For office use only	Team Control Number	For office use only
T1 ________________	**65914**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**E**	F4 ________________

2017

MCM/ICM

Summary Sheet

How to develop? Smart growth！

With the acceleration of urbanization, Urban development is becoming more and more important. Smart growth is about helping every town and city become a more economically prosperous, socially equitable, and environmentally sustainable place to live. So it is very important to define its metric and help a city to make a smart growth plan.

We choose Lhasa and Atlanta to research and our structure and ideas of this paper are as follows:

1)We applied analytic hierarchy process to build a comprehensive evaluation system of smart growth. It includes three aspects of economy, environment and society, as well as various small indexes of each aspect.

2)In order to evaluate smart growth, we determine the weight of economic, society and environment by entropy weight method. And we use the metric of “Smart growth” to evaluate the current growth plan. We find that the local government should improve the social equity for Atlanta, and the economic development for Lhasa.

3)Based on the characteristics of the city, we make a new growth plan according to entropy weight of each indicators. Then we compare the two cities according to the analysis of the potential factors in their development. And we find that the Atlanta government can soften social inequality through tax and transfer payments, while Lhasa can achieve economic growth by adjusting the industrial structure

4)We adopt the method of gray prediction and linear regression to analyze the change of the other indexes when the population doubles in 2050. Our conclusion is that the Atlanta government can regulate social income distribution by levying the inheritance tax and property tax while Lhasa government should increase crop production and infrastructure investment to support this level of growth.

We hope our research can play a positive role in the smart growth of this two cities.

Keywords: Analytic hierarchy process, Entropy weight method, Gray prediction, Linear regression

Contents

1. Introduction

Urban planning affect many of the things that touch people's everyday lives—their homes, their health, the schools, their children attend, the taxes they pay, their daily commute, the natural environment around them, economic growth in their community, an opportunity to achieve their dreams and goals. Smart growth is to solve urban development decisions and aims to create neighborhoods that are economically thriving, environmentally responsible and socially equitable. It is an urban planning theory that originated in 1990's as a means to curb continued urban sprawl and reduce the loss of farmland surrounding urban centers. The ten principles for smart growth are:

（1）Mix land uses

（2）Take advantage of compact building design

（3）Create a range of housing opportunities and choices

（4）Create walkable neighborhoods

（5）Foster distinctive, attractive communities with a strong sense of place

（6）Preserve open space, farmland, natural beauty, and critical environmental areas

（7）Strengthen and direct development towards existing communities

（8）Provide a variety of transportation choices

（9）Make development decisions predictable, fair, and cost effective

（10）Encourage community and stakeholder collaboration in development decisions

These broad principles must be tailored to a community's unique needs to be effective. For example, one community can provide choices in housing and transportation so that the residents can find a home they can afford and can easily reach jobs, stores, parks, schools, houses of worship and offer economic opportunities while protecting the environment so that residents' needs can be met now and in the future.

Therefore，in this paper we will implement smart growth theories into city develop plan to help cities get better.

2. Problem Analysis

2.1 Restatement of the Problem

Through the above introduction, the problem can be summarized as follows:

First of all, we establish the corresponding metric to evaluate the realization of a city's "smart growth".

Secondly, we choose two cities (Lhasa and Atlanta) and use our metric to evaluate whether the current government plan is helpful to realize the "smart growth"". And according to the principle of "smart growth", we should make a new plan for their growth based on the geographical environment and human environment. What's more, we will explain the components and initiatives of the new plan and use our smart growth metric to evaluate it.

Thirdly, according to the each indicator involved in the new plan, we hope to achieve the two goals：

(1) The rank of the individual initiatives as the most potential to the least potential;

(2) To compare these indicators and their rankings between the two cities, and analyze the differences and reasons.

Finally, if the city population doubles in 2050, we will give a adjustment program to support the population growth.

2.2 Resolving Idea

- **Task 1**

We take advantage of Analytic hierarchy process (AHP) to develop an evaluation system of "smart growth" as our metric.

We will use the "smart growth" comprehensive metric as a first grade index, the economic prosperity, environmental sustainability and social justice as secondary indexes, and per capita GDP, CPI etc. as the tri-grade evaluation index.

- **Task 2**

We choose two cities, and collect their data of each tri-grade evaluation index in 10 years. Focused on the "smart growth" principles, we establish the model and determine the weight of each tri-grade evaluation index by improved entropy .We can also get the weight of the three secondary indicators .By comparing the weight of the city's economic, environmental and social indicator, we can know whether this 2 city achieve a balanced development in these three aspects, which is to meet the 3E principles of smart growth. At the same time, according to the results of the model, we can evaluate the current government's city development plan.

