Spatial Disaggregation of Population Data with 3D Building Information

——A case study of Deqing County

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1 Introduction

Why?

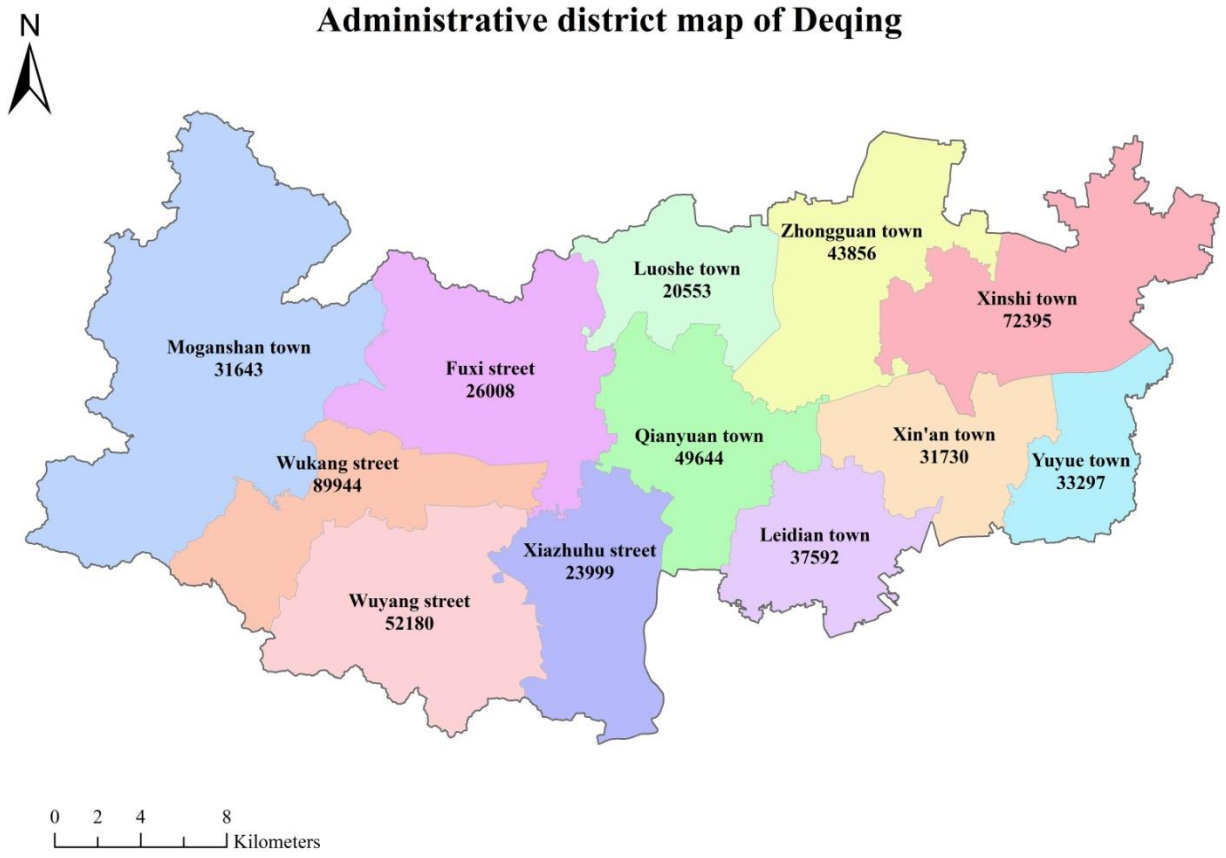
- statistical information on socio-economic activities is widely available,
- aggregated to country or regional administrative units,
- useful for assessments,
- smooth out spatial variations in impact

Definition — **Spatial disaggregation are processes by which information at a coarse spatial scale is translated to finer scales, while maintaining consistency with the original dataset** *[Monteiro et al. 2018]*.

Objective — Provide more localized estimates and spatial analysis.

An example of Deqing

Name (town)	Population
Wukang	89944
Fuxi	26008
Xiazhuhu	23999
Wuyang	52180
Luoshe	20553
Zhongguan	43856
Moganshan	31643
Qianyuan	49644
Leidian	37592
Xinan	31730
Xinshi	72395
Yuyue	33297



Disaggregation without Geospatial Information

In early stage, as lack of auxiliary data related to population,

Negative Index Model *[Feng & Zhou 2003; Wu & Gao 2010]*,

Nuclear Density Estimation Model *[Lu et al. 2002; Yan et al. 2011]* , etc

were often used.

- Principle – *(urban geography) population density decreases from the city center to the periphery.*
- Advantages - *simple model, simulation of continuous population distribution; suitable for large and medium-sized cities population density simulation*.
- Insufficiency - *The value of city center and bandwidth* τ *is subjective, not suitable for small cities and rural areas.*

Spatial information used for disaggregation

Recently, various types and resolutions of population-related auxiliary data can be obtained, such as:

- *land cover,*
- *traffic network*
- *DEM,*
- *water system,*
- *night lighting,*
- *OSM,*
- *mobile phones,*
- *…….*

Many population data disaggregation methods have been developed, *which can be dividide into 4 categories*:

Existing methods for disaggregation with spatial information

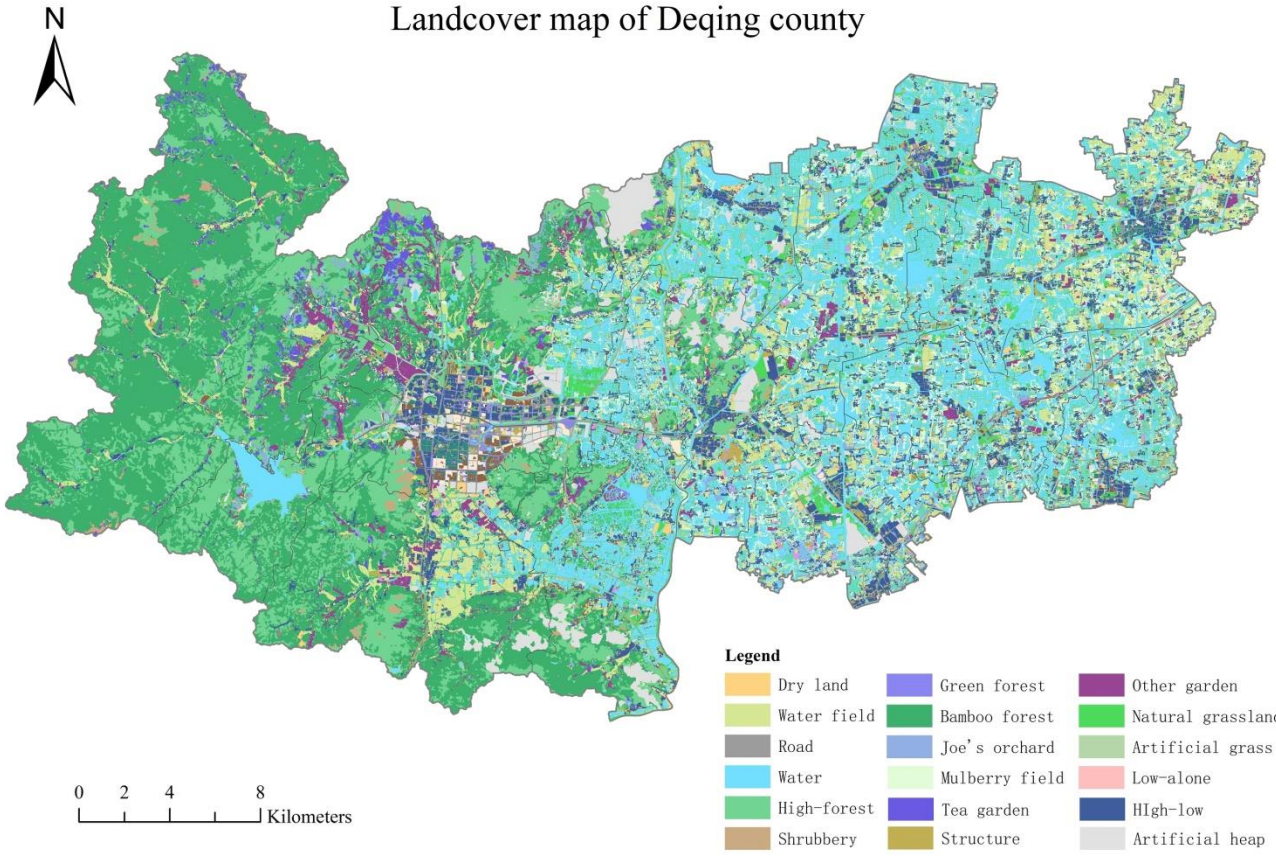
- Dasymetric mapping method
- Regression method
- Multi-factor synthesis method
- Spatio-temporal simulation method

A comparative analysis of existing disaggregation methods

Types	Related factors	Advantage	Disadvantage
1.Dasymetric mapping （**Bi-d** [*Holt et al. 2004; Langford 2007*]; **Tri-d** [*Mennis 2003; Lloyd 2016*]; **Multi-d** [*Su et al. 2010*]）	Population, types of land cover, Topography, traffic network, impervious surface, etc.	Model **simple & easy**, ensures the total population unchanged, suitable for **fine-scale population spatialization.**	Difficult accurate determine the **weight** of population allocation **in each sub-area**.
2. **Regression method** [*Zhuo et al. 2005; Gallego et al. 2011; Malone 2012; Lu et al. 2015; Rosina et al. 2017*]	The area of all types of land , and corrected by DEM, residential spots, night lighting, OSM data.	model needs **fewer parameters,** is **easy to model**, results are controllable. suitable for **large scale** population spatialization.	difficult to reveal the **difference** of population distribution under the **same land type**, and limited by the problem of **light pixel overflow**.
3. **Multi-factors synthesis** [*Dobson et al 2000; Liu et al. 2003; Yue et al. 2003; Liao et al. 2010; Yao et al 2017; Monteiro 2018*]	Population, land use, water factors, transportation network, River system, DEM, city size and location, residential areas, etc.	**Comprehensive consider** - ing the influence of natural, economic and social factors, The results of the model are **convincing.**	The fusion weight is more **subjective**, and the index is changeable, which increases the **complexity** and **redundancy of the model**.
4. **Spatio-temporal simulation** [*Deville et al. 2014; Bakillah 2014; Lwin et al. 2016; Chen et al. 2018*]	Demographic data, mobile location data (i.e. cell phone), etc.	suitable for describing spatial **dynamic distribution** of population in **urban areas**, and can estimate the permanent population	Poor results in **country rural & poor areas**。

Strategy for disaggregation in this study

- According to:
  - the area distribution of Deqing County ,
  - High-resolution land-cover data,
  - population statistics (in towns),
- **Dasymetric & area weighting method** will be adopted.



