CHINESE GEOGRAPHICAL SCIENCE
Volume 6, Number 4, pp. 342－350, 1996
Science Press, Beijing, China

LAND RESOURCES SURVEY BY REMOTE SENSING AND ANALYSIS OF LAND CARRYING CAPACITY FOR POPULATION IN TUMEN RIVER REGION

Zhang Yangzhen(张养贞) Chang Liping(常丽萍) Zhang Bai(张柏)
Zhang Shuwen(张树文) Huang Tieqing(黄铁青)
Changchun Institute of Geography, the Chinese Academy of Sciences, Changchun 130021, PRC
Liu Yaqin(刘雅琴)
Changchun Cadre Secondary Specialized School, Industrial and Commercial Bank of China, Changchun 130062, PRC
(Manuscript was received in June 1996)

ABSTRACT: The Tumen river region including Yanji, Tumen, Longjing and Hunchun cities is situated in the east part of Jilin Province. The region is an important economic exploitation area in the province. The total area is 10,228.86 km^2. There are superior geographical location, rich natural resources, various gemorphological types and less farmland in the region. The remote sensing technique is adopted in the survey of present landuse. The newest Landsat and CCT data are selected in the survey. Comparing the data obtained from remote sensing survey with the data from land detail investigation we can see that the paddy-field, garden for planting fruits, residential area and factory and mine, traffic land have increased in different extents, especially, the residential area is increased rapidly, but the forest land, grazing land have decreased. The unused land has been used. Land productive potentiality system is a multi-hierarchic comprehensive-complex system of natural economy. Its core is photosynthesis of green vegetation, which is affected by factors such as radiation, temperature, rainfall, soil fertility and management level. According to calculation of productive potentiality, the analysis of carrying capacity for population has been done and the conclusion is drawn. After 2000, the population growth in the region will be restricted by lack of reserve of farmland resources and level of grain production. Existing land and its reserve resources can not carry a population more than 150×10^4. It is estimited that the grain only depends on transportation outside to

meet the needs of population growth and social development after 2000.
KEY WORDS: landuse, remote sensing, land carrying capacity

The Tumen River region is situated in the east part of Jilin Province. The middle and lower reaches of the Tumen River lies in the boundary area between China, North Korea and Russia. Because its geographic advantages and regional conditions, the region possesses remarkable position in the economic development belt along the boundary. With grouping and internationalizing of the world economy the region will be a hot point area of economic development in Northeast Asia in the 21st century. However, the coordinative development of the region's economy depends on reasonable utilization of various resources. Land is a basic condition and site for production and living of human being. Land resource inventory and effective utilization is necessary key link for region's economic development.

The Tumen River region includes Yanji, Tumen, Longjing and Hunchun cities. The total area is 10,228.86 km^2. twenty-three nationalities such as Chao, Han, Manchu, etc. live in the region.

I. PRESENT LAND USE AND ITS DYNAMIC CHANGE

1. Remote Sensing Survey of Land Resources

The remote sensing technique is adopted in the survey of present landuse. The newest Landsat TM image and CCT data are selected in the survey. They are 115 – 30 and 115 – 31 TM images and CCT data acquired in July 1994 and 114 – 30 TM image in October 1993. The transplanted paddy-field in TM false colour image is dark green colour. There is a distinctive appearance between paddy-field and dry-field and other landuse types. Because the dry-field which is just at the jointing stage hasn't completely covered by crop, the image shows light green colour mixing the crop with soil. The river shape is very clear, narrow flood plain on both sides of the river can be seen. Water body is dark blue. The towns, villages, factories and mines located in the river plain, are cyan on the images, distinguished slightly from dry-field. The forest with large area distributed in the mountain is red. Mountain ridges and shadow are obvious.

The image processing is made at the Sun Station using the CCT data and ERDAS soft ware. Its program is as follows.

(1) Image enhancing processing is carried on at first so that landuse type appears more clearly in image.

