

LAND USE CHANGES AND THEIR DRIVING FORCE IN THE BEIJING METROPOLITAN AREA, CHINA

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Abstract In this paper the authors tried to analyse land use changes in the southern part of Beijing City and make clear their driving force. In consideration of discussions about land use changes in this area, ten factors in terms of them were identified as elements of their driving force: the institution of landholding system, the agricultural policy, the arrangement of agricultural infrastructure, the improvement of natural environment, the innovation of farming technology, urbanisation and industrialisation, population increase and movement, the changes of eating habits, natural resources, and the level of economic development. Driving force of land use changes can be also considered as the system consisting of five sub-systems such as policy, population, urbanisation, technology and resources. Therefore, land use changes under the pre-socialistic economy were based on the linkage of sub-systems such as policy, technology and resources. Under the socialistic economy, land use changes were based on the linkage of sub-systems such as policy, technology, resources and urbanisation. At present, land use changes under the socialistic market economy are based on the linkage of sub-systems such as policy, technology, resources, urbanisation and population.

Key words: land use changes, driving force, agricultural land use, urban land use, Beijing City

1. Introduction

China in the 20th century has made drastic changes not only politically but also socio-economically and culturally. Especially the Beijing metropolitan area as the modern capital city is one of the regions where more remarkable changes have been effected in China (Institute of Geography, Chinese Academy of Sciences 1990; Sit 1995). These regional changes can be explained through the land use change. In this paper the authors tried to analyse land use changes in the Beijing metropolitan area and make clear their driving force. The driving force is a set of internal and external factors inducing land use changes (Turner *et al.* 1995). These factors in terms of land use changes are

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mainly classified into direct and indirect ones. Population, economic activity, regional policy, and land resources are identified as the direct factors of land use changes. On the other hand, the social system, technological innovation, value sense, life style, and national policy are identified as the indirect ones (Meyer and Turner 1994). It is needless to say that the land use reflects the variety of human activities and environmental conditions in a particular region or on the ground, and the explanation of land use changes and their driving force is to make clear how the regional and environmental changes are brought about (Himiyama 1994; Kitamura and Ohtsubo 1996).

Here, the southern part of Beijing City, where the land use has made remarkable changes with the urban growth, was analysed in detail. Beijing City is one of provincial regions (the first class administrative regions) in China, and has the areal extent enough to be almost equivalent to the Tokyo metropolitan area. The territorial jurisdiction of Beijing City is defined as the metropolitan area with the planning division of Beijing Regional Authority (Sit 1985 1995; Kikuchi and Zhan 1996) and consists of 18 counties (ten words and eight prefectures): the four words of Xicheng, Dongcheng, Xuanwu, and Chongwen in the city center, the four words of Haidian, Chaoyang, Fengtai and Shijingshan in the suburban area, the two words of Mentougou and Fangshan in the outer suburban area, and eight prefectures of Daxing, Tongxian, Shunyi, Changping, Pinggu, Miyun, Huairou and Yanqing in the outer suburban area.

Land use changes in China were analysed by the mutual comparison among land use maps of different periods. These land use changes were historically, politically and socio-economically divided into the periods of the pre-socialistic economy, the socialistic economy and the socialistic market economy (Wo 1985; Wo and Guo 1994). Drawing of these land use maps in three periods was based on the *gaihozu* of 1935 that meant the maps produced by Japan to cover outside its mainland before World War II (Himiyama *et al.* 1995), the Chinese Land-Use Maps of 1982 (Editorial Committee of 1:1,000,000 Land-Use Map of China 1990), and field surveys and satellite remote sensing of 1995 respectively (Yu 1986). Before the mutual comparison among land use maps, each map was divided into 800 meshes of two kilometers around, and the percentage of all kinds of land use in each mesh was measured in accordance with the dot-sampling method. Then the authors applied the modified Weaver's method to the percentage of respective land use in each mesh (Weaver 1954; Doi 1990), and individually obtained the combination pattern of land use with respect to the mesh. Furthermore the authors paid attention to elements of this combination pattern, and analysed historical and spatial changes of these elements among three periods. According to a series of analysis, the authors made clear typical land use changes and their driving force in the southern part of the Beijing metropolitan area.

2. Various Aspects of the Land Use in the Southern Part of the Beijing City

Geographical circumstances in the land use

Beijing City is situated in the northwestern parts of the Huapei (North China) Plain,

and is adjacent to Hopeh province and Tianjin City. The area of Beijing City is 1.68 square kilometers, and makes up just 0.17 percent of the total area throughout this country. As concerns the landform of the whole Beijing City, the land slopes gently from the west to the east, and the mountains and their foot, hills, alluvial fans, diluvial uplands, alluvial lowlands, and marshes are almost regularly distributed from the west to the east. The alluvial lowlands make up approximately 40 percent of the total area throughout Beijing City's territory, and provide the major space of economic activity for people. On the other hand, because the gentle slopes of the mountains and hills facing south are good sunshine condition, agricultural land use is mainly developed with fruit growing. On the high mountains of more than 800 meters above the sea level, however, agricultural land use is little developed because the forest land and grassland are more predominant than other land use.