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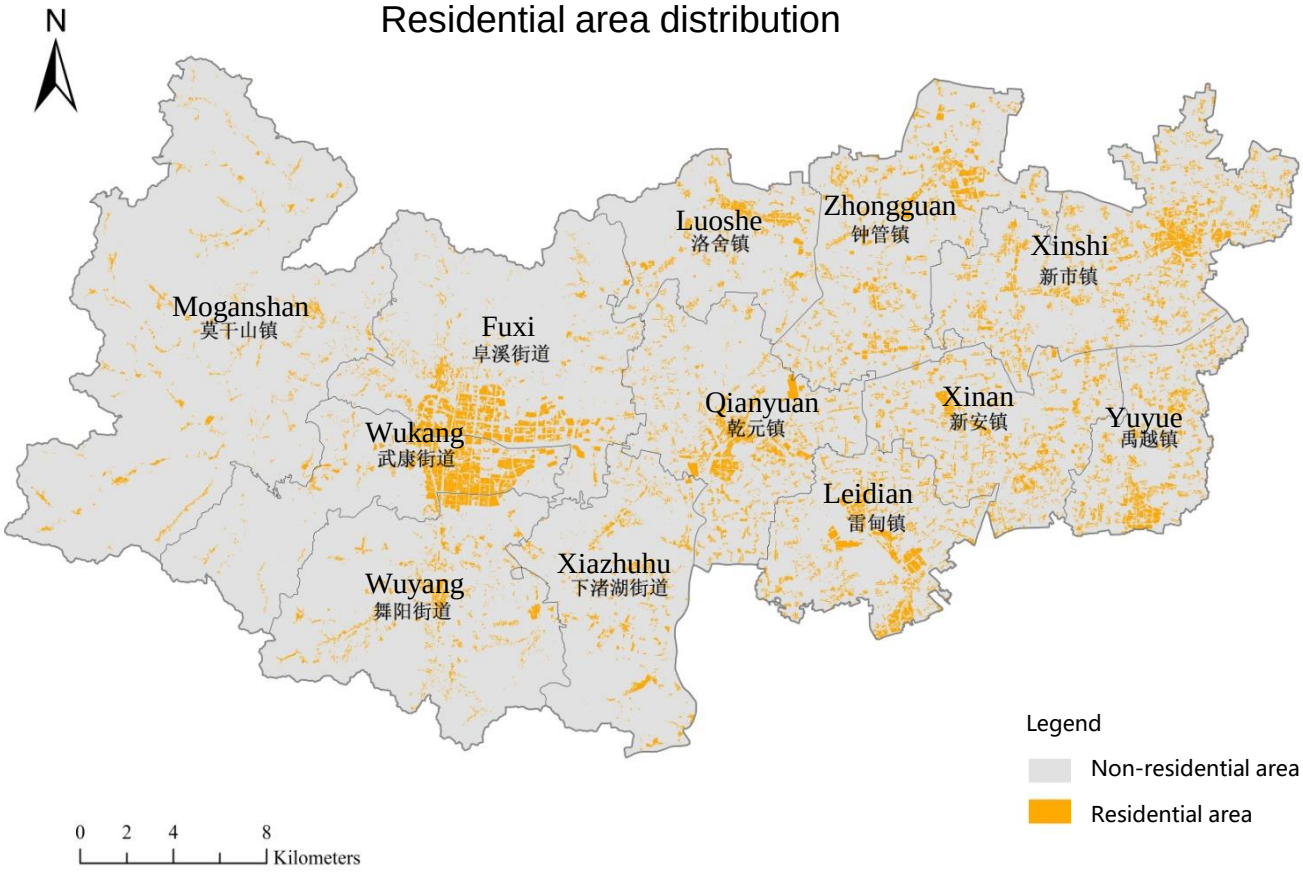
2 Procedure used in this study

a) **Dasymetric -** Dividing into *residential areas* and *non-residential areas*.

b) **Area weighting** -The *residential areas* should be weighted according to 6 types of residence.

c) **population calculation** -

d) **Spatial rasterilation –** according to 30m×30m cell.



Classification scheme of building density

By the density and height of buildings in residential areas, it will be divided into 6 types[according to the "*Survey Contents and Indicators of Geographical Conditions "(No.GDPJ 01—2013)*] :

Types	description	Building density	Number of floors
H-M	**H**igh density & **M**ulti-floor building	≧50%	≧4
L-M	**L**ow density & **M**ulti-floor building	< 50%	≧4
H-L	**H**igh density & **L**ow-floor building	≧50%	< 4
L -L	**L**ow density & **L**ow-floor building	< 50%	< 4
M-S	**M**ulti-floors & **S**ingle building		≧4
L-S	**L**ow-floors & **S**ingle building		< 4

Example -1

H-M

L-M

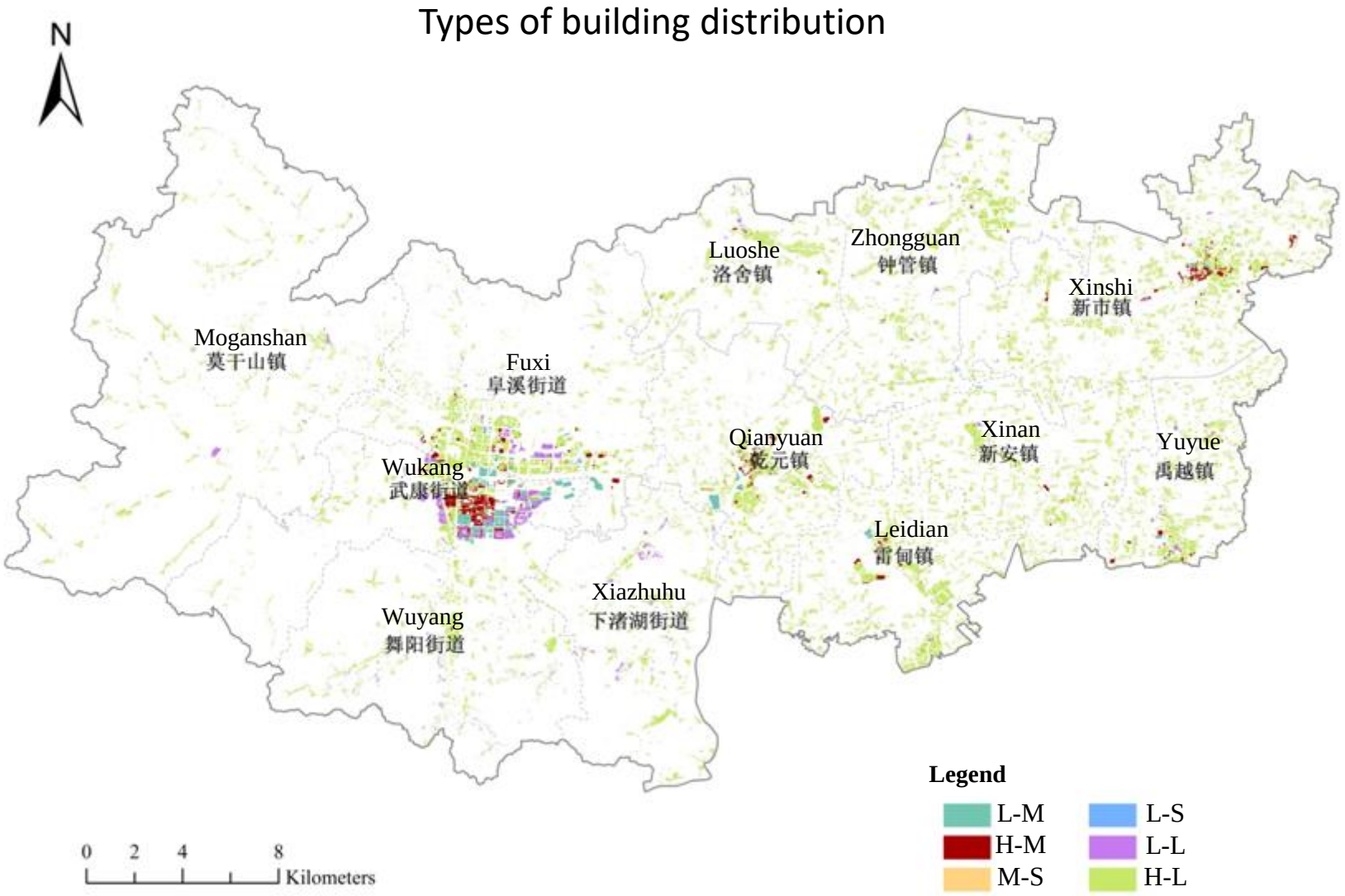
Example -2

Example -3

M-S

L-S

Distribution map of six types



Weight determination for disaagregation

- The weight *p* of a resident cell is

$$p = \lambda \times h$$

λ- building dentisy in a resident cell;
h – the average of all building floors in a cell.

- The population *n* of a resident cell is

$$n_i = \frac{s_i p_i}{\sum_{i=1}^{m} s_i p_i} N$$

s- area of a resident cell;
N – the whole population number in a administrite unit.

