

# GIS Mapping and Analysis of Tai Linguistic and Settlement Patterns in Southern China

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## Abstract

By integrating linguistic information and physical geographic features in a GIS environment, this paper maps the spatial variation of terms connected with wet-rice farming of Tai minority groups in southern China and shows that the primary candidate of origin for proto-Tai is in the region of Guangxi-Guizhou, not Yunnan or the middle Yangtze River region as others have proposed. In addition, Tai speaking people (Zhuang and Bouyei) settle at low elevations along rivers where they can practice irrigated rice farming, in contrast to the Yi, members of the Sino-Tibetan language family, who are found at higher elevations. The patterns of different ethnolinguistic groups exploiting different ecological niches are likely true for all of Asia. GIS technology has great potential to help explain such patterns and understand population movements and distributions.

## I. INTRODUCTION

The Tai have been closely identified historically with the emergence of irrigated rice technology and culture. Several very interesting articles (O'Connor [11], Tanabe [13], Watabe [14]) have appeared recently dealing with the early development by the Tai in southern China of a truly revolutionary technological and societal complex in an environmental niche that lends itself to a unique type of irrigation engineering—"Müang Fai." Müang [A1]<sup>1</sup> means 'irrigation channel, ditch, canal' and fai [A1] means 'dike, weir, dam.' Müang Fai is a system of gravitational irrigation that employs dikes or weirs to direct water from streams and rivers through a series of man-made ditches or channels. The extent and importance of this technology is described by Tanabe [13], who has written the best and most complete comparative study of rice-growing ecology and technology to date.

Müang fai irrigation is thus a skillfully designed system from water input at the fai through distribution by terminal networks. The farming system which has been established within the intermontane basins depends upon this tremendously well organized system of water utilisation. The existence of such systems and associated customary regulations is also recorded outside Thailand especially in Sipsong Panna of Yunnan (China), the Shan

States of Burma, the Tonkin hills of Vietnam, and in Laos. This implies that an irrigation system essentially similar to müang fai is widely distributed among Tai-speaking populations and hill dwellers in intermontane basins and mountain valleys throughout the northern part of mainland Southeast Asia.

O'Connor [11] has written a brilliant essay synthesizing what he believes was a regional phenomenon—the revolutionary development of a new "agro-cultural complex" (p. 973). One can infer from his new cultural history that the early Tai taught the neighboring Burmese to the west and the Vietnamese to the east a new way to produce dependable crops of rice by using a system of water channels to carry water into leveled fields into which rice seedlings are carefully transplanted. From a comparative-historical linguistics standpoint, it is interesting to note that the Tai word müang [A1], in fact, has been borrowed into Vietnamese ('gutter, ditch, canal' - Nguyen Dinh-Hoa [10]) and Burmese ('ditch' - Judson [6]). In both cases, it is not unreasonable to assume that both the term and the technology were borrowed in a single act. The term *khan* [A2] 'small dike between or surrounding rice fields to impound water' has been borrowed by the Chinese, further supporting the claim to Tai primacy.<sup>2</sup>

According to O'Connor, a village-as-unit cooperative social structure that was needed to bring manpower to bear on the digging of water channels and weirs

<sup>1</sup> [A1], [A2], and so on indicate the proto-Tai tone categories used by Li Fang-Kuei [8] and others. Because of the necessity to provide the end reader with an IPA font, we shall not use a linguistically sophisticated phonemic transcription in this paper. Our GIS tables and maps, however, are constructed with IPA notation.

<sup>2</sup> Luo Meizen, personal communication.



