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On the land use in Three Gorges Reservoir area

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Abstract: In this study the arable land changes in two counties (Zigui and Xingshan) in the Three Gorges Reservoir area in China are investigated. The statistical data from the officially published statistical books are used to study these changes in the two counties during the past 50 years since 1949. The changes of arable land, changes of arable land per capita, and changes of multiple crop index in Zigui and Xingshan counties are examined. Using an index method, we conclude that the two counties are critical in the sustainable utilization of arable land.
Key words: land use changes; Three Gorges Reservoir area
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1 Introduction

The earth's environment and habitability are now, as never before, affected by human activities. Human-induced land use/cover changes advance at an accelerating pace (Turner *et al.*, 1994). Because these changes in terrestrial ecosystems affect climate, soils, vegetation, water resources and biodiversity, they are closely linked with the issue of the sustainability of socio-economic development (IGBP/HDP, 1995).

Since the start of the Three Gorges Dam Project (TGDP) in China in 1993, eight years have passed, and in 1997 the main course of the Yangtze River was dammed. By June, 2003, the water level of the reservoir is expected to be raised to the 135-m mark and by the year 2009, when the entire dam structure is scheduled to be completed, the water will be raised to 175 m. New towns and cities have been built and many people that lived in areas to be inundated have already been resettled or in the process of resettlement. Concerning this process, the land use changes and the agricultural sustainability of the reservoir area are of much concern.

In this study the arable land changes in the two counties (Zigui and Xingshan) in the reservoir area are investigated. We use the statistical data from the officially published statistical books to study these changes in the two counties during the past 50 years since 1949.

The first objective of this research is to see how the arable land use changed during the past half century in these two counties. The second objective is to discuss the criticality of sustainable utilization of arable land in Zigui and Xingshan counties.

2 Research area

Located in the west of Hubei Province, central China, Zigui County borders Yichang County in the east, Changyang County in the south, Badong County in the west, and Xingshan County in the north. It is 66.6 km in east-west direction and 60.6 km in north-south direction. The Yangtze River flows through this county and divides it into two parts. The Three Gorges Project dam site is located in Sandouping Town, which is in the eastern part of this county. Xingshan County

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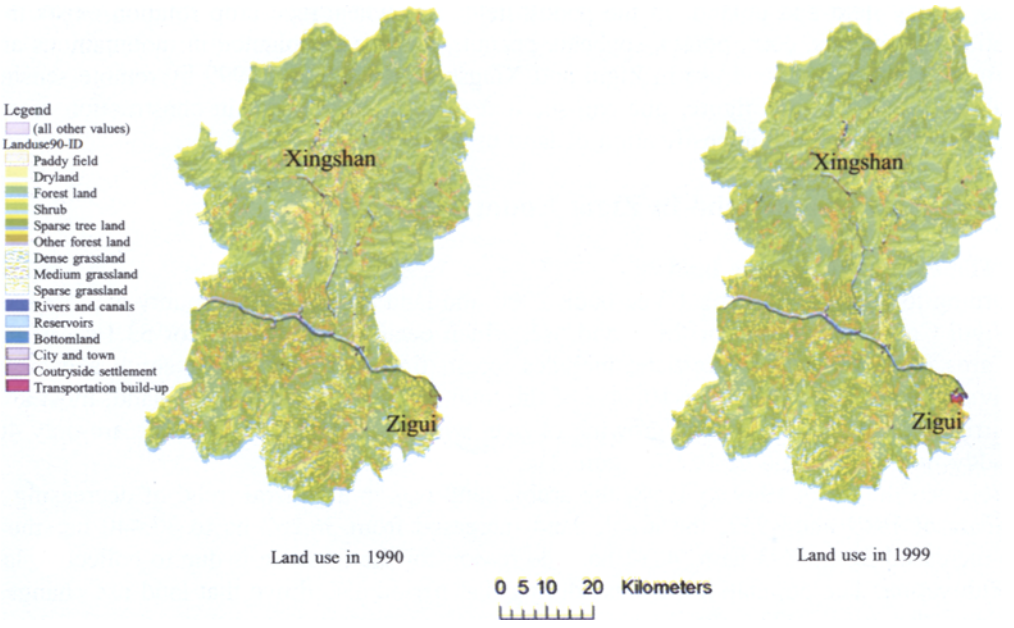

Figure 1 Land use in Zigui and Xingshan counties in 1990 and 1999 interpreted from remote sensing (TM) data

borders Zigui County in the south, Shennongjia Forest Reserve in the north, Yichang County and Baokang County in the east, and Badong County in the west (Figure 1). Xiangxi River, a subtributary of the Yangtze River flows through Xingshan County. The two counties of Zigui and Xingshan cover an area of 4755 km^2 (Table 1).

