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An approach to the fluctuation mechanism of ecotone

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Abstract: In this paper, the relationship among land productivity, population pressure and the fluctuation mechanism of ecotone is analyzed, taking counties and banners of southeast Inner Mongolia plateau as an example, which is the most fragile part in the farming and husbandry interleaving belt of north China due to its severe desertification degree and low level of economic development. The C_v for the total output value of agriculture decreases from southeast to northwest, with the same rule as which the overloading population cumulated distributes, and both indicators have close relation with the high linear coefficient of 0.83. These reveal the fluctuation mechanism for ecotone: fluctuation of the level of economic development is a scientific and practical measure both to weakness degree and to instability of ecotone, because it is a synthesized response to the variation of climate as well as irrational land uses, which reinforce and magnify the fluctuation. In detail, the heavier the population overloading, the severer the grassland reclamation, the stronger the dependence of regional productivity on rainfall, the lower the level of economic development, the rougher the fluctuation of ecotone, but the weaker the PRED system.

Keywords: fluctuation mechanism; land productivity; population overloading; weakness degree

Introduction

Area of upland and rear hill is situated in the southeast Inner-Mongolia plateau between Hebei Province and Inner-Mongolia Autonomous Region. In which, there are great population pressure on land, heavy erosion of water and wind, rapid desertification expansion and high fluctuation of eco-social compound system, which bring low living standard of local residents. As a result, the area become the most fragile part of ecotone in north China (Zhu, 1994; Sun, 1997). As its special in eco-geography and major factor in global environmental change, it also become the core region of NECT in IGBP (Zhang, 1997). Along with the research to the typical section going deeper gradually in recent years, scientists suggest several indexes to measure the situation of man-land relation of ecotone. These indexes are grouped into population pressure, desertification, natural disaster and sensitivity, which are interrelated each other but emphasized particularly on. When talking about the reason for the weakness to farming-husbandry interleaving belts in north China, some scholars consider that the huge belt should be "interface fragile" owing to its transitional features between humid and arid zone (Niu, 1998). For the elements of ecotone should have higher horizontal gradient than rest belt, from which are served as interface indexes to distinguish ecotone, when they across transitional belt. Nevertheless being just in the tail of maritime monsoon, the farming-husbandry interleaving belts in north China totally represents the feature of the fluctuation ecotone, like Sahel in Africa in continental scale. The fluctuation of ecotone makes the transitional belt not only the most distinct character but also the principal reason for the weakness to ecotone. In the paper, to approach the fluctuation mechanism of ecotone, we will discuss the relation among fluctuation, population pressure and weakness in the eco-social compound system from the viewpoint of man-land relation, taking the area of upland and rear hill as typical section, which stretches 500 km long and 300 km wide and deals with 18 counties and banners.

1 The representation of the fluctuation of ecotone

In the region the fluctuation factors can be classified into two groups that one mainly dominated by climate or natural disaster, such as pasture plant, grain output, number of livestock and total national product, the others dominated by social factors of national policies and traditional living habits, such as land reclamation, population growth, excessive firewood gathering. From viewpoint of eco-system,

fluctuation can be reduced into four levels on the basis of energy transfer sequence. First or primary level is climate (precipitation, wind and water erosion force etc.), second is the vegetation (pastoral plant and grain output), third animal, fourth regional productivity (total output value of agriculture, total value of national economy and so on). Conflict between man and land separately focuses on three different contradictions: livestock and grass, farming activities and erosion force of climate, real population and real land bearing capacity. It is the regional productivity that finally decides the population capacity. Here, we will center on the fluctuation of total output value of agriculture to discuss its spatial distribution.

Using the total output value of agriculture and that of per capita, which are all from the year book of Inner Mongolia from 1978 to mid-1990s (all are changed into price of 1980), we calculate the fluctuation coefficient with the following formula: $Y_c = Y_r - Y_t$, where, Y_c is the climate yield; Y_r is the real yield; Y_t is the tendency yield; $C_v = \delta_{n-1} X^{-1}$, where, C_v is the fluctuation coefficient; δ_{n-1} is the deviation of climate yield; X is the average yield.

In yield procession, the smoothed average of 5y is approximately served as tendency yield, and yield of real minus tendency is that of climate.



Fig.1 C_v (%) for total output value of agriculture

Calculation results showed that the fluctuation coefficient of the total output value of agriculture and that of per capita, the C_v , have great consistency with high linear correlation of 0.99. Hence both indicators can represent fluctuation of regional land productivity or level of economic development, and can replace each other also. The C_v for the total output value of agriculture decreases from southeast to northwest, just opposite to that of cereal crop. The highest fluctuation takes place in the semicircle area of Qahar Youyi Houqi, Shangdu, Huade, Taibusqi, Guyuan and Wuchang, 37% of Kangbao and Shangyi reaches the highest of the region. Guyang that lies in the west is the other higher point of 29.7%. Siziwang Qi, Darhan Muming Qi, Bai Qi, Duolun, Wuchuan and Qahar Youyi Zhongqi are between 20% - 25%, the C_v for the pasturing area of Sonid Youqi, Huang Qi and Lan Qi is below 14%, with Sonid Youqi being the lowest of the whole research area (Fig.1)

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2 Population pressure

In general, the lagging economic ultimately results from the integration of natural and social factors for the farming-husbandry interleaving belts. Unstable rain makes itself the background for vulnerable environment, and desertification is landscape representation for ecosystem degradation, but it is overloading population that functions as a direct driver to weakness. So, land bearing capacity not only shows the population that land can continuously support in the area, but also reveals the compatible state of land and man as well as economical and ecological future.

