Mapping Accessibility and Shortage of the Protestant Church in China: Applying Two Spatial Research Methods

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Abstract

The issues of church accessibility and church shortage are critical for understanding religious market and religious economy in China. Assisted by GIS, this article uses and compares two spatial research methods, the Two Step Floating Catchment Area (2SFCA) and the Network Analysis Method (NAM), to examine the church accessibility and church shortage in the thirty-one provincial capital cities of China. Despite the two different methods, this article sets up a common criterion in determining the geographic area of church shortage, or rather determining the number of Protestants who cannot reach the nearest churches from their residential locations within 30 minutes through driving or public transportation. The research findings discovered by both methods have identified nine provincial capital cities in the three regions of China as the areas of church shortage and low church accessibility.

Keywords: Church accessibility, Church shortage, Spatial study of religion, Religious market, China studies, multi-methods

Contents

1. Introduction

In an effort to study the Protestant market in China, the authors have completed two projects that focus on: 1) Hangzhou, China and Chicago, USA (Hong and Zeng, 2012) and 2) four provincial capital cities in China (Hangzhou, Zhengzhou, Fuzhou, and Hefei) (Hong et al., 2014). This article is designed to apply two innovative methods to addressing the issues of church accessibility and driving time between the demand-side (Protestant members' residential area) and the supply-side (Protestant church).

Measuring the driving distance between church and Protestant living areas is critical in analyzing the church accessibility and church shortage in the specific regions. Assisted by the Geographic Information System (GIS), the magnificence of spatial study is capable of adding time and space considerations to study the gap of supply and demand in a religious market. This article is a pioneering effort to combine two spatial research methods to jointly test the issues related to the Chinese church accessibility and church shortage. These methods include the Two Step Floating Catchment Area (2SFCA) method and the Network Analysis Method (NAM).

Specifically, this article uses both methods to examine thirty-one provincial capital cities in three Chinese regions (east, central, and west) in order to estimate the percentage of Chinese Protestants who could not reach their nearest churches within the specified time and distance. The similar and different results produced by both methods will improve research methodology and reveal additional research findings on the Protestant market and religious economy in China.

2. Methodology: The Two Step Floating Catchment Area and the Network Analysis Method

This project relies on ArcGIS 10.1 studying the driving time from the Protestant residential areas to the Protestant churches in specific locations, in an attempt to estimate the percentage of Protestants who cannot reach their nearest church within the allotted time frame. The project has applied both 2SFCA and NAM measuring and comparing the driving time and the geographic areas between the designated locations to understand their church accessibility and church shortage.

First, this study utilizes the 2SFCA method as the main tool for studying church accessibility. Developed by John Radke and Lan Mu, the 2SFCA was originally designed to "develop a method which measures access to social services for each household and makes adjustments among service providers to better accommodate under-served regions" (Radke and Lan, 2000). The 2SFCA method is a special case of a gravity model of spatial interaction that was developed to measure spatial accessibility to primary care physicians (Luo and Wang, 2003a). The 2SFCA can also be used, however, to measure other types of accessibility such as accessibility to jobs, gas stations, bank branches, cancer care facilities, etc. The 2SFCA method not only has most of the advantages of a gravity model, but it can also intuitively interpret the result as a special form of physician-to-population ratio (Wang, 2006). In essence, the 2SFCA method measures spatial accessibility as a ratio of primary-care physicians to population, combining two steps. First, it assesses "physician availability" at the locations of physicians (supply) as the ratio of physicians to their surrounding population (i.e., within a threshold travel time from the physicians). Second, it sums up the ratios (i.e., physician availability derived in the first step) around (i.e., within the same threshold travel time from) each location of residents (demand) (Luo and Wang, 2003b).

In applying this method to church accessibility, this project searches all Protestants' residential locations (k) that are within a threshold travel time (d_0) from the Protestant church location j, and compute the number of Protestant churches to Protestant population ratio R_j within the catchment area:

$$R_j = 10000 * \frac{s_j}{\sum_{k \in \{d_{kj} \le d_0\}} P_k} R_j = 10000 * \frac{s_j}{\sum_{k \in \{d_{kj} \le d_0\}} P_k},$$

Here, P_k is the Protestant population of Protestants' residential location k whose centroid falls within the catchment (i.e., $d_k \le d_0$), S_j is the number of Protestant churches at location j; and d_{kj} is the travel time between k and j. (Wang and Luo, 2005).

As the second step of the 2SFCA, for each Protestant population location i, this study searchs all Protestant church locations (j) that are within the threshold travel time (d_0) from location i (i.e., catchment area i), and sum up the number of church to the number of Protestant population ratios R_j at these locations:

$$A_i^F = \sum_{j \in \{d_{ij} \le d_0\}} R_j = \sum_{j \in \{d_{ij} \le d_0\}} \left(\frac{S_j}{\sum_{k \in \{d_{kj} \le d_0\}} P_k} \right),$$

Where A_i^F represents the accessibility at Protestants' residential location i based on the 2SFCA, R_j is the church-to-Protestant ratio at church location j whose centroid falls within the catchment centered at i (i.e., $d_{ij} \le d_0$), and d_{ij} is the travel time between i and j. To be doable and measurable, the threshold time may be set at 30 minutes of driving for all locations. A larger value of A_i^F indicates a better church accessibility at a location. The 2SFCA method is effective in identifying areas with low church accessibility (Wang and Luo, 2005).

Rather than using the street map based on travel time, this paper is using a simplified 2SFCA, which uses the straight line of distance travel time because there are not sufficient street map data in all Chinese cities. The analysis unit involves polygon integrated census information and the church point. Due to the insufficient data, this study assumes that the population is distributed throughout the district equally.

It is worth noting that the colors or shapes of the map developed by the 2SFCA represent the different scores of the church accessibility in a specific city. The darker the color the higher the church accessibility score. According to the definition of church accessibility, non-color section or white color signifies that the accessibility score is zero, indicating that there are no churches available within 30 minutes of one-way driving. To interpret the distribution of the accessibility score, Wang and Luo define health professional shortage areas through assessing spatial and non-spatial factors for healthcare access as an integrated approach (Wang and Luo, 2005). As a result, they identify the area with score lower than 1/3,500, which is around 0.00028571, as a Health Professional Shortage Area (HPSA),

according to the criteria for HPSA designation. In particular, HPSA defines that the area should be classified as the health professional shortage if the residents can't reach their nearest health clinic within 30 minutes of driving (U.S. Department of Health and Human Services, 2004). Following this definition as a reference, this study uses 30 minutes of one-way driving as a criterion to estimate the shortage of church in Chinese large cities.

However, the threshold score for church shortage may have to be redefined due to its different characteristics from health care. Demonstrated by Map 1 below, the areas without color or white color represent church accessibility scores lower than 1/10,000, indicating that Protestants who are living in the areas must take more than 30 minutes of one-way driving to reach the nearest church destinations or meaning that one church may not be enough for Protestants. The areas with the blue color symbolizes the best or highest church accessibility score, demonstrating that the Protestants in these areas are able to reach their closest churches within 30 minutes of one-way driving and at the same time, one church may be abundant for the Protestants around that area.
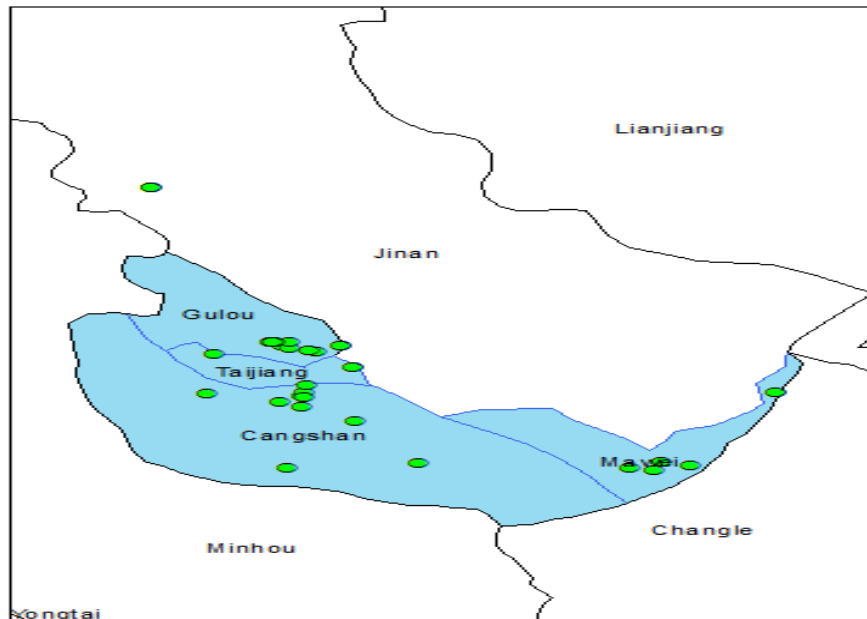

Map-1. The Map Sample by the Two Step Floating Catchment Area (2SFCA)

To supplement the 2SFCA method, it is vital to apply the additional spatial research method, the Network Analysis Method (NAM), to the study of church shortage in China. The NAM is to integrate and analyze network data, maps, and spatial information through GIS and other spatial statistical methods in an attempt to calculate church availability and accessibility. Different from the 2SFCA, the NAM is capable of demonstrating a street layer which "can contain the road type, distance, and travel speeds (miles or kilometers per hour) permitted in the underlying data table within GIS. This allows users to identify a station location, specify a travel time, and run a network analysis" (Environmental Systems Research Institute (ESRI), 2006).

As the first step, the NAM completes the map transformation designed to change the map to the right format and proper setting before it is usable and applicable, as the raw map data is only available online. In doing so, the NAM should transfer the current map format to the coverage format and export the coverage data back to the shapefile that can be edited through the ArcGIS software. Creating a network dataset is the second step of the NAM. Given that the shapefile documents are transferred from the original online maps, it is critical to create the network dataset for further network analysis. The third step is to import church point coordinates, including the longitude and latitude of each location, to locate the coordinates as the service facilities. The network analysis is the next step, in which the church points and the maps should be imported into the software. After running the built-in function through the network analysis, the project is able to calculate the driving time covering the selected areas by using three different time periods--15 minutes, 30 minutes, and 45 minutes--that represent the distances of 6km, 12km, and 18km, respectively. Furthermore, the network analysis will allow this project to calculate the coverage areas through using the built-in function, arrange the resulting data through Excel, and determine the percentage of Protestants or number of Protestants who cannot reach their nearest church within the designated time.