Table 1 Land area, arable land area, and population in Zigui and Xingshan counties in 1999

	Land area (km^2)	Population	Arable land (ha)
Zigui	2427.00	403838	26069
Xingshan	2328.00	189400	14841
Total	4755.00	593238	40910

*Source: Statistics Bureau of Yichang City, 2000

Three classes characterize these two counties' landforms: low mountain (less than 600 m), middle mountain (600-1200 m), and high mountain (more than 1200 m). In Xingshan County, the middle and high mountainous land makes up 85%. The highest elevation is in Xiannu Mountain, Xingshan of 2426.9 m and the lowest in Maoping, Zigui of 40 m.

The climate in this area has distinct four seasons, humid and hot in summer, dry and cold in winter, of subtropical terrestrial monsoon climate type, with serious influence by the mountainous topography and geomorphology. The annual average temperature is from 13.1℃ to 18℃, but it varies with the altitude. The rainfall is from 960 mm to 1600 mm per year, and it is concentrated in summer.

The vegetation is largely pine, oak, mixed shrub, and bamboo. The soil belongs to camisoles, luvisols, fluvisols, and phaeozems.

According to the official statistical data, by the end of 1998, there is a population of 403,838, of which 209,355 are male and 194,483 are female in Zigui County. The population density is 166 persons/km^2 (Statistics Bureau of Zigui County, 1999). By the end of 1998, there is a population of 189,400 in Xingshan County, of which 98,800 are male and 90,600 are female, with a population density of 81 persons/km^2 (Statistics Bureau of Xingshan County, 1999).

The principal activity in the rural area is basically grain production for self-consumption, and the principal crops are rice, wheat, corn, and potato. In uplands, the farmers will more often plant tea for cash crop. In low valley area, there are two harvests a year; while in high mountainous area there is only one harvest. The crop system can be classified into two classes,

that is, paddy field and upland. In the paddy field, rice-wheat/rape crop rotation exists in lower elevation. In uplands, corn, potato, soybean, peanuts, and tea are planted in mountainous area.

Figure 1 shows the land use in Zigui and Xingshan in 1990 and 1999 by remote sensing data (Landsat TM). From this figure, one can see that there is an increase in construction area (color in purple), signifying the intensification of land use.

3 Changes of arable land in Zigui County

3.1 The changes of arable land

According to Yichang Statistical Yearbook 2000, the land area in Zigui County is 2427 km^2.

Zigui County is mainly for forestland use, which occupies 129,000 ha or 53.16% of the total land area (Figure 2). This forestland includes forest, firewood land, slash, shrub and bush land. The arable land is 26,069 ha, or 10.74% of the total land area. Of the arable land, most are slope non-irrigated land, not fit for the growing of rice, which occupy 82.86%. There are only 4038 ha of paddy field by the end of 1998 (Figure 3).

Between the years 1949 to 1998, the arable land was in a general trend of decreasing, but in the years of 1949 and 1952, the arable land increased from 36,267 ha to 37,440 ha; the paddy field increased from 4793 ha to 4817 ha. The reason for the increase is due to collective land use and cultivation. The population increase during that period also drove that land use change.

Since the year 1993, the arable land has decreased continuously because of the start of the Three Gorges Dam Project (TGDP) then. Due to dam building, arable land is being lost because of the conversion to construction area. Local people's resettlement also occupied arable land. The paddy field decreased from 4818 ha to 4308 ha, which means a loss of 510 ha of paddy field or a 10.5% loss. While during the period from 1949 to 1991, the paddy field changed little from 4793 ha to 4884 ha. The significant drop of the paddy field confirms that large projects