(2) Administrative boundary is drawn up in the image. We make the image part out of administrative boundary darken by reducing the brightness and make the

image part within administrative boundary become bright by increasing the brightness. The further image processing is carried on only within the boundary.

(3) Training sections are selected according to land use type. 5 – 10 sections are chosen for each type.

(4) Image classification is carried out by using maximum likelihood classifier method and one colour is given for each landuse type.

(5) The number of pixel of every landuse type is calculated to get the area of each landuse type.

2. Landuse types

(1) Farmland: It includes paddy-field, dry-field, vegetable plot and small patch planting crops, the area of vegetable plot and small patch are not counted, because they are too little and dispersive (Table 1).

① Paddy-field is mainly distributed in flat ground along both sides of rivers. The area is 32,469.8 ha.

② Dry-field is mainly distributed in table land and slopes of hill and mountain. Its area is 77,180 ha.

(2) Orchard: The orchard area in the region is as large as 11,019.2 ha, and orchard for each person is 0.01168 hm^2, more than the average level of the whole country and the whole province. Apple-pear is famous fruit in the region. The orchard is distributed in the terrace of the river.

(3) Forest land: It covers an area of 786,350.3 ha, accounting for 77% of the total area in the region. Main forest land is secondary one. Artificial coniferous forest was planted after 1949.

Table 1 Landuse situation in 1994 (ha)

Landuse type	Yanji	Tumen	Longjing	Hunchun
Paddy-field	2429.16	3336.10	14569.30	12135.21
Dry-field	9541.26	11394.76	38878.57	17365.93
Orchard	1103.00	1029.52	7413.15	1473.54
Forest	48298.72	84457.65	218523.12	435070.84
Grazing	1098.39	2161.24	234.62	16837.20
Residential	4858.07	3360.69	9662.70	6791.25
Traffic	619.47	1294.47	2515.82	1642.76
Water area	1503.60	4475.49	6762.09	15745.48
Unused land	4437.54	4036.40	20696.84	7123.52
Total	73889.21	115546.32	319256.21	514194.73

(4) Grazing land: It includes pasture and waste grassland, with an area of about 20,331 ha only accounting for 2% of the total area.

(5) Residential area and factory and mine area: They include city, town, village, mine, factory and special land. The area is about 24,673 ha. It is increasing

rapidly.

(6) Traffic land: It includes railway, highways and roads between villages, covering an area of 6,072.5 ha.

(7) Water area: It includes river, reservoir, irrigation canal and ditches, covering an area of 28,496 ha.

(8) Unused land: It includes waste grass land, marsh land, bare rock, a low bank of earth between fields and unreclaimed land. The area is about 36,294 ha (Fig. 1).

3. Dynamic Change of Landuse

Comparing the data obtained from remote sensing survey with the data from land detail investigation, we can see that the paddy-field, orchard, residential area and traffic land have increased in different extents, especially, the residential area is increased rapidly but the forest land, grazing land and dry-field have decreased (Table 2). The tendency of the dynamic change is going to continue, with the regional development of agriculture, fruits product development and population growth.

Table 2 Dynamic change of land resources (ha)

Landuse type	TM classification in 1994	Detail investigation of land	Change rate (%)
Paddy-field	32469.8	31678.8	2.5
Dry-field	77180.5	78435.45	-1.6
Orchard	11019.2	10486.64	5.1
Forest	786350.3	788949.6	-0.3
Grazing	20331.5	20214.8	0.6
Residential	24672.7	21787.04	13.2
Traffic	6072.5	5598.81	8.5
Water area	228495.7	28495.66	0.0
Unused land	36294.3	37240.29	-2.5
Total	1022886.5	1022886.5	

II. LAND PRODUCTIVE POTENTIALITY SYSTEM

Land productive potentiality system is a multi-hierarchic comprehensive-com plex system of natural economy. Its core is photosynthesis of green vegetation, which is affected by the factors such as radiation, temperature, rainfall, soil fertility and management level. The aim of the paper is to reveal the regional difference of natural potentiality through analysis of every factor influencing productive potentiality[1].