Another benefit of using the NAM is that it allows us to figure out the average driving speed in the cities based on the selected samples. Assuming that the provincial capital cities in China have the similar traffic conditions, this project selects Beijing, Shanghai and Xi'an as three samples. Google Maps is effective in calculating the selected starting and ending locations for the randomly selected routes around the center of the representative city, including one at the city center, one at the city boundary, and the last one between the city center and city boundary. Given the designated distance and driving time, the project lists the driving speed information regarding the three cities: Beijing--14.71km/h, 25.85 km/h, and 38.54 km/h; Shanghai--18.00 km/h, 21.4 km/h, and 25.89 km/h; and Xi'an--32.40 km/h, 32.88 km/h, and 39.00 km/h. As a result, the average driving speed is 27.63 km/h. To ensure consistency across calculations, this study sets up 24km/h for all provincial capital cities as the average driving speed.

Demonstrated by Map 2 below, the NAM is able to visualize different driving times (in minutes) and distances in a designated location. While the inner circle (green color) symbolizes 15 minutes of driving time and the middle circle (yellow) means 30 minutes of driving, the outsider circle (red) one represents 45 minutes of driving. Each spot on the map represents the location of a Protestant church. To make the calculation consistent with the 2SFCA, this study selects 30 minutes as the common time unit to test the church accessibility and church shortage in China following the NIH's definition of the health professional shortage area.
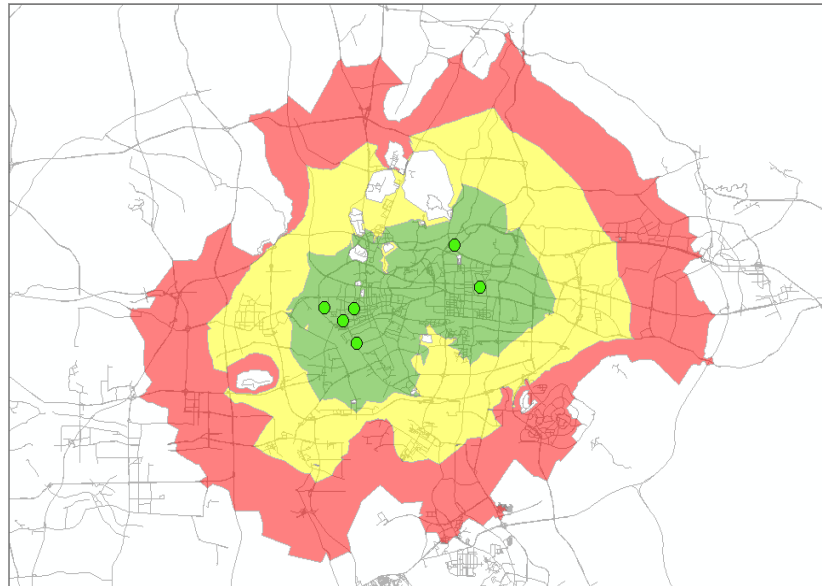
Map-2. Map Sample by the Network Analysis Method (NAM)

3. Data

Searching and verifying the data concerning Chinese Christianity is exceptionally challenging due to the lack of church transparency, including both official Protestant churches and non-official churches, such as the house churches. While the authors are fully aware of inaccurate and incomplete data in measuring church accessibility and church shortage in China through the 2SFCA and the NAM, the project has tried its best to utilize the following data as the key references:

The number of total Chinese Protestants. While a variety of resources released different numbers of Chinese Protestants, such as the Pew data (58 million) (Pew Research Center, 2011), the project relies on the official data, which reported 23,050,000 of Chinese Protestants in 2009 (Research Project Team of the Institute of World Religious Studies in the Chinese Academy of Social Sciences, 2010). Although this study fully recognizes that the official data has underestimated the real Protestant members in China, the project doesn't have enough empirical evidence nor the intellectual capability to disprove this estimate.

The number of total Chinese Protestant churches. After carefully studying the *2004 China's Economic Census Data with GIS Maps* released by the Chinese government, this project follows this official estimate, which was 14,509 of Chinese Protestant churches in 2004, excluding Catholic churches and non-official Protestant house churches (China Census Bureau, 2005). Furthermore, data compiled and designed by the University of Michigan and Purdue University, the "Spatial Explorer of Religion" (China Census Bureau, 2005) has developed a network that incorporates the aforementioned 14,509 churches through spatial information technology. This study notices the time disparity between the number of Protestants in 2009 and the number of churches in 2004, but in light of the limited data, the project has to use the data during the similar periods as the estimated reference.

The number of Protestants at the levels of province and provincial capital city. Unfortunately, this study is unable to find any official information concerning the number of Protestants at the levels of province and city. Therefore, this study has to selectively rely on 1) the data released by The Amity Foundation (2004) the county and city Gazetteers (*fang zhi*); and 3) Ying Fuk-Tsang (2009).

The spatial street and district maps at the level of city. This study is relying on the following three resources to calculate the church accessibility score and church shortage: 1) the "CloudMade" website[1] to retrieve the information concerning the spatial street maps in the thirty-one provincial capital cities; 2) the "Bo Ya Di Ming" website (博雅地名网)[2] to recover the district map information about the cities; and 3) Google Maps at the levels of country, province and city.
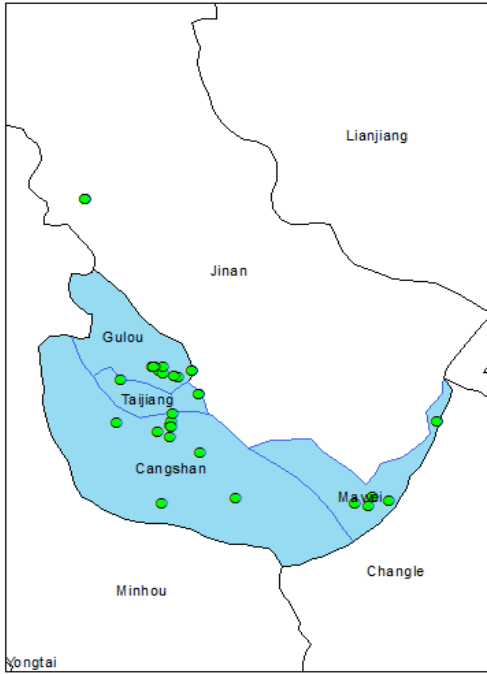
4. Spatial Church Accessibility in East China

Mainland China is comprised of three regions, east, central, and west regions, and thirty-one provinces and municipalities in addition to Taiwan, Hong Kong, and Macau. East China includes eleven provinces and municipalities, such as Zhejiang, Fujian, Shanghai, Liaoning, Jiangsu, Beijing, Shandong, Hebei, Guangdong, Tianjin, and Hainan.

In applying the aforementioned 2SFCA method to the study of church accessibility in east China, this study selects 30 minutes or 12 km as the reference to figure out the church accessibility score in eleven provincial capital cities in east China. In other words, the project defines the areas in which the Protestant population cannot reach their nearest churches within 30 minutes through either driving or public transportation as the church shortage or low church accessibility. Map 3 (including eleven maps in the eleven provincial capital cities) demonstrates that the areas with white color represent a zero church accessibility score; Protestants living in these areas cannot reach their nearest churches within 30 minutes. Here, in addition to the areas with the white colors, the blue color illustrates that the Protestants can't reach their nearest church within 30 minutes of one-way driving.

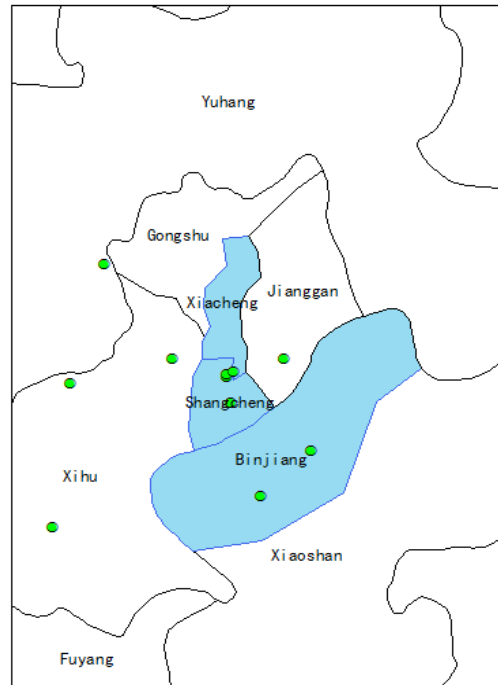[1] See its website: http://downloads.cloudmade.com/asia/eastern_asia/china.
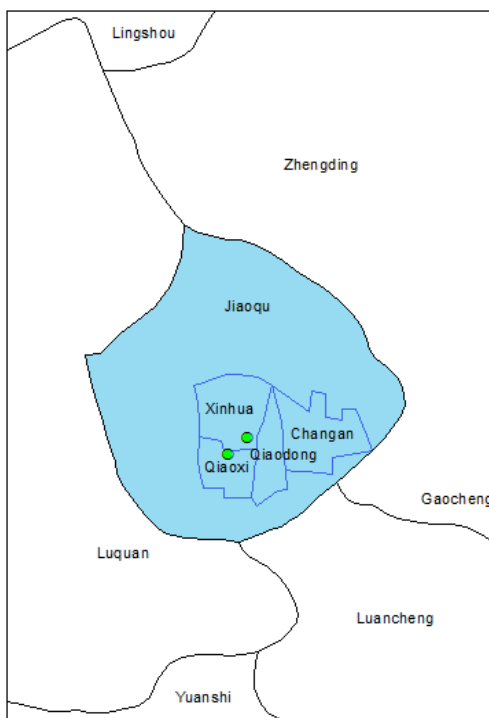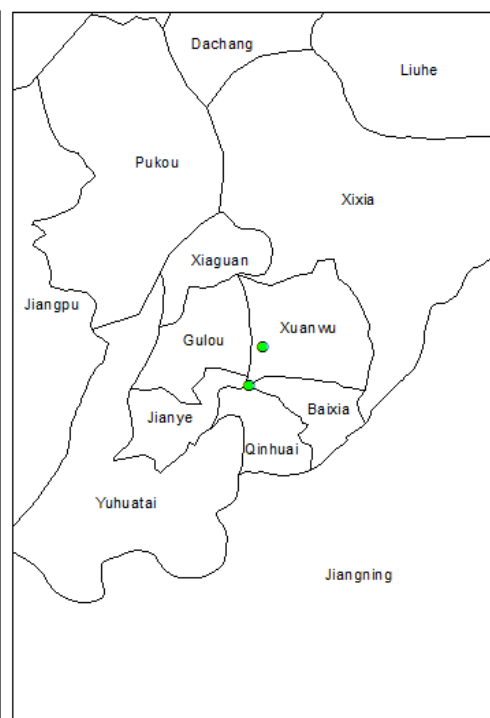[2] See its website: http://www.tcmap.com.cn/.