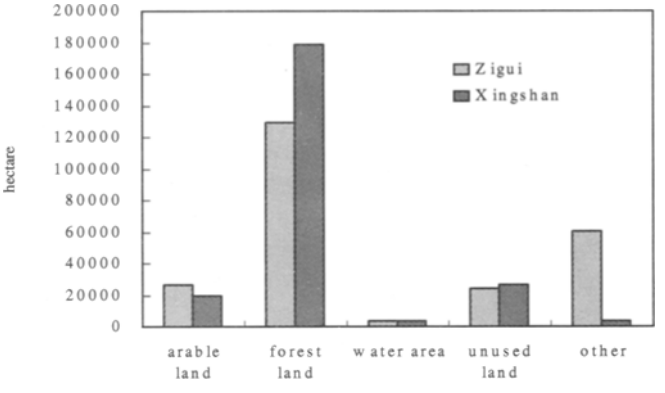

Figure 2 Land use composition in Zigui and Xingshan counties

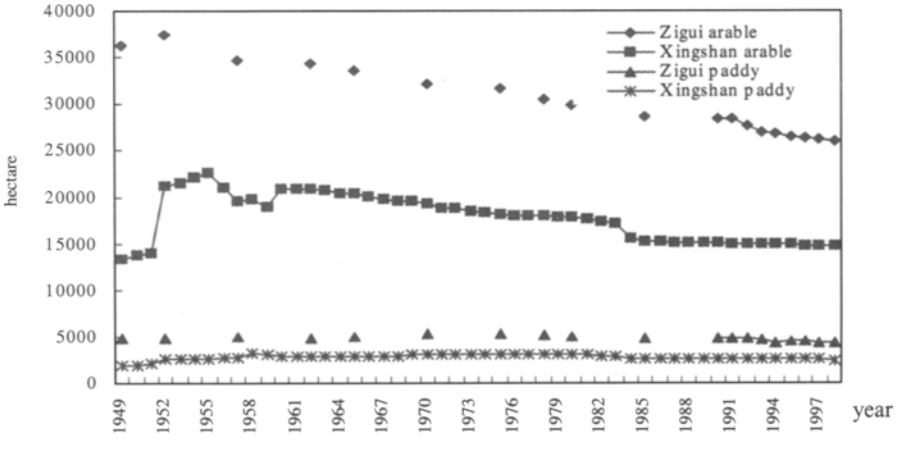

Figure 3 Changes of arable land between the years 1949-1998 in Zigui and Xingshan counties

have considerably caused land use changes.

By 2003, the water level of the reservoir is planned to be raised to the 135-m mark, and by 2009, more than 266.7 ha of paddy field and garden plot will be inundated (Statistics Bureau of Zigui County, 1999). The stock of arable land in Zigui County is very limited because most of the land is mountainous and has a steep slope.

3.2 The changes of arable land per capita

In 1949, the population density in Zigui County is 99 persons/km^2 (Figure 4). By the end of 1998, the population density in Zigui County is 166 persons/km^2. This means a population density increase of 67.68% between 1949 and 1998. Figure 4 shows the population change in Zigui County from 1949 to 1998. During the years 1959 to 1961, there was a big famine because of a failure of the great leap forward policy and the population density dropped from 122 to 117 persons/km^2.

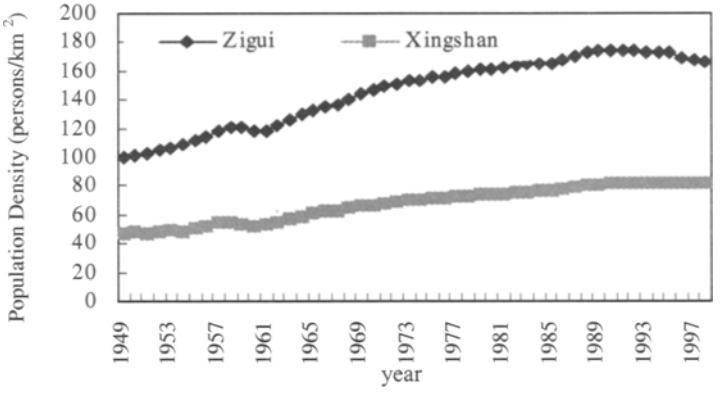

Figure 4 Changes of population density from 1949 to 1998 in Zigui and Xingshan counties

From 1962 to 1991, there is a steady population increase. Since the start of TGDP, with the local people's resettlement and emigration, the population had decreased (Figure 5).

In spite of the population decrease in recent years, the arable land per capita continued to decrease (Figure 5). This recent decrease is due to the conversion of arable land to construction area and other uses in these years. In 1949, there was 0.15 ha of arable land per capita and 0.02 ha of paddy field. By the end of 1998, there was 0.06 ha of arable land per capita and 0.01 ha of paddy field. This means a drop of 60% in the arable land per capita and a drop of 50% in paddy field per capita from 1949 to 1998.