2.1 Standard and method

In 1991, according to the two index of meat and grain, the research item on productivity of land resource and population bearing capacity in China publicized the regional estimation about population bearing capacity of 1985, 2000 and 2025 for the three potential zones of northwest, semiarid and arid of Inner Mongolia Autonomous Region. The main point is that the grain imbalance between supply and demand quite stands out in the studying region, where population overloaded in successive years. In the paper, in term of three levels of primary, well-being and scientific (Table 1), the author will calculate calorie and protein population bearing capacity of 18 counties and banners assuming that there is no regional and annual relief of grain. Statistic include overall yield of grain, pork, beef and mutton from 1983 - 1992. By analyzing the difference between real population and real supporting population we will

have a good understanding of the situation of ecotone. As for content criteria for meat and grain, we take respectively Siziwang Qi, Shangdu and Zhangbei to represent that of pasturing, agro-husbandry interleaving zone of Inner Mongolia and four counties of Hebei Province. Output of grain and meat are processed in the weighed average. Meat yield is corpus and net meat ratio is 80%. General food structure and nutrition component of China is taken as conversion criteria of calorie and protein.

Table 1 Nutrition level of land productivity supporting capacity

Nutrition level	Ningxia		Qinghai		Area of upland and rear hill	
	Calorie, kcal/a	Protein, g/a	Calorie, kcal/a	Protein, g/a	Calorie, kcal/a	Protein, g/a
Primary	876000	25550	915420	24638	912500	25550
Well-being	1021635	29200	1019810	29200	1022000	29200
Scientific	1094635	36500	1089890	36500	1095000	36500

2.2 Spatial distribution of overloading population cumulated

Based on the calculation, the overloading population cumulated under calorie standard for primary distributes the whole region during 10y but in different extent, and that under protein standard has the same spatial tendency as under calorie, the only difference is the latter is much higher than the former, and both distribution comply with the coming rule: Agro-husbandry interleaving zone is heavier than pasturing area, the east of pasturing area is higher than west. Zhangbei, Kangbao and Shangyi form the region above 120 persons/km², and Kangbao with 240 persons/km² overloaded most severely of the whole area. Qahar Youyi Houqi, Shangdu, Huade and Guyuan become the second high center of 80 persons/km², Fengning, Bai Qi, Huang Qi, Qahar Youyi Zhongqi, Wuchuan and Guyang between 10 - 30 persons/km². Duolun of 4 persons/km² is the least of all (Fig. 2; Sun, 2000). Under calorie criteria for primary during 10y, overloading frequency is also obtained: Wuchuan, Guyang, Duolun are the least only for 1y, Fengning for 2y, the other counties and banners between 4 - 5y, and the pasturing zone maintained the highest frequency (Table 2). The geographical distribution in population pressure suggested that the number and frequency of overloading differ from each other. In the pasturing zone, the frequency is high but the overload population cumulated is low, which is contrary to agro-husbandry interleaving zone. From analysis above, the population pressure decreases from SE to NW, namely, from agro-husbandry interleaving belt to pasturing one (Table 2).



Fig.2 Overload population cumulated under primary level of calorie unit during 1983 - 1992 (people/km²)

3 Fluctuation mechanism

3.1 Relationship between fluctuation and population pressure

The fluctuation of total output value of agriculture, the C_v , maintains high linear correlation with population pressure. Speaking concretely, there exists coefficient of 0.76 between the C_v and cumulated overloading number under primary calorie standard, 0.70 between the C_v and that under primary protein standard, and 0.84 with agro-population density. High positive coefficients among above indexes speak well for their close links. In the region, where land productivity fluctuates frequently, there are heavy overloading population and high agro-population density. Meanwhile, population density distributes the same as its pressure. In the south of the area, agro-population density in the early 1950s increases from 10 - 15 persons/ km² to 40 - 60 of 1990s, with the average growth rate of 31%. The density for the north of the area increases to 4.8 persons/km². Of the region, Zhangbei takes the lead with 82 persons/km² and

Sonid Youqi of 1 come the last during 1990s.