Furthermore the climate condition (cumulative temperature and frostless period) in Beijing City is adequate to growing of wheat, corn and kaoliang, and their crops are harvested with the rotation of double cropping a year or three croppings in two years. This region has relatively abundant precipitation of 640 millimeters, but 70 percent of the precipitation is concentrated in summer. Since there is very little precipitation in spring, the cultivation of wheat and spring-sown crops has to depend at least on irrigation. Owing to the progress of the urbanisation and industrialisation of this country in recent years, however, water for agricultural use competes with water for industrial use and human life. Thus the irrigated farmland has been not expanded since the late 1980s.

The population of Beijing City was 116,430,000 in 1994, accounting for 0.97 percent of the total population of the whole country. The population density is 64.4 persons per square kilometers, which suggests that the Beijing metropolitan area is one of the regions with the highest population density throughout the country. Also in the population of Beijing City, the urban population (urban census population) and the rural population (rural census population) account for 64.4 and 35.6 percent respectively. Therefore, Beijing City is also one of the regions that urban population accounts for a high proportion in the whole population. The average percentage of the urban population in this country is 28.6 percent.

In examining the distribution of population by county (word or prefecture) of Beijing City (Fig. 1), the census population is much distributed in the central districts of the city, and there is a tendency that the census population is less distributed in the areas from the suburbs to the outer suburbs. Especially in the northern part of the city, the census population is lesser distributed than in the southern part of city, and most of population is the rural one. Also in both sectors from the south to the west and from the south to the east, the census population is more distributed than in other sectors, and the difference between the census population and the real habitant population tends to be greater. This difference indicates the population inflow from the peripheral and rural areas to the urban areas. The "blind (disordered) inflow" of population has been one of the most important factors in land use changes of the Beijing metropolitan area. From the viewpoint of the population movement, the southern part of Beijing City can be said to be one of the typical regions of remarkable land use changes.

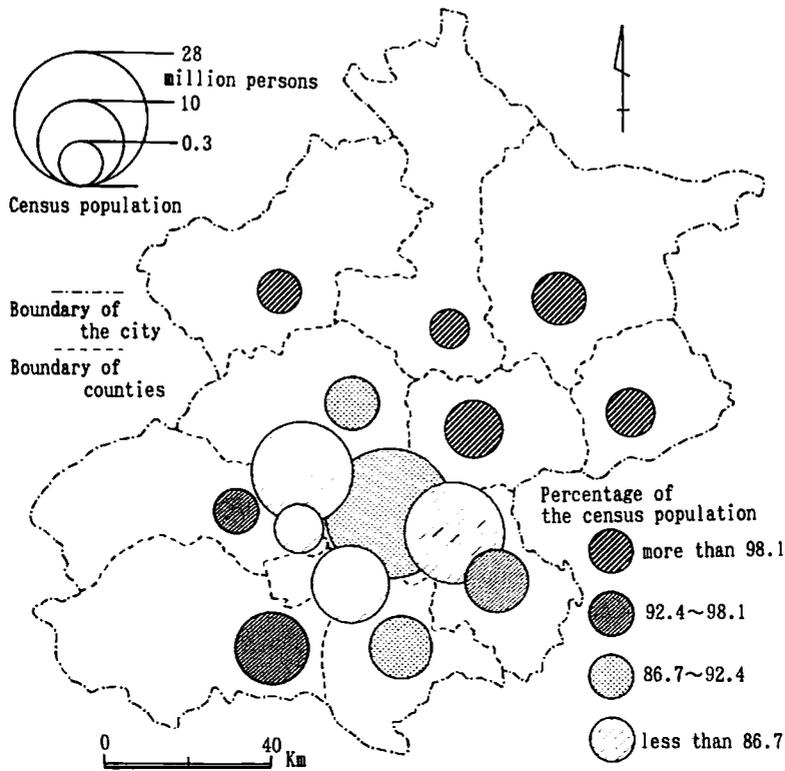


Fig. 1 Distribution of population in Beijing City (1995)
Data sources: The Statistical Yearbook of Beijing City

Land use in 1935

According to Fig. 2, the authors tried to discuss about the distribution and characteristics of land use in 1935. The center of Beijing City was the palace and had the landscape of a typical walled town, so that urban and rural land use were clearly separated from each other with the ramparts as a boundary. Since the built up area was developed within these ramparts, the suburban and outer suburban areas were not extensively developed beyond them in comparison with the larger extent of Beijing City's territory. Because urban land use was expanded into outer areas through some castle gates, the local expansion of urban land use was developed around them (Fig. 3). In the outside of the built up area, small central places and rural centers were dispersed at random and they were agglomerated settlement patterns.