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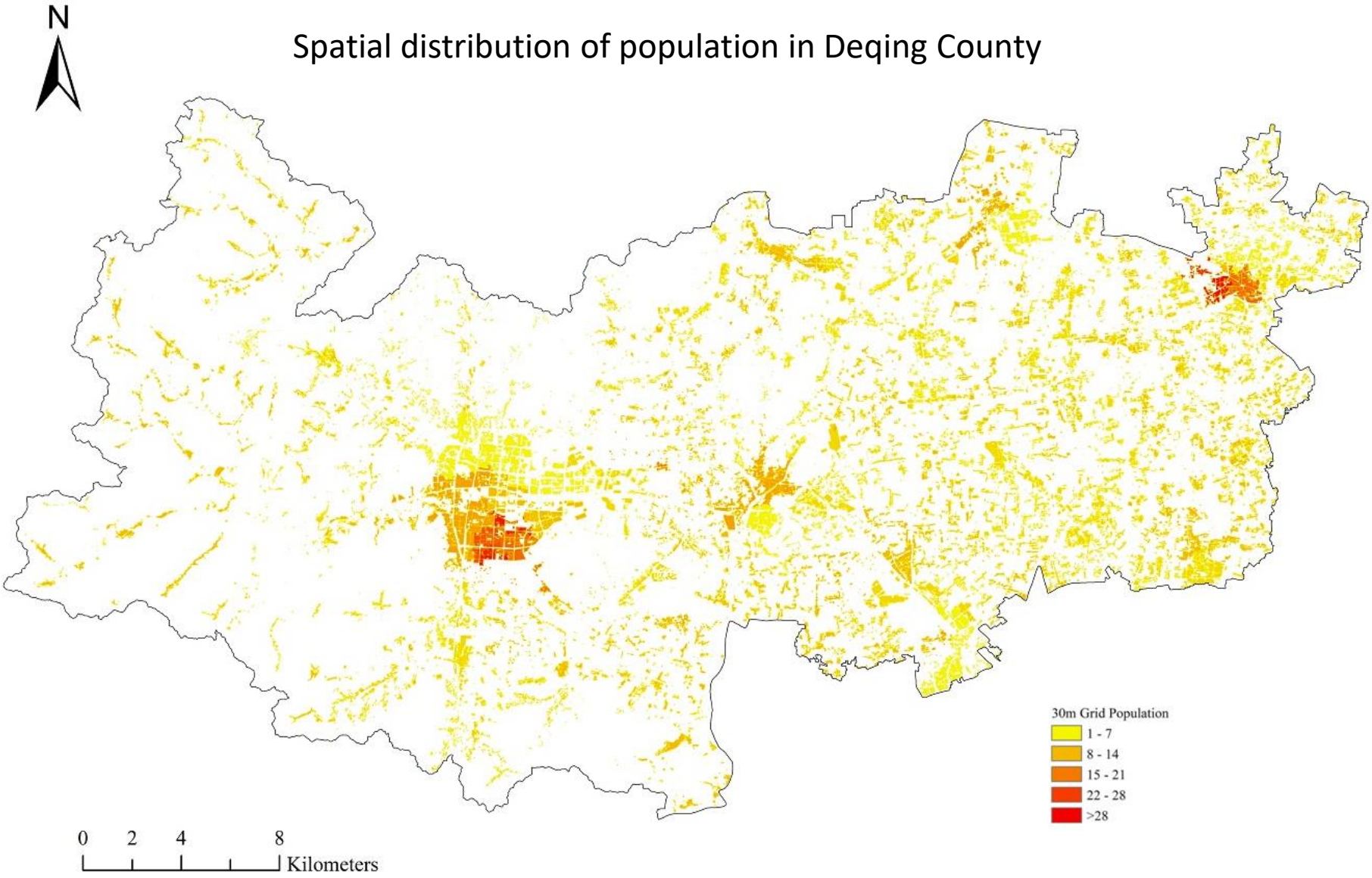
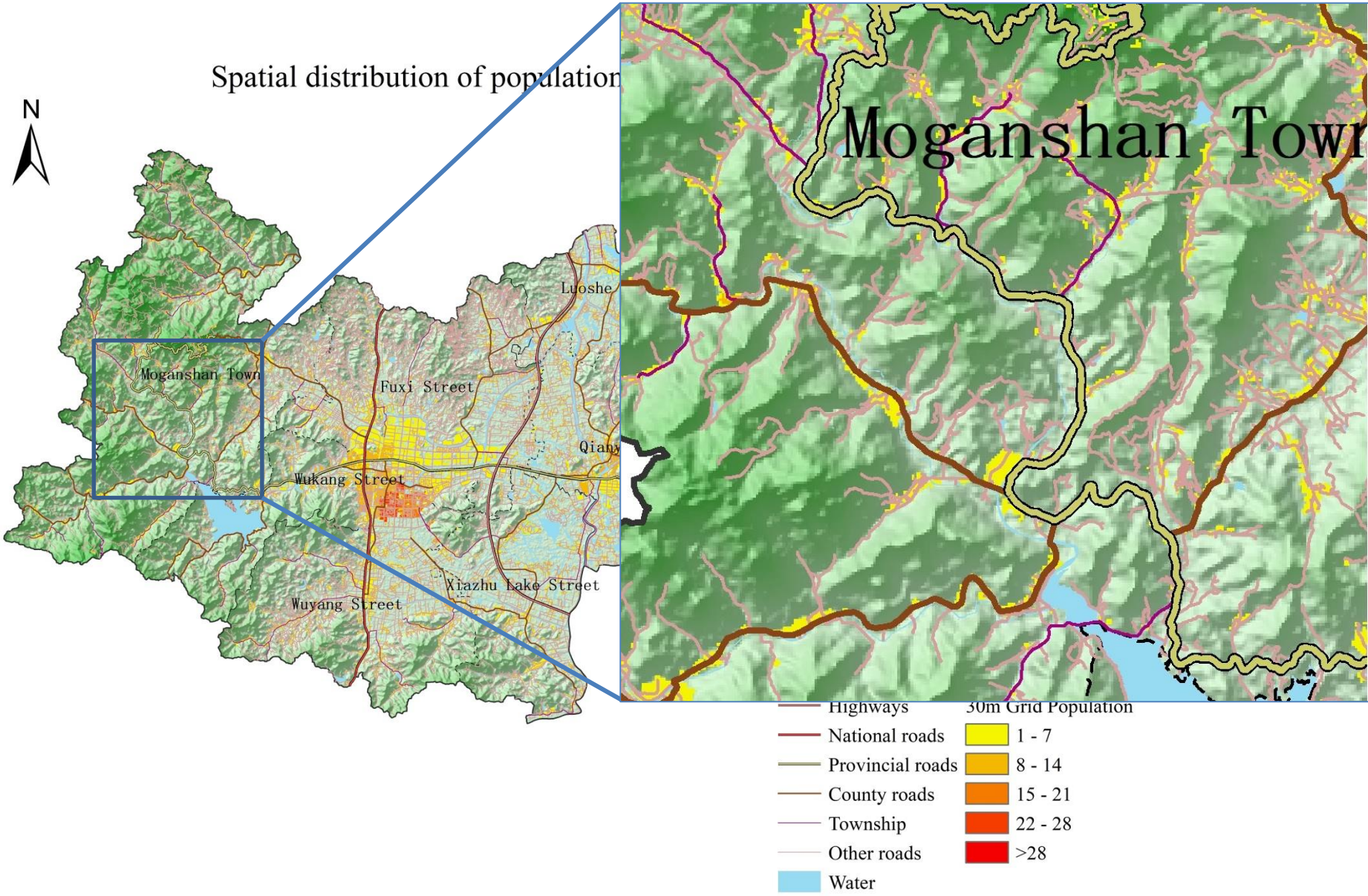
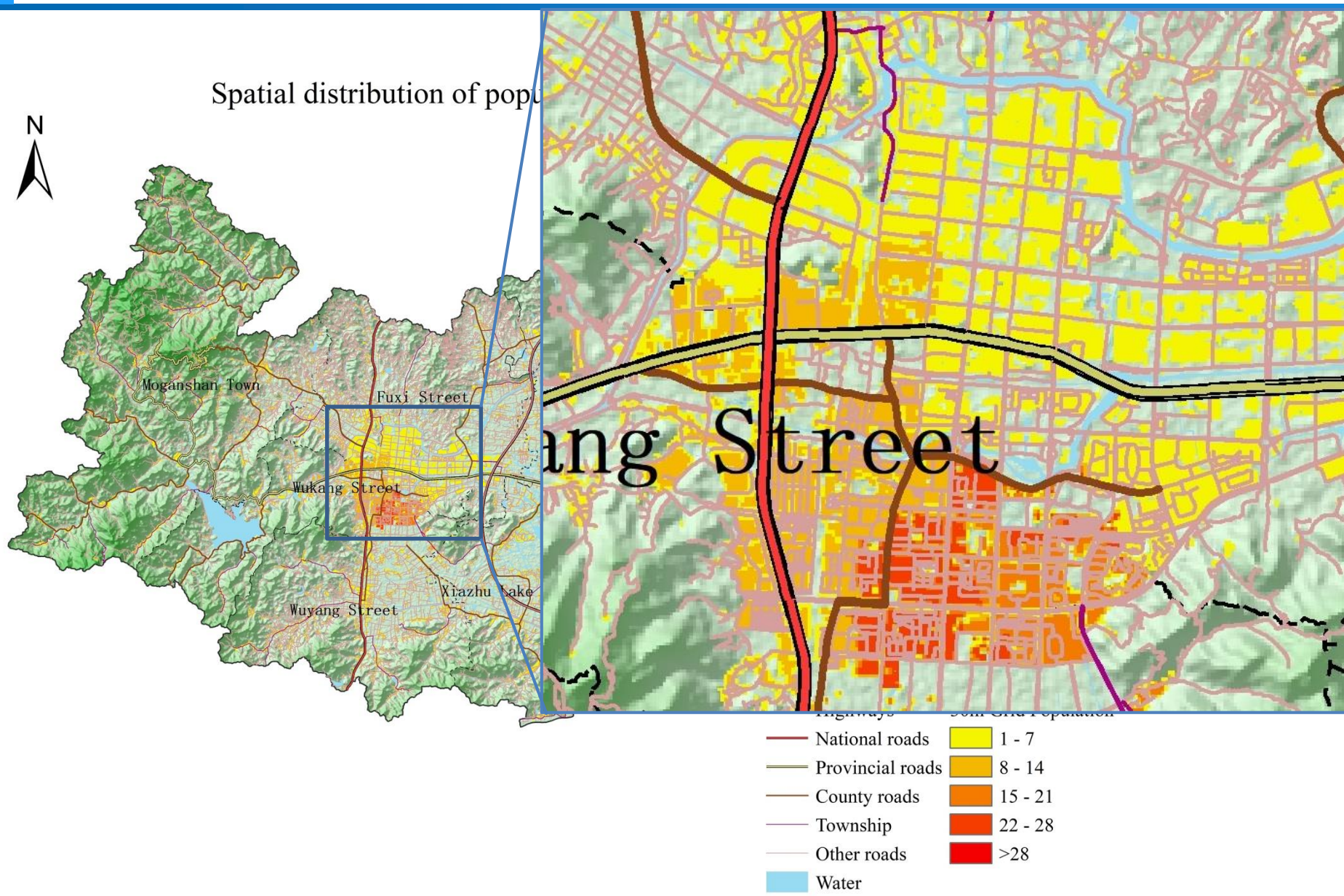
Spatial distribution of disaggregated population