Table 2 Overloading population of typical counties during 1983 - 1992

Category	Overload item	Time, year	Calorie		Time, year	Protein		10 ² people/km ²
			Max., 10 ⁴ people	Cumulated, 10 ⁴ people		Max., 10 ⁴ people	Cumulated, 10 ⁴ people	
Siziwangqi	Primary	3	7.1	14.1	4	7.2	16.1	0.06
	Well-being	4	8.2	19.3	6	8.5	24.9	0.10
	Scientific	5	8.8	23.7	8	10.1	42.3	0.17
Shangdu	Primary	4	17.7	48.7	4	19.1	57.4	1.32
	Well-being	4	19.1	56.8	5	20.6	67.7	1.56
	Scientific	4	19.9	61.3	8	22.3	91.4	2.10
Zhenglanqi	Primary	6	2.5	9.8	6	1.8	6.3	0.06
	Well-bing	7	2.8	12.5	7	2.3	9.8	0.10
	Scientific	7	3.0	14.1	7	2.8	14.4	0.14
Zhangbei	Primary	5	23.8	67.2	5	25.0	76.9	1.84
	Well-being	5	24.9	78.0	5	26.1	88.3	2.11
	Scientific	5	25.5	84.0	6	27.4	106.0	2.54

3.2 Fluctuation mechanism

The fluctuation of the economic level is a scientific and practical measure to weakness degree and the fluctuation of ecotone, because it is a synthesized response to the variation of climate as well as irrational land uses, which reinforce and magnify the fluctuation. The C_v of ecotone comprehensively reflects the land structure, situation of people overloading and the economic level of local residents. Dry farming fluctuates hardly because of its strong dependence on rainfall, but second and tertiary industry generally restrain and cushion the fluctuation. In the end, the percentages that three industries separately accounting for determine the fluctuation of ecotone, which also can be looked upon as the extent of stability of the PRED system (Fig. 3). From this dynamic model, we can see clearly that physical and social factors directly or indirectly influence the fluctuation, such as diversity of crop, landscape heterogeneity of land uses, capacity to combat natural disaster, the acreage of guaranteed irrigated cultivated land and the rate of livestock. Of all factors, the grassland reclamation, the irrational land use, plays the most important role in the fluctuation promotion of semiarid and sub-humid zone.

The single-crop farming dominates the area of upland and rear hill, both farming and husbandry make up the principal part of the agriculture, with the rest such as forestry and subsidiary accounting for a little. High husbandry proportion in the agriculture can cushion and lower the fluctuation of the PRED. For example, for this region there exists strong linear correlation above 0.80 between the C_v of the ecotone and the proportion that the output value of farming making up in the total agriculture. Although there is a severe annual fluctuation of the grain yield along the dry farming belt, the high husbandry proportion obviously regulates their C_v to the lowest point of 7%. Huang Qi, Bai Qi and Lan Qi, where husbandry value accounts for as high as 85% in the agriculture, are the typical examples of the husbandry cushion. Just opposite to the pastoral zone, four counties of the upland of Hebei, in spite of little more rain than north, the C_v is certainly magnified as a consequence of the highest farming percentage and lowest husbandry of only 35% in total agriculture. The C_v has negative linear correlation with the level of economic development, such as -0.81 with the total output value of agriculture per capita, and -0.83 with net income per capita of 1997. Basing the analysis above, we can come to a conclusion: over population

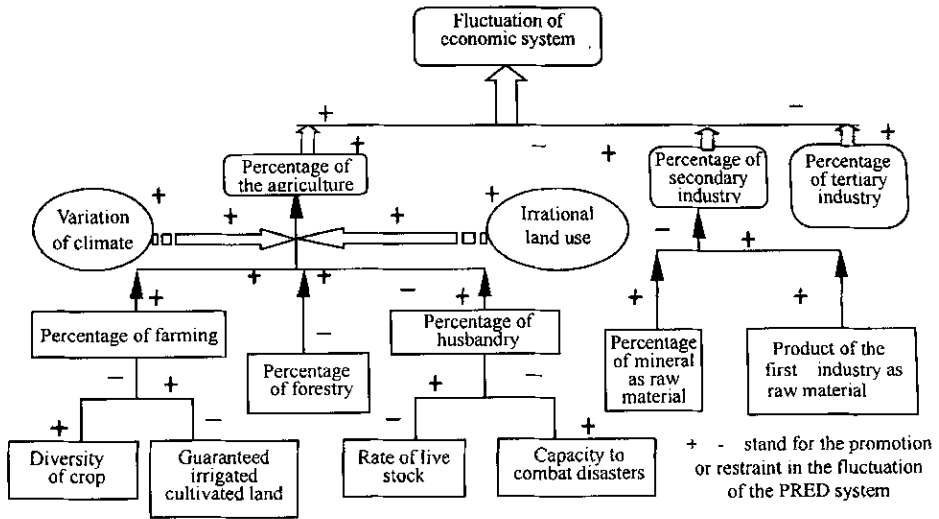


Fig.3 Dynamic model for fluctuation of ecotone

overloading put a direct pressure on land use, furthering the reclamation of grassland and undulating stabilized sand dunes which directly incurs the rapid land degradation. On the other hand, the increases of reclamation of grassland was accompanied by the decrease of the cushion role that husbandry played in agriculture. Therefore, the heavier the population overloading, the severer the grassland reclamation, the stronger the dependence of regional productivity on rainfall, the lower the level of economic development, but the rougher the fluctuation of the PRED. In essential the fluctuation of ecotone, the C_v , or the instability of the PRED, should be the scientific and practical index to weakness of ecotone.

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