- **Task 3**

According to the result of task 2, we can use the weight of each index to analyze its importance on a society's development and can make a new growth plan for the city. We determine the weight of the three-dimensional indicator (economic, social and environmental) through entropy method. Then we can analyze whether this two city achieved a balanced development in 3E.We will also draw the ESI (Evaluated Synthetical Index) curve of each city to determine the success of our plans.

- **Task 4**

According to the result of task 3, we can rank tri-grade evaluation index by their weight, in order to analyze their potential contribution to the development of cities. At the same time, we will make a compariation between these 2 cities.

- **Task 5**

1)Get the relational expression between the population and the other indexes through the multiple linear regression.

2)Through the gray prediction model，we can get the forecast value of each tri-grade evaluation index in 2050

3) We can get the predicted value of the population through regression prediction model and observe whether it doubled in 2050.If not, we continue use the entropy weight method to determine the weight of each index, in order to change our develop

plan which can support this level of growth.

3. Symbol and Assumption

3.1 Assumption

In order to have a better study on this model, we simplify our model by giving the following assumptions:

1. Economic indicator has a positive impact on smart growth metric.
2. Environment indicator has a positive impact on smart growth metric.
3. Social indicator has a positive impact on smart growth metric.
4. Only considering the influence on economic, environmental and social indicator of the components listed below, the other components 'influence are negligible.
5. It is Objective and fair to select indicators and there is no obvious preference.
6. All data collected by the survey are definitely accurate;

3.2 Symbol

Table 1: The Meaning Of Symbol

Symbol	Meaning
Z_1	Economic indicator
Z_2	Social indicator
Z_3	Environmental indicator
X_1	Population
X_2	Per Capita GDP
X_3	Per capita income
Y_1	Property tax
Y_2	TSI（Transportation Services Index）
Y_3	Unemployment rate
Y_4	Per capita expenditure on education
W_1	AQI（air quality index）
W_2	Forest coverage rate
V_1	CPI（Consumer Price Index）
V_2	Average wages of staff and workers
V_3	Urbanization level
V_4	GDP （Gross domestic product ）
V_5	Proportion of primary industry
V_6	The proportion of secondary industry
V_7	The proportion of the tertiary industry
G_1	Savings of rural-urban residents at the end of the year
G_2	Passenger traffic
G_3	Number of post offices
G_4	Enrollment rate
G_4	Number of schools
G_6	Per capita living space of rural-urban

G_7	Quantity of social health service agencies
G_8	Rural-Urban income gap
E_1	green coverage ratio
E_2	Investment of environmental pollution treatment
E_3	Environmental noise level
E_4	Air quality rate

4. Model

4.1Task 1: Metric of City Smart Growth

4.1.1 Design Principles of Metric

Based on the principles and indicators of “Smart Growth”, we are seeking a city’s rational growth. It aims to achieve three goals:

（1）To create a healthy environment and focus on a balanced development between the environmental protection and economic promotion.

（2）To improve the level of community services and facilities and build a competitive community .

（3）To create a good social relations and focus on social equity.

4.1.2 Establishment of evaluation index system of Urban Smart Growth

Based on the "Smart growth" theory, we are trying to classify its main influence factors into three categories (Social indicator, environmental indicator and economic indicator), 6 minor sorts and 28 items.

Target layer	Subsystem layer	Theme layer	Index layer
"Smart growth" comprehensive metric	Economic indicator	Social index	Urbanization level
			CPI（Consumer Price Index）
			GDP (Gross domestic product)
			Population
			The proportion of primary industry
			The proportion of secondary industry
			The proportion of the tertiary industry
		Personal index	Per Capita GDP
			Average wages of staff and workers
			Per capita income
	Social indicator	Social equity	Property tax
			Unemployment rate
			Enrollment rate
			Rural-Urban income gap
		Social comfort	TSI（Transportation Services Index）
			Per capita expenditure on education
			Quantity of social health service agencies
			Passenger traffic

			Number of post offices
			Number of schools
			Per capita living space of rural-urban
			Savings of rural-urban residents
	Environmental indicator	Ecological environment	Air quality rate
			Green coverage ratio
			Forest coverage rate
		Living environment	AQI（air quality index）
			Investment of environmental treatment
			Environmental noise level

4.1.3 Criteria of evaluation index system of Urban Smart Growth

Smart Growth emphasizes urban sustainability. So our modeling team felt that economic indicator, social indicator, and environmental indicator had an identical impact on the city's Smart Growth. That is to say the weight of each index are 1/3.