On the other hand, agricultural land use was dominant in the plain, but there were regional differences in the combination patterns of land use elements. In diluvial uplands and alluvial lowlands of the eastern side of the city center, the single combination pattern of upland fields was predominant because the calcic sandy soil with poor water

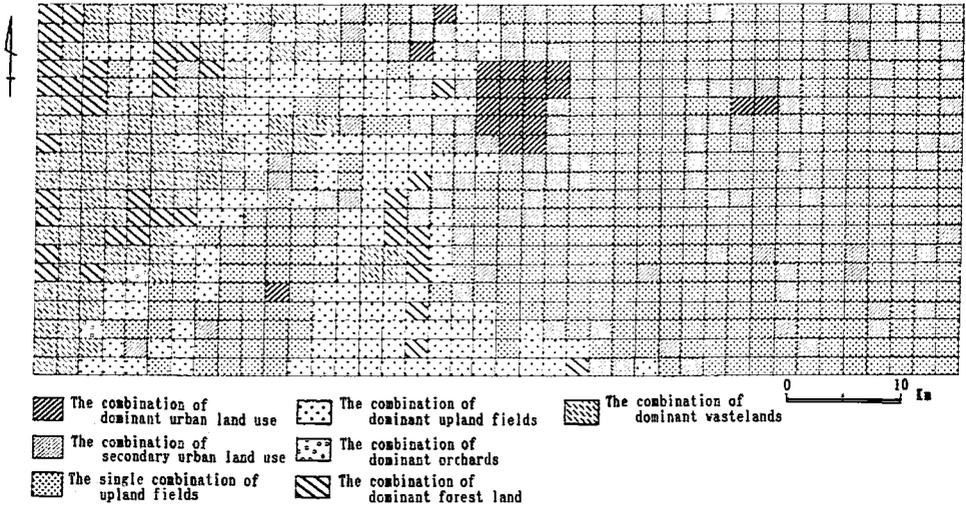


Fig. 2 Land use in the southern part of Beijing City (1935)
 Data sources: "Beijing" and "West Beijing" of *Gaihozu*

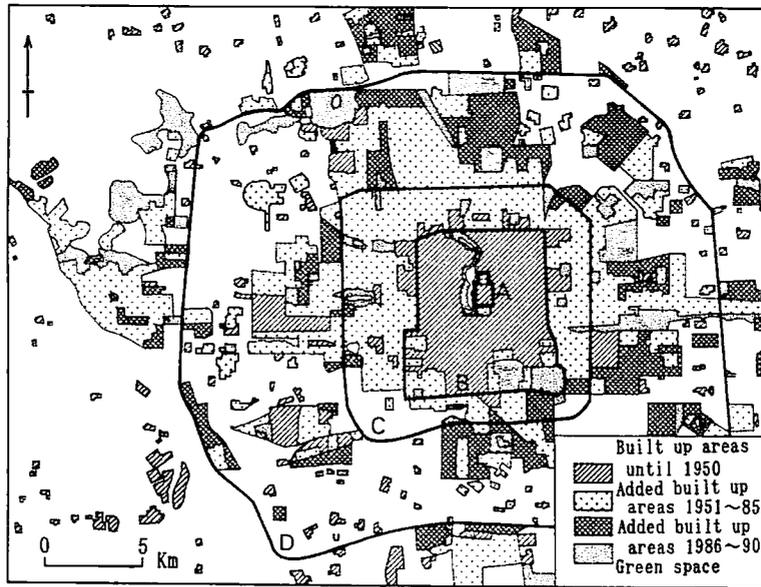


Fig. 3 The expansion of built up areas in Beijing City
 A: Old palace, B: Second Ring Road, C: Third Ring Road, D: Fourth Ring Road
 Data sources: Atlas of Land Resources in Beijing City

retentivity was inadequate for the agricultural land use without upland fields. In this farmland wheat, barley and kaoliang were cultivated with the rotation system of a single cropping a year. In the southwestern side of the city center, alluvial lowlands extended along the Yungting Ho, and diluvial uplands were developed out of the lowlands. While a part of the lowlands and uplands have been used as farmland, the hinterland was left as wastelands (undeveloped land). Therefore the combination pattern of both the upland field and wasteland tended to be much dominant in the southwestern side of the city center. On the gentle slopes of the mountains and the lower hills in the western side of the city center, the combination pattern of both farmland and forest land was generally dominant. Furthermore in a part of the slopes facing the south, the combination made up mainly of orchards such as apples and peaches.

