# Effects of Urbanization and Industrialization on Farmland System in Shandong Peninsula

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**Abstract** [Objective] The aim was to study the effects of urbanization and industrialization on farmland system in Shandong Peninsula. [Method] In Shandong Peninsula, the effects were studied and analyzed using remote sensing and image interpretation with spatial data analysis and statistic data analysis. [Result] During researching periods in Shandong Peninsula, wasteland area changed from decreasing to increasing; farmland area was declining; orchard and forestry areas were increasing, mainly resulting from political policies and benefits maximization of farmers. Meanwhile, chemical fertilizers and agricultural mechanization are more frequently applied with industrialization and urbanization, leading significant effects on environment, industry and urban. [Conclusion] More policies should be formulated to promote harmonious development of society, economy and environment.

Key words Urbanization and industrialization; Shandong Peninsula; Farmland system; Management method of farmland

ince the reform and open-up, China has been under industrialization and urbanization. According to the data of State Statistics Bureau, our country has enhanced from 17% to 41% in urbanization [1], and small cities in China increased from 3 000 to 19 216 during 1978 to 1998, excluding 5 000 developing towns<sup>[2]</sup>. In addition, GDP in our country has increased at 9.6% yearly since 1978, twice higher than that of global average speed [3]. Globally, GDP of China ranks second, but some ecological changes have been brought by industrialization and urbanization.

Farmland system has also been through changes under the influence. Based on researches conducted by Liu *et al.*<sup>[4]</sup>, construction lands in cities and countryside in eastern coastal areas in China increased and forest lands decreased with economic development, presenting a pattern of decreasing in south and increasing in north for farmland. Furthermore, farmland has reduced due to urbanization and industrialization, and farmland landscape becomes weaker<sup>[5-6]</sup>. Shandong Peninsula is located in coastal areas of Bo River, where farmland system has been through changes under influencing of urbanization and industrialization. However, few researches are available on effects of urbanization on farmland system. In the research, effects of urbanization and industrialization on farmland system in Shandong Peninsula were researched and explored for better economic development by farmland.

#### Materials and Methods Survey of study areas

Shandong Peninsular, located in

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Corresponding author. E-mail: qslu@yic.ac.cn Received: April 14, 2012 Accepted: April 23, 2012 east of Shandong Province and Jiaolai River, is dominated by hills and plains (Fig.1), with elevation at 0-1 130 m and area at 33 747 km<sup>2</sup>, totaling 22 counties or cities. The area is continental monsoon climate, warm and moist in summer, and dry and cold in winter. In addition, annual rainfall averages 600–700 mm and annual temperature is at 10 °C. Crops in the area mainly include wheat, corn, peanut and apple. Total population is about 16.66 million and population density is 493 person/km<sup>2</sup>.

#### **Data collection**

Spatial data of farmland system in Shandong Peninsula were collected with remote sensing image, and remote sensing data in three stages, from United States Geological Survey, were chosen for exploration of land changes in recent years, as follows: MSS from the 1970s to 1980s, TM in the 1990s and in 2006. The auxiliary data in clude topographic map (1:100 000), vegetation map (1:1000000), social economic data, photos taken in field study, from a library in research institution in coastal areas of Yantai, Institute of Geographic Science and Natural Resources Research (CAS), statistical yearbook and field study respectively in 2009.

#### Data analysis

According to classification method proposed by Liu *et al.*, farmland system in Shandong Peninsula is divided into plowland, orchard, forest land, water, city, countryside and wasteland. Visual interpretation bank of remote sensing image was established based on topographic map and field study with remote sensing images pro-

#### cessed. According to the established bank, images in three terms in Shandong Peninsula were interpreted. In ArcGIS, spatial analysis was conducted on system data of farmland in three terms to obtain changes of farmland system from the 1970s to 2006 and to further analyze effects of urbanization and industrialization on farmland system.