4.2Task 2: Evaluation of current plans

4.2.1Method

（1）Data Normalization

Considering that data of Smart growth measured on different scales, it is necessary to a standardize them into a notionally common scale. Therefore all data in our research need to be adjusted before used in models.

All the 22 indicators we study on can be divided into three categories while normalizing: economic indicator, social indicator which reflect social fairness and comfort, and environment indicator. In our model, assume that n (n=22) indicators and 2 samples of cities are considered. In following equations, x_{ij} (x_{ij}>0) represents the original value of indicator i for sample city j, where (i=1,2,...,22) and (j=1,2). r_{ij} is standardized data:

$$r_{ij} = \frac{\left(x_{ij} - \bar{x}_{ij}\right)}{s_{ij}}$$

$\bar{x}_{ij}$ is mean value, s_{ij} is standard deviation, r_{ij} is generally located in[-1,1]. So we eliminate the negative value and get z_{ij}.

（2）Entropy weight

Entropy weight is a mathematical method to calculate a comprehensive index on the basis of comprehensive consideration of various factors. As an objective method of determining weights, the weights are determined according to the amount of information transmitted to decision makers. The entropy weight method can accurately calculate the amount of information contained in the evaluation index of urban smart growth plan, which can solve the problem of large amount of information and accurate quantification of Urban Smart Growth evaluation.

We will explain the basic principles of entropy method in the following. Suppose the evaluation period of city j is n.It has i evaluation indexes of city smart growth, respectively x_{ij}（i=1,...,m）.

So we can get each evaluation index of every year. Then we can get the normalized matrix after the data standardization: R $=\left(r_{ij}\right)_{m\times n}$.

Further, we can calculate the entropy of information of each data. The entropy of information of data i can be defined as followed:

$$H_{ij} = -K\sum_{j=1}^{n} f_{ij}\ln f_{ij}$$

Where: $f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}}, k = \frac{1}{\ln n}$（suppose that if $f_{ij} = 0$，$f_{ij}\ln f_{ij} = 0$）

When entropy value is determined, we can get its entropy weight w_{ij} by the following equation:

$$w_{ij} = \frac{1 - H_{ij}}{m - \sum_{i=1}^{m} H_{ij}}$$

Therefore, we evaluate a city's current smart growth plan by the entropy weight of social indicator, environmental indicator and economic indicator.

We judge whether the government plan is successful by analyzing the balanced development of society, economy and environment.

4.2.2 City Selection

We selected the cities of Lhasa, Tibet, China and Atlanta, Georgia, USA as our research cities. Later we will summarize the economic, geographic and environmental characteristics of Lhasa and Atlanta respectively, and explain the reasons for choosing the two cities.

Lhasa is the capital of Tibet Autonomous Region of China. It is located in the western minority areas of China. It is a medium-sized city with a population of about 500,000. With the increasing level of social and economic development in Lhasa, the supportive capacity of the natural environment to social and economic development has been declining. The per capita area of arable land has continued to decline, grassland degradation, land desertification and the income gap have increased. Population birth rate is high and the population cultural quality is low. This has led to a low level of sustainable development in Lhasa, but in recent years the development of Lhasa has begun to change as the Chinese government attaches more importance to sustainable development. Therefore, we selected Lhasa as the research city, and made an evaluation of its growth plan in recent years.

Atlanta, an area of more than 350 square kilometers and a population of more than 50 million, is the capital and largest industrial and commercial city of Georgia in the eastern United States. In July 2000, the EPA eased its funds based on GRTA's agreement to enforce ARC's 1999 25-Year Transportation Plan, designating approximately $40 billion towards over 2,000 transportation projects and programs intended to increase mobility and reduce harmful emissions, including major transit projects, bicycle paths, and sidewalks. This is called smart growth plan .Soon, the city of Atlanta's residents and business owners, began to join the smart growth plan.

So in this paper, we will choose Lhasa and Atlanta as our object to research.

4.2.3 Results

We can get the weight of each index by entropy weight method:

Table 2：The results of weight

City	Economic indicators（Z_1）	Social indicator（Z_2）	Environment indicator（Z_3）
Lhasa	0.4248	0.2322	0.3430
Atlanta	0.7834	0.0438	0.1729

From the above results，we find:

1) Lhasa can ensure a balanced development in economic, society and environment.

2) However, Atlanta put too much attention on the development of the economy.

It ignores the social equity in its development. So Its current growth plan is not satisfied with 3E principles of smart growth.

4.3Task 3

4.3.1Analysis

1）Lhasa

According to the entropy weight method, we rank indexes according to their contribution degree to smart growth.

