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The effects of basic arable land protection planning in Fuyang County, Zhejiang Province, China

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A B S T R A C T

The purpose of this study is to determine whether basic arable land protection planning has reduced arable land loss in Fuyang County, Zhejiang Province, China and, if so, to identify how much arable land has been saved by the implementation of land use planning. Land use data covering 10 years, from 1999 to 2008, were collected from Fuyang County for analysis. A logistic discrete-time hazards model was used to model the conversion of arable land, and the effects of basic arable protection planning were estimated. The Youden index was used to determine the cut-off point for predicted probabilities, and the effects were estimated based on the classification with the cut-off point. Furthermore, an analysis framework combining effectiveness-based assessment and goals-based assessment was developed. The results suggest that basic arable land protection planning is effective, with the odds of basic arable land being converted to other uses decreasing by 89 percent compared with arable land outside the basic arable land protection district in Fuyang County, and the conversion of arable land in general decreasing by 72 percent due to basic arable land protection planning. Considering both the effectiveness and goal's achievement, the implementation of basic arable land protection planning is judged to be effective, but not entirely successful. Certain factors made basic arable land protection planning effective, these include the reallocation of approval rights for arable land conversion to the central government from the local government, the application of new technology in the central government's inspections of the local governments' land use regulation and land administration, the raising of compensation standards for arable land expropriation, the creation of a Supervisor of State Land, and the readjustment of the local land and resources administrative system. However, other factors made the implementation of basic arable land protection planning not completely successful, including a top-down administrative system of land use planning, differences of interests regarding land administration between the local and central governments, and the system by which local government cadres' performances are evaluated.

Introduction

Although increases in agricultural land have been observed in some special areas (Verburg, Overmars, Huigen, de Groot, & Veldkamp, 2006; Yu, Zang, Wu, Liu, & Na, 2011), farmland loss is one of the most significant land use changes in countries with rapid economic development. This subject has attracted the interest of researchers because such losses may threaten food security (Nizeyimana et al., 2001) and so has been the subject of studies since the 1970s (Foster & Macconnell, 1977; Plaut, 1980). A great deal of research has analyzed the driving forces behind farmland loss. Some studies noted links between farmland loss and urban sprawl (Alphan, 2003; Chen, Chen, Shi, & Tamura, 2003; Deng & Huang, 2004; Fazal, 2000; Levia, 1998; Mori, 1998; Nizeyimana et al., 2001; Plaut, 1980; Yeh & Li, 1999; Zhang, 2000) or urbanization (Chen, 2007; Shrestha, York, Boone, & Zhang, 2012; Su, Jiang, Zhang, & Zhang, 2011; Thapa & Murayama, 2010); some ascribed it to population growth (Doos, 2002), while others credited it to industrialization (Kurucu & Chiristina, 2008; Wu & Zhang, 2012), economic booms (Firman, 2000), construction of transportation infrastructure, rural urbanization and the expansion of rural settlements (Liu, Wang, & Long, 2008), political choice (Kelly, 1998), the changing role of local government (Skinner, Kuhn, & Joseph, 2001), land use policies (Gao, Liu, & Chen, 2006), and other ideas.