3.3 Changes of multiple crop index (MCI) in Zigui County

The changes of multiple crop index in Zigui County from 1949 to 1999 are shown in Figure 6. In 1949, the multiple crop index in Zigui County is 119.87. In 1998, it increased to 217.88. The increase of multiple crop index indicates an increase of arable land use intensity in this area.

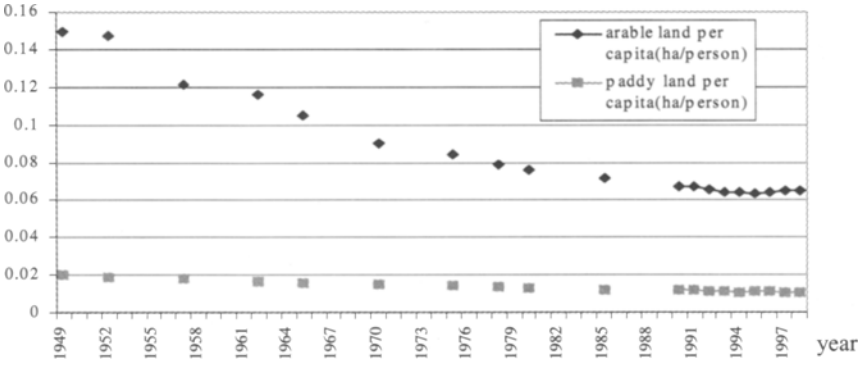

Figure 5 Changes of arable land per capita between the years 1949-1998 in Zigui County

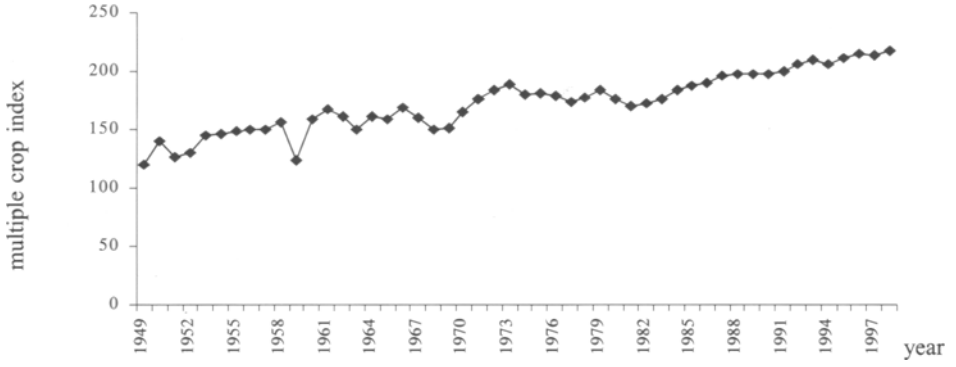

Figure 6 Changes of multiple crop index in Zigui County, 1949-1998

4 Changes of arable land in Xingshan County

4.1 The changes of arable land

According to the official statistical data in 1998, the land area in Xingshan County is 2327 km^2, 100 km^2 less than Zigui County. As in Zigui County, the land is also mainly for forest use, which occupies 178,833 ha or 78% of the total land area (Figure 2). The arable land is 14,727 ha, or 6% of the total land area. Of the arable land, most are slope non-irrigated land, not fit for the growing of paddy rice, which occupy 83.16%. There are only 2480 ha of paddy field by the end of 1998 (Figure 3).

Between the years 1949 to 1998, the arable land is in a general trend of decreasing, but between 1949 and 1955, the arable land increased from 13,293 ha to 22,627 ha. The paddy field increased from 1953 ha to 3146 ha from 1949 to 1958. This increase is also due to collective land use and cultivation. The population increase during that period also drove that land use change.

From the year 1960, the arable land decreased continuously. Since 1983, the arable land has been decreasing at an accelerating speed. This change is caused by the non-irrigated land abandonment because of the reform and opening up policy. Many farmers migrated to cities to do wage-earning jobs that were more rewarding.

4.2 The changes of arable land per capita

In 1949, the population density in Xingshan County is 47 persons/km^2 (Figure 4). By the end of 1998, the population density in Xingshan County is 82 persons/km^2. This means a population density increase of 74.47% between 1949 and 1998. Figure 4 shows the population change in Xingshan County from 1949 to 1998.