The combination of dominant wasteland was more distributed on the mountains and higher hills in the western part of the city. Although most of these highland regions were once covered with deciduous broadleaf trees, bare mountains and wastelands were often dominated at this time because of the deforestation to obtain fuel wood of city dwellers. In this region the steep slopes of the mountains and the karst landform were reflected on the land use of dominant wastelands. The gradient of their mountainous slopes is so steep as to be more than 20 degrees, from which they are considered to be inadequate for agricultural land use or farmland. Furthermore the vegetation on the mountains takes too much time for the restoration because of the karst landform.

As a whole, the land use in terms of upland fields was distributed in accordance with the land condition of this metropolitan area, and no upland field was distributed in regions of bad land conditions such as steep slopes and marshes. At the period of the pre-socialistic economy, that is to say, the important characteristics of agricultural land use can be pointed out harmonious land use patterns with natural conditions. These land use patterns were developed by the location of agriculture and farmland in accordance with land conditions without the nature reformation and the farmland expansion.

Land use in 1982

The authors prepared the map of Fig. 4 to discuss about the distribution and characteristics of land use in 1982. According to this figure, the castle walls that once enclosed the city center were destroyed, and the ring roads as a loop highway were constructed along the sites of old ramparts. Urban land use was continuously expanded from the city center to its outskirts because of removing the castle walls, so that the expansion of urban land use has been more remarkable than other land use in the suburbs. Especially within the Third Ring Road, built up areas were extended with the conversion from non-urban into urban land use, and urban land use began to extend over the outside of that road (Fig. 3). Although many dispersed constellations were constructed according to the city planning with the view of dispersing urban functions in the suburbs, but those constellations not only caused the urban sprawl but also accelerated the expansion of continuous urban land use from the city center.

The combination patterns of land use including paddy fields appeared in the southern and the southwestern sides of the city center, and the combination mainly composed of paddy fields became to be dominant especially in the alluvial lowlands and hinterland of

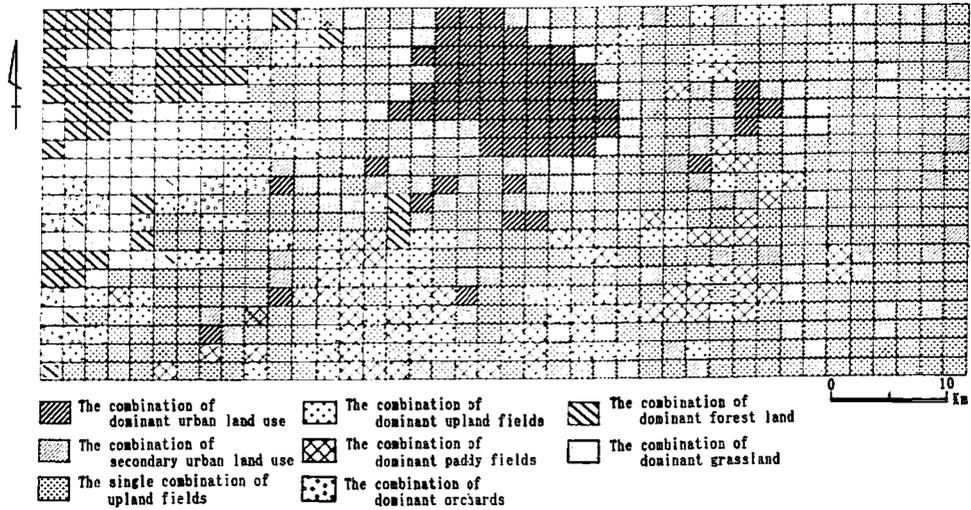


Fig. 4 Land use in the southern part of Beijing City (1982)
Data sources: Land use maps of China

the Yungting Ho. This expansion of paddy fields was resulted from agricultural reclamations of the undeveloped land for the increase of food production, and from the beginning of paddy rice cultivation that could supported a great deal of population. The combination mainly composed of paddy fields was also distributed in upland field region of the city's eastern side. These paddy fields were developed with the conversion of hollows where soil as materials was removed for the road construction, and with the expansion of irrigation systems in upland field region.

On the mountainous slopes and the lower hills in the western part of the city, the combination including upland fields was extensively distributed with the terracing and the land leveling of gentle slopes. On their slopes facing south, the combination mainly composed of orchards tended to be dominant, and their distribution tended to be changed from the dispersed into the spatial and cluster patterns. In addition, the combination mainly composed of grassland and forest land tended to be dominant in the mountains and higher hills, and there was few combinations of wasteland in those highland regions.