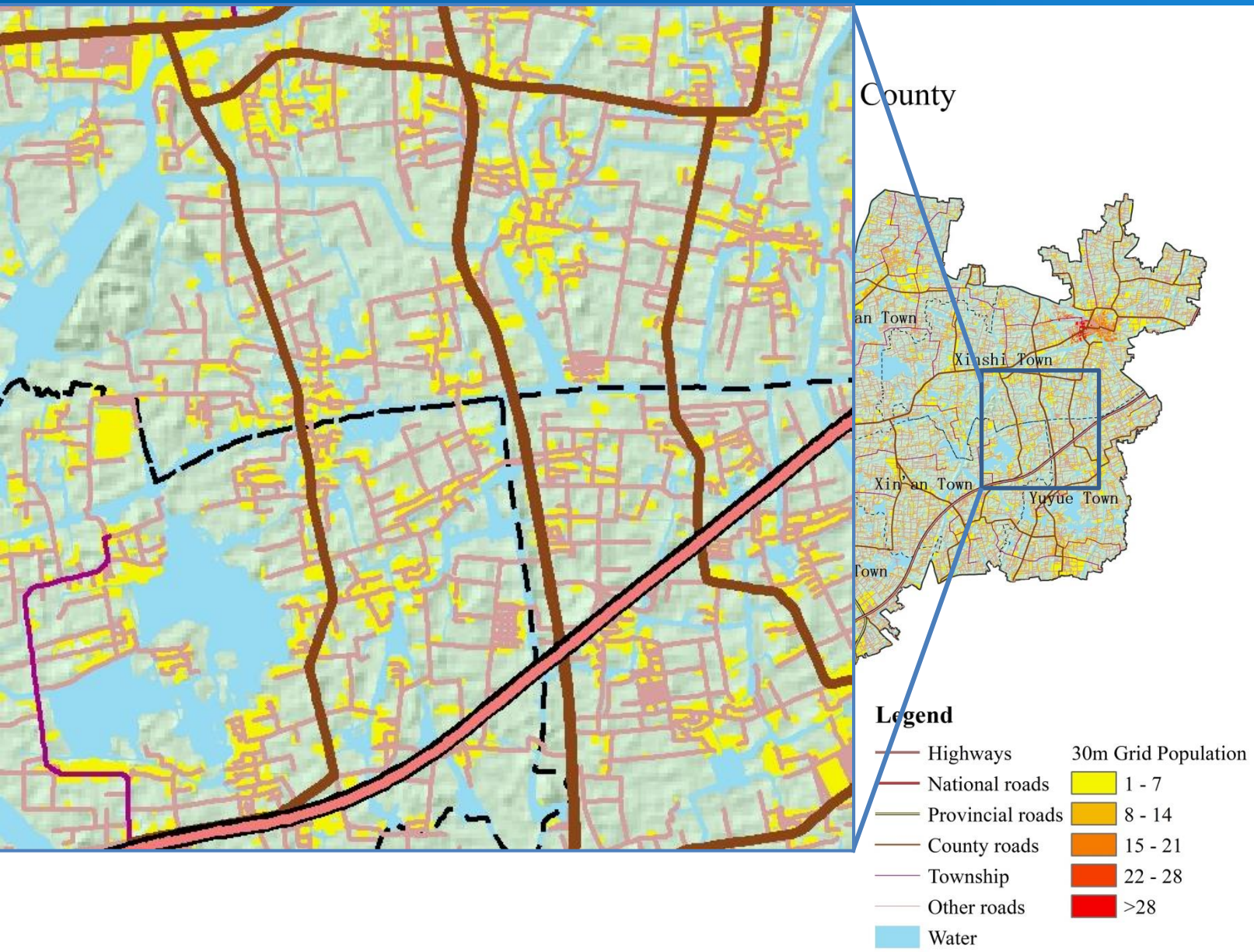
Overly map- Mountain Area



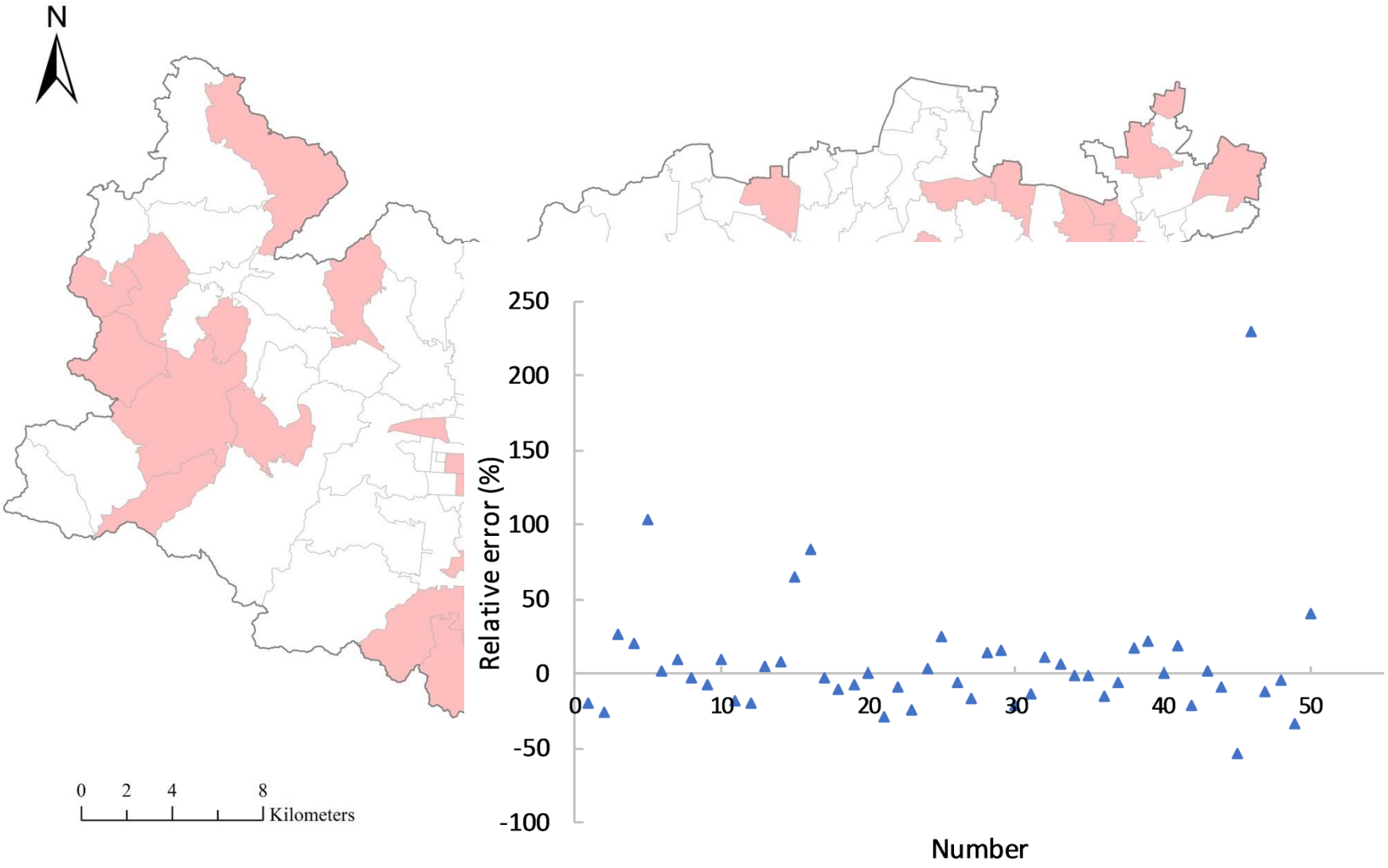
Overly map- urban area



Overly map- rural area



Sample points verification & error analysis



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Quantitative assessment of SDGs indicators

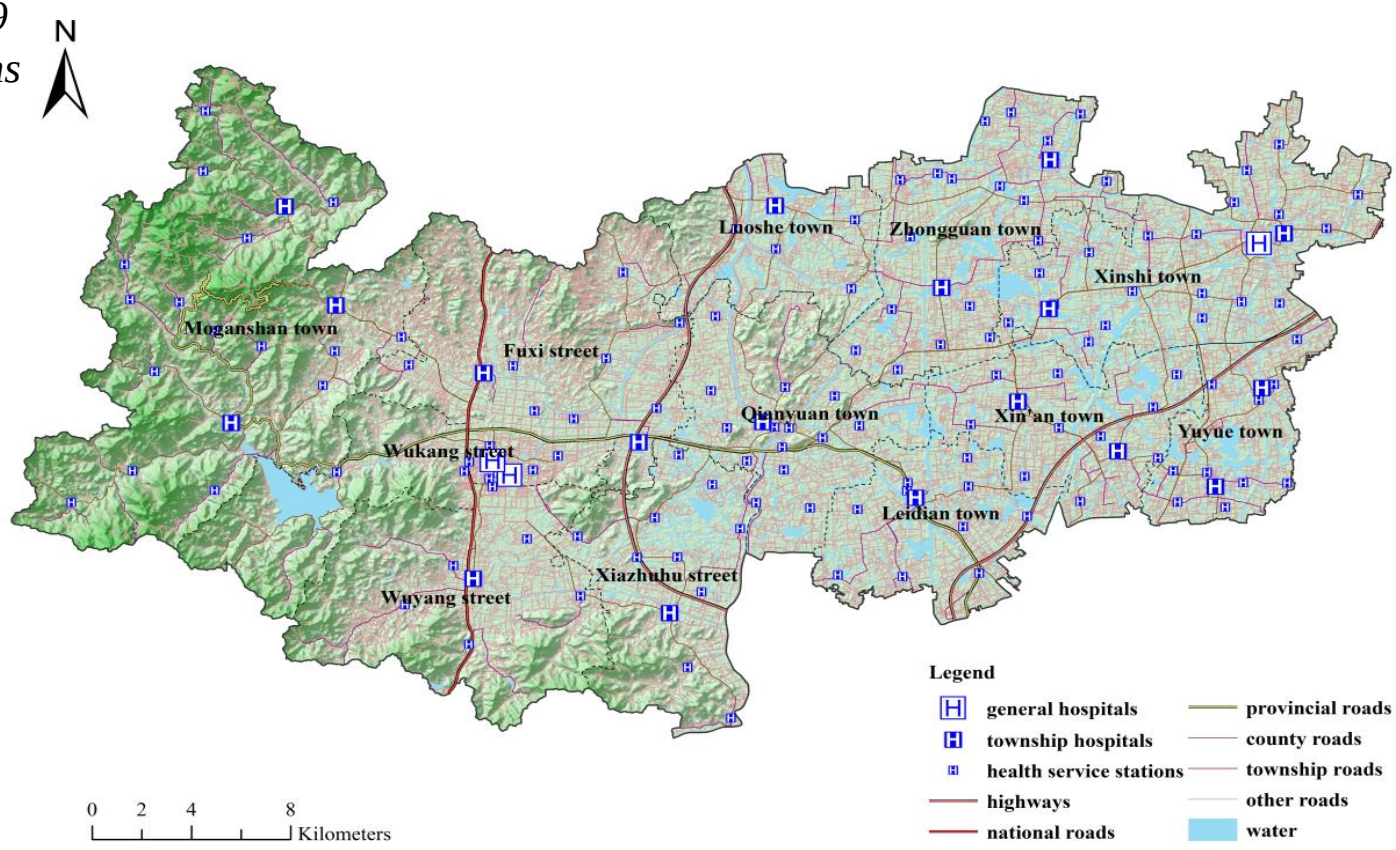
- Indicator 3.8.1- *coverage the basic health services;*
- Indicator 4.a.1- *allocation of educational resources;*
- Indicator 9.1.1- urban traffic
    a. *The proportion of rural population living within 2 km of the whole season highway;*
    b. *Traffic accessibility;*
    c. *X hour life circle*

Appl.1- indictor 3.8.1

SDGs— indictor3.8.1 *Coverage of basic health services*

Deqing County has:

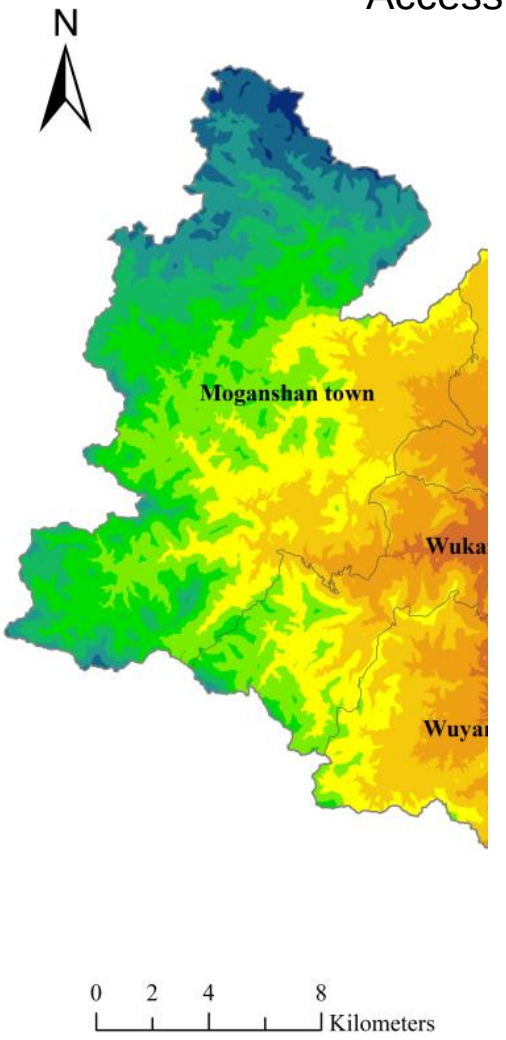
- *general hospitals- 3*
- *township hospitals -19*
- *Health service stations -134*