a. Fuzhou
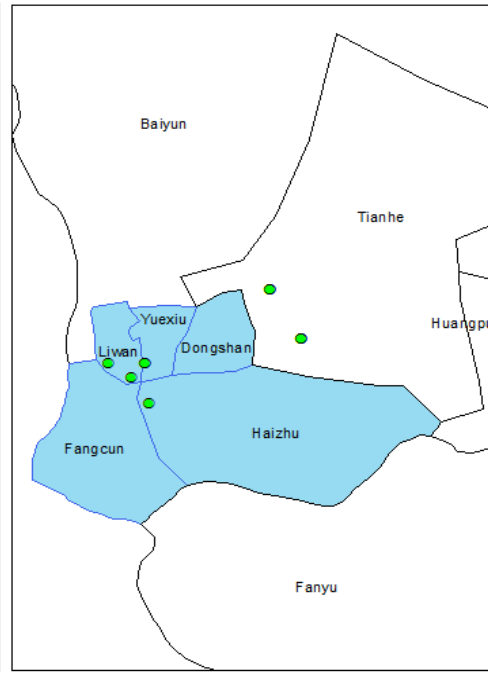
b. Guangzhou

c. Haikou

d. Hangzhou

e. Shijiazhuang

f. Nanjing

g. Shenyang

h. Jinan

i. Shanghai

j. Tianjin

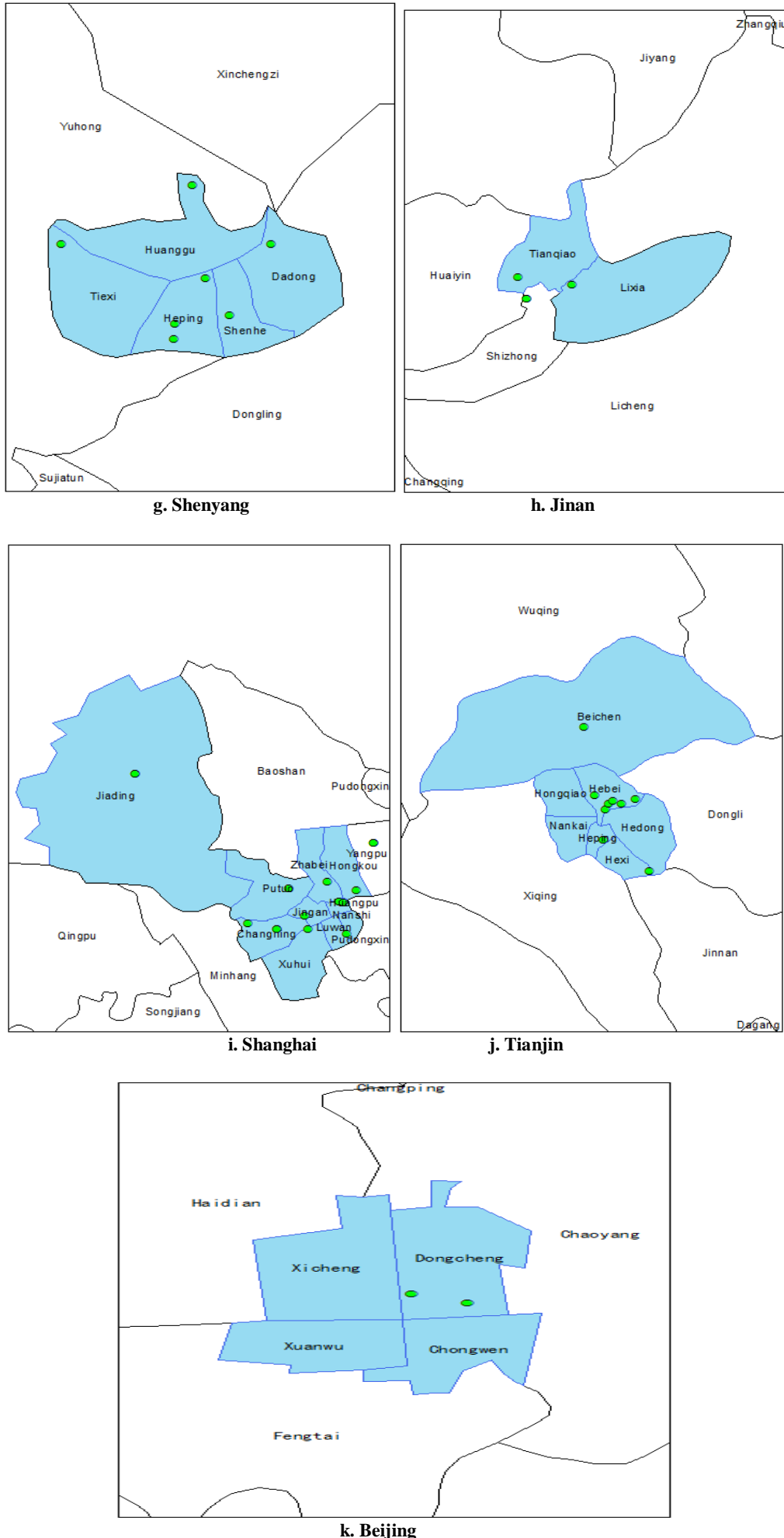**k. Beijing**

Map-3. Spatial Maps of Church Accessibility by the 2SFCA in East China

Table 1 below summarizes the church accessibility scores in the eleven cities above and concludes that some percentages of the Protestants in nine cities need to take more than 30 minutes of one-way or 60 minutes of round trip transportation to arrive at the nearest churches. It is worth noting that the calculation of the percentages of Protestants who must take more than 30 minutes to reach the nearest church is based on the assumption that the density of the protestant (ρ) is the same in different districts. Then, the percentage of Protestants can be calculated by using the following formula:

[(area that can be reached in 30 minutes)* ρ]/[(total area of the city)* ρ]= (area that can be reached in 30 minutes)/(total area of the city).

Table-1. Church Accessibility in East China by the 2SFCA

Provincial Capital Cities	Percentage of Protestants that Have Lower Accessibility Score than 1/10000
Nanjing	100.0%
Haikou	94.8%
Beijing	83.8%
Jinan	73.7%
Shenyang	69.4%
Fuzhou	67.7%
Hangzhou	64.9%
Guangzhou	42.8%
Shanghai	10.4%
Shijiazhuang	0.0%
Tianjin	0.0%

In addition, it is meaningful to use the NAM to check the reliability of the 2SFCA method on the study of church accessibility and church shortage. Following the aforementioned NAM, this study selects 30 minutes as the same driving time in eleven provincial capital cities in east China. Table 2 show the results in terms of 1) their accumulated areas; 2) Protestant members; 3) the area coverage; 4) Protestants who can't reach the nearest church within 30 minutes, and 5) the number of Protestants in the area.

Table-2. Church Accessibility in East China by the NAM (30 minutes)

12km (30 minutes)	Accumulated Area (km2)	Protestants and Area Coverage	Protestants Can't Reach the Nearest Church	Number of Protestants in the Area
Haikou	153.1992	6.53%	93.47%	467
Beijing	593.2156	60.61%	39.39%	18,625
Jinan	568.0469	71.76%	28.24%	31,881
Fuzhou	1,097.782	105.80%	0.00%	58,089
Guangzhou	512.6185	138.33%	0.00%	17,998
Hangzhou	974.5984	133.84%	0.00%	157,423
Nanjing	464.8829	178.66%	0.00%	105,760
Shanghai	1,297.462	448.95%	0.00%	151,468
Shenyang	1,097.721	142.75%	0.00%	69,912
Shijiazhuang	435.4794	108.51%	0.00%	12,820
Tianjin	1,101.038	636.44%	0.00%	15,385

Illustrated by Table 2, Haikou, Beijing, and Jinan should be the areas which have the issues of church shortage because 93.47%, 39.39%, and 28.24% of their Protestants have to take more than 30 minutes of one-way driving to their nearest churches. For the remaining eight cities in east China, all Protestants were able to reach their nearest churches within 30 minutes of one-way driving.

Significantly, both the NAM and the 2SFCA identified Haikou, Beijing, and Jinan as having church shortage with zero church accessibility. Note that the rankings of church shortage and the percentages of Protestants taking more than 30 minutes to their nearest churches are different among the three cities, based on the two research methods due to their different analysis database. Actually, their differences can be reduced by using more detailed district maps through the 2SFCA method. However, given the lack of data infrastructure and spatial resources in China, the detailed district maps are hard to obtain or develop. As a result, it can be concluded that the NAM is more effective than the 2SFCA in the countries with few district maps and spatial data.