Generally speaking, farmland has been developed with the conversion of the lowlands and swampy hinterland into paddy fields, and with the conversion of the mountainous slopes and lower hills into upland fields since the establishment of the socialistic economy. Taking the opportunity of the founding of the People's Republic of China, the Chinese Communist Party attached importance to the agricultural policy that was planning to increase the food production and to stabilise the food supply. Therefore there was more agricultural investment to enlarge farmland and to develop the rice cultivation. According to these agricultural policies, farmland were enlarged with the land leveling and terracing on the mountainous slopes and the lower hills, and the productivity of farmland was increased with the irrigation and land improvement in alluvial lowlands.

On the other hand, the wasteland was converted into the grassland and forest land for the protection against soil erosion in the highland, so that there was not a small amount of investment for the environmental conservation.

Land use in 1995

Here is Fig. 5 which shows the distribution of land use and its characteristics in 1995. This figure provides the opportunity of our discussions about land use. Urban land use is accelerated to be expanded, and built up areas are also expanded between the Third and Fourth Ring Roads. In the suburbs, built up areas of some dispersed constellations are also expanded and connected with the city center. With the progress of these urbanisations, some dispersed constellations tend to be independently constructed in the outer suburbs of Beijing City. In terms of the directional trend of urbanisation, urban land use is developed in the eastern and western sides of the city center (Fig. 3). These directional trends are reflected in the construction of large-scale industrial districts and the location of large-scale public establishments such as research institutes and universities (Fig. 6). With these construction and location as a turning point, urban land use has been expanded into the suburbs and outer suburbs.

As regarding agricultural land use, the combination patterns mainly composed of paddy fields are decreased as a whole and merely leave in the alluvial lowlands and hinterland of Yungting Ho. The decrease of paddy fields has been caused by the shortage of irrigation water, the increasing demand of water for drinking and the development of market gardening as the suburban agriculture. On the other hand, the combination patterns mainly composed upland fields have tended to increase not only with the

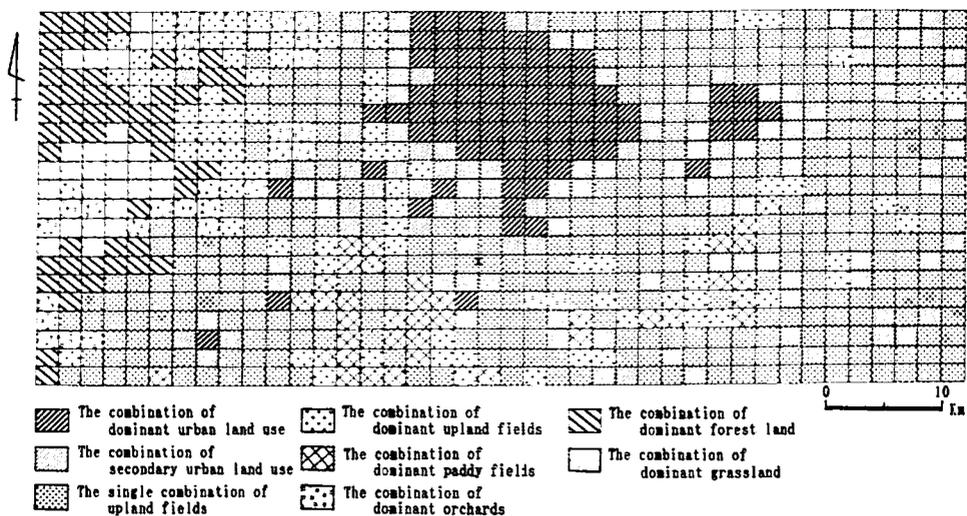


Fig. 5 Land use in the southern part of Beijing City (1995)
Data sources: Satellite remote sensing and field surveys

