight influence the construction of settlements at both regional and local levels. This gives settlements certain characteristics of distribution, scale, hierarchy and morphology. Although natural factors do affect settlement patterns, they do so indirectly through their influences on nearby agricultural resources. Restricted by the scarcity of farmland, the Hakka people have often had to settle in marginal landscapes prone to floods or with sub-optimal sunlight. Subsistence is sometimes only achieved by the labour-intensive farming of terraced hillsides. As such, the Hakka have struck a delicate balance with nature. In summary, this closed agrarian society is fundamentally dependent on the availability of farmland, indicating that the Hakka people suffered great survival pressures after migrating to the region.

Keywords: Dabu County; natural environment; traditional settlement; spatial pattern; farmland

1. Introduction
The relationship between settlement patterns and the natural environment has been extensively discussed in the field of architectural research. (Tian, 1999; Ye, 2001) Studies on settlements located in various types of terrain and climate have shown that the natural environment is a key factor affecting settlement patterns and characteristics (Hauser-Schäublin, 1990; Moughtin, 1984; Devitt, 1979). However, existing studies are mostly based on the analysis of individual cases (Eben Saleh, 1999; Belakehal, 2004; Jiang, 2011). Such methods deduce "regularities" from "examples", which leads to deficiencies in logical deduction. In this research, the authors conducted a field survey covering 89 traditional Hakka settlements in the Dabu region, China. At both the regional and individual levels, spatial and static analyses were employed to ascertain the impacts of the natural environment on settlement patterns, and to investigate their mechanisms.

Historically, China has suffered from several wars. Thus, many clans migrated from the northern provinces to southern ones such as Guangdong, Jiangxi and Fujian Provinces. However, the most favourable land for settlement was already occupied, so the immigrants (or so-called "Hakkas") had to settle in mountain areas (Hsieh, 1929; Leong, 1997). Located in eastern Guangdong Province, Dabu is a typical mountainous county with little flat land. It is recorded in the chorography compiled in the Qing Dynasty, "Dabu County was abound with mountains which had their own names, and it was impossible for one to remember them all". It was also known as "the Mountain within Mountains" (Liu, 1943). More than 90% of the county's land consisted of mountains that were unfavourable for settlement, while only 5.8% was cultivated land. However, even with an extremely limited amount of land, the Hakka built a large number of unique settlements over hundreds of years (Lin, 2013; Chen, 2007). Thanks to the mountainous terrain and inconvenient transportation, these traditional settlements are well preserved and have become a precious part of China's cultural heritage.

Most traditional settlements in Dabu County were built in the Qing Dynasty or before, and maintain rich cultural relics such as Lung Wai housing and Tulou (earthen structures) which have been extensively studied (Wu, 2008; Lu, 2008; Pan, 1998; Wu, 2010). The present study aims to answer the following questions. Firstly, how did residents of Dabu County...
establish settlements in such a special natural environment after settling in the mountains? Secondly, how did the terrain, river system and sunlight affect the location and morphology of settlements? Thirdly, what are the roles played by the natural environment in settlement construction in Dabu, a region with a profound culture and history?

2. The Relationship between Topology and Settlement Patterns

We know from experience that flat land is more suitable for building settlements. Even China’s current planning code describes land with slopes steeper than 25 degrees as being unsuitable for building on. Dabu County is located in mountainous territory featuring many steep slopes and little flat land. In this case, is it possible for traditional settlements move onto steeper slopes? After analysing a digital elevation model of the region, we determined the slope of terrain where 89 historical settlements are located. The results show that, except for one settlement located on a slope of 15–20°, settlements are distributed on slopes of less than 15°. Among these, 69% occur on slopes of less than 5° and 91% are on slopes of less than 10°.

This finding shows that, although flat land is limited, the traditional settlements of Dabu are generally not built on steep slopes, but are mainly distributed on gentle slopes, just like other ordinary settlements. Thus, it can be seen that gradient is a rigid constraint on traditional settlement location. The basic building techniques available to traditional people no doubt imposed great challenges to building on steep slopes. Settlements were also subject to: 1) difficult engineering; 2) high construction costs; 3) high risk of natural disasters such as floods and landslides; and 4) relatively little arable land nearby. Therefore, it is more difficult to build settlements on steep slopes than on flat land.

The hierarchy and scale of a settlement are closely related to the topographical conditions of its environment. Settlements in the Dabu region fall into three size categories, namely, cities, towns and villages. The green patches in Fig.2. indicate regions with a slope of less than 5°. We can see that the one city in Dabu County is located in the largest patch, while other towns are all distributed between the nearby large patches, and most villages are built within or near smaller patches.