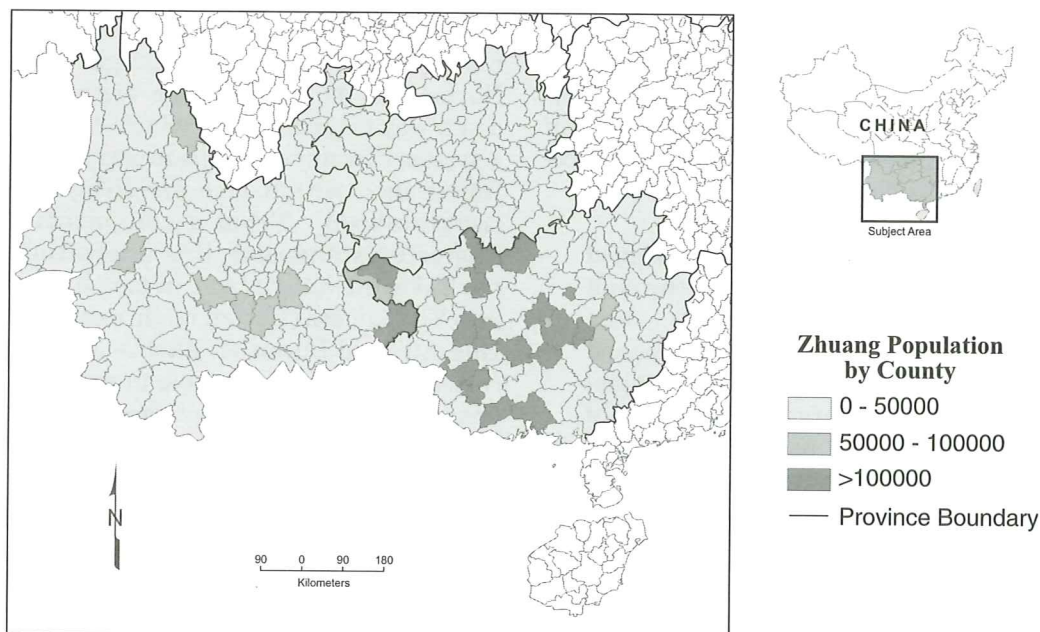
and their maintenance year in and year out led, in turn, to political advantage and the eventual hegemony of the Tai (and their Burmese and Vietnamese neighbors) in what was previously a predominantly Mon-Khmer region (now Cambodia). O'Connor's study shows that, by contrast, the independent, household-as-unit gardening style of agriculture favored by the earlier Khmer agriculturists did not lead to dependable rice production or the political consequences of communal cooperation. The Khmer were at the mercy of annual flood waters during an unpredictable monsoon season; the Tai, by contrast, controlled the flow of water from mountain-fed streams into fields or *naa*[A2] surrounded by water-retaining bunds. The result over time was a steady, inexorable expansion of irrigated rice production and a well-fed, expanding population. The Tai have been depicted by historians as warrior types; in the final analysis, rice may have been their best weapon and the hunger of their adversary, where the term is appropriate, their best expansionist strategy (Condominas [2]).

O'Connor's comparisons and histories focus primarily on the Tai of Yunnan proximate to the lands of the Burmese and the Vietnamese and the historically antecedent Pyu, Mon, and Khmer. In this paper, we will enlarge the picture somewhat to bring into view the Tai-speaking ethnic minority groups of Guangxi Zhuang Autonomous Region and Guizhou Province to the east of Yunnan Province, i.e., Zhuang and Bouyei (Buyi)<sup>3</sup> (see Figures 1-2). In addition, Yi minority group is also included (Figure 3) in this study with the intention of contrast them with Tai, with whom they are markedly different.

## II. OBJECTIVES AND METHODOLOGY

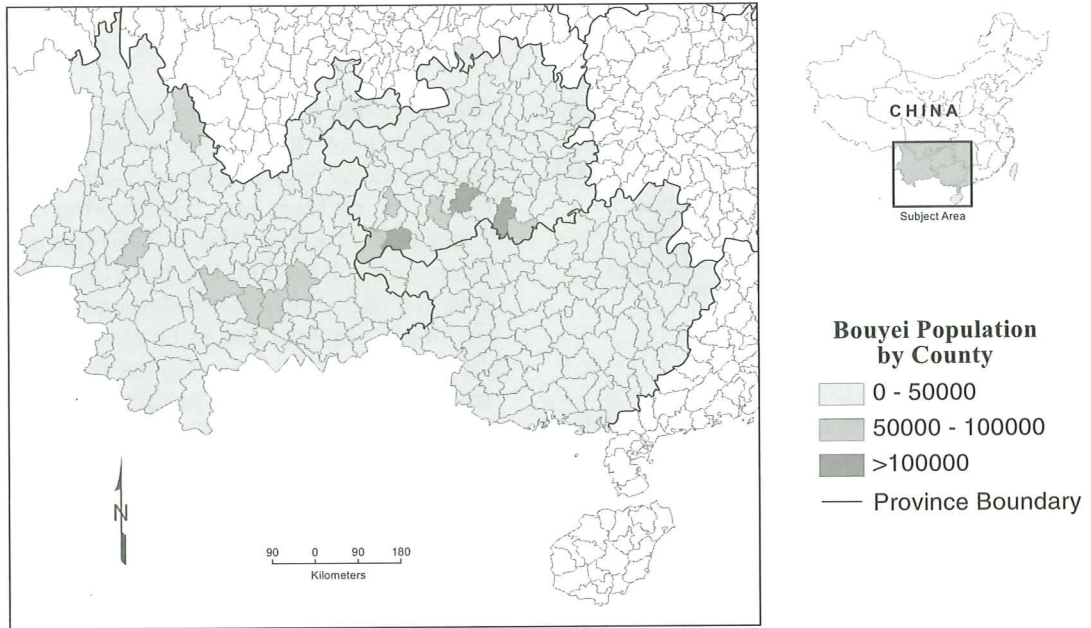
The geographic center of this historical advance in agricultural technology has been placed by some scholars in Yunnan Province (Watabe [14]). Chamberlain [3] places the origin for Tai speakers in the lower Yangtze valley - the area where rice was first domesticated some 6-8,000 years ago. Some Thai scholars have argued that the Tai were always in Thailand. That is, they did not come from some point outside of Thailand. However, the linguistic evidence for these suppositions has not been convincingly presented. The main purpose of this paper is to employ the methodology of comparative-historical linguistics and the technology of GIS to see if the theory of Yunnan origins of irrigated rice growing by the Tai of Yunnan can be supported or if the data point to the Tai of a different region.