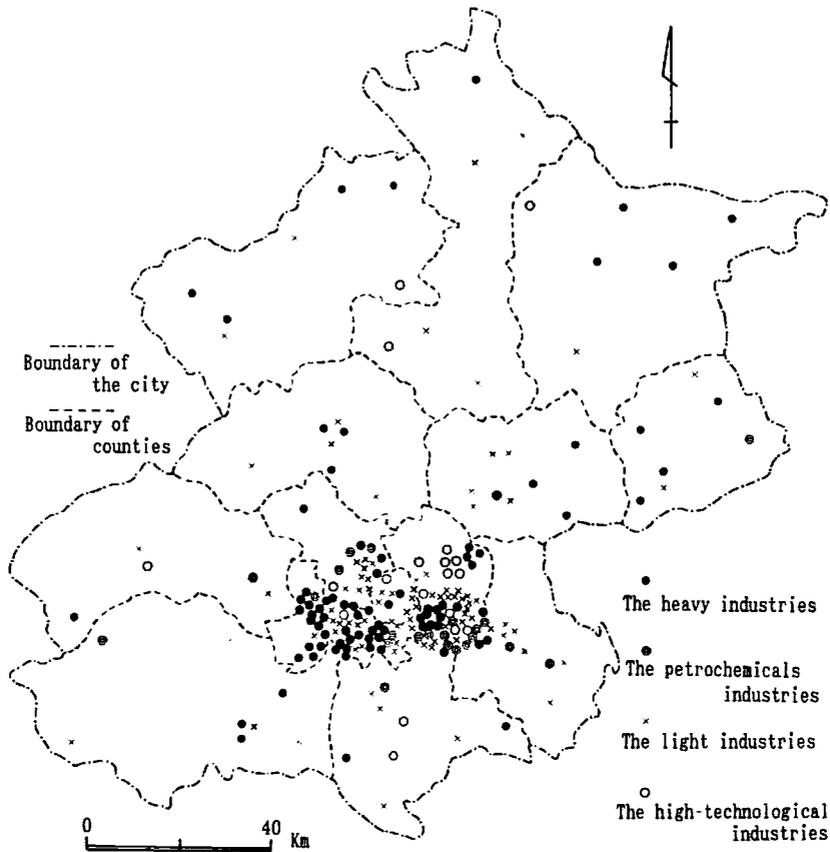


Fig. 6 Distribution of main industrial factories in Beijing City (1990)
Data sources: Atlas of Land Resources in Beijing City

decrease of paddy fields and the development of horticulture, but also with the increase of owner operate farmers after the introduction of the agricultural production responsibility system. Because owner operate farmers often abandon to cultivate farmland, the combination patterns including wastelands tend to be much distributed in the suburbs. Most of these wastelands are characterised as the social vacant land.

Furthermore, the combination patterns mainly composed orchards tend to increase in the suburbs as well as the mountainous slopes and lower hills. The dispersive distribution of these combinations has changed into the extensive one with the development of the socialistic market economy. In the mountains and higher hills, land use of grasslands has been replaced by the forest land because the afforestation has been developed since the beginning of the socialistic economy. Therefore, the combination patterns mainly composed forest land tend to increase in these highland regions.

As a whole, the agriculture under the socialistic market economy has changed from

the planned food production to the commercial production, so that agricultural land use has been diversified with various patterns according as the rent and the profitability. Because each farmer has could used and cultivated individual farmland since the introduction of the agricultural production responsibility system, the farm managements in this area have been gradually divided into three types: the cooperative farming, the contract farming and the small-scale family peasant farming. In the cooperative farming, that combines with advantages of both the people's commune and the enterprise farming, farmers cultivate high profitable crops such as vegetables intensively. As the rural population moves from the peripheries of Beijing City into the urban and urbanised areas, flowed farmers from the outer suburbs and peripheries play an important role in the contract farming, and cultivate traditional food crops such as wheat, rice and maize instead of local farmers. In the family peasant farming, farmers hold the farmland of about 40 ares per farm household and cultivate various crops such as food crops and vegetables on a small scale.

Particularly in the contract farming, which is more typical management than others, the local farmers work in the township enterprises and have large incomes from both wages and farming rents. While this contract farming contributes to be maintained agricultural land use continuously, the cooperative farming contributes to be intensified agricultural land use in terms of cash crop production. As contrasted with both the contract and cooperative farming, the increase of family peasant farms is one of the factors that urban land use is developed instead of agricultural land use, or that the framework of agricultural land use is broken in the suburbs of Beijing City.

3. Land Use Changes in the Southern Part of Beijing City

The trends of land use changes between 1935 and 1982 were summarised in Table 1 that indicated the number of meshes related to main land use changes. As is evident from

Table 1 The number of meshes related to main land use changes between 1935 and 1982 in the southern part of Beijing City, China

	1982	Waste	Grass	Forest	Orchard	Upland	Paddy	Urban	Total
1935		land	land	land		field	field	land use	
Wasteland			63	36	14	53	12		178
Grassland									
Forestland			2		3	51	11	4	71
Orchard						1			1
Upland field				2	14		81	81	178
Paddy field									
Urban land use									
Total			65	38	31	105	104	85	428

Data sources: Mesh maps of land use in 1935 and 1982

this table. there were four main trends: the conversion from upland field into both urban land use and paddy fields. and the conversion from wasteland into both upland fields and grassland. In comparison with land use maps of 1935 and 1982 (Fig. 7), it was clear that the trend of changing into urban land use was dominant both along the Second Ring Road, that was constructed in the site of the Ming era's castle wall, and around dispersed constellations of the suburbs. This trend was based on the development of systematic transportation networks, the establishment of priority development districts and the planned arrangement of dispersed constellations.