#### **Results and Analysis** Changes of urbanization and industrialization in Shandong Peninsula

As shown in Fig.2, Shandong Peninsula has been through urbanization and industrialization at a rapid speed, for example, urban area increased from 37 469 to 176 257 hm<sup>2</sup> during 1978 to 2006. The expansion rate was at 3.6% from 1978 to 1999 and at 27% from 1999 to 2006, showing a rapid developing speed. Meanwhile, GDP in Shandong Peninsula improved as well, for example, GDP



Fig.1 Location of study area



Fig.2 Changing trend of GDP during 1978-2006

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enhanced from 700 million RMB in 1978 to 23 billion RMB in 1999 and even achieved 69.8 billion RMB in 2006.

#### Changes of farmland

As shown in Fig.3 and Table 1, wasteland area changed from increasing to decreasing in Shandong Peninsular. For example, wasteland area increased from 527 968 to 199 833 hm<sup>2</sup> during 1978 to 1999 and achieved 267 468 hm<sup>2</sup> from 1999 to 2006. In researching period, plowland was declining in Shandong Peninsula, for example, plowland area decreased from 1 387 041 hm<sup>2</sup> in 1978 to 1 370 834 hm<sup>2</sup> in 1999. During 1978–1999. plowland decreased by 16 207 hm<sup>2</sup> and reduced to 1 073 644 hm<sup>2</sup> in 2006. In contrast, orchard and forest areas were increasing in researching period, for example, orchard and forest land increased to 941 766 hm<sup>2</sup> in 1978, 1 202 802 hm<sup>2</sup> in 1999 and 1 325 388 hm<sup>2</sup> in 2006.

In 1978, household contract responsibility system was applied in China and lands were distributed to farmers individually. On the other hand, some wastelands were transformed into orchard and forest lands by farmers, reducing wasteland area during 1978-1999. After 1999, lots of plow lands around cities were transformed into construction lands and the unused lands were taken as wasteland. Meanwhile, coastal reclamation project was conducted in some areas and the new lands became wasteland. In Shandong Peninsula, about 90% of lands are orchard. Since 1978, more famers chose to transform plowland into orchard for the benefits brought by the latter are higher than that of the former, leading to larger orchard and forest lands from 1978 to 2006.

#### Changes of water

As shown in Fig.3 and Table 1, water area changed from increasing to decreasing. For example, water area was 53 746 hm<sup>2</sup> in 1978 and achieved 91 384 hm<sup>2</sup> in 1999, increasing by 37 638 hm<sup>2</sup> in 1999 with annual growth rate at 3.4%. However, water area reduced to 81 978 hm2 in 2006, decreasing by 9 406 hm<sup>2</sup> with depletion rate at 1.5%. During 1978-1999, more agricultural water were required due to transformation of wasteland to orchard, and water used in forest lands and urban areas increased with industrial development. Hence, local governments began to expand or establish some reservoirs, such as Gaolin Reservoir in Mouping District in Yantai City, Xiaozhushan Reservoir in Qingdao, Jihong Reservoir in Qingdao and Bahe Reservoir in Rongcheng. Since 1999, water area declined for increase of municipal and agricultural water and some ponds around some cities changed into construction land due to urbanization.

## Adjustment of farmland management

As shown in Fig.4, chemical fertilizer was increasing in farmlands in Shandong Peninsula. The applied amounts increased from 3 880 t in 1978 to 85.90 million t in 2006, increasing by 1.2 times. Before 1999, governments mainly aimed at improving local GDP and related policies were few and farmers believed that the

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Table 1 Changes of farmland system use in Shandong Peninsula during 1978-2006

Туре	Area // hm²			1978–1999		1999–2006	
	1978	1999	2006	Area change	Annual change // %	Area change	Annual change//%
Plowland	1 387 041	1 370 834	1 073 644	-16 207		-297 190	
Orchard and forest land	941766	1 202 802	1 325 388	+261 036	1.4	+122 586	1.5
Water	53 746	91 384	81 978	+37 638	3.4	-9 406	-1.5
City	37 469	67 173	176 257	+29 704	3.8	+109 084	23.2
Countryside	81 273	104 357	114 322	+23 084	1.4	+9 965	1.4
Wasteland	527 968	199 833	267 468	-328 135	-2.9	+67 635	4.8

National policies and maximization of famers' benefits contribute to changing trend of farmland.