The linguistic theory of "directionality of language change" indicates that as people migrate and spread from their homeland, the greatest changes in the language usually occur at the point of origin, while the older or "proto" forms are preserved at the periphery or points most distant from the homeland, forming a wave-like pattern (e.g., Edmondson [5]; Bailey [1]). For example, Siamese (Thai of the Central Plains and one member of the Southwestern Tai branch of the Tai family, see Figure 4) is a noteworthy example of a Tai language that preserves many of the older or proto-Tai features at the periphery. Conversely, languages or dialects of the Northern Tai branch—the reputed area of origin of proto-Tai, such



**Figure 1.** Zhuang population distribution by county in the study area.

<sup>3</sup> Bouyei is the official English name and Buyi is Chinese Pinyin.



**Figure 2.** Bouyei population distribution by county in the study area.

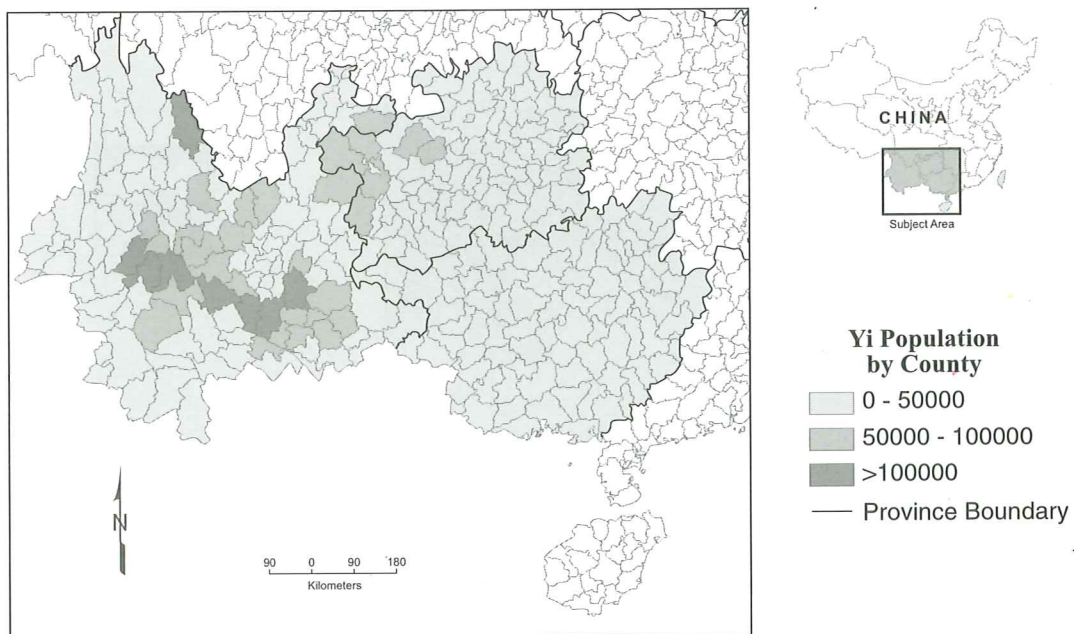
as Po-Ai, Yay, and Saek, would expectedly reflect the greatest change, all things considered.

Thus, we plotted terms, such as the various pronunciations of the word “rice,” used in the *müang* [A1] *fai* [A1] techno-culture on a linguistic map of the areas that are candidates for the historical origin of the irrigated rice revolution in southern China. By assigning a numerical score (1 to 3) to each citation of a word showing degree of change from proto to modern Tai, we attempted to quantify the changes of the terms and used GIS to visualize the wave-like pattern. In

addition, terrain analysis of topographic data using GIS showed that wet-rice growing Tai people primarily concentrate in places with physical characteristics favorable to the growing of wet rice and the maintenance of their water-based culture.

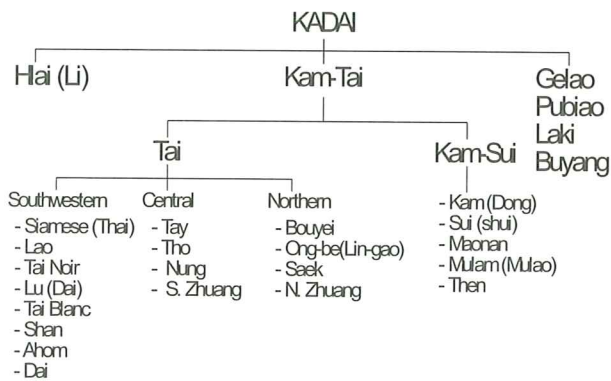
**III. GIS MAPPING AND ANALYSIS**

As a first example of the series of linguistic changes, that indicate the direction of change from the putative point of origin to the periphery, we examine the



**Figure 3.** Yi population distribution by county in the study area.





**Figure 4.** Diagram showing Tai language family tree. Both the Zhuang and Bouyei languages are part of the Tai language family. Figure adapted after Li [7] and Edmondson [4].