In connection with the trend of changing into upland fields it was superiorly distributed in the mountainous slopes and lower hills. In these regions the development and reclamations of farmland were based on the physiocratic policies that attached importance to agriculture. the increase of agricultural investment. the terracing and leveling of the slopes, the technological innovation of farming, and the land improvement. These were also significant conditions of the conversion from the alluvial lowlands, hinterland and the hollow places removing soil into paddy fields. Especially it was typical to convert from the undeveloped land of alluvial lowlands and hinterland into paddy fields, or from irrigated upland fields into paddy fields. These trends were reflections of the agricultural policy that intended to stabilise the food supply with rice production, and of the cold resistant *Japonica* rice that was diffused in the north China.

On the other hand, the trend of changing into orchards was observed in places and its distribution was dominant in the mountainous slopes and lower hills. This trend was based on the terracing of gentle slopes facing south and the increase of fruit demand in the city dwellers. Furthermore. the trend of changing into forest land was based on the

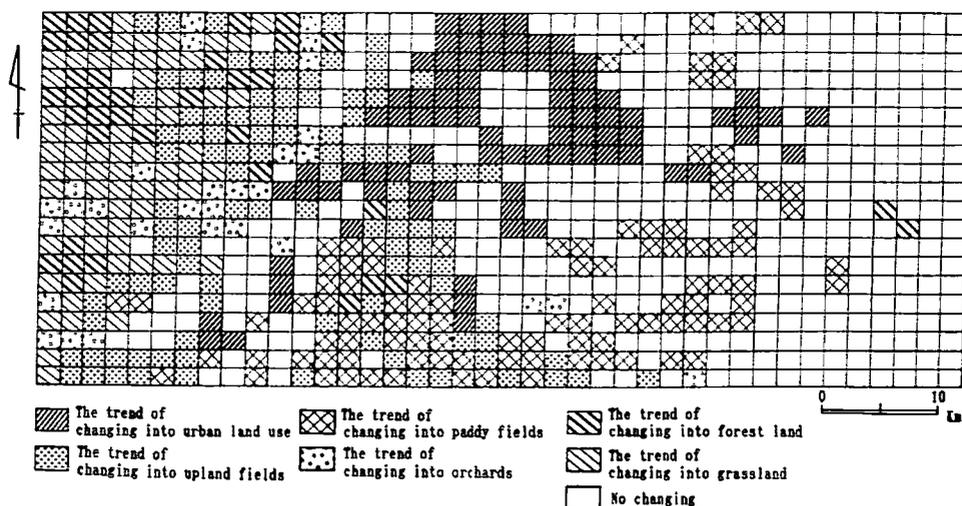


Fig. 7 Land use changes in the southern part of Beijing City between 1935 and 1982
Data sources: Mesh maps of land use in 1935 and 1982

afforestation for the protection against soil erosion, so that its distribution tended to be expanded from the patches of existed forest land into their surroundings. Most parts of the steeper slopes and bare land were also converted into grassland to protect from the soil erosion. Therefore the trend of changing into grassland was typically observed on the steeper slopes and bare land.

Then the authors considered the trends of land use changes between 1982 and 1995 on the basis of Table 2 indicating the number of meshes related to main land use changes, and of Fig. 8 indicating the spatial distribution of some trends of land used changes. As is evident from Table 2, there were three main trends during this period: the conversion

Table 2 The number of meshes related to main land use changes between 1982 and 1995 in the southern part of Beijing City, China

1982	1995	Waste land	Grass land	Forest land	Orchard	Upland field	Paddy field	Urban land use	Total
Wasteland									
Grassland				31	3	11			45
Forestland					3	13			16
Orchard									
Upland field		9				14		46	69
Paddy field					1	42		4	47
Urban land use									
Total		9		31	21	66		50	177