Table 3

Index	Rank
The proportion of primary industry	1
The proportion of secondary industry	2
GDP	3
The proportion of the tertiary industry	4
Population	5
Urbanization level	6
Average wages of staff and workers	7

2）Atlanta city

Similarly we rank indexes in the development of Atlanta city

Table 4

Index	Rank
Property tax	1
Per capita expenditure on education	2
TSI（Transportation Services Index）	3
Unemployment rate	4

3）Comparison of Development Level Between Lhasa and Atlanta city

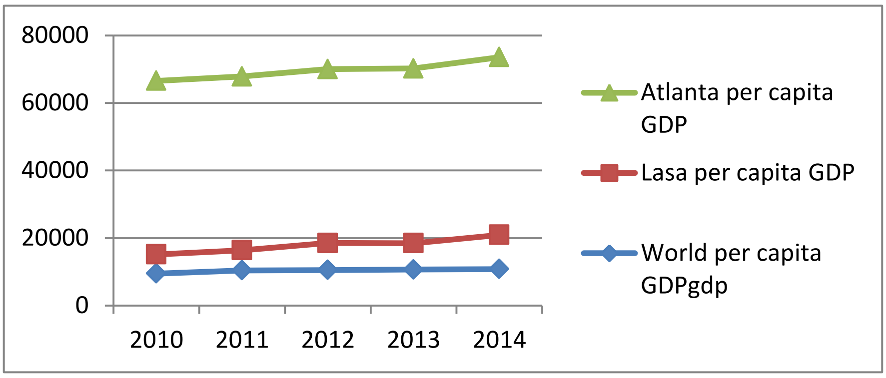


Figure.1

According to the results of task 2, though Lhasa can achieve a balanced development in society, economic and environment compared with Atlanta city, its development level is low. So it develops very slowly. We should make a new plan to help it get a rapid and healthy development.

As for Atlanta, Its current growth plan do not satisfied with 3E principles of smart growth. Perhaps in the process of rapid growth of the economy, it ignores the social equity and environmental issues. This caused a growing gap between rich and poor. So it can sacrifice a part of GDP to improve social equity and environment.

4.3.2Our growth plan

According to above-mentioned analysis and smart growth principles, we develop a new growth plan for both cities over the next few decades.

1) A plan for Lhasa

In order to improve environmental quality and promote social equity，we will take measures in the following aspects:

①To increase the investment in public infrastructure, such as building more schools and post offices.

②To shorten the gap between urban and rural places. The government should support the development of underdeveloped areas, promote the urbanization process

③To save energy and reduce the cost, increase resource utilization rate and reduce waste.

2) A plan for Atlanta city

Its aim is to improve the social equity, the government can take action in the following:

①To increase the property tax to realize the fair distribution of social wealth. At the same time, to encourage the government raise taxes on the rich, for example, to levy estate tax.

②The priorities should be to increase education spending, invest in transport infrastructure and improve the social environment.

③The government should encourage to protect natural forest resources, carrying out afforestation and improving the ecological environment.

④To set up a set of corresponding laws and regulations to combat racism, sexism, exclusion, and ethnocentrism.

4.3.3 Evaluation to our plan

In this question, we will use the comprehensive evaluation method to evaluate the success of our smart growth plan. Comprehensive evaluation method can determine the importance and weight of each index based on the evaluation index system of the research object

According to it, we can calculation the comprehensive evaluation index, in order to describe a phenomenon quantitatively. The specific evaluation model is:

$$ESI = \sum_{i=1}^{m} W_i \times C_i$$

In the above formula, ESI is a comprehensive evaluation index, W_i is the weight of index i, C_i is its dimensionless value, m is the number of evaluation indexes.

According to our growth plan, we can predict the development of the indicators in the next five years. On this basis, we will get the ESI value in five years. Its trend of change is as follows:

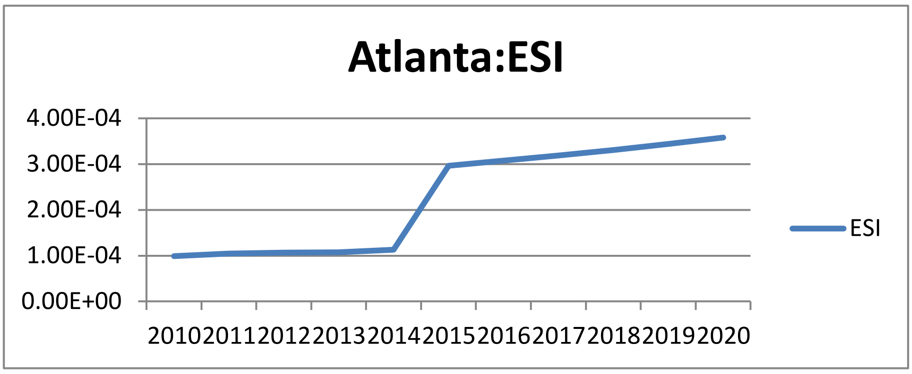


Figure.2

We can see that ESI has been increasing significantly since 2015, so we can conclude that our growth plan for Atlanta is effective and successful.