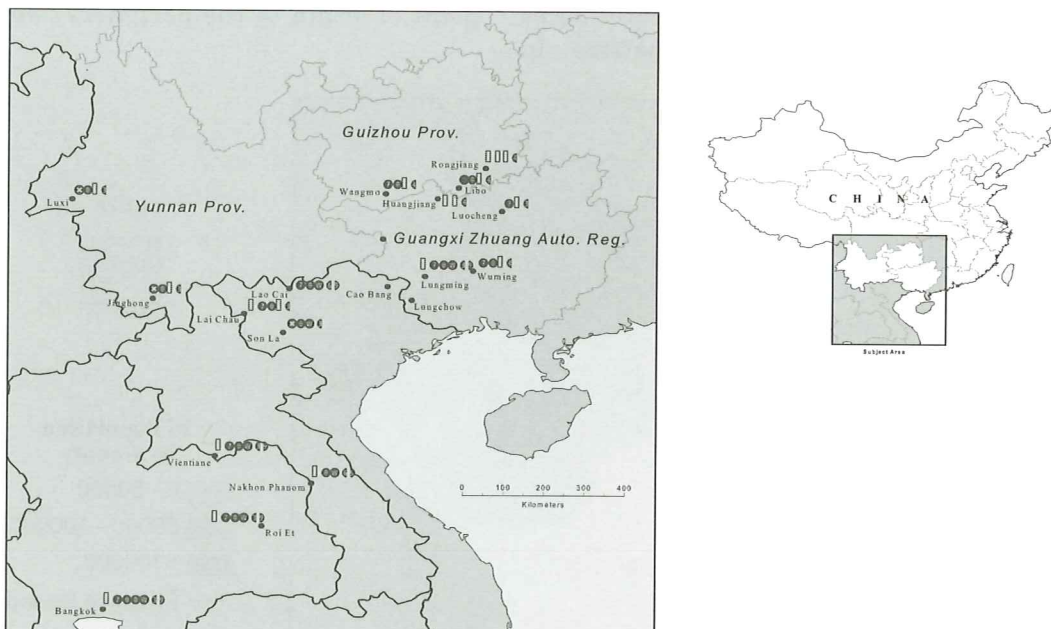
linguistic geography of the word for ‘rice’ itself, which is shown in Figure 5. The pronunciations of the word in different languages are summarized in Table 1. The relationship of languages within the Tai language family and other language families more distantly related is shown in the family tree diagram in Figure 4.

The data for administrative boundaries and most of the place locations in Figure 5 were obtained from the Center for International Earth Science Information Network (CIESIN, <http://www.ciesin.org/>). Some place location data were obtained from the GEONet

Names Server at National Imagery and Mapping Agency (NIMA, <http://164.214.2.59/gns/html/>).

The proto-Tai form has been reconstructed by Li [8] and others as \*khau [C3], which is identical to the form in many Southwestern Tai languages, such as Yuan (Chiang Mai), Lue, and Tai Mau (Chinese Shan). Siamese differs from \*khau [C3] only in vowel length: *khaau* [C3]. Based on the principle of directionality, Bouyei *au42*, which has undergone a loss of the initial kh- would appear to be at or near the point of origin; the Lue and Tai Dam forms *khau* [C3] are two examples of forms at the periphery, and they preserve the proto-form. Thus, Figure 5 shows a qualitative direction of change and indicates that the point of origin is somewhere in the border region of Guangxi and Guizhou.

Next, we attempted to quantify the changes of the terms and used GIS to visualize the wave-like pattern. We selected a small, initial set of 21 lexical items that might define the *müang* [A1] *fai* [A1] techno-cultural complex: rice, rice seedlings, irrigated rice field, irrigation channel, weir, and so forth, and gave each term at each location a score according how the term is pronounced at the that location. A score of 1 is given to a word that is most close to the proto-Tai pronunciation, 3 to a word that is most different from the proto-Tai pronunciation, 2 to those that fall in between. Figure 6 shows the contour map of mean



**Figure 5.** This map shows the spatial variation of the pronunciation of the word “rice” in Tai languages (in bold font). The spatial pattern indicates that the origin (where most change occurred) is in the Guizhou-Guangxi border. Province names are labeled with italic font and the place names are labeled with a smaller font. Places outside of China are also included to show a more complete picture of spatial pattern and direction of spread.