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Many tools have been developed and utilized to stem farmland loss based on these analyses. Some technical tools that have been developed include the agricultural land evaluation and site assessment (LESA) system developed by the America Soil Conservation Service (T. Daniels, 1990; T.L. Daniels, 1990; DeMers, 1988; Demers, 1989a, 1989b; Ferguson, Bowen, & Kahn, 1991; Huddleston, Pease, Forrest, Hickerson, & Langridge, 1987; Stamm, Gill, & Page, 1987; F. Steiner, 1987; F. Steiner, Dunford, & Dosdall, 1987; F.R. Steiner, 1994; Tyler, Hunter, & Steiner, 1987; Ward, 1991; Wright, Zitzmann, Young, & Googins, 1983), and the application of GIS and improved models based on that system (Demers, 1989a; Dung & Sugumaran, 2005; Hoobler, Vance, Hamerlinck, Munn, & Hayward, 2003; Williams, 1985). Some market-based tools have also been developed and used to preserve farmland, such as the purchase of development rights (T. Daniels, 1990; T.L. Daniels, 1990), and the transfer of development rights (McConnell & Walls, 2009). Command-and-control tools, such as zoning, are another important family of farmland preservation tools (Munroe, Croissant, & York, 2005; Nellis & Maca, 1986). Land use planning is a tool that should also be mentioned in any discussion of farmland protection because it is one of the most important and widely adopted tools in preserving farmland (Smith & Giraud, 2006) and has been viewed as a comprehensive tool to manage land use and to control land use change. Because of this the impact of land use planning has also attracted researchers' attention. To date, research on the impact of land use planning has focused on aspects such as impact on housing markets (Leishman & Bramley, 2005), housing prices or values (Bramley, 1993; Ihlanfeldt, 2009; Thorsnes, 2000), land rents (York & Munroe), housing supply and real estate development (Bramley, 1993; Thorson, 1997; Tse, 2001; Vermeulen & van Ommeren, 2009), fragmentation of land (Munroe et al., 2005; Saizen, Mizuno, & Kobayashi, 2006), and ex-urbanization (Esparza & Carruthers, 2000). Although land use planning has been used as a tool to control farmland conversion to other uses, there have been relatively few studies examining its effectiveness. Some earlier studies used descriptive analysis of a land use category's change or the comparative analysis of farmland conversion under different planning regulations to describe the effect of land use planning (Daniels & Nelson, 1986; Nelson, 1999; Pease & Jackson, 1979). However, this method of evaluating land use planning's effects may overemphasize planning's influence, as it discounts other factors that also most likely influence development decisions (Kline, 2005). A "hedonic" approach has been used to evaluate zoning's effects on farmland protection, namely the influence of zoning on land value has been treated as an impact on the expectation of farmland development (Nelson, 1988).

Land use regulation is one tool for controlling land use based on land use planning, and its effects have been assessed (Lichtenberg, Tra, & Hardie, 2007; Wu & Cho, 2007). A recent study examined the effects of Oregon's (USA) land use planning program on the conversion of forest and farmlands (Kline & Alig, 1999). This study applied a more immediate indictor to depict zoning's effects on farmland preservation by building empirical models describing the probability of forests and farmland being developed. The data used in the study did not cover all of the forest and farmlands in the study region, but instead drew upon a systematic sampling of plots. These types of data are suitable for examining the influence of land use planning on the likelihood of forest and farmlands being converted to developed uses, yet these data may create some difficulty in calculating the area of forest and farmlands that have been saved from development. Another study assessed the impact of land use planning on farmland protection, where changes in building densities on forest and agricultural lands was used as a dependent variable, and the evaluation of the effectiveness of the land use planning program was based on the statistical relationship between the dependent variable and zoning variables (Kline, 2005). In that analysis, the change in the numbers of new buildings was used a proxy for the change of farmland and forest. In this study, data from two periods – between 1974 and 1984 and between 1984 and 1994 – were used to estimate the effect of land use laws on forest and farmland (Kline, 2005).

The studies summarized above provide insights into the influence of land use planning; the current study seeks to add to the existing literature by focusing on whether basic farmland protection planning has affected the conversion of farmland and reinforced farmland protection in Fuyang County, China. Fuyang County is a suitable case study site due to its good database on land use and change, its location near a large city, and its history of land use planning. An empirical model is constructed describing the probability of farmland conversion to non-agricultural use as a function of basic farmland protection planning and other variables. The model is then used to judge whether basic farmland protection planning has saved farmlands from conversion and, if so, how much farmland has been saved due to the implementation of land use planning.

Study area and background

Study area

Fuyang County is located in the west of Zhejiang Province, a province undergoing one of the country's most rapid industrializing and urbanizing processes (see Fig. 1). Fuyang County is one of the county-level divisions of Hangzhou City, which is the capital of Zhejiang Province, a prefecture-level city, and an important city in the Yangtze Delta Region. Fuyang County is located in the southwest of Hangzhou City and is approximately 32 km from the city center. Its area is 1831 km^2, of which hilly terrain accounts for 75.9%, plains account for 17%, and water bodies account for 5.4% (http://hzfzw.hz.gov.cn/wzxg/qsjj/). In 2010, Fuyang County's annual mean temperature was 17.2 °C, annual rainfall was 1510.6 mm, and the annual non-frost period was 336 days (Bureau of Statistics of Hangzhou City, NBS Survey Office in Hanghou, & Hangzhou Bureau of Socio-economic Survey, 2011).