Data sources: Mesh maps of land use in 1982 and 1995

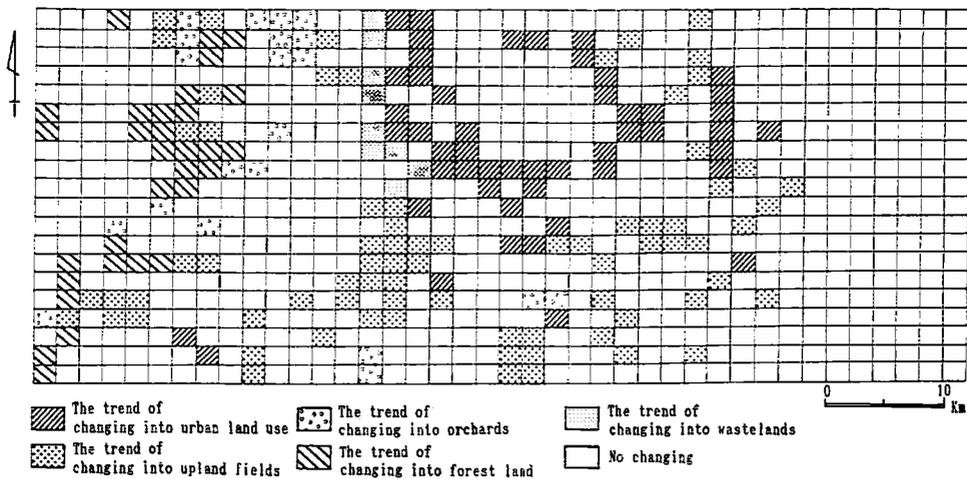


Fig. 8 Land use changes in the southern part of Beijing City between 1982 and 1995
Data sources: Mesh maps of land use in 1982 and 1995

from grassland into forest land, the conversion from upland fields into urban land use, and the conversion from paddy fields into upland fields. According to the comparison of land use maps between 1982 and 1995 (Fig. 8), it was clear that the trend of changing into urban land use was dominant in the suburbs, particularly in both the western and eastern sectors extended from the city center. The distribution of its trend was related to the location of industrial districts and dispersed constellations (Fig. 6), the arrangement of high-speed transportation networks, and the expansion of built up areas because of the internal migration. These conditions were based on the economic policy attached importance to industry instead of agriculture.

In terms of the trend of changing into agricultural land use, while the trends into both upland fields and orchards became to be dominant, the trend into paddy fields disappeared in this area. These conversions from paddy fields into upland fields were directly based on the shortage of water for irrigation, and were indirectly caused by the development of cash crops cultivation, the innovation of farming technology, and the changed eating habits of Beijing's city dwellers. The trend of changing into forest land also continued to be dominant in highland regions of Beijing City, so that the conversion from grassland into forest land could be distinguished from the others. The development of this trend can be explained by the continuous afforestation for the protection against soil erosion. On the other hand, the trend of changing into wastelands appeared around built up areas of the city center. These wastelands were characterised as the social vacant land.

4. Driving Force of Land Use Changes in the Southern Part of Beijing City: in a Substitution for Conclusion

In consideration of above mentioned discussions about the trends and characteristics of land use changes in the southern part of Beijing City, the authors could identify ten factors as driving force of land use changes: the institution of landholding system, the agricultural policy, the arrangement of agricultural infrastructure, the improvement of natural environment, the innovation of farming technology, urbanisation and industrialisation, population increase and movement, the changes of eating habits, natural resources, and the level of economic development. Although driving force of land use changes can be explained by these factors, it requires some further explanations. In the sense that driving force is a kind of the systems, it consists of five sub-systems: the policy, population, urbanisation, technology and resources. Therefore, various types of land use changes are based on the systematic linkage of these sub-systems.

As the result of some discussions about driving force of land use changes in the southern part of Beijing City, their outlines were summarised in Fig. 9 that indicated systematic linkages of the sub-systems. Firstly, land use changes under the pre-socialistic economy were based on the systematic linkage, that was regarded as driving force, of sub-systems such as policy, technology and resources. Secondly, land use changes under the socialistic economy were based on the systematic linkage of sub-systems such as

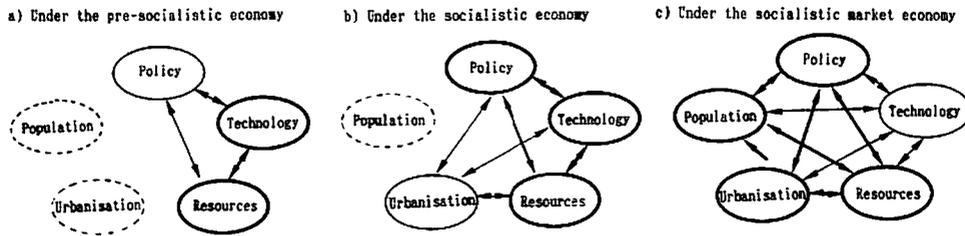


Fig. 9 The driving force based on the linkage of sub-systems related to land use changes in the southern part of Beijing City
 Arrows and ellipses with the thick line indicate more important linkages and sub-systems. Ellipses with the broken line have no influence on the system of driving force.

policy, technology, resources and urbanisation. Finally, land use changes under the socialistic market economy were based on the systematic linkage of sub-systems such as policy, technology, resources, urbanisation and population. With the progress of market economy, therefore, the system of driving force has tended to be complicated because the numbers of its elements and linkages have increased.

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