**Table 1.** The word “Rice” Spoken in Different Languages and Location

Language Group	Language	“Rice”	Location Spoken
Tai	Siamese	κηααω3	Bangkok
	Isan	κηαω3	Roi Et
	S. Zhuang	κηαω3	Lungming
	Lao	κηαω3	Vientiane
	Tai Don	κηαυ3	Lai Chau
	Saek	Ψαω6	Nakhon Phanom
	Tai Dam	ξαω3	Son La
	Tai Dehong	ξαυ3	Luxi
	Tai Lue	ξαυ3	Jinghong
	Yay	ηαω6	Lao Cai
	N. Zhuang	ηαυ4	Wuming
Bouyei	ηαυ4	Wangmo	
Kam-Sui	Sui	?αυ4	Libo
	S. Kam	θδυ4	Rongjiang
	Maonan	ηυ4	Huangjiang
	Mulam	ηυ3	Luocheng

**Note:** See Figure 4 for a tree diagram of the language group. The languages are sorted in the order of decreasing similarity to the proto-Tai word of “rice”- \*khau [C3]. In other words, going down the list, you are going in a general direction from a pronunciation most similar to proto-Tai (at periphery) to one most different (at origin).

score of all the words at each location. Physical barriers to population spread such as streams and mountain ridges are considered during the contour interpolation using Arc/Info “topogrid” command. Following the principle of “directionality of language change” enunciated by Bailey [1] and Edmondson [5], Figure 6 visually shows wave-like pattern of change with the high values at the origin and the low values at the periphery. There are two high value regions in Figure 6: one in southeastern Yunnan-Vietnam border, the other Guangxi-Guizhou border. However, the high value region in Yunnan-Vietnam border area has fewer data points, and thus more data points are needed to confirm its status as an area of origin. On the other hand, the numbers next to the location point, which are the actual values from which the contours are interpolated, indicate that the highest values (greatest change) are in the Guangxi-Guizhou area. In other words, the primary candidate of origin lies in the border region of Guangxi and Guizhou, and the general direction of change moves southwestward toward Vietnam and Thailand.

Finally, since agriculture and cultural practices of the Tai people are water dependent, their migration and settlement patterns are expected to follow places that

are suitable for such practices (e.g., wet-rice growing), i.e., in flat, low lying areas or intermontane valleys that will have good access to water. As a preliminary attempt, we analyzed the 30-arc second global topographic data obtained from EROS Data Center of USGS (<http://edcdaac.usgs.gov/gtopo30/gtopo30.html>) (see Figure 7) and population data by county from CIESIN. The results are shown in Figures 8, which plotted the mean elevation and mean slope of each county verses the minority population of each county. Both the Zhuang and the Bouyei groups, who speak Tai languages and specialize in growing wet rice, show patterns consistent with wet rice growing requirements; i.e., large concentrations of these groups are located in areas of low elevation and low slope (flat). This is in comparison with other counties that do not have high concentration of these two ethnic groups. However, the pattern for the Yi ethnic group is in great contrast with those of Zhuang and Bouyei. The contrast is based on linguistic and cultural grounds on the one hand, and in their geographical location and, as consequences, agricultural practices on the other. Yi population tends to concentrate at higher and steeper places (Figure 8). The Yi belong to the Sino-Tibetan language family. Their agriculture and cultural practices are based on dry land crops grown at higher elevations than those the Tai utilize. The Yi people mainly grow buckwheat and potatoes, along with other crops, but not wet rice (Ramsey [12], p. 253) and thus live at higher and steeper places (Moseley [9], p.24). Such relationships are also evident by comparing Figures 1-3 with Figure 7.

Both the Zhuang and Bouyei languages are part of the Tai language family. They belong to the Northern and Central branches of the Tai parent stock (Figure 4). They are essentially neighboring languages spoken in southern China. Zhuang has 15,000,000 speakers, the largest minority in China. Their greatest concentration is in the western half of Guangxi Zhuang Autonomous Region (Figure 1). Zhuang is further subdivided into Northern and Southern based on geographical spread in Guangxi. Bouyei, however, is spoken by fewer speakers, the majority of whom live in Guizhou province (Figure 2). The Yi (also known as Lolo), on the other hand, are members of the Sino-Tibetan language family, to which the Han Chinese belong. The Yi are widely dispersed throughout southern China, predominantly in the mountainous regions of Guizhou and Yunnan (Figures 3 and 7). In summary, the Zhuang-Bouyei (Tai) and the Yi (Sino-Tibetan) stand in strong contrast linguistically and culturally to each other.