From 1962 to 1991, there is a steady population increase. Since the start of TGDP, with the local

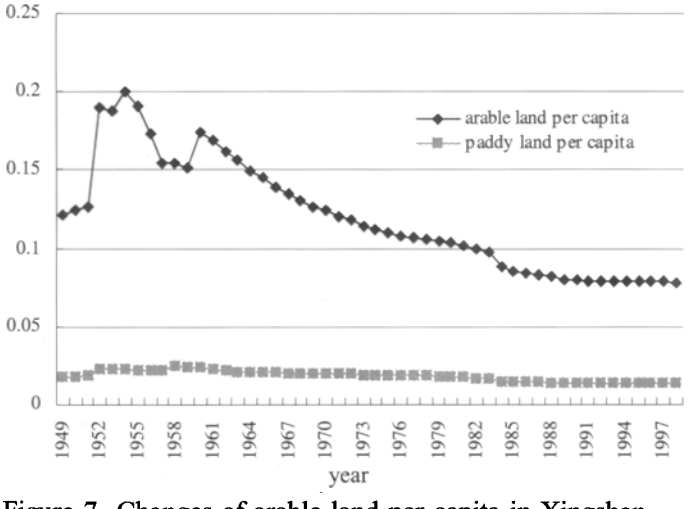

Figure 7 Changes of arable land per capita in Xingshan County from 1949 to 1998

people's resettlement and emigration, the population had decreased.

In spite of the population decrease in recent years, the arable land per capita continued to decrease (Figure 7). In 1949, there was 0.12 ha arable land per capita and 0.018 ha of paddy field. By the end of 1998, there was 0.078 ha of arable land per capita and 0.013 ha of paddy field. There was a drop of 35% in arable land per capita from 1949 to 1998. A drop of 27.78% of paddy field per capita is observed in the same period.

4.3 Changes of multiple crop index in Xingshan County

In 1949, the multiple crop index in Xingshan County is 125.07. In 1998, it increased to 191.71. The increase of multiple crop index also indicates an increase of arable land use intensity in this area.

5 Discussion of sustainable utilization of arable land in two counties

In the above two sections, we show that the arable land changes from 1949 to 1998 in Xingshan, which dropped 35% in arable land per capita and 27.78% of paddy field per capita, are less great than in Zigui County, which dropped 60% in arable land per capita and 50% of paddy field per capita. This difference of changes of the two is due to that the TGDP construction site is in Zigui County. Compared with Zigui County (with a MCI of 217.88 in 1998), the change of multiple crop index in Xingshan County (191.71 in 1998) is less great too.

In order to evaluate the criticality of sustainable utilization of arable land, 14 factors are selected (Sun, 1999). Table 2 lists the factors.

Table 2 Evaluation index system of sustainable utilization of arable land

		Index	Data source	Weight
Productivity	1	Food productivity change	Statistics	0.25
	2	Food productivity change by unit	Statistics	0.50
	3	Cotton productivity change	Statistics	0.25
	4	Cotton productivity change by unit	Statistics	0.50
	5	Oil productivity change	Statistics	0.25
	6	Oil productivity change by unit	Statistics	0.50
Stability	7	Fertilizer usage change by unit	Statistics	0.75
	8	Effective irrigated area change	Statistics	0.50
	9	Cattle change by unit	Statistics	0.50
Protection	10	Total cultivated land change	Statistics	0.75
	11	Cultivated land change by agri. population	Statistics	1.00
Economic value	12	Planting productivity change	Statistics	0.50
	13	Planting productivity change by unit	Statistics	0.75
	14	Planting productivity change by agri. population	Statistics	1.00

Index of sustainability of the utilization of arable land is calculated by the following method:

$$SI = Ei*Wi \ (i = 1, 2, 3, ..., n)$$

where Wi is a weighting number for each factor. The SI is classified into four categories: sustainable (75-100), basical sustainable (50-75), critical sustainable (25-50), and non-sustainable (0-25). With an SI value of 41.75, Zigui County is critical in the sustainable utilization of arable land. Xingshan County is rated as critical, with an index of 45.25.

6 Summary

In Zigui and Xingshan counties, the arable land is lost at an accelerating speed. The arable land per capita was decreasing from 1949 to 1998. The multiple crop index in the two counties increased in the same period. This showed an intensification of the land use in the two counties.

The marginal land resource is very limited in these two counties. Most of the land is mountainous slope area. More intensification of land use and the cultivation of the marginal land

can cause serious soil erosion and deterioration of the arable land quality. With the upcoming inundation of valuable arable land in 2003 and 2009, more arable land will be lost.

With the start of the TGDP, more development and tourism activities are expected, the human-induced intensification of land use will continue. The project brings development opportunities for this area, but the protection of the fragile environment and the people resettlement need to be paid more attention to.

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