In an attempt to visualize the driving distance in each specific city, the project sets up three different driving times (15 minutes, 3F0 minutes, and 45 minutes, respectively), demonstrated by the different ranges of ring (see Map 4, including 11 city maps). While the inner ring or the smallest one symbolizes 15 minutes of driving time and the middle ring means 30 minutes of driving, the outer ring or the largest one represents 45 minutes of driving. Each spot on the map corresponds to the location of a church.
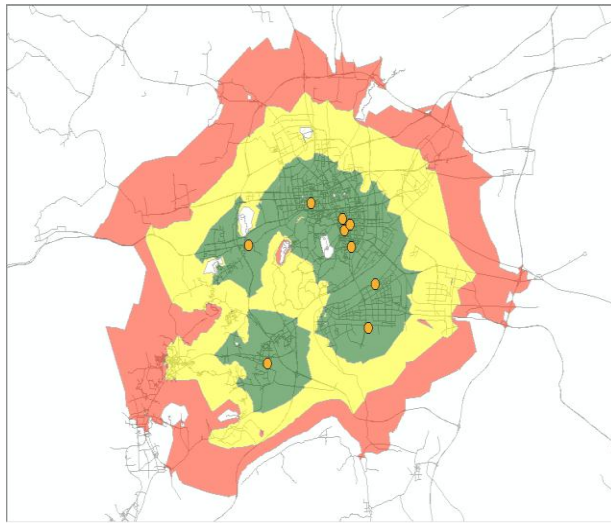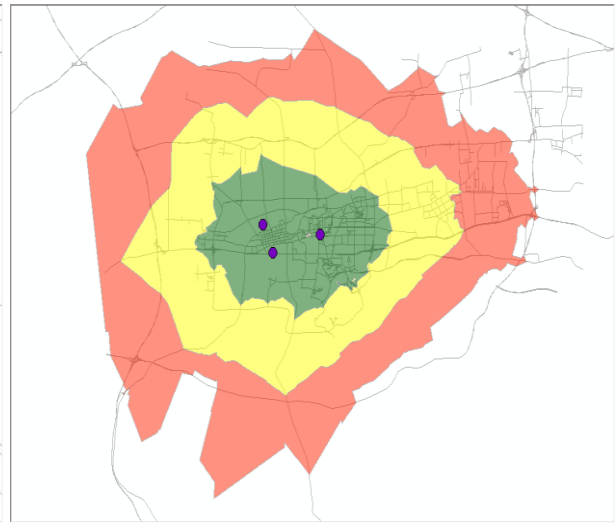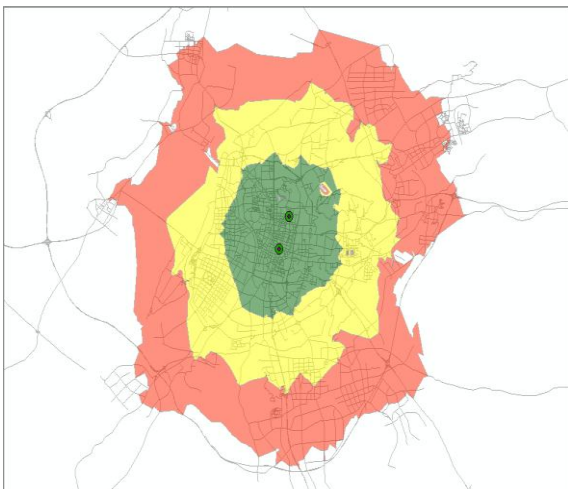

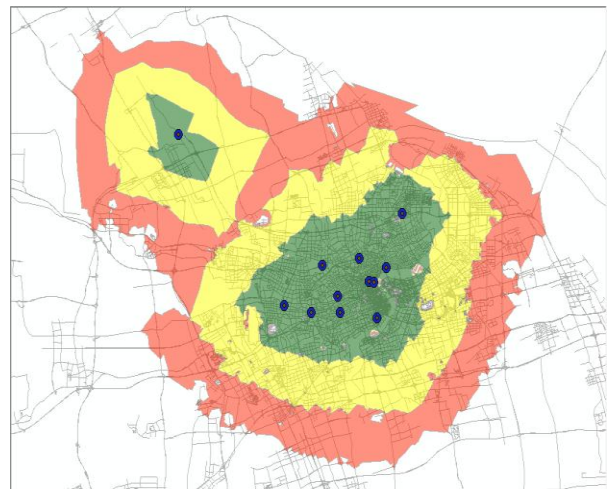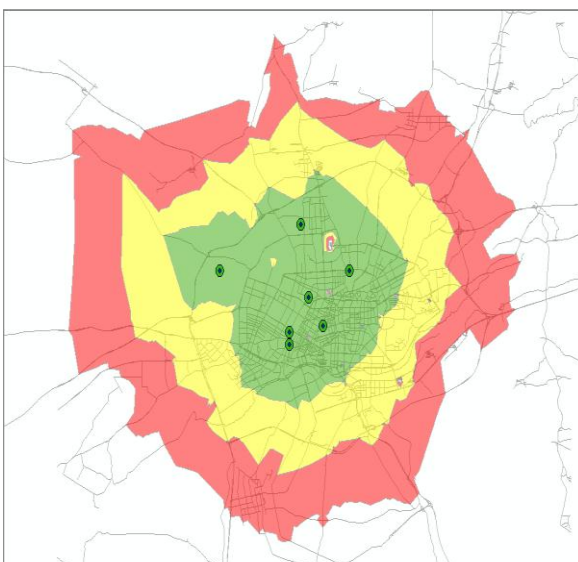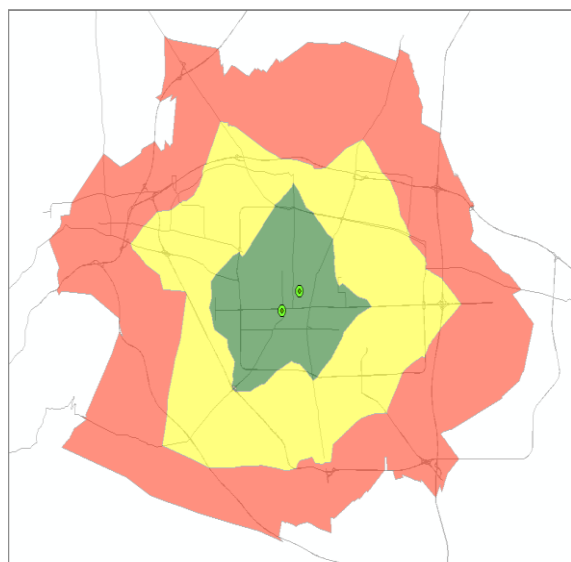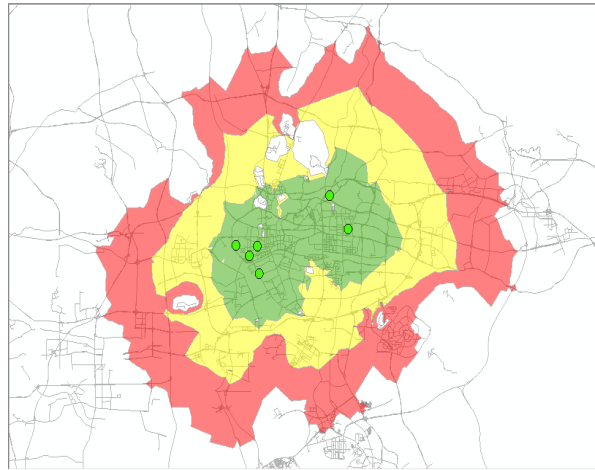**a. Beijing**   **b. Fuzhou**
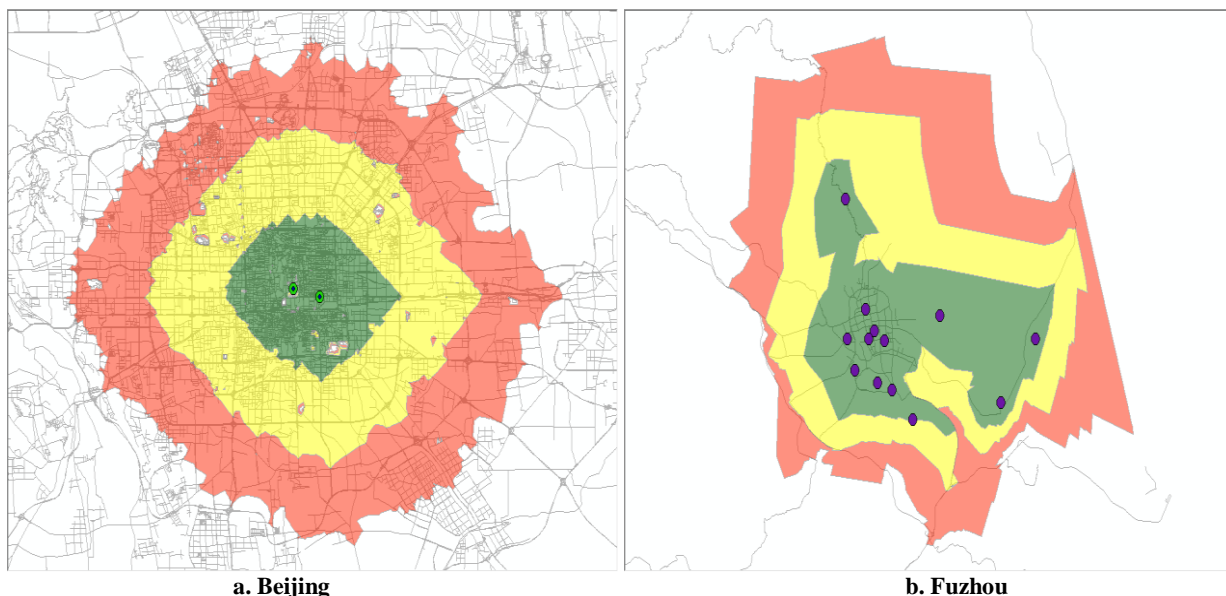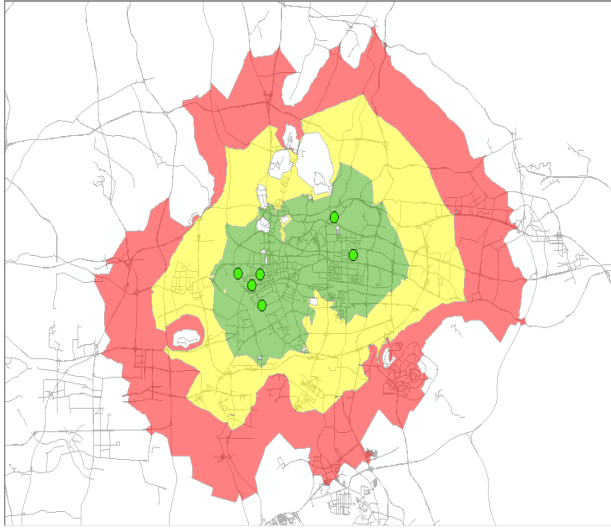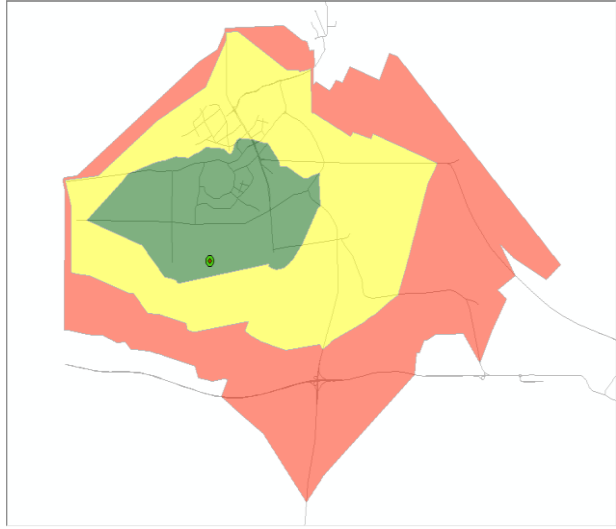
c. Guangzhou

d. Haikou

e. Hangzhou

f. Jinan

g. Nanjing

h. Shanghai

i. Shenyang

j. Shijiazhuang

k. Tianjin
Map-4. Spatial Driving Maps in East China by the NAM
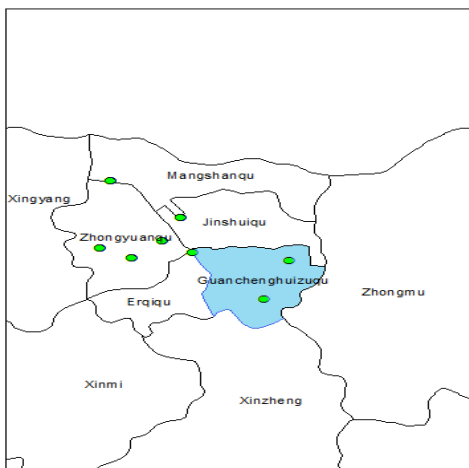
5. Spatial Church Accessibility in Central China