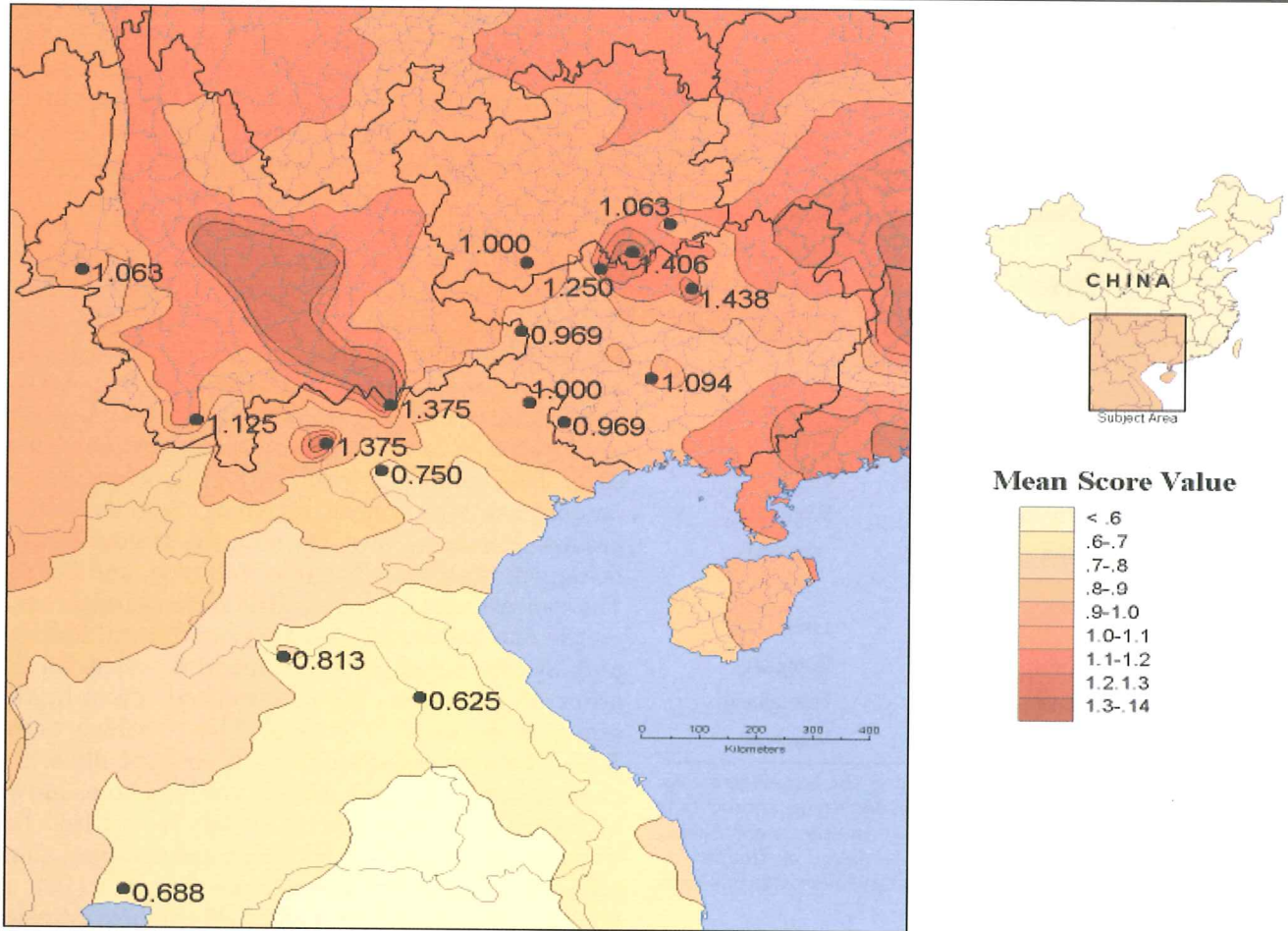


Figure 6. (see next page)