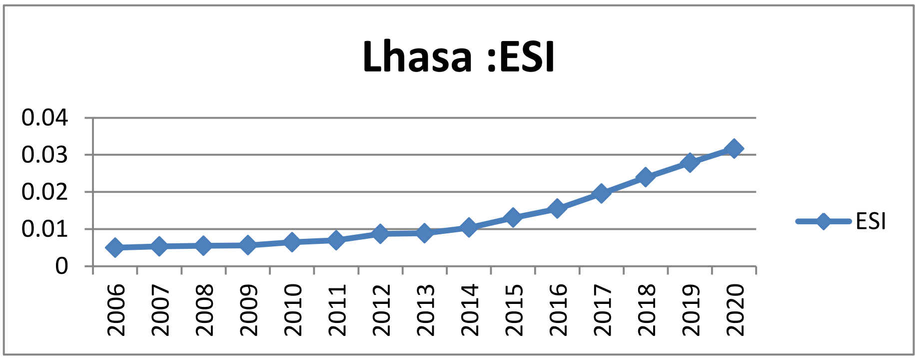


Figure.3

We find that ESI has a accelerated growth since 2015， so we can conclude that our growth plan for Lhasa is effective and successful.

4.4 Task 4

In accordance with the new Urban Development Plan, we are predicting the indicators for the next five years so that they can successfully complete the new urban growth plan in five years. At the same time, we calculate the weight of each index later in five years by entropy weight method, according to the weight of the index to analyze the intrinsic potential of the index, the results are as follows:

Table 5: Development Index of Atlanta city ranking

Index	Weight	Rank
Property tax （Y_1）	0.1701	1
AQI （W_1）	0.115	2
Per capita income （X_3）	0.1132	3
Per capita expenditure on education （Y_4）	0.1094	4
TSI （Y_2）	0.1046	5
Population （X_1）	0.1029	6
Unemployment rate （Y_3）	0.1012	7
Forest coverage rate （W_2）	0.1	8
Per Capita GDP （X_2）	0.0837	9

From the above table, We can see that, in the City of Atlanta ,the most potential index is property tax and the least potential index is Per Capita GDP. This may be closely related to US development plans. Taking into account the history of Atlanta, the physical and geographical conditions, we can understand that the city of Atlanta is already a very wealthy region, The future development of the city will pay more attention to social equity

Table 6: Development Index of Lhasa ranking

Index	Weight	Rank
Rural-Urban income gap （G_8）	0.0689	1
Air quality rate （E_4）	0.0571	2
Proportion of primary industry （V_5）	0.0527	3
Unemployment rate（Y_3）	0.0508	4
Number of post offices （G_3）	0.0491	5
The proportion of secondary industry （V_6）	0.0484	6
green coverage ratio （E_1）	0.0455	7
Enrollment rate （G_4）	0.0453	8
Quantity of social health servicagencies （G_7）	0.0444	9
Investment of environmental pollution treatment （E_2）	0.0441	10
Per capita living space of rural-urban （G_6）	0.0434	11
Number of schools （G_5）	0.0433	12
GDP （V_4）	0.043	13
Quantity of social health service agencies （V_7	0.0426	14
CPI（V_1）	0.0423	15
Population （X_1）	0.0423	16
Per Capita GDP （X_2）	0.0422	17
Urbanization level （V_3）	0.0419	18

Passenger traffic (G_2)	0.0413	19
Savings of rural-urban residents (G_1)	0.0383	20
Average wages of staff and workers (V_2)	0.0369	21
Environmental noise level (E_3)	0.0362	22

From the above table, We can see that , in Lhasa ,the most potential index is rural-Urban income gap and the least potential index is environmental noise level. This may be closely related to Chinese development plans. Taking into account the history of Lhasa, the physical and geographical conditions, we can understand that Lhasa is an underdeveloped city. So the future development of the city will still pay more attention to economic development and social equity.

In summary, due to there are economic development and cultural differences between Lhasa and Atlanta city, resulting the two cities will face two different development path.

4.5Task 5:How can our plan supports this level of population growth?