Fuyang County has 4 subdistricts, 15 towns, and 6 townships. According to the Statistical Yearbook of Hangzhou City 2011, the total population of Fuyang County in 2010 was approximately 650,200, with a population density of 355 persons per square kilometer, which is approximately 2.6 times the average population density of China as a whole. Of the total population in 2010, 21 percent was non-agricultural and 79 percent agricultural, while the proportion of non-agricultural population in 2000 was 16 percent. There are approximately 331,500 employed persons in the rural area, with 67.5 percent of those working in non-agricultural sectors. Only 107,900 are engaged in traditional agriculture work. The gross domestic product (GDP) per capita of Fuyang County amounted to 64,101 Yuan (RMB) (Bureau of Statistics of Hangzhou City et al., 2011), which is 2.16 times the per capita GDP of China, and increased at the rate of 12.3%, which was approximately 1.2 times that of China. The proportion of GDP contributed by the agricultural industry is 6.9%, and the secondary industry's GDP constituted 60.7 percent (Bureau of Statistics of Hangzhou City et al., 2011). During the past decade, industrialization has increased at an unprecedented rate, and the mean annual growth rate of industrial GDP was approximately 26 percent from 2000 to 2010.

With this rapid economic growth, especially industrial growth, arable land in Fuyang County faced the risk of conversion to non-agricultural use. Between 1999 and 2008, approximately 1169 ha

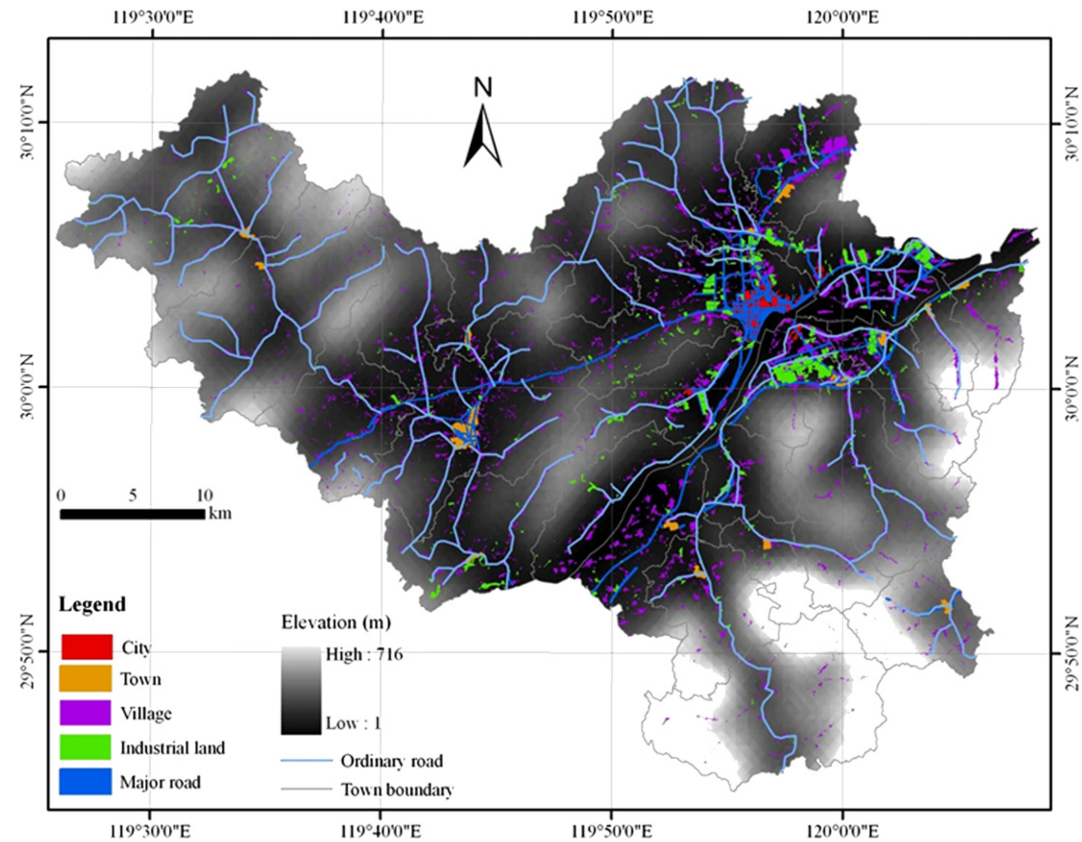

Fig. 1. Location of study area.

of arable land were converted to industrial, urban, residential or other uses, 205 ha of which was basic arable land. The 1169 ha of converted arable land accounts for approximately 4.23 percent of the total amount of arable land in 1999.