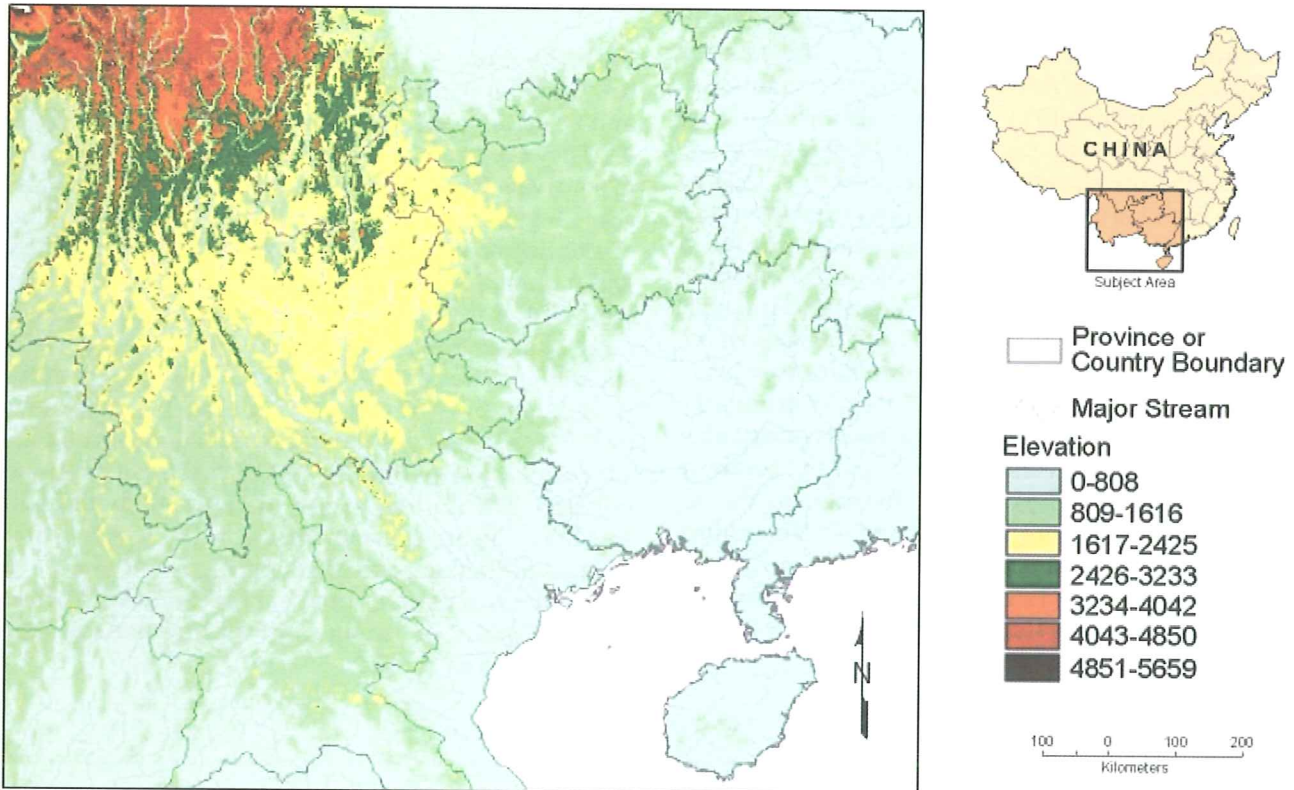


Figure 7. (see next page)



**Figure 6.** This map shows the contour of mean scores for 21 rice culture related words at each location. A score of 1 is assigned to a word that is most close to the proto-Tai pronunciation, 3 to a word that is most different from the proto-Tai pronunciation, 2 to those that fall in between. The lower the mean value, the closer the word is to the proto-Tai form (periphery), the higher the value, the more different the word is from the proto-Tai form (origin). The number next to location point is the mean score value at each location. The contours are interpolated from these mean scores using Arc/Info "topogrid" command. Major streams are incorporated as break lines during the interpolation because they may represent the topographic barrier for population migration.

**Figure 7.** Digital Elevation Model (DEM) of the study area with province/country boundary superimposed. DEM data were obtained from the 30-arc second global topographic data from EROS Data Center of USGS.

#### IV. PRELIMINARY FINDINGS

The handful of lexical items used to plot a linguistic geography and spread of Tai *müang* [A1] *fai* [A1] technology is only a preliminary attempt to see what conclusions can be drawn as a first approximation. More detailed data and further comparative research are needed. However, from this preliminary comparative study of the geographic spread of *müang* [A1] *fai* [A1] technology, it appears safe to say that, like proto-Tai itself, the phenomenon had its origins to the east of the Southwestern Tai languages of Yunnan. Judging from the degree and direction of change, the primary candidate of origin is in the Guizhou-Guangxi area. In addition, Tai settlement patterns, here illustrated by the Zhuang and Bouyei, are shown to be closely linked to the physical environments that are favorable for growing of wet rice, i.e., at low and flat areas with good access to water.

From this first approximation, combining history with comparative-historical linguistics, it would not seem unreasonable to offer a provisional two-part conclusion. First, *müang* [A1] *fai* [A1] technology was relatively well developed by the proto-Tai period, that is, roughly 2000 years ago or more. Second, accepting the linguistic argument that proto-Tai origins can be traced back to the Guizhou-Guangxi area, Tai irrigation engineering of rice fields employing water channels and weirs originates there as well—not in Yunnan. GIS mapping and analysis can integrate linguistic and geophysical information to help explain Tai migration and settlement pattern and has great potential in

linguistic geography research. Moreover, by incorporating images and speeches from the hundreds of Tai languages and dialects and taking advantage of the new development in Web-GIS, both the temporal and spatial changes of Tai can be dramatically brought together in cyberspace.