1) The energy of solar radiation is the only energy source of photosynthesis. The amount of solar radiation in the region determines the quantity of energy that

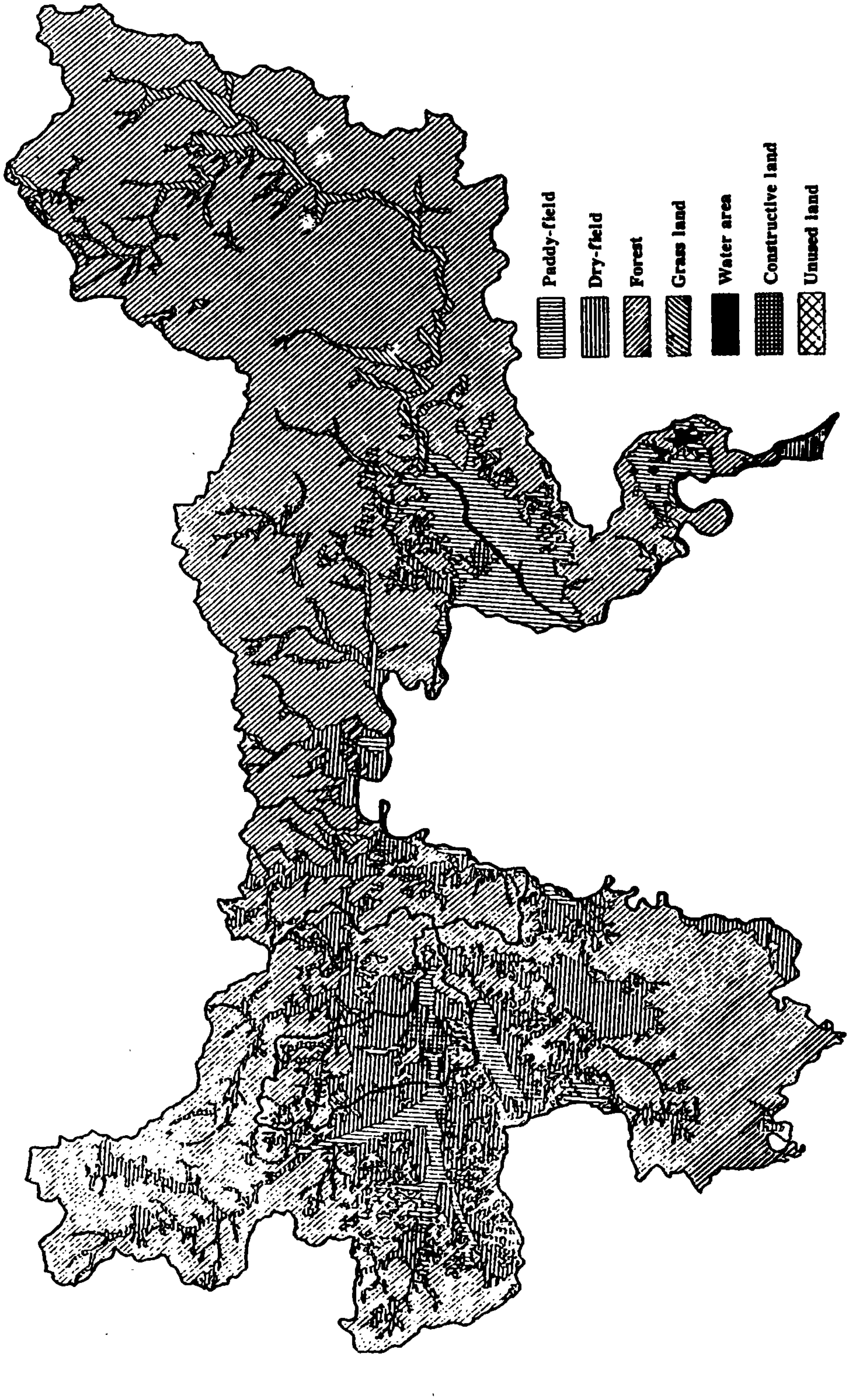

Fig. 1 Landuse of lower Tumen River region

photosynthesis can accumulate. Only a part of radiation energy can be provided to green vegetation for photosynthesis. This part of radiation is called photosynthetic effective radiation. The relation between photosynthetic effective radiation and total radiation can be explained as:

$Q_{light} = 0.43\ Q_{direct} + 0.57 Q_{scattering}$

Q_{light} ——photosynthetic effective radiation

Q_{direct} ——direct radiation

$Q_{scattering}$ ——scattering radiation

Mr. Huang Bingwei indicates $Q_{light} = \eta . Q$

η——ratio coefficient (Mr Huang Bingwei determines it is 0.49)

Q——solar radiation

The level of photosynthetic potentiality of every city in the region is obtained (Table 3) [1] according to appendent table of the level of photosynthetic potentiality in every township, Jilin Province.

2) The influence of temperature on energy convension and light-temperature potentiality. The growth of crop requires suitable temperature condition. Tempera ture controls the bio-chemistry of photosynthetic speed and breathing rate

Table 3 Photosynthetic potentiality (kg/ha)

	May	June	July	Aug.	Sept.	Total amount
Yanji	3180	3840	3480	3090	2655	16245
Tumen	3180	3570	3225	3105	2865	15945
Longjing	3540	4215	3810	3555	3015	18135
Hunchun	2910	3660	3540	3225	3120	16455

of crops. For a certain region, the amount of radiat ion and temperature condition are the most basic condition forming crop potentiality and they are relative stable, so we make light-temperature productive potentiality as the most possible potentiality of crop or call it the upper limit of land (crop) productivity (Table 4).

Table 4 Light-temperature potentiality (kg/ha)

	May	June	July	Aug.	Sept.	Total amount
Yanji	795	1965	2610	2280	825	8475
Tumen	840	1800	2460	2205	945	8250
Longjing	1005	2295	2940	2625	960	9825
Hunchun	480	1530	2430	2255	1110	7905

3) The influence of water on energy conversion and land (crop) climatic productive potentiality. Water is the most active factor among ecological factors. Wa-

ter, which participate all physiological process of crop growth, is a basic condition of crop growth. Atmospheric precipitation is the principal source of crop water under natural condition. Precipitation hardly meets the needs of crop growth, affected by time and space limit and regional difference of rainfall. According to Long Siyu's study on relation between yield and precipitation for many years climate potentiality is obtained (Table 5).

Table 5 Climate potentiality (kg/ha)

	May	June	July	Aug.	Sept.	Total amount
Yanji	570	1965	2355	2280	645	7815
Tumen	465	1140	2295	2130	660	6690
Longjing	690	2160	2535	2625	810	8820
Hunchun	375	1530	2430	1995	1110	7440

4) The influence of soil on formation of crop productive potentiality and natural potentiality of crop. Soil is one of the basic conditions for crop growth. The main effect on crop productivity is the difference of soil fertility, which reflects synthetically various properties of soil. We calculate function of effect of soil on crop productive potentiality using method of weight mean of soil type.

$$f(s) = \frac{1}{100}\sum_{i=1}^{n} Ai \cdot Pi$$

Ai——Percentage of soil area of type i in the total region area.

Pi——Fertility and grade value of soil of type i

The value of natural potentiality is 4,920 kg/ha in Yanji, 4,005 kg/ha in Tumen, 4,455 kg/ha in Hunchun and 4,500 kg/ha in Longjing.

Undoubtedly, input and management are important factors to raise the level of productivity. The input is mainly to adjust and control water and fertility factors to influence the potentiality to increase yield, so that the level of productive force is close to light-temperature productive potentiality constantly. Therefore in the circumstance of constantly raising management level, with reference to climate potentiality and natural potentiality level, applying fertilizer in line with soil type and developing the farmland irrigation and water conservancy project in real production, the high land output can be obtained.