Fuyang County's basic arable land protection planning program

Farmland loss has dominated recent changes in Chinese land use (Veldkamp et al., 2001). Since 1978, rapid urban expansion and land marketization has intensified the loss of farmland in China's urban periphery (Chen et al., 2003; Wang & Scott, 2008; Xiao et al., 2006). In some regions of China most of the land use change is constituted by conversion of agricultural land into urban areas or to industrial use (Seto & Kaufmann, 2003; Seto et al., 2002; Weng, 2002). Moreover, the conversion of land to non-agricultural use is rapid and extensive throughout China (Ho & Lin, 2004b), and the loss of arable land is not only observed in the urban periphery, but also in rural areas, such as the Yangtze River Delta and the Pearl River Delta, due to rural industrialization (Long, Tang, Li, & Heilig, 2007; Xie, Yu, Bai, & Xing, 2006; Xu, 2004; Yeh & Li, 1999).

It is essential for China to increase food production to keep up with its growing population and changing consumption patterns (Verburg, Chen, & Veldkamp, 2000), and some researchers view the rapid decline of arable land as a threat to China's food security (Chen, 2007; Tong, Hall, & Wang, 2003). This is also the point of view held by the Ministry of Land and Resources and its predecessor, the State Bureau of Land Administration, founded in August of 1986. Due to the potential impact of the loss of available farmland, China's central government has since the 1980s initiated land use policies that support the preservation of farmland, including issuing a Land Administration Law, carrying out land use surveys and setting up of land administration bodies in governments above and at the county level. Land use planning has been viewed as a leading issue in the land administration system, which has been called "head of dragon" by scholars and officials from land administration departments in the Chinese government. Following this point of view, land use planning has been expected to help regulate land use and control farmland conversion, and land use planning has been used as an important tool to curb the rapid loss of arable land.

As far as administrative divisions in China are concerned, there are four levels of local government: province, prefecture, county and township. The land use planning system of China is comprised by land use planning at all five levels, consisting of a national land use planning outline, province-level general land use planning, prefecture-level general land use planning, county-level general land use planning, and township-level general land use planning. Since 1980, three National Land Use Planning Outlines have been compiled and carried out. The National Land Use Planning Outline (1986–2000) was authorized by the State Council of China in February 1993, and most of the provincial governments had compiled province-level general land use plans by the end of 1996. The National Land Use Planning Outline (1997–2010) was compiled by the State Bureau of Land Administration in 1997 and was authorized by the State Council of China in 1999. The National Land Use Planning Outline (2006–2020) was authorized by the State Council of China on October 2008. The Land Administration Law of the People's Republic of China explains that general plans for land use at a lower level shall be compiled according to the general plans for the utilization of land at the next highest level. The Fuyang County General Land Use Plan (1997–2010) is Fuyang County's first land use plan and was authorized by the People's Government of Zhejiang Province in 1999.