Central China covers eight provinces, including Henan, Anhui, Heilongjiang, Jilin, Hubei, Shanxi, Jiangxi, and Hunan. Using the 2FSCA method testing eight provincial capital cities in central China, Map 5, including eight city maps, shows that Harbin, Changsha, Taiyuan, and Hefei cities have the highest percentage of area with zero accessibility score.
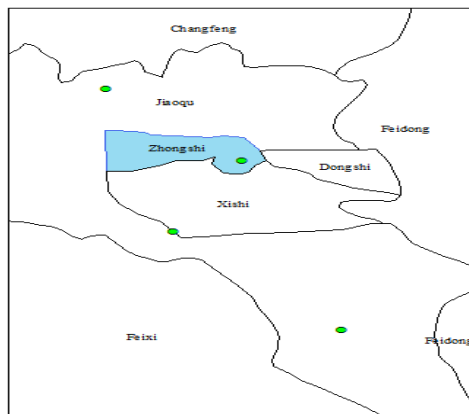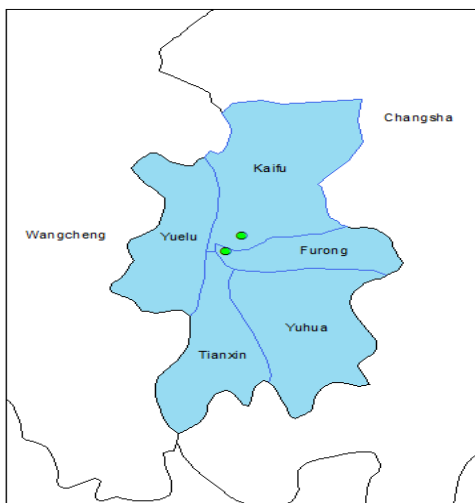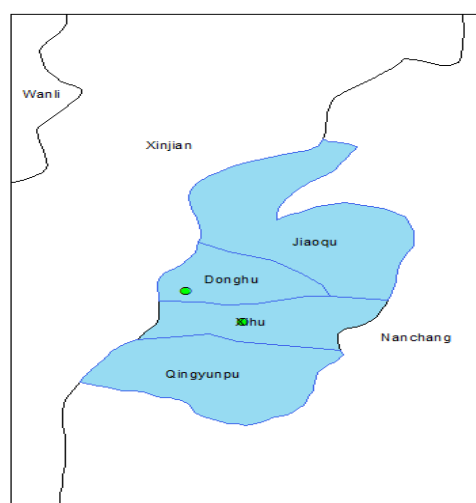

a. Hefei
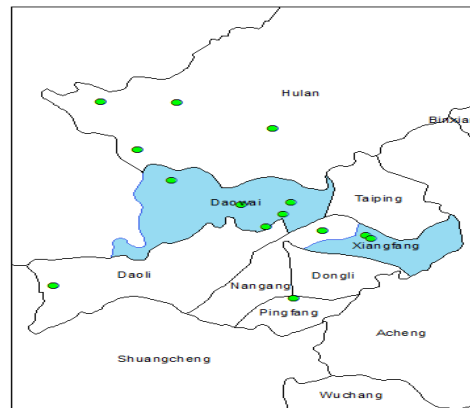
b. Harbin

c. Zhengzhou
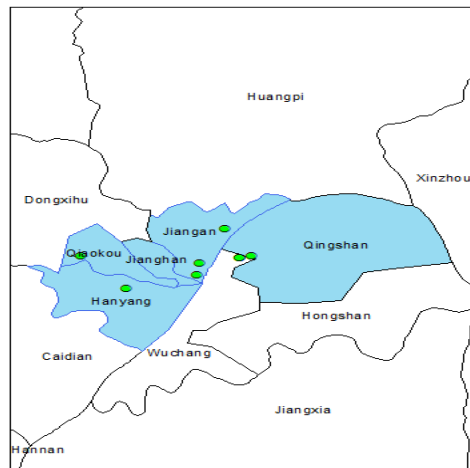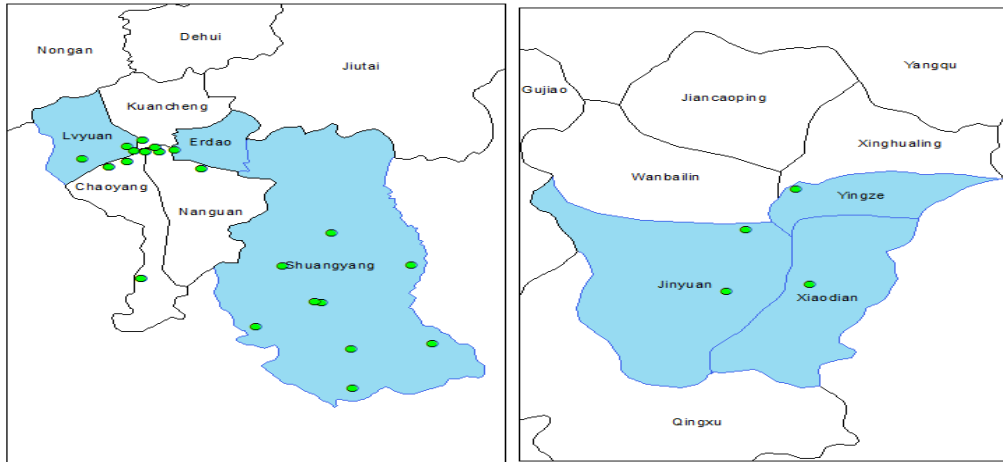

d. Wuhan

e. Changsha

f. Nanchang

g. Changchun   **h. Taiyuan**

Map-5. Spatial Maps of Church Accessibility in Central China by the 2SFCA

Table 3 below provides the statistical perspective in identifying the rankings of church shortage cities and calculating the percentages of Protestants taking more than 30 minutes of one-way driving to the nearest churches. As a result, Harbin (64%) (Map 5-b), Changsha (45%) (Map 5-e), Taiyuan (16%) (Map 5-h) and Hefei (1%) (Map 5-a) should be identified as the areas with the lowest church accessibility scores and the worst church shortage situation.

**Table-3.** Church Accessibility in Central China by the 2SFCA

Provincial Capital Cities	Percentage of Protestants that Have Lower Accessibility Score than 1/10000
Hefei	95.7%
Harbin	76.9%
Zhengzhou	70.5%
Changsha	44.6%
Taiyuan	15.8%
Changchun	0.0%
Nanchang	0.0%
Wuhan	0.0%

Similarly, the project needs to apply the NAM as an additional way to compare the results provided by the different spatial research methods. Shown by Table 4 below, some percentages of Protestants in Hefei, Harbin, Zhengzhou, Changsha and Taiyuan could not reach their nearest churches within 30 minutes. The Protestants in the remaining three cities in the region could take less than 30 minutes to reach their nearest churches. Therefore, Hefei, Harbin, Zhengzhou, Changsha and Taiyuan could be defined as the areas of church shortage based on the results provided by the NAM.

Table-4. Church Accessibility in Central China by the NAM (30 minutes)

12km (30 minutes)	Accumulated Area (km2)	Protestants and Area Coverage (%)	Protestants Can't Reach the Nearest Church (%)	Number of Protestant in the Area
Changsha	350.5395	36.18%	63.82%	3,442
Taiyuan	923.2529	65.21%	34.79%	10,134
Nanchang	75.44191	88.76%	11.24%	17,540
Harbin	4,620.649	99.42%	0.58%	63,940
Changchun	3,601.888	124.16%	0.00%	40,287
Hefei	774.0141	106.50%	0.00%	81,924
Wuhan	860.9509	304.36%	0.00%	65,230
Zhengzhou	1,102.777	108.51%	0.00%	135,929