Through linear regression, we can get the relationship between the two urban population and other three indicators:

（1）Lhasa

Through the gray prediction model, we get the predicted values of the three-level indicators in 2050, the results are as follows:

Table 7

Index	Forecast value
Proportion of primary industry (V_5)	0.0692531
Savings of rural-urban residents at the end of the year (G_1)	600172
Enrollment rate (G_4)	302934
Quantity of social health service agencies (G_7)	5
Unemployment rate (Y_3)	7.06641%
Rural-Urban income gap (G_8)	0.394197
Investment of environmental pollution treatment (E_2)	343.876
Environmental noise level (E_3)	61.507
Air quality rate (E_4)	0.829852

We substitute above indexes into linear regression equation:

$$M = 120.685 + 0.177V_5 + 0.006G_1 + 0.0004G_4 + 0.02G_7 + 2.165W_8 - 5.429G_8 - 0.641E_2 - 0.747E_3 - 41.738E_4$$

The result as follows:

Present value of population (M)	Target value (M^*)	Forecast value of Population M_f
530300	1050600	614335

Because of $M_f < M^*$, the developed plan does not meet the conditions. Next, we will analyze the weight of each tri -level index

Table 8

Index	Weight
CPI（V_1）	0.0423
Per Capita GDP（ X_2）	0.0422
Average wages of staff and workers （V_2）	0.0369
Urbanization level （V_3）	0.0419
GDP（ V_4）	0.043
Population （X_1）	0.0423
Proportion of primary industry （V_5）	0.0527
The proportion of secondary industry （V_6）	0.0484
The proportion of the tertiary industry （V_7）	0.0426
Savings of rural-urban residents at the end of the year （G_1）	0.0383
Passenger traffic （G_2）	0.0413
Number of post offices （G_3）	0.0491
Enrollment rate （G_4）	0.0453
Number of schools （G_5）	0.0433
Per capita living space of rural-urban （G_6）	0.0434
Quantity of social health service agencies （G_7）	0.0444
Unemployment rate（ Y_3）	0.0508
Rural-Urban income gap（ G_8）	0.0689
green coverage ratio （E_1）	0.0455
Investment of environmental pollution treatment （E_2）	0.0441
Environmental noise level （E_3）	0.0362
Air quality rate （E_4）	0.0571

Table 9

Index	Contribution	Rank
Rural-Urban income gap （G_8）	0.0689	1
Air quality rate （E_4）	0.0571	2
Proportion of primary industry （V_5）	0.0527	3
Unemployment rate （Y_3）	0.0508	4
Number of post offices （G_3）	0.0491	5

We rank the weights and filter out the five most important indexs:

Therefore, if the population of Lhasa doubled in 2050, it is necessary to intensify efforts to narrow the urban-rural income gap, improve air quality, increase the proportion of the primary industry, increase the grain output year after year and reduce the social unemployment rate. In addition to, increasing public infrastructure investment, to improve the Lhasa society's population carrying capacity.

（2）The City of Atlanta

Through the gray prediction model, we get the predicted values of the three-level indicators in 2050, the results are as follows:

Table 10

Index	Weight
Per capita income （X_3）	80619.6
Property tax （Y_1）	0.52875
AQI（W_1）	17.1074
Forest coverage rate （W_2）	0.679725

We substitute above indexs into linear regression equation，

$$M = -142685.822 + 3.817X_3 + 28.119Y_1 - 158.335W_1 + 1239961.465W_2$$

The result as follows：

Present value of population（M）	Target value（ M^*）	Forecast value of Population M_f
463878	927756	1005200

Because $M_f > M^*$, Therefore the current development plan can be achieved by 2050 population doubled. So the indicators of our plan only need to maintain the current growth rate, it can support population growth.

5.Model Checking

We use the factor analysis, KMO test and Bartlett sphere test to verify evaluation indexs are reasonable or not. First of all, we do the following test for the evaluation index system of Atlanta City.