#### V. DIRECTIONS FOR FURTHER RESEARCH

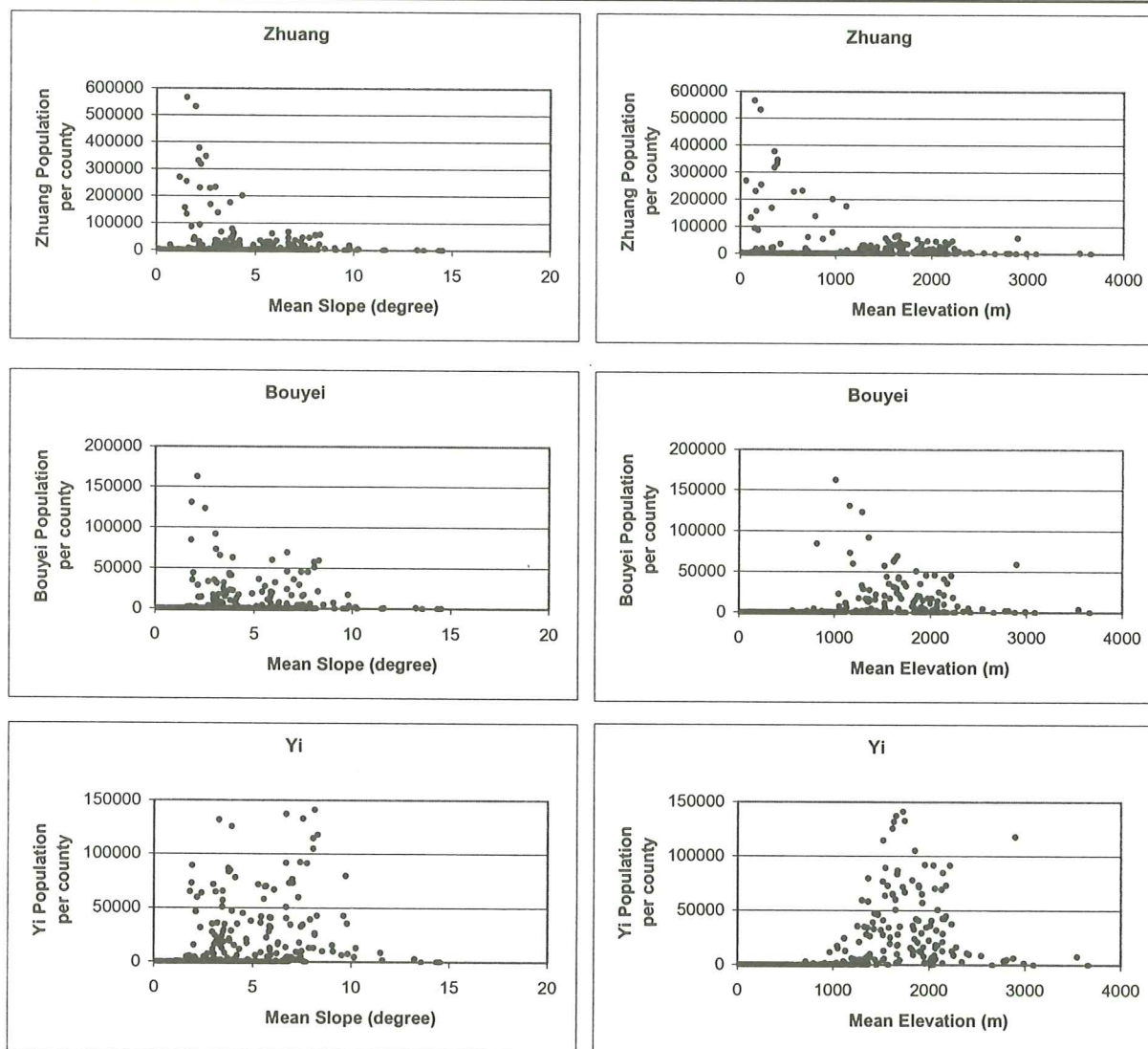
A fuller and more interesting answer to the questions raised in this paper would be realized with a complete comparative study of the sort begun here with an aim towards reconstructing all of the details of the techno-culture and beyond. In such a study, the research would go into greater technical detail about the physical construction and maintenance of the water channels and weirs and the social dimensions of organizing labor and incorporating beliefs systems into the successful operation of a system that pits man against nature. We have just barely scraped the surface of historical sources in Chinese that predate the Christian era: gazetteers and rich descriptions of the non-Han peoples of the South and the emergence of agriculture, especially the domestication and spread of grains such as millet and rice. It is a fascinating story best told with the assistance of GIS.

#### ACKNOWLEDGEMENT

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**Figure 8.** Minority group population versus mean elevation (right column) and mean slope (left column) of each county within study area. High concentration of Tai-speaking group (Zhuang and Bouyei) settled in counties of low mean elevation and low mean slope. This is in contrast with the Yi people who mainly grow buckwheat and potatoes and thus concentrate in higher and steeper places (Ramsey [10], p.253).

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