Map 6 (including eight city maps) below provides the spatial driving maps for eight provincial capital cities in central China. Similarly, the different rings represent the different driving distances and time, such as 15, 30 and 45 minutes, respectively.
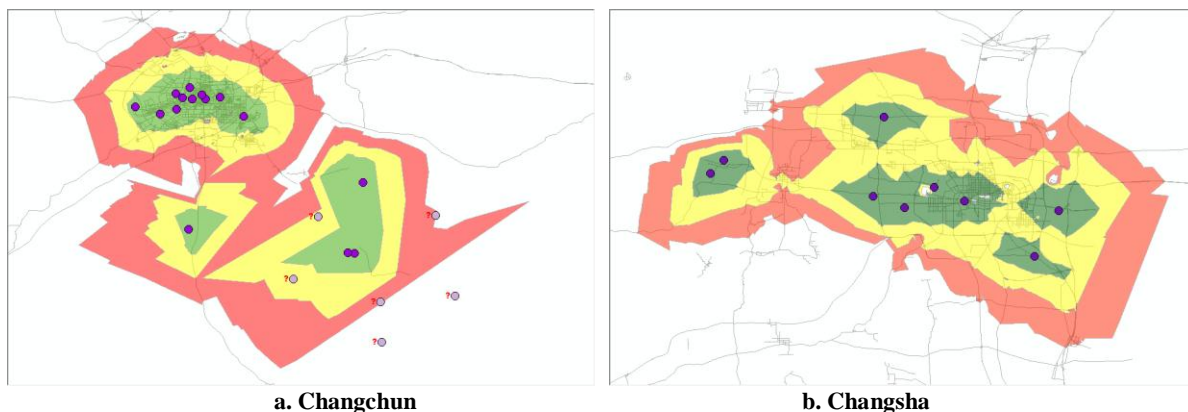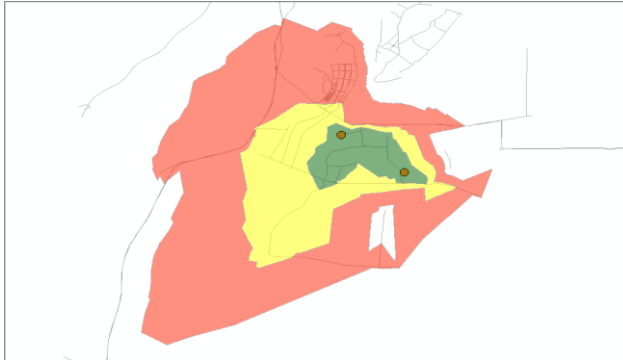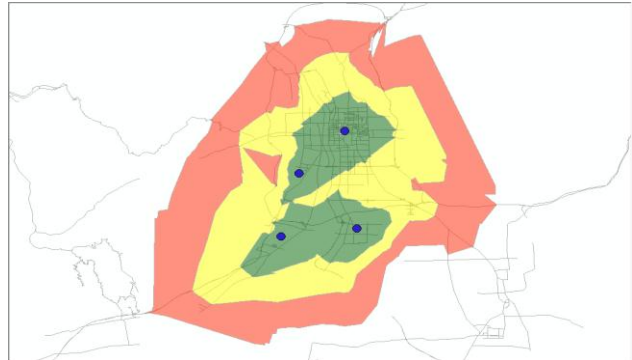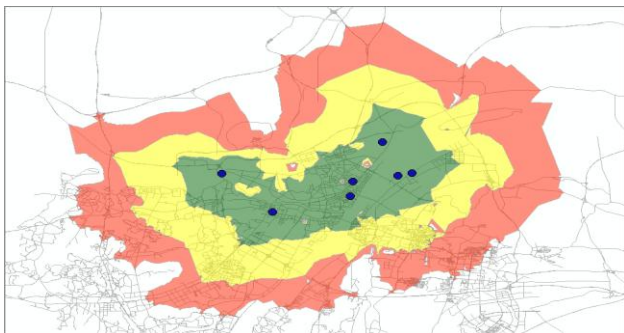

a. Changchun   **b. Changsha**
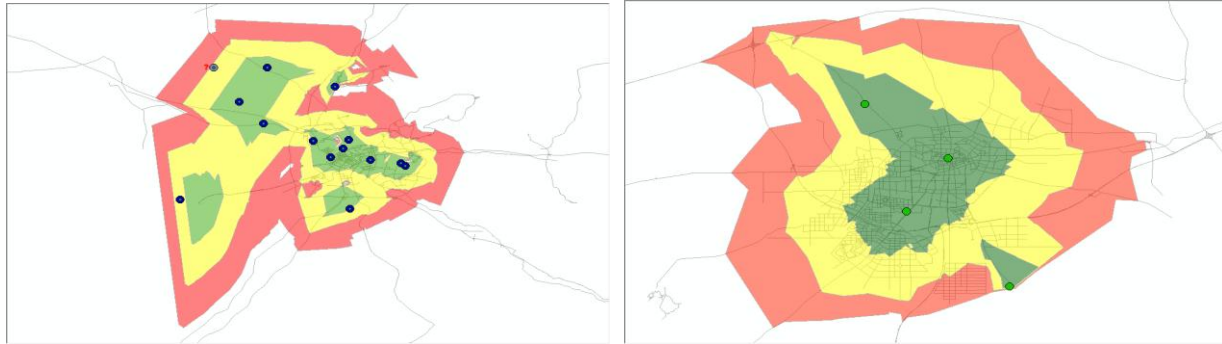
c. Harbin   **d. Hefei**
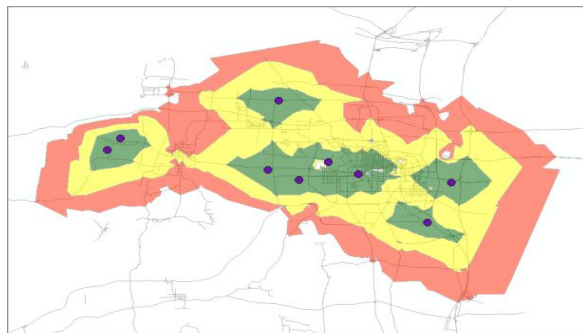
e.Nanchang   **f. Taiyuan**

g. Wuhan   **h. Zhengzhou**

**Map-6.** Spatial Driving Maps in Central China by the NAM

A closer look at the comparative data from the 2SFCA and the NAM reveals interesting results. On one hand, both shared the similar discovery that Changsha, Taiyuan, and Harbin should be identified as the areas of church shortage, although the rankings of church shortage in the three cities are different. On the other hand, they also showed some disparities: while the NAM confirms Nanchang as the area of low church accessibility, the 2SFCA identifies Hefei and Zhengzhou as the areas of church shortage. Again, their different results could be minimized by applying more detailed and accurate district maps through the 2SFCA method.
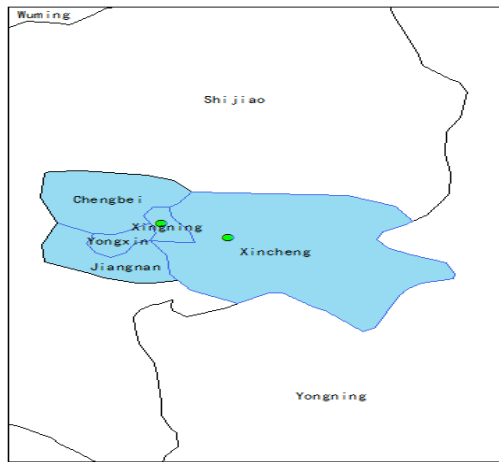
6. Spatial Church Accessibility in West China

In addition to east and central China, west China includes twelve provinces and municipalities: Yunnan, Chongqing, Shaanxi, Sichuan, Gansu, Guizhou, Xinjiang, Neimenggu (Inner Mongolia), Ningxia, Qinghai, Guangxi and Xizang (Tibet). However, this project doesn't include Tibet and Yinchuan because the project is unable to find any church information from the official data. Fortunately, the 2SFCA is capable of assessing the church accessibility in ten other western cities with the assistance of GIS. Map 7, including ten city maps in west China, demonstrates a variety of church accessibility scores. While the blue color represents high accessibility scores, the white color or non-color areas stand for zero accessibility scores or the worst areas of church shortage.
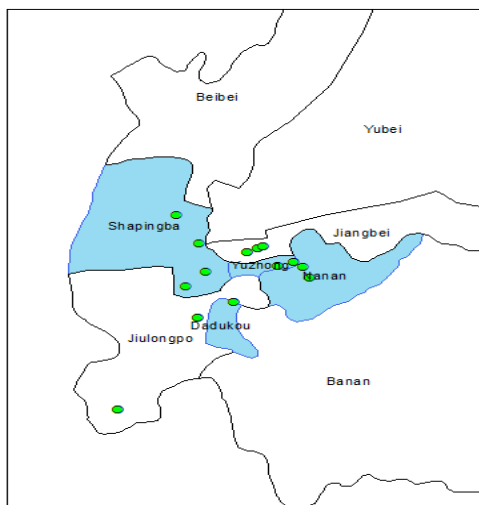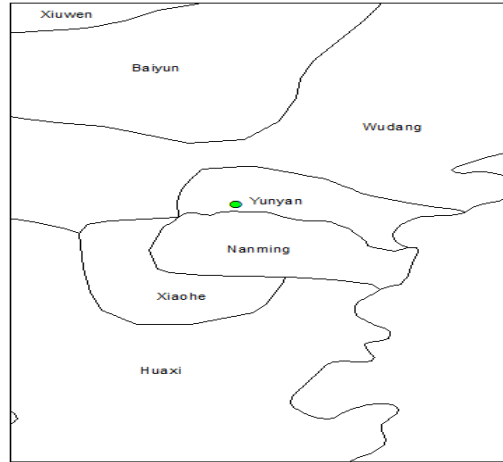