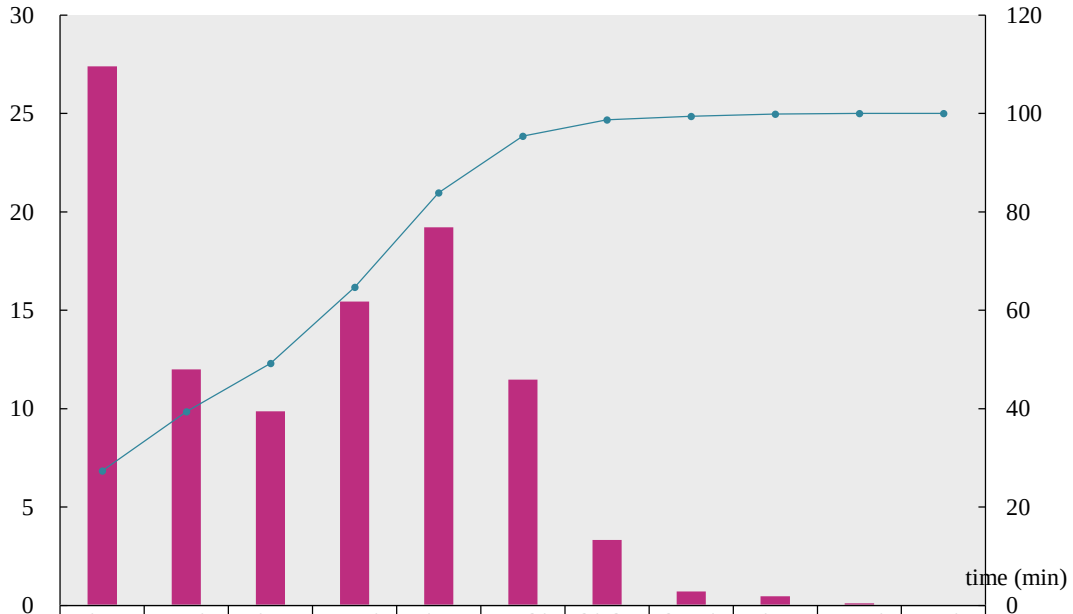


Layout of medical and health facilities in Deqing County

Accessibility of general hospitals

Accessibility of general hospitals in Deqing County



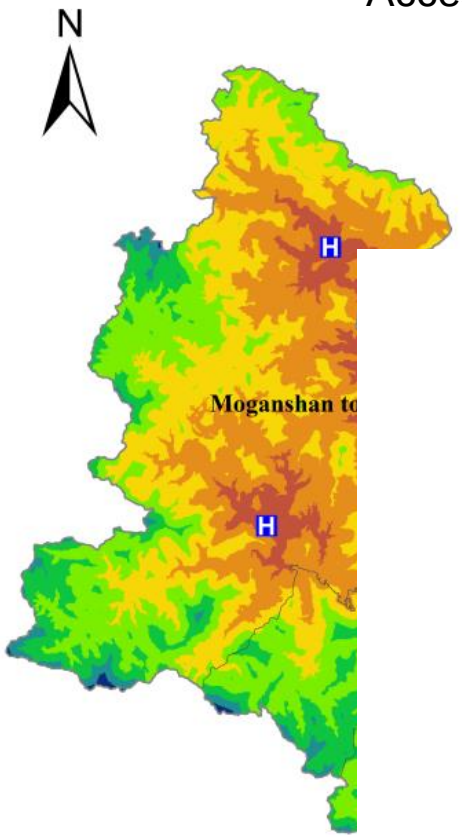


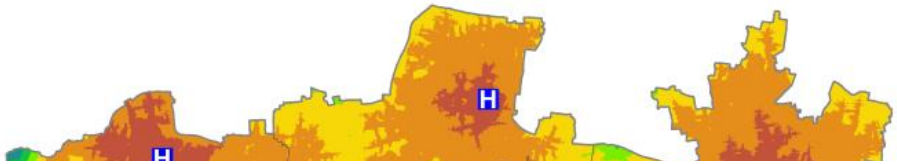
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	>50
distribution frequency (%)	27.391	11.993	9.862	15.451	19.213	11.481	3.324	0.706	0.465	0.107	0.006
cumulative frequency (%)	27.391	39.384	49.247	64.698	83.910	95.391	98.715	99.421	99.887	99.994	100.000

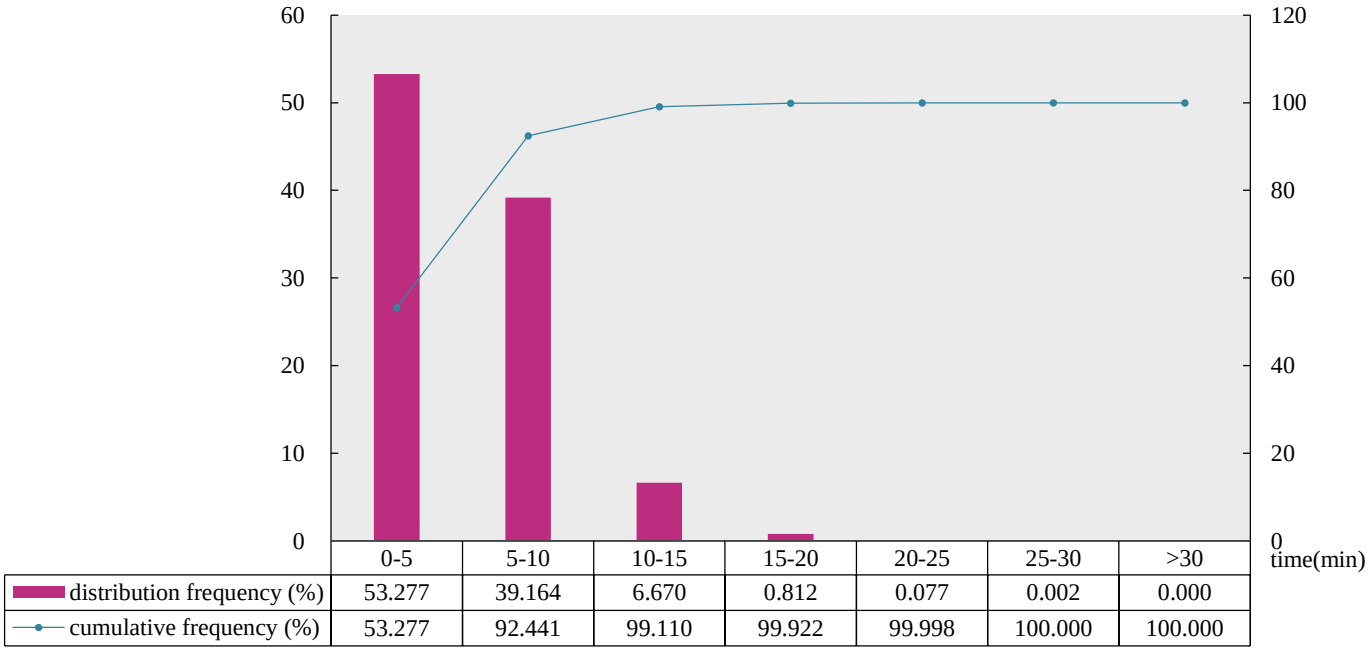
Distribution frequency and cumulative frequency of service population of general hospitals

Accessibility of township hospitals

Accessibility of township hospitals in Deqing County





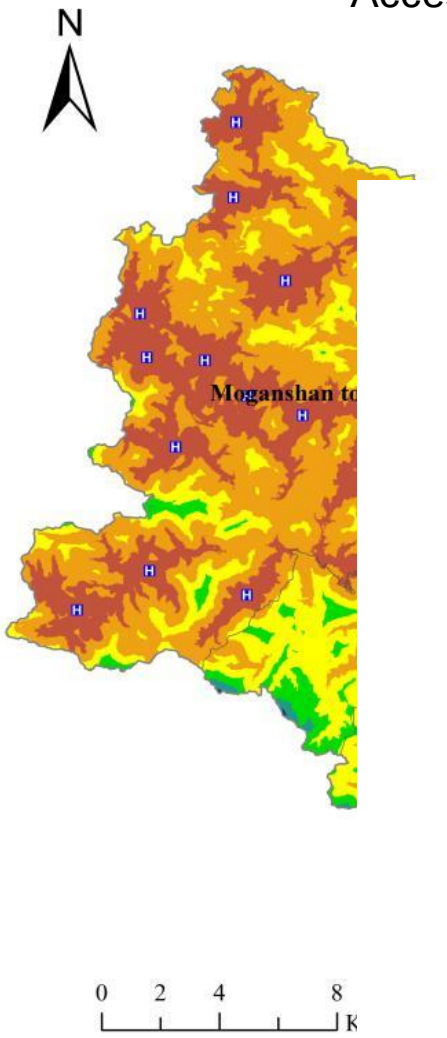


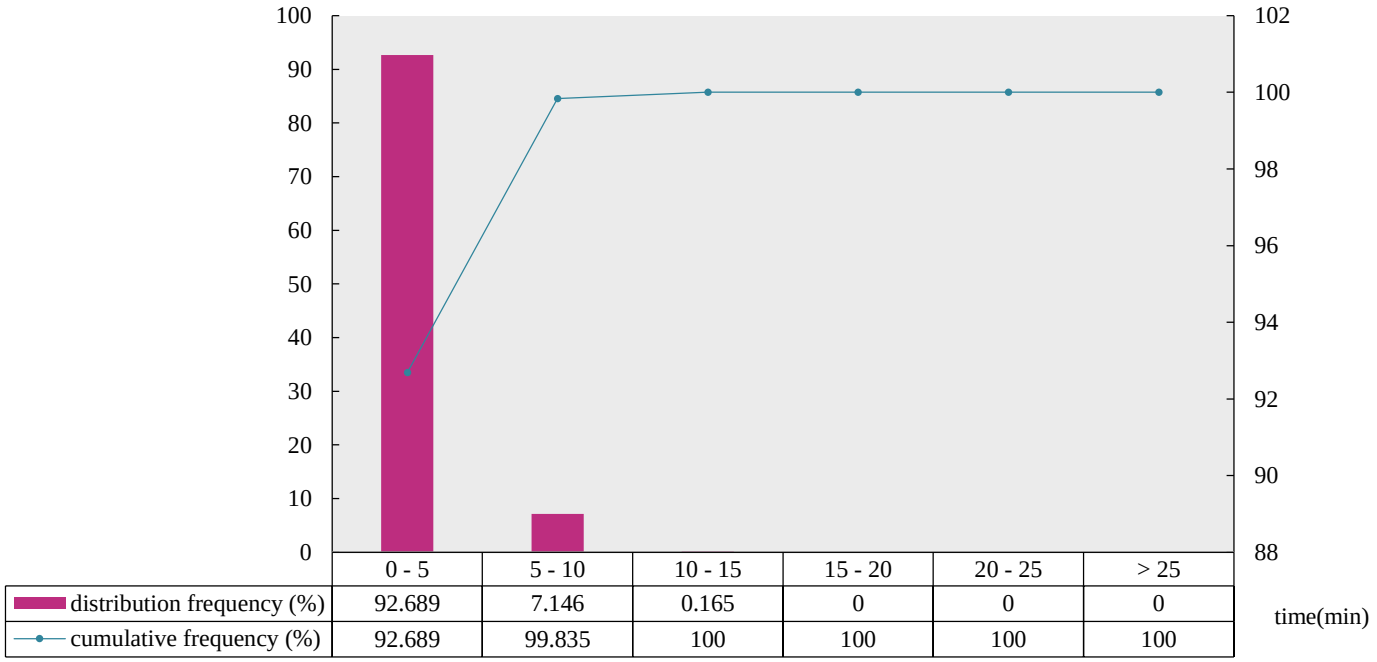
	0-5	5-10	10-15	15-20	20-25	25-30	>30
distribution frequency (%)	53.277	39.164	6.670	0.812	0.077	0.002	0.000
cumulative frequency (%)	53.277	92.441	99.110	99.922	99.998	100.000	100.000

Distribution frequency and cumulative frequency of service population of township hospitals

Accessibility of health service stations

Accessibility of health service stations in Deqing County





	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	> 25
distribution frequency (%)	92.689	7.146	0.165	0	0	0
cumulative frequency (%)	92.689	99.835	100	100	100	100

Distribution frequency and cumulative frequency of service population in health service station