Since settlements cannot be built on steep slopes even when land resources are scarce, and since farmland largely occurs in flat areas, are there any conflicts between the construction of settlements and the lack of land resources? If so, how can such conflicts be resolved? To answer these questions, we considered each settlement and its environment as an individual analytic unit. Using 89 such units, we investigated the relationships between the settlements and the surrounding mountain and farmland. The results show that 69 (79%) settlements were distributed...
at the foot of mountains rather than on completely flat land, with their layouts stretching along the elevation contours. Meanwhile, the flattest land was usually used as farmland (Fig.3).

Such a phenomenon demonstrates that the fundamental principle of settlement construction is to ensure that farmland is not occupied. Encroachment on farmland leads to decreased grain output and threatens the existence and development of settlements. This logic motivates the Hakka people to locate their settlements at the foot of mountains and around farmland. Another advantage of such location is that the relatively high terrain helps to avoid the frequent floods common to the Dabu region (Wu, 2002). After all, it is much easier to reclaim farmland after flooding than to rebuild homes.

However, with the constraint of limited land resources, how can these settlements develop further? First of all, built areas do not expand towards farmland because this would compromise subsistence agriculture. Therefore, settlements usually sprawl up mountain slopes gradually in a pattern of concentric circles. After long-term development, a layered morphology takes shape (see Fig.4.). Meanwhile, there are two methods for farmland development – exploitation of flat, unused land, and construction of terraces on slopes. Since it is much more difficult and expensive to construct terraces, the first preference would be for flat land. Nevertheless, farmland now occupies most flat land or slopes suitable for terraces, which limits further settlement expansion. Generally speaking, land resources fundamentally constrain the development of Hakka settlements.

3. Relationship between River Systems and Settlement Patterns

Dabu County, located less than 100 km from the ocean, enjoys abundant rainfall. Due to its hilly topography, rainwater converges in the valleys and forms rivers. Numerous rivers and streams occur across the county, which was known as the "thousand-river county" in ancient times. Relevant studies have shown that rivers have both positive and negative impacts on traditional settlements. On one hand, settlements are built near rivers because the residents need water. On the other hand, settlements remain a certain distance away from rivers to avoid flooding. Settlements always face the dilemma of being "close to rivers" or "away from rivers" (Wu, 1991), which is a universal problem for Chinese traditional settlements.

However, owing to the hilly topography, most flat land in Dabu County is located within valleys between mountains where rivers also run through. Large basins are usually low-lying and flood frequently. Under such circumstances, how can settlements make full use of water resources while avoiding flood disasters?

This study found that residents of settlements above town level in the Dabu region adopt a special logic regarding floods. That is, "flooded but not submerged, affected but not destroyed". The open basins are valuable resources, but the settlements built in and
around basins inevitably face floods. In such a dilemma, town residents find a good compromise, namely, multi-floor buildings. Such buildings usually have three or more floors so that residents can evade floods on the higher floors, for normally only the first or second floors are submerged in a flood. Besides, floods are often brief, so after flood waters recede, the settlement quickly returns to normal after a good cleaning. According to our survey, this strategy can be found in the main local towns. Residences in these towns often have doors on the second and third floors. Some families keep a boat with which to escape once floodwaters reach the highest floor. Such peculiar measures indicate that land resources in Dabu are so scarce that residents risk floods in order to live on marginal land.

The relationship between the locations of traditional villages and rivers also has distinct characteristics. Firstly, rural settlements are usually small, thus they could be located at the foot of a mountain to avoid floods. Secondly, most rural settlements are distributed along small rivers. Only 1 out of the 75 sample settlements were located near a large river. Two reasons contribute to this phenomenon: larger rivers have more serious floods, and small rivers are sufficient to supply most rural settlements.

Thirdly, most rural settlements are on the convex bank of rivers. Only 6 out of the 75 sample settlements were located on the concave bank. Normally, a river's concave bank suffers from erosion, while its convex bank gains sediment. Driven by inertia and centrifugal force, the river scours the concave bank and creates erosion grooves. In the meantime, compensating currents arise from the river bottom and carry sediments to the convex bank. Due to the slower flow of water near the convex bank, these sediments accumulate and finally form a point bar. Hence, building settlements on the convex bank favours flood avoidance and water-soil conservation.

Lastly, with a river flowing by, villages are always in line with the farmland, which is somewhat different to the classical "山" settlement pattern, in which the village is located on the opposite bank to the farmland (Chen, 2008). This could be attributed to the fact that it was much too sophisticated and expensive to build bridges over wide rivers in ancient times. Therefore, the width of a river acted as a constraint on the location of small rural settlements. Meanwhile, a bridge's vulnerability to floods and need for regular maintenance or reconstruction could also become an important consideration when deciding settlement location.