Fig.3 Changes of land use of farmland system during 1978-2006 in Shandong Peninsula



Fig.4 Changes of mechanical power and fertilized quantity during 1978–2006

more fertilizers were, the higher the production would be. Hence, more and more chemical fertilizers were applied. After 1999, urban areas developed at high speed, but living standard in countryside was still low. Therefore, much importance was attached to agricultural production to balance development between city and countryside and a series of measurements were issued accordingly, for example, customs duties for import of fertilizer resource production were reduced; more materials of fertilizer could be purchased at low price by fertilizer enterprises; expanse in fertilizer circula-

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tion was lowered, which promoted chemical fertilizer application and led to some environmental problems as well, such as N increase of ground water and eutrophication<sup>[7–11]</sup>.

As shown in Fig.4, total mechanical power increased yearly. For example, it increased from 300 000 kw in 1978 to 17.50 million kw in 2006. Before 1978, agricultural production mainly depended on human and animal powers, determining lower mechanical power. In contrast, farmers were encouraged to buy smaller machines after 1978 and the machine oils were at lower price. With development of industrialization and urbanization, some rural population chose to make a living in urban areas, leading to little labor force in countryside. Hence, more and more farmers began to purchase agricultural implements to make up human shortage. With economic development, more measures are proposed to support agricultural production. After 1999, governments even provided subsidies for farmers to promote mechanical power in agriculture.

#### Conclusions

Farmland system changes under influence of industrialization and urbanization. With the help of remote sensing images and social statistical data, wasteland, plowland, orchard and farmland change differently by industrialization and urbanization, resulting from policies and benefits maximization. Meanwhile, agricultural management changes accordingly, and more chemical fertilizers and machines are applied. Machine application actually provides more labors for industrial and urban development, but some environmental problems occur. In general, more encouraging policies should be formulated with industrialization and urbanization, to promote agricultural production and reduce pollution for harmonious development of society and environment.

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## 城市和工业化对山东半岛农田系统的影响

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摘 要 [目的]对城市和工业化对山东半岛农田系统的影响进行研究。[方法]以山东半岛为研究区 通过遥感解译、数据空间分析、社会统计数据 分析,了解城市和工业化对农田系统的影响。[结果]山东半岛的荒地面积在研究时段先减后增,耕地面积逐渐减少,而果园和林地的面积逐年增加。造成这种差异趋势的主要原因是政府政策和农民利益最大化等因素共同作用的结果。同时,工业和城市化发展使用于农业生产的化肥施用量 和农业机械总动力逐渐增加。这种发展趋势对环境、工业和城市化带来了不同影响。[结论]为了社会经济和环境的和谐发展,政府应制定更多的政 策来协调社会经济和环境的发展。

关键词 城市和工业化 山东半岛 浓田系统 浓田管理方式

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### 基于 MODIS 影像序列的三峡截流前后洞庭湖面积变化序列分析

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摘要 [目的]基于 MODIS 影像序列,对三峡截流前后洞庭湖面积变化序列进行分析。[方法]基于 2000~2010 年的 MODIS 影像序列,分析三峡大 坝建立前后,洞庭湖水体面积在枯水期和丰水期的变化,同时对汛期和干旱期洞庭湖面积变化与城陵矶水文观测站的相关关系进行研究。[结果] 自三峡大坝建立后,对洞庭湖在枯水期和丰水期的水体面积差有很大影响,在枯水期,洞庭湖水体面积与城陵矶水位线性关系较弱,而在丰水期, 洞庭湖面积变化与城陵矶水位有较强的线性关系。[结论]该研究通过对城陵矶水位变化过程可大致估算出洞庭湖面积变化的大小,为洞庭湖水体 变化的研究提供的研究基础。

关键词 洞庭湖 ;MODIS ;面积变化

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