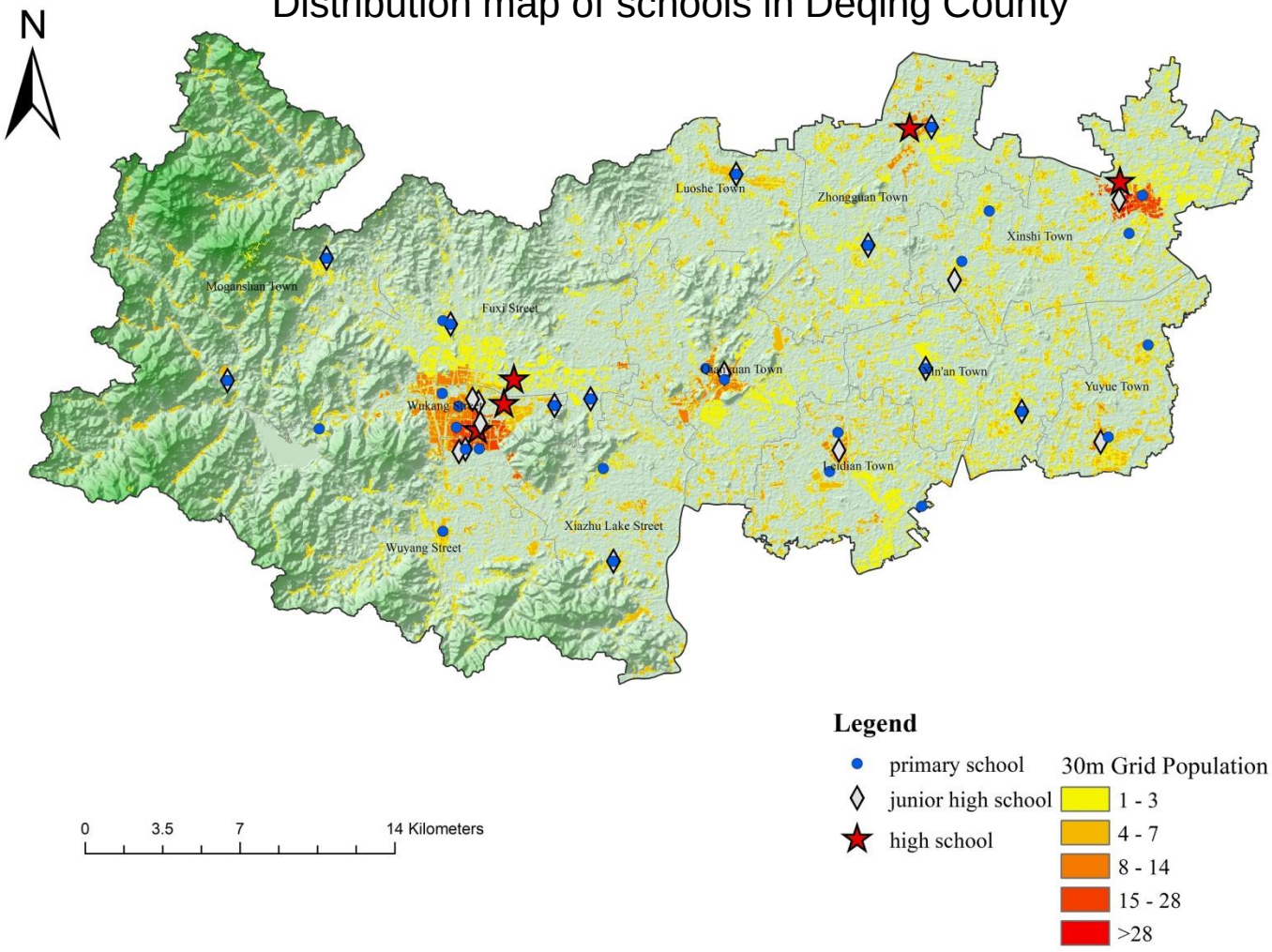
Appl- 4.a.1

SDGs—Indicator 4.a.1- *allocation of educational resources*

At the end of 2017, Deqing County had:

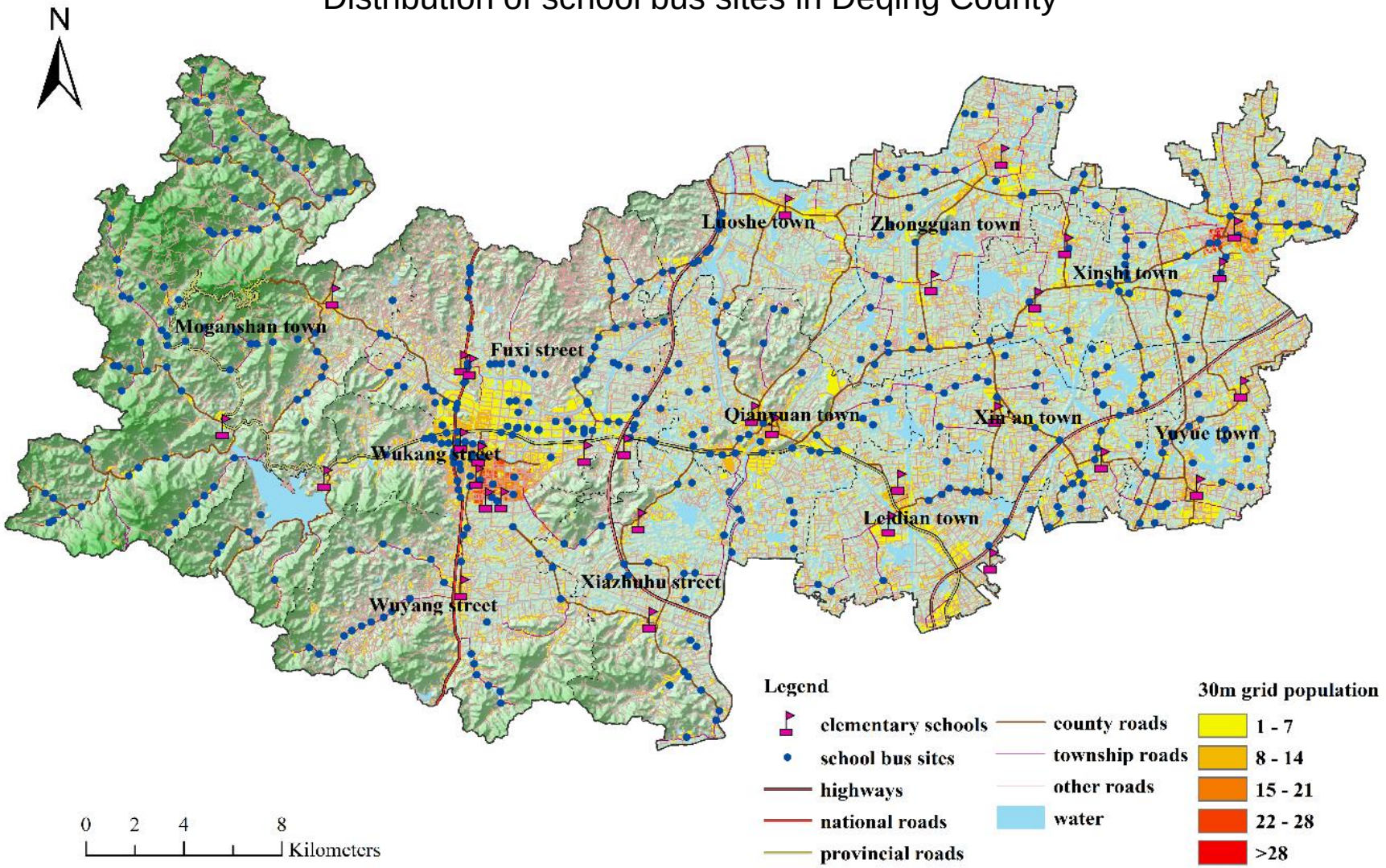
- *17 primary schools*
- *21 junior middle schools and 1 special school.*
- *5 senior secondary schools;*

Distribution map of schools in Deqing County



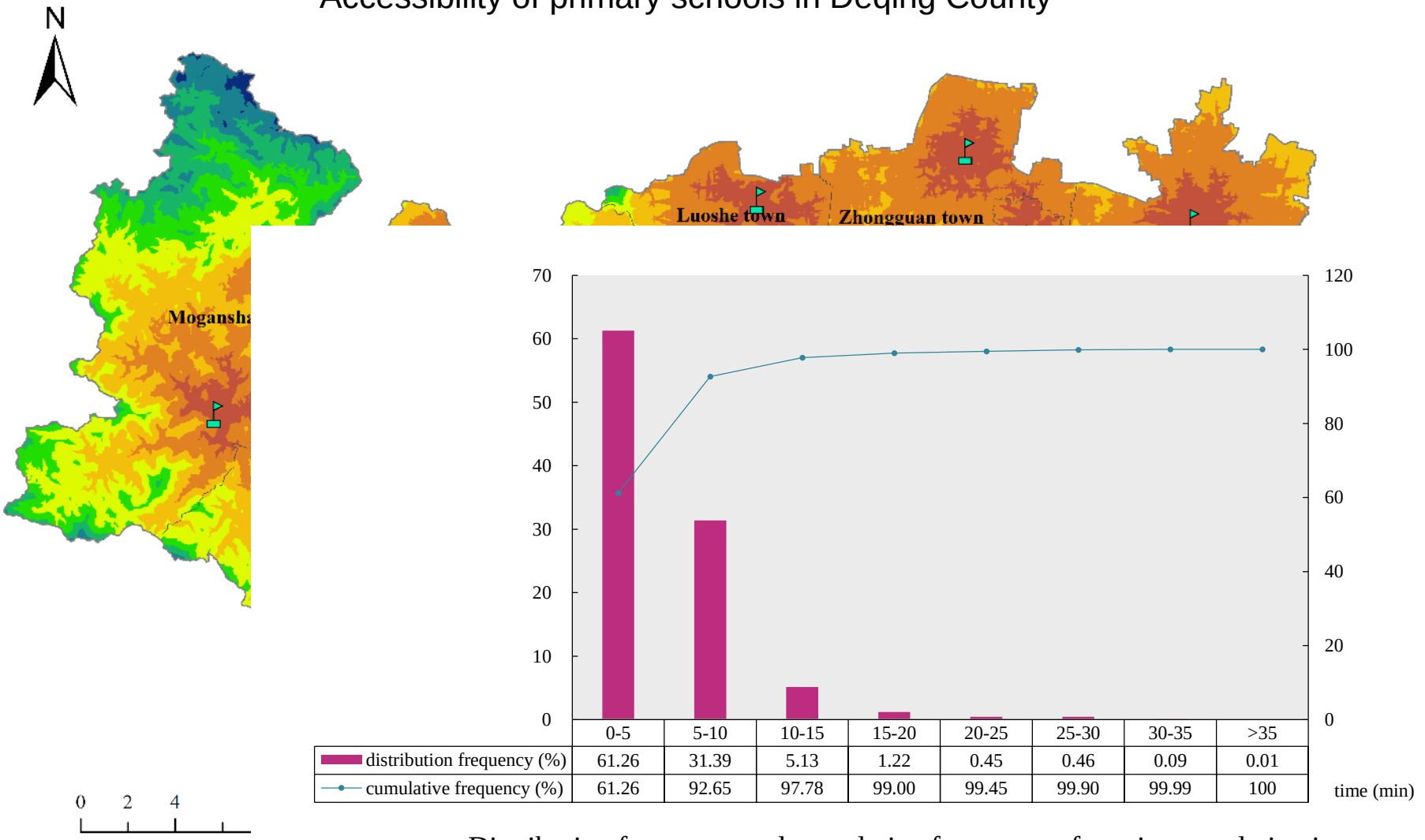
Distribution of school bus

Distribution of school bus sites in Deqing County



Accessibility of primary schools

Accessibility of primary schools in Deqing County



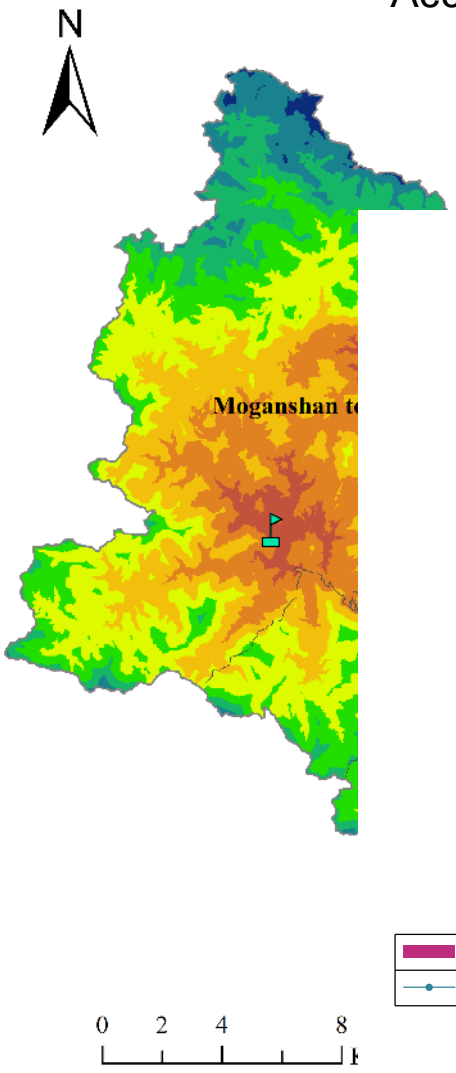
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	>35
distribution frequency (%)	61.26	31.39	5.13	1.22	0.45	0.46	0.09	0.01
cumulative frequency (%)	61.26	92.65	97.78	99.00	99.45	99.90	99.99	100