a. Chongqing   **b. Lanzhou**
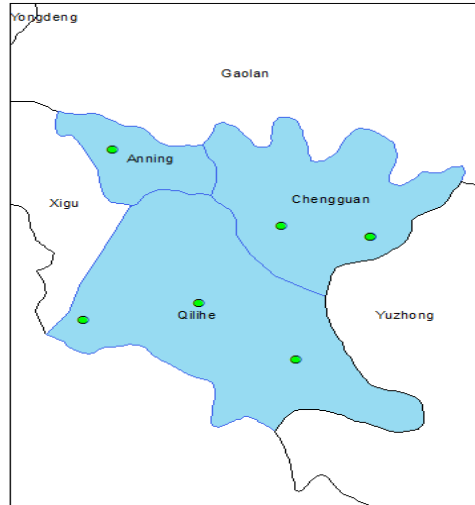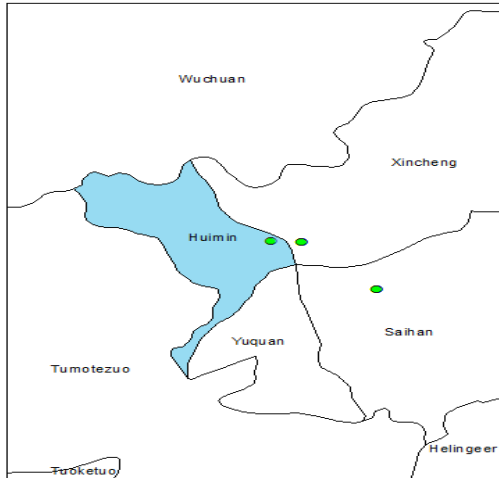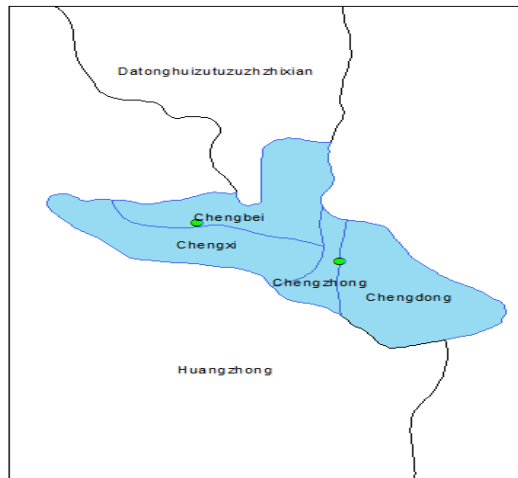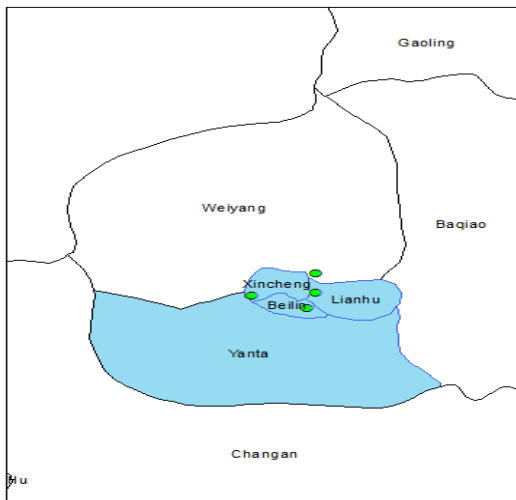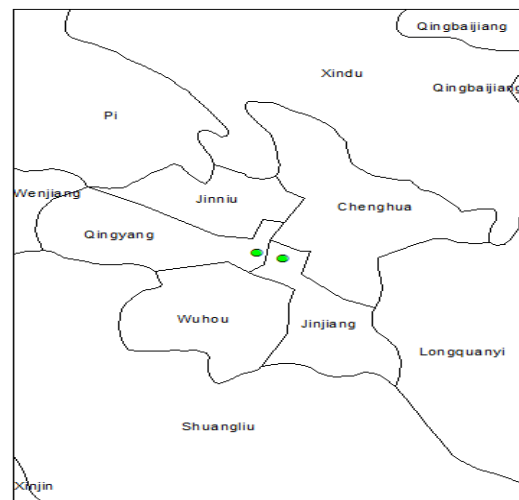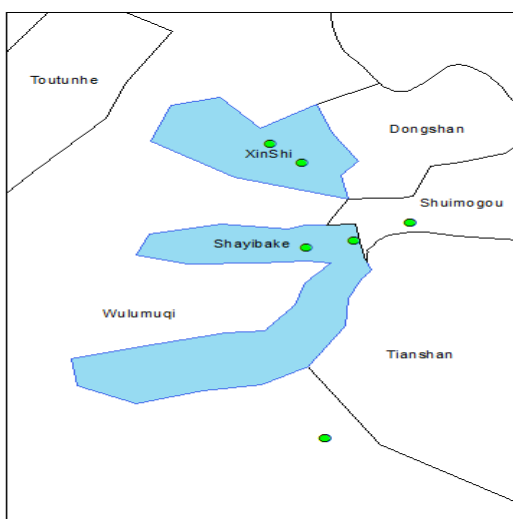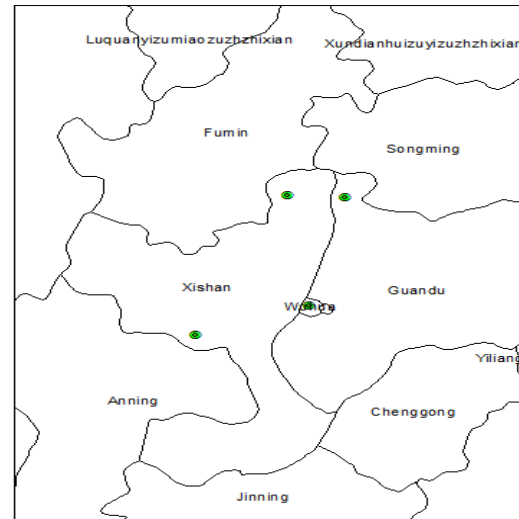
Map-7. Spatial Maps of Church Accessibility in West China by the 2SFCA

Table 5 below reveals clear information concerning the church shortage situation in west China. Given that some Protestants in Chengdu, Kunming, Nanning, Huhhot, Urumqi, and Chongqing must take more than 30 minutes to

reach their nearest churches, these six cities may be categorized as the areas with low accessibility scores and serious church shortage according to the 2SFCA.

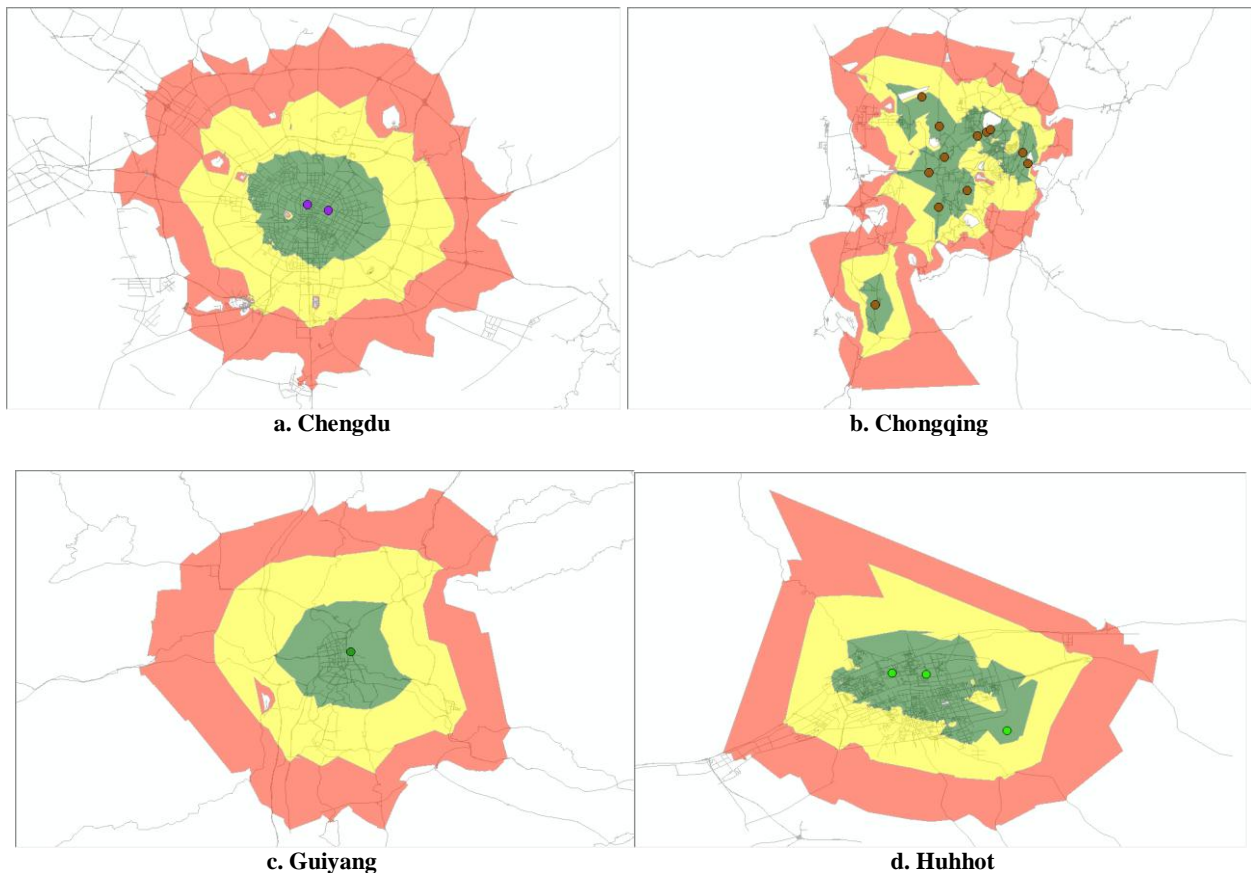**Table-5.** Church Accessibility in West China by the 2SFCA