5.1 KMO Measuring Standard

Table 11

KMO value	Explanation	KMO value	Explanation
0.90≤KMO<1.00	**Very suitable**	**0.60≤KMO<0.70**	**Not suitable**
0.80≤KMO<0.90	**Suitable**	**0.50≤KMO<0.60**	**Very unsuitable**
0.70≤KMO<0.80	**Intermediate**	**KMO<0.50**	**Very unsuitable**

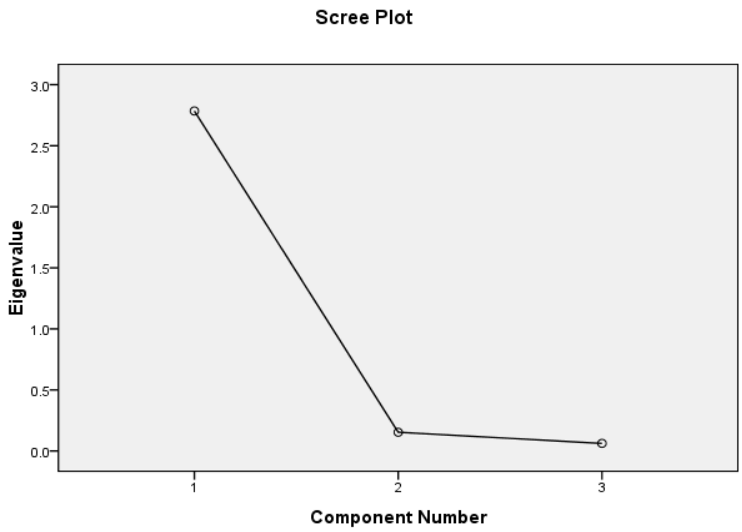
5.2 Model Checking Result

5.2.1 Test of Economic Indicator

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.752
Bartlett's Test of Sphericity	**Approx. Chi-Square**	7.858
	df	3
	Sig.	.009

As can be seen from the table, KMO value of 0.752> 0.7, and according to KMO Measuring Standard we can conclude that Bartlett's test result is intermediate, so the variable indicators can be analyzed, and verify the variables between the independent assumptions. As can be seen from the following scree plot, the economic indicator only involves a component variable ， that is to say there is no inverse, which means that the economic indicator is a single-dimensional indicator.

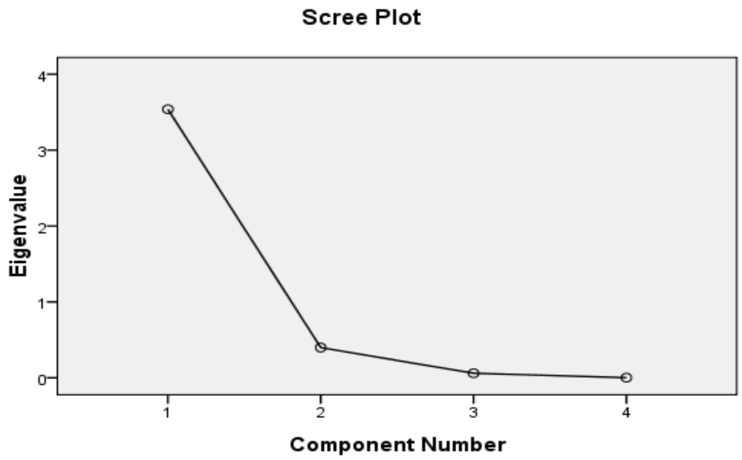


5.2.2 Test of Social Indicator

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.691
Bartlett's Test of Sphericity	**Approx. Chi-Square**	16.057
	df	6
	Sig.	.013

As can be seen from the table, KMO value of 0.691> 0.6, and according to KMO Measuring Standard we can conclude that Bartlett's test result is not suitable, so the variable indicators can be analyzed, and verify the variables between the independent assumptions. As can be seen from the following scree plot, the social indicator only involves a component variable ， that is to say there is no inverse, which means that the social indicator is a single-dimensional indicator.



5.2.3 Test of Environment Indicator

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.800
Bartlett's Test of Sphericity	**Approx. Chi-Square**	.867
	df	1
	Sig.	.002

As can be seen from the table, KMO value of 0.8, and according to KMO Measuring Standard we can conclude that Bartlett's test result is suitable , so the variable indicators can be analyzed, and verify the variables between the independent assumptions. As can be seen from the following scree plot, the environment indicator only involves a component variable ，that is to say there is no inverse, which means that the environment indicator is a single-dimensional indicator.

In the above paper, we only tested the City Atlanta evaluation indicators and the test of Lhasa is the same method.

6. Model Evaluation

In this paper, we use three modes: the entropy weight method, multiple linear regression and gray prediction. Each model has its advantages and disadvantages, and then discusses its strengths and weaknesses.

6.1 Strengths

1）In the whole index system, the entropy weight method is used almost everywhere. This method fully excavates the information contained in the original data, and obtains the objective results, which avoids the problem of too much subjectivity in the general weight solution method.

2）These models are simple and easy to be applied to real life, and have a strong guiding significance for the future development of the city.

3）Using the multiple regression method to consider the many factors in the model, which leaded to the reliability of the model greatly improved.