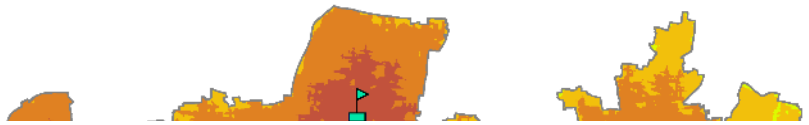
time (min)

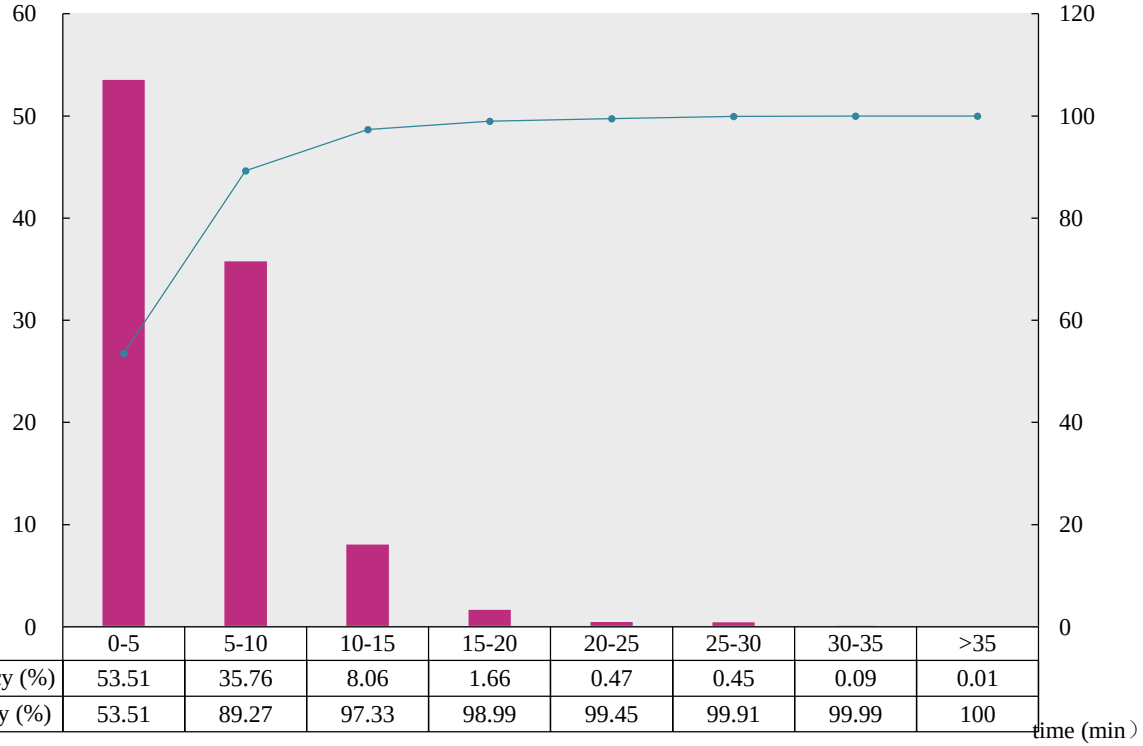
Distribution frequency and cumulative frequency of service population in primary schools

Accessibility of junior high school

Accessibility of junior high schools in Deqing County





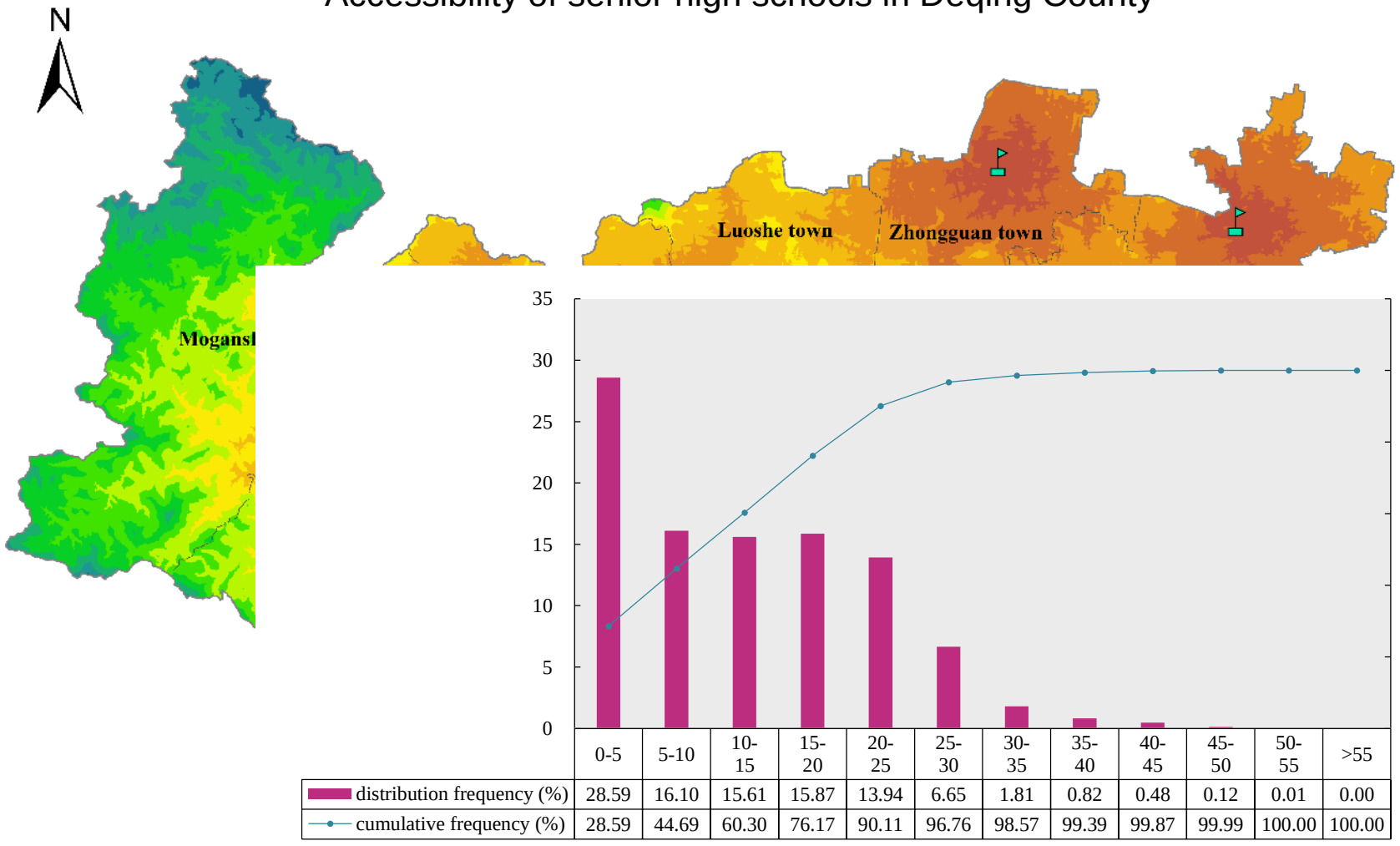


	0-5	5-10	10-15	15-20	20-25	25-30	30-35	>35
distribution frequency (%)	53.51	35.76	8.06	1.66	0.47	0.45	0.09	0.01
cumulative frequency (%)	53.51	89.27	97.33	98.99	99.45	99.91	99.99	100

Distribution frequency and cumulative frequency of service population in junior high schools

Accessibility of senior high schools

Accessibility of senior high schools in Deqing County



	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	>55
distribution frequency (%)	28.59	16.10	15.61	15.87	13.94	6.65	1.81	0.82	0.48	0.12	0.01	0.00
cumulative frequency (%)	28.59	44.69	60.30	76.17	90.11	96.76	98.57	99.39	99.87	99.99	100.00	100.00

Distribution frequency and cumulative frequency of service population of general high schools

Appl. -Indicator 9.1.1

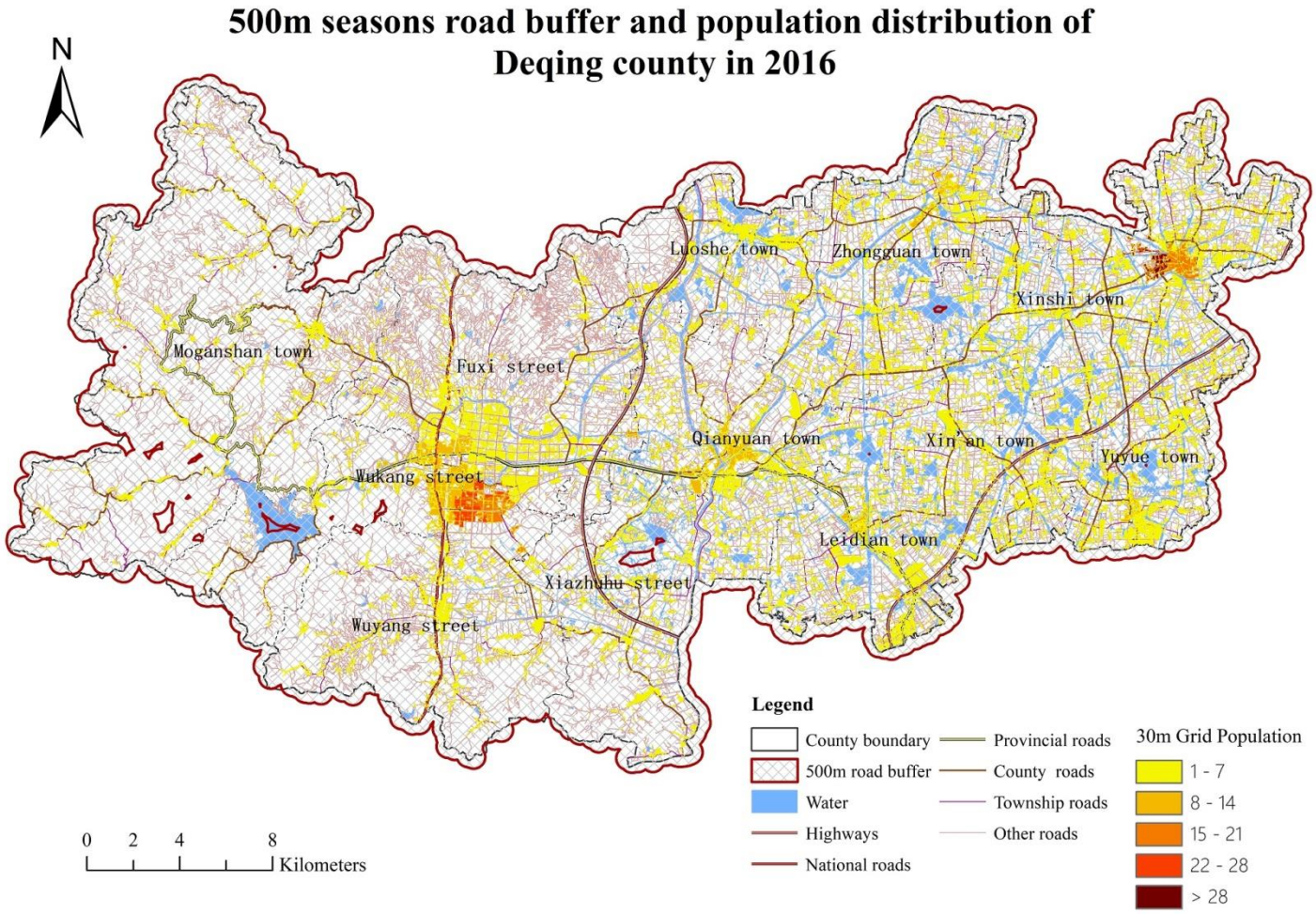
- SDGs-Indicator 9.1.1-
  a. *The proportion of rural population living within 2 km of the whole season highway;*
  b. *Traffic accessibility;*
  c. *X hour life circle*