III. THE ANALYSIS OF LAND RESOURCE CARRYING CAPACITY FOR POPULATION

Land resource carrying capacity is a systematic perspective for regional land, grain, population and social development. The aim is to provide exact scientific basis for drawing up the principles and policies for population, grain and agriculture

development through quantitatively expounding land resource productivity and carrying capacity for population in different periods in the region.

The definition of land resource carrying capacity for population given by Commission for Integrated Survey of Natural Resources, the Chinese Academy of Sciences is "the limit of population carried by land productivity under certain productive condition and living level". The definition expounds that the land can produce grain for human being existence and land productivity is limited in a given condition. Composition of food and life style of people vary with social background, land resource carrying capacity for population is a dynamic system with different production condition, productivity, nourishing level and consumption level (Table 6).

Table 6 The level of food consumption of residents in 2000 (kg/people. a)

	First project	Second project
Grain	195	185
Potato	35	35
Bean	8	10
Vegetable	160	160
Edible oil	5	6
Meat	22	25
Milk	4	6
Aquatic product	7	10
Egg	8	8
Fruit	12	12

According to the statistics and forecast of population and urban development and distribution made by us, there were 94×10^4 people in the region in 1993, and the population will increase to 122×10^4 by 2000, and 148×10^4 by 2005, 179×10^4 by 2010, the population will reach to 250×10^4 by the end of this century.

There are more mountains and less farmland in the region. The population density is 92 people/km^2. The reserved farmland resources is inadequate. In 1992, the unit grain yield was 3,480 kg/ha, which was close to the average unit grain yield of Jilin Province in the same year . If the unit grain yield in 2000 is 3,480 kg/ha, the planned crop areas are 93,771 ha and 94,674 ha, respectively, the total yield of grain and soybean are 42,900 t and 43,313 t, the light-temperature potentiality (the upper limit of land productivity) are 775,361 t and 782,803 t, respectively (Table 7).

Table 7 Total yield of grain and soybean in 2000 (t)

	93771 ha	94674 ha
Light-temperature potentiality	775361	782803
Real potentiality	429002	433131

On the basis of analysis of present landuse and land resource evaluation, and two planning projects of crop area(the first is 93,771 ha, the second is 94,674 ha) for the region in 2000, the land carrying capacity for population can be calculated (Table 8).

Table 8 Land resource carrying capacity for population ($\times 10^4$ people)

	93771 ha	94674 ha
First project	121.87	123.05
Second project	119.17	120.30

According to calculation of synthetic consumptive target in 2000, the meat, eggs and milk are all converted by land elementary productivity——grain. Their conversion rates are 0.18, 0.25 and 1.4 respectively. Calculated with this critrion the grain converted by meat, egg and milk for each person in 2000 is 157 kg for the first project and 175 kg for the second project. The total grain for each person in 2000 is 352 kg for the first project, 360 kg for the second project. From analysis of result of land resource carrying capacity for population we can see that if the level of forecast of grain, meat, egg and milk is realized, there is a population of 122×10^4, the carrying capacity for population of this region correponds basically to the forecast value for 2000. If calculating with the second project of 360 kg of grain per capita, the grain yield is slightly deficient, which shows that both the farmland area and the total grain yield in the regon are not sufficient.

Because of more mountain and less farmland in the region, the enlargement of farmland area will be restricted in many ways. After 2000, the population growth will be restricted by lack of reserve of farmland resources and level of grain production. Of course, there is a great potentiality of the land resource carrying capacity. The land carrying capacity of light-temperature potentiality is less the twice of real productive level. Therefore, one should develop social productivity, enhance the level of unit area productivity, raise the land quality. The level of land productivity can raise constantly through application of modern scientific technological achievement and increasing input level of land. But it is difficult to reach the upper limit of land productivity. Existing land and its reserve resource can not carry a population of 200×10^4 and even 250×10^4. It is estimated that the grain only depends on transportation from outside to meet the needs of population growth and social development after 2000.

REFERENCES

[1] Wang Xiangren, Wei Jisheng. Study on Overall Planning of Landuse of Jilin Province. Beijing: Beijing Normal University, 1992. 194－209, 216 219－222, 277. (in Chinese)