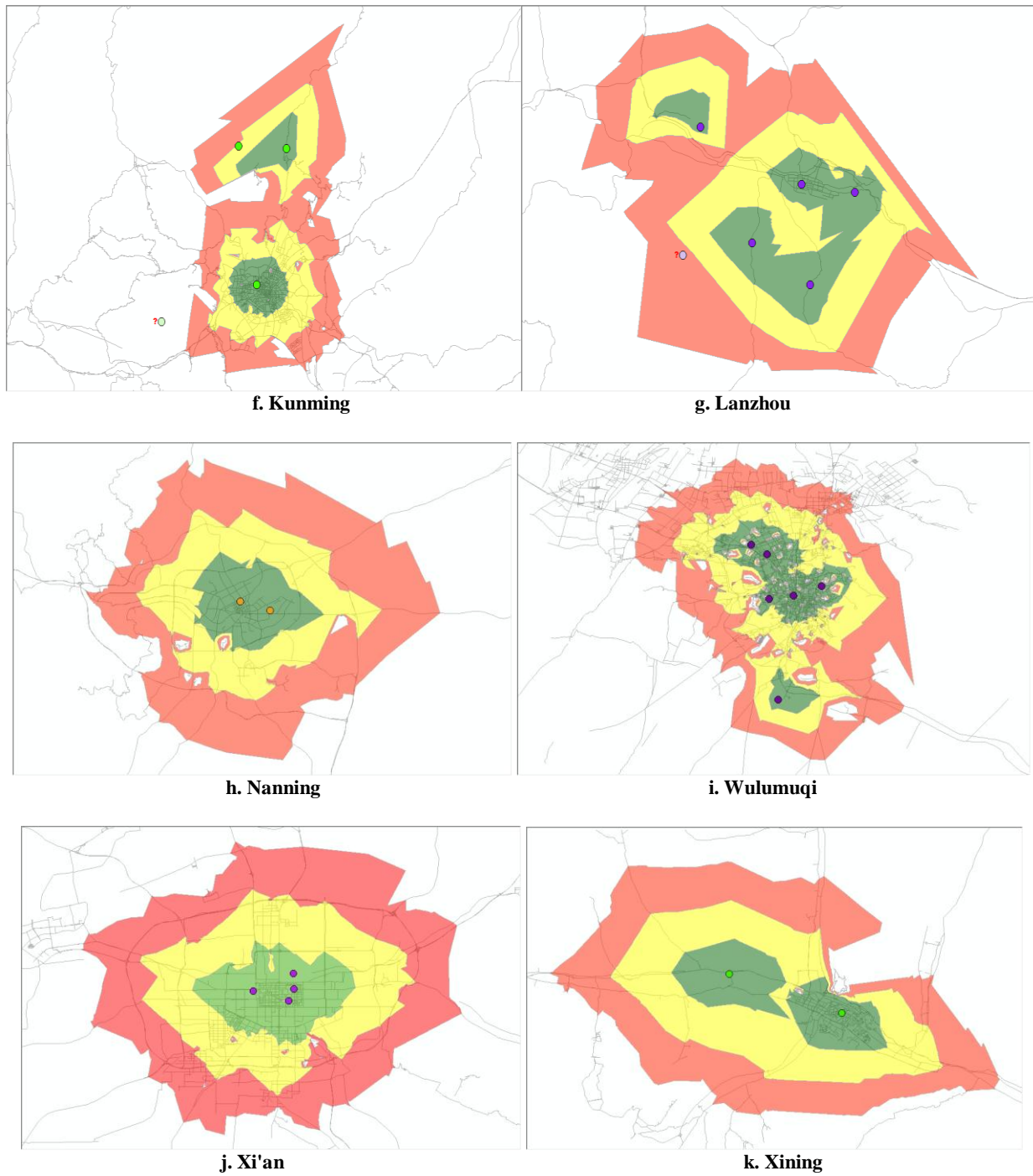| Provincial Capital Cities	Percentage of Protestants that Have Lower Accessibility Score than 1/10000
Chengdu	100.0%
Kunming	100.0%
Nanning	90.8%
Huhhot	84.8%
Urumqi	43.6%
Chongqing	37.9%
Guiyang	0.0%
Lanzhou	0.0%
Xi'an	0.0%
Xining	0.0%
Lasa	N/A
Yinchuan	N/A

Similarly, the project needs to test west China's church accessibility through the NAM to confirm whether or not its results are similar to the 2SFCA. Following the same research method, the NAM is able to discover the percentage of Protestants who could not reach the nearest church within 30 minutes of one-way driving or with the distance of 12 km (see Table 6). As a result, Table 6 shows that Nanning, Kunming, Huhhot and Chongqing could be determined as the areas of church shortage because 18%-80% of Protestants in these four cities could not arrive at their nearest churches in 30 minutes of driving from their residential locations.

Table-6. Church Accessibility in West China by the NAM (30 minutes)

12km (30 minutes)	Accumulated Area (km2)	Protestants and Area Coverage (%)	Protestants Can't Reach the Nearest Church (%)	Number of Protestants in the Area
Nanning	330.5973	20.37%	79.63%	1,292
Kunming	501.8277	23.13%	76.87%	14,398
Huhhot	697.2991	33.19%	66.81%	2,623
Chongqing	1,183.309	82.40%	17.60%	251,322
Chengdu	466.7656	110.87%	0.00%	29,266
Guiyang	466.7656	154.09%	0.00%	22,981
Lanzhou	1,383.937	196.86%	0.00%	22,981
Urumqi	1,150.604	138.96%	0.00%	22,981
Xi'an	557.8924	613.07%	0.00%	65,570
Xining	633.3008	130.07%	0.00%	65,570
Lasa	N/A	N/A	N/A	N/A
Yinchuan	N/A	N/A	N/A	N/A

Map 8 provides the spatial evidences regarding the driving time demonstrated by three different times (15, 30 and 45 minutes, respectively) with three different rings.

a. Chengdu

b. Chongqing

c. Guiyang

d. Huhhot

f. Kunming

g. Lanzhou

h. Nanning

i. Wulumuqi

j. Xi'an

k. Xining

Map-8. Spatial Driving Maps in West China by the NAM

Obviously, the results from the NAM and the 2SFCA methods share their consensus that Nanning (Map 8-h), Kunming (Map 8-f), Huhhot (Map 8-d) and Chongqing (Map 8-b) should be the areas of church shortage. However, the 2SFCA highlights the cities of Chengdu and Urumqi as the locations of low church accessibility.

To demonstrate a clear nationwide picture concerning China's shortage of Protestant churches and the church accessibility in the 31 provincial capital cities, it is essential to summarize and compare the results from the NAM and the 2SFCA methods (see Table 7). Generally speaking, the results by both methods conclude that the following ten provisional capital cities should be identified as the areas of church shortage: Haikou, Beijing and Jinan in east China; Changsha, Taiyuan and Harbin in central China; and Nanning, Kunming, Huhhot and Chongqing in west China. However, both methods attest the different results in the remaining several cities in three regions. While the NAM identifies Nanchang as the low church accessibility, the 2SFCA method classifies additional ten cities as the areas of church shortage.

To provide the overall information concerning the average percentages for those Protestants who could not reach their nearest church within 30 minutes, column 4 of Table 7 adds the average percentages of Protestants calculated by the NAM and the 2SFCA and shows the rankings of the combined percentages. As a result, among the ten cities with the church shortage in China, Haikou has the lowest church accessibility and highest percentage of Protestants who must take more than 30 minutes to reach their nearest churches (94.15%). By contrast, Taiyuan has its relatively lowest percentage of Protestants (25.3%) who need more than 30 minutes travel to attend their church services.

Table-7. Provincial Capital Cities with the Shortage of Protestant Church in China

Name of City	% of Protestants can't reach the nearest church: NAM	% of Protestants can't reach the nearest church: 2SFCA	Average Percentages and Rankings (%)
1. Haikou	93.47	94.8	94.15
2. Kunming	76.87	100	88.44
3. Nanning	79.63	90.8	85.24
4. Hohhot	66.81	84.8	75.8
			Continue

5. Beijing	39.39	83.8	61.59
6. Changsha	63.82	44.6	54.2
7. Jinan	28.24	73.7	50.97
8. Harbin	0.58	76.9	38.74
9. Chongqing	17.6	37.9	27.77
10. Taiyuan	34.79	15.8	25.3

7. Conclusion: Comparative Studies on the Two Spatial Methods

Assisted by GIS, it is an innovative effort to utilize the 2SFCA and the NAM addressing the Protestant church accessibility, church shortage, and religious market in China. This study has proved that the combined methods are better than one method alone to optimize the spatial study of religion.

Obviously, the key difference between the two methods is that while the NAM relies on the spatial street maps, the 2SFCA is using the district maps that can only be divided into a few small districts instead of streets, and thus cannot be measured by its center allowing higher accuracy. For instance, within the area A below, there is a B area with slash lines in which the residents in the area C can reach there within 30 minutes (see Figure 1 below). Here, churches are located in the area C. Based on the NAM, the area B can't be identified as the area with church shortage. However, the area A_C, the center of the area A, is beyond the area C. Therefore, according to the 2SFCA method, the area B should be determined as the location of church shortage. In other words, the different methods based on the street maps (the NAM) or the district maps (2SFCA) may generate slightly different results in the same location.
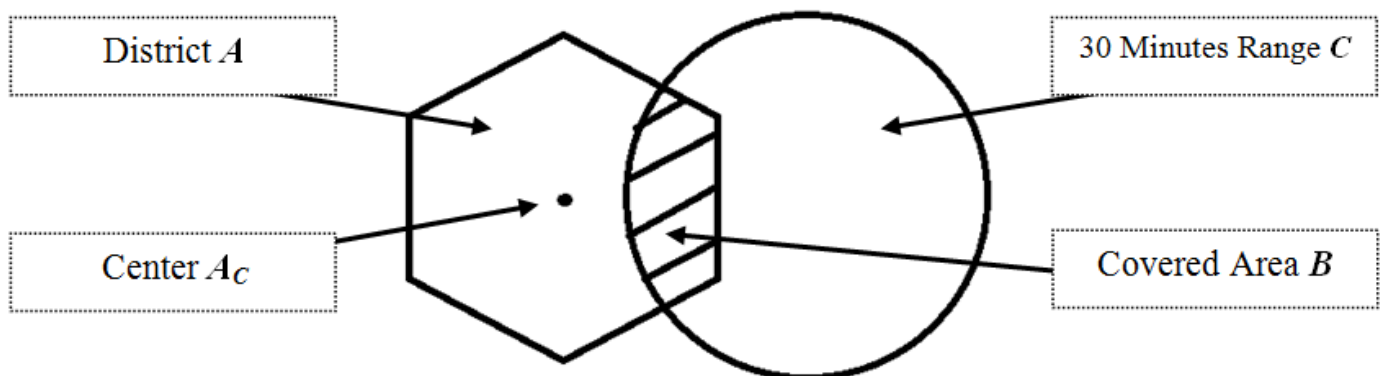

Figure-1. Sketch on the Differences between the NAM and 2SFCA Methods

It is worth noting that although the 2SFCA may be somewhat less accurate than the NAM, the inaccuracy can be significantly diminished by using more detailed district maps. While both methods are useful in studying the church shortage and religious market, the 2SFCA is much more capable of calculating the accessibility scores for each small area and demonstrating the different degrees of church accessibility in a given area. Needless to say, in light of the incomplete district maps and spatial data in China, it is difficult, if not impossible, to use the 2SFCA method to study China's church accessibility based on the accurate and comprehensive district maps.

Thus, applying two methods on the same research subject may generate the supplemental effects and added values based on their similar and different results. On one hand, their similar conclusions would have much more powerful credibility and solid foundation to support each other on the study of church shortage in China. On the other hand, their different discoveries would invite further in-depth study and inspire the innovation of new additional research methods benefitting from the deficiencies of the two methods.

In conclusion, although the theory-driven and qualitative research on Chinese religious markets is important, the innovative research methods supported by the qualitative analysis are vital to improve the quality of religious studies. Evidently, in addition to the spatial study of Chinese Protestantism, it is compulsory to integrate the conventional research methods, such as survey, interview, observation, and statistics. Given the complex nature of religious studies, the interdisciplinary study is necessary to enhance our understanding of religions and society in China and other parts of the world.

8. Acknowledgment

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