Tab. Proportion of population from *X* km to the road

Indictor name	2014	2015	2016	2017	2018
The proportion of rural population living within 500 meters	99.997%	99.997%	100%	100%	100%
The proportion of rural population living within 1000 meters	100%	100%	100%	100%	100%
The proportion of rural population living within 2000 meters	100%	100%	100%	100%	100%

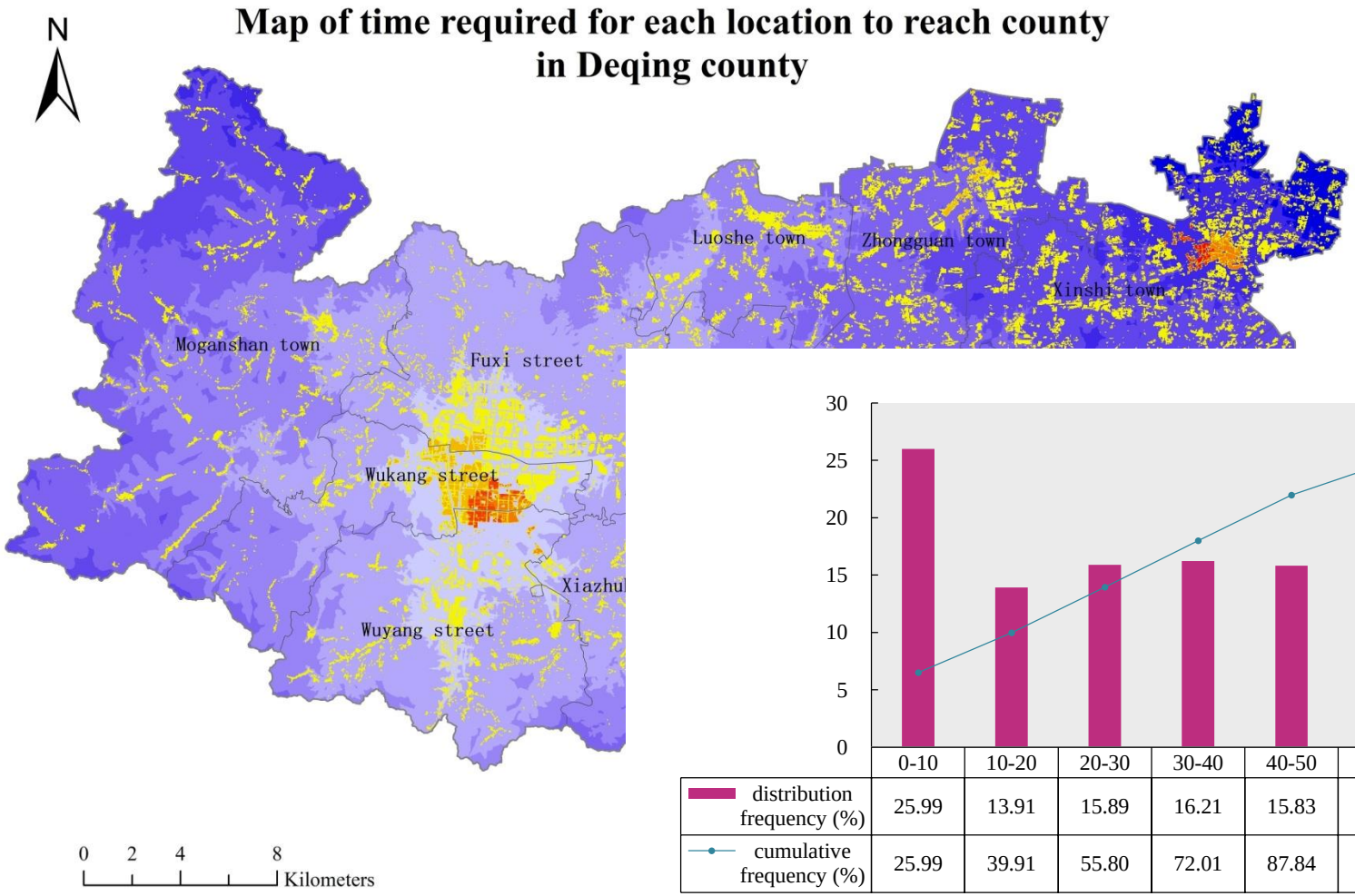
Indicator 9.1.1*a- population living within 2 km*

- SDGs-Indicator 9.1.1*a-The proportion of rural population living within 2 km of the whole season highway;*



9.1.1b- *Traffic accessibility to urban*

- SDGs-Indicator 9.1.1- *b. Traffic accessibility;*

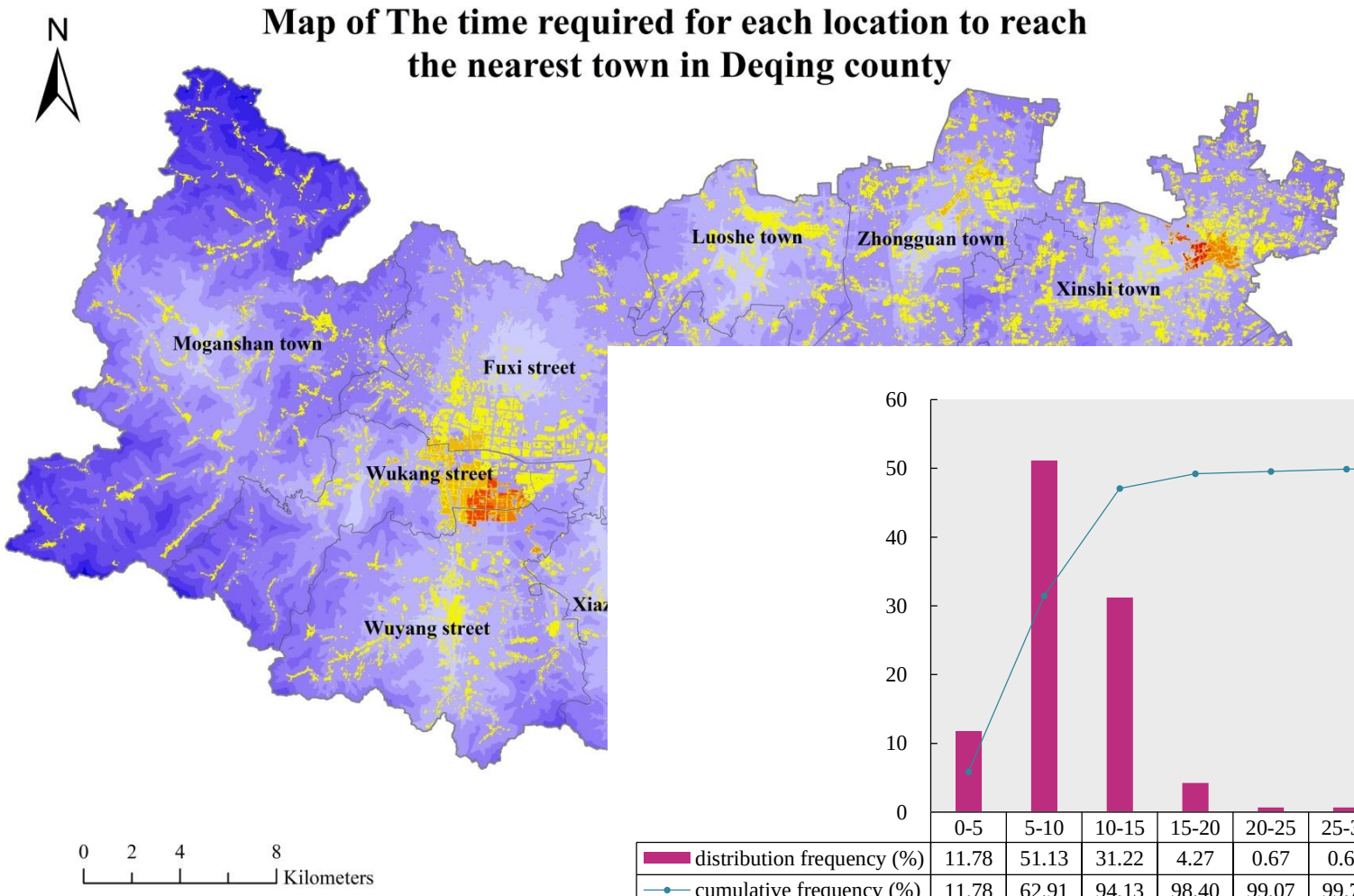


	0-10	10-20	20-30	30-40	40-50	50-60	60-70
distribution frequency (%)	25.99	13.91	15.89	16.21	15.83	11.12	1.04
cumulative frequency (%)	25.99	39.91	55.80	72.01	87.84	98.96	100

time(min)

9.1.1c- *X hour life circle to town*

- SDGs-Indicator 9.1.1-*c) X hour life circle*



	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	>40
distribution frequency (%)	11.78	51.13	31.22	4.27	0.67	0.68	0.24	0.01	0
cumulative frequency (%)	11.78	62.91	94.13	98.40	99.07	99.75	99.99	100	100

Main Contents

5 Conclusions

Populations, aggregated to a town administrative units in this study, is disaggregated to 30m×30m cell by spatial information. The main objective is to assess some SDGs indicators with a fine quantitative mode and spatial analysis.

- **Dasymetric area weighting method is used in this research, in which Dasymetric mapping is by high resolution land-cover data and area weighting by 3D building information.**
- **Through the sample (50 villiges) validation, the average accuracy is about 77.4%.**
- **As a case study of Deqing, quantitatively assess some SDGs indicators,** such as health care (3.8.1), education(4.a.1), urban traffic (9.1.1) **, and accessibility analysis.**

Thanks