4. The Relationship between Sunlight and Settlement Pattern

The location that was considered ideal for ancient Chinese settlements was facing south, with water in front and hills behind. This layout is the classic model extensively adopted in ancient settlement construction (Chao, 2004). According to architectural historians, such a layout ensures that the settlement would always face the sun. Due to the inadequate hygiene conditions of the time, people used sunlight to eliminate bacteria and ensure better health (Liu, 1998). However, this...
layout may not be available in certain areas of Dabu County that are located in mountainous terrain. In this case, what new features would the settlement orientation take on?

This study surveyed 89 settlements and took the most common orientation of houses as the overall settlement orientation (Wang, 2009). Results are shown in Table 2. Settlements do indeed face every direction, with 41% facing south and approximately 20% facing each of the other directions (east, west and north). This indicates that while a southward orientation is still preferred, it is no longer a fundamental necessity for settlements in Dabu, due to the restrictions of the surrounding terrain.

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Number of settlements</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>20</td>
</tr>
<tr>
<td>South</td>
<td>36</td>
</tr>
<tr>
<td>West</td>
<td>17</td>
</tr>
<tr>
<td>North</td>
<td>16</td>
</tr>
</tbody>
</table>

The orientation of traditional settlements is also influenced by farmland. As a mountainous area, Dabu has many long and narrow valleys. In many cases, the foot of mountains is not always suitable for building settlements. For example, for a valley oriented east to west, a steeper northern side implies that a settlement can only be built on the southern side of the valley and, consequently, the buildings face north. But it does not mean that these buildings cannot get enough sunshine. After conducting sunlight analysis of Dabu County based on its digital elevation model, we found that settlements with northward, westward and eastward orientations are always on low hills which do not greatly interfere with sunlight. Furthermore, there are no settlements on the steeper north side of mountains, which are in shadow for longer. Generally speaking, local settlements do not strictly adhere to the traditional rules governing a settlement's orientation at the cost of sunlight.

The results suggest that daylight does affect settlement patterns in the Dabu region, but does not directly influence settlement orientation. As long as the settlement can get enough sunlight, southward orientation is not a decisive factor. The reason is that for the Hakka people, farmland is always the top priority. No matter how powerful the cultural tradition is, survival and development are always the primary considerations. Therefore, we conclude that the classical model of Chinese settlement patterns is an ideal model that has gradually changed through history. For locating large and important settlements, it usually serves as a basic guideline. For locating small rural settlements, it only serves as a reference, because the specific conditions often require alteration of the ideal layout.

Table 2. Orientation of Traditional Settlements, Dabu County

5. Conclusion and Discussion

This study has described the influences of the natural environment on patterns of traditional settlement in the Dabu region. The results indicate that there is a strong relationship. Sometimes the natural factors play a vital role in shaping the settlements. It is clear that the core issue is the relationship between settlement areas and farmland. First, the terrain of gentle slopes and basins determines the amount and distribution of farmland and, consequently, determines the layout, scale and hierarchy of settlements. Second, farmland is so scarce that no encroachment on it is tolerated. Therefore, settlements are built in the foothills of mountain ranges while flat and open areas are used for farmland. Third, in order to utilise low-lying basins, town settlements employ multi-storey buildings for flood evasion, while smaller rural settlements are built on the convex banks of rivers to ensure accessibility to a stable area of farmland. Lastly, to make full use of farmland, settlements are not bound to a southward orientation as long as daylight is adequate.

It is noteworthy that although terrain, rivers and sunlight have various impacts on the location of traditional settlements, these occur indirectly via their influences on agricultural resources. Because of the extreme scarcity of farmland in the Dabu region, Hakka people may settle in flood-prone areas with sub-optimal sunlight and farm labour-intensive terraces on hillsides. They have struck a delicate balance with nature to be able to live in a marginal landscape. From a historical perspective, settlement patterns in this region are indicative of the living pressures and helplessness faced by the Hakka people after migrating to the area, which has significant economic and political implications.

Acknowledgements

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Notes

1 The Han people, originally from northern China, migrated and settled in the south. Being relatively isolated from the outside world, they developed their own dialects, customs and culture, which were different from those of the local communities. They are mainly scattered in the mountains of eastern Guangdong Province, western Fujian Province and southern Jiangxi Province.
2 Among the 89 traditional settlements, 75 of them are rural and the rest are cities and towns.
3 The short "..." under the "..." stands for the village; the "..." stands for the low hills surrounding the village; the "..." stands for the main peak of the hills; the "..." stands for the pond in front of the village; the "..." stands for crops growing in front of the pond. See Chen Zhihua. For reference: Traditional Village. Beijing: SDX Joint Publishing Company, 2008.
4 House orientation was taken as the direction perpendicular to the ridge line of the house's central room.
References