4）These models simplified the calculation

6.2 Weaknesses.

1）The forecast data are not precise enough. In the gray prediction model, we use only 10 years of data to predict about 40 years of data, resulting data in the 2050 and the actual situation does not match.

2）Improved Smart growth model is affected by many factors, but we only consider part of the factors. Moreover,selecting indicators inevitably was affected by subjective factors, which may lead to bias results

7. Reference

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Appendix

1. Entropy weight method

```
function shangquan(A)
% standardization
LA=min(min(A));
UA=max(max(A));
A=(A-LA)/(UA-LA);
% Calculate the information entropy of each index
[m,n]=size(A);
P=zeros(m,n);
Q=zeros(m,n);
lam=1/log(n);
H=zeros(m,1);
for i=1:m
    P(i,:)=A(i,:)/sum(A(i,:));
    for j=1:n
        if P(i,j)~=0
            Q(i,j)=P(i,j)*log(P(i,j));
        end
    end
    H(i)=-lam*sum(Q(i,:));
end
% To determine the variability of  each index
D=1-H;
% Determine the entropy weight of each index
W=D/sum(D);
disp(W);
```

2.Gray Forecast

```
 function gm (x0, m)% Define the function gm (x0, m), x0 is the original data, m is the predicted number
 n = length (x0);
 x1 = zeros (1, n);
 x1 (1) = x0 (1);
for i = 2: n% Calculate the accumulation sequence x1
x1(i) = x1 (i-1) + x0 (i);
end
i= 2: n;% parallel to the original series shift and assign y
y(i-1) = x0 (i);
y= y ';% changes y to a column vector
for i = 1: n - 1;
% Calculates the first column of the data matrix B
c(i) = - 0.5 * (x1 (i) + x1 (i + 1));
end
```

```
b= [c 'ones (n-1,1)];% Constructs the matrix B
au = inv (B '* B) * B' * y;% Calculates the parameter a, u matrix
for i = 1: n + 1 + m;% Calculate the value of the predicted cumulant sequence
au (2) / au (1); exp (-au (1)) = (x0 (1)
end
yc (1) = ago (1);
for i = 1: n-1;% Restore the value of the sequence
yc (i + 1) = ago (i + 1) -ago (i);
end
for i = 2: n;
error (i) = yc (i) -x0 (i);% Calculates the residual value
end
yc (1) = ago (1);
 for i = 1: n-1 + m;% The value of the restored list
 yc (i + 1) = ago (i + 1) -ago (i);
end
c= std (error) / std (x0);% Calculate the posteriori error ratio
p= 0;
for i = 2: n
if (abs (error (i) - mean (error)) <0.6745 * std (x0))
p= p + 1;
end
end
p= p / (n-1);
wl = min (abs (error));
w2 = max (abs (error));
for i = 1: n;% Calculates the degree of association
w(i) = (w1 + 0.5 * w2) ./ abs (error (i)) + 0.5 * w2);
end
w= sum (w) / (n-1);
plot(2017: n + 2016], x0, '+', [2017: n + 2016 + m], yc, '*')
grid on;
xlabel ('Time');
 ylabel ('index value (xx)');
 % title ('Sustainable City Gray Model Forecast Curve');
  % Legend ('Measured', 'Predicted', 4);
fprintf ('a, u value:')
fprintf ('% g', au)% Outputs the values of the parameters a, u
fprintf ('\ nCumulative Sequence: \ n')
fprintf ('% g', ago)% Outputs the value of the cumulative number column ago
fprintf ('\ n raw sequence: \ n')
fprintf ('% g', x0)% Outputs the original sequence value
fprintf ('\ n Forecast: \ n')
fprintf ('% g', yc)% Outputs the predicted value
```

```
fprintf ('\ n residual: \ n')
fprintf ('% g', error)% Outputs the value of the residual
fprintf ('\ n posterior difference: \ n')
fprintf ('% g', c)% Outputs the value of the posteriori error ratio
fprintf ('\ n small error probability: \ n')
fprintf ('% g', p)% Outputs the value of the small error probability
fprintf ('\ n Affinity: \ n')
fprintf ('% g \ n', w)% Output correlation degree w
```

3. Data normalization processing

```
FlattenedData = OriginalData(:)'; % Expand the matrix to one column and then transpose it to one row
MappedFlattened = mapminmax(FlattenedData, 0, 1); % Normalized
MappedData = reshape(MappedFlattened, size(OriginalData)); % Revert to the original matrix form
```

4. Solve ESI

```
q1=ATATz1;
  q2=ATATz2;
  q3=ATATz3;
  Q=[q1 q2 q3];
ESIATAT= Q*ATATz
```