According to the Land Administration Law of China and the Basic Farmland Protection Regulation passed in 1994 and revised in 1998, farmland is divided into two types, basic farmland and ordinary farmland. Basic farmland, or basic arable land, refers to the cultivated land demarcated as basic farmland by the government for special protection, which has a different meaning in China from farmland in most countries. Basic Farmland Protection Regulation does not apply to fishponds, tree fruits and so on (Lichtenberg & Ding, 2008). Ordinary farmland refers to cultivated lands that are not designated as basic farmland. Compared with ordinary farmland, basic farmland or basic arable land is under more stringent protection. According to the Land Administration Law of China as revised in 1998, only the State Council and province-level governments have the right to approve the conversion and expropriation of farmland. The conversion and expropriation of basic farmland shall be approved by the State Council. The conversion and expropriation of ordinary farmlands exceeding 35 ha also shall be approved by the State Council, while province-level governments can approve the conversion and expropriation of ordinary farmland of less than 35 ha. According to the Land Administration Law of China and the Basic Farmland Protection Regulation, basic farmland protection shall be part of general land use planning, and county-level general land use planning and town-level general land use planning shall demarcate basic farmland protection zones. In practice, the basic farmland protection plan was compiled as the general land use plan was compiled, and it was included in the general land use plan. The Basic Farmland Protection Regulation stipulates that the following cultivated land shall be demarcated as protected areas of basic farmland: a) cultivated land producing grain, cotton, and oil crops as approved by the relevant department of the State Council or the local governments at and above the county level; b) cultivated land with good irrigation, soil, and water conservation facilities, and medium and low quality cultivated land where an amelioration plan is being carried out or will be carried out; c) vegetable production bases; d) experimental fields for agricultural science and educational purposes; e) other cultivated land determined as basic farmland by the State Council. Farmland outside the basic farmland protection zones of a district are usually called ordinary farmland. The Land Administration Law of China and the Basic Farmland Protection Regulation request that the areas of basic farmland demarcated by province-level governments make up over 80% of the cultivated land within their administrative areas, and province-level governments usually require lower-level administrative areas also to designate more than 80% of such land for basic farmland protection.

The demarcation or assignment of basic farmland protection zones in Fuyang County was completed in 2000 and was based on the basic farmland protection plan included in the Fuyang County General Land Use Plan (1997–2010). A second round of land use planning for Fuyang County was also carried out and the Fuyang County General Land Use Plan (2006–2020) was approved by the Government of Zhejiang Province in December 2010, coming into operation in 2011. Therefore, the Fuyang County General Land Use Plan (1997–2010) created in 1999 was still valid prior to 2011.

Data and methods

Data sources

The data on the land use of Fuyang County that were collected cover 10 years, from 1999 to 2008. The data come from the Bureau of Land and Resources of Fuyang County, which is the land administrator in Fuyang County. The analysis of arable land conversion to other uses is based on ten yearly maps of converted arable land from 1999 to 2008. The data on arable land and the conversion of arable land were extracted from the yearly digital maps of land use for Fuyang County, and the analysis of data regarding arable land converted to other uses is based on yearly converted arable land maps from 1999 to 2008. According to the Land Administration Law of China, any land users wanting to convert agricultural land to non-agricultural use must submit an application to the Bureau of Land and Resources for permission to convert, and after the permission has been approved the conversion can be carried out. Any conversion of agricultural land to non-agricultural purpose without permission is illegal. After the land is converted, the Bureau of Land and Resources of Fuyang County check whether the land was converted at the designated location and within the permitted area and shape.

According to the Land Administration Law of China and Measures for the Administration of Dynamic Cadastral promulgated by the State Bureau of Land Administration (which was merged into China's Ministry of Land and Resources in 1998) and the Regulation of Land Survey issued by the State Council in 2008, the Ministry of Land and Resources of China arranges an annual land use change survey, with county-level departments or divisions of land use administration carrying out the survey. Whether the land use change is legal or illegal, land use conversions, especially the agricultural land conversion to non-agricultural purposes, are recorded in the annual land use change survey. Furthermore, Hangzhou City's land use has been monitored by the Ministry of Land and Resources of the People's Republic of China since 2000. The Bureau of Land and Resources Administration of the Zhejiang Province check Hangzhou City's land use data with the assistance of remotely sensed data and field work. Such work is also carried out by the Ministry of Land and Resources in China. The remotely sensed data generated by The Bureau of Land and Resources Administration of the Zhejiang Province or the Ministry of Land and Resources in China are integrated into the annual map of land use by the Bureau of Land and Resources of Fuyang County.

For purposes of this study, arable land was divided into a 15 m $\times$ 15 m grid from the 1999 map of arable land. A binary variable was generated to record the arable conversion process. A value of "1" for a grid of 15 m $\times$ 15 m was assigned if it was converted to non-agricultural use during an observed time interval and "0" otherwise. Another variable was generated to record the grid's attributes. A value of "1" for a grid was assigned if it was deemed basic arable land during a specific time period and "0" otherwise. The value of "0" was assigned to all the grids before basic arable land protection planning formally came into place. Given that the Fuyang County General Land Use Plan (1997–2010) was approved in 1999 and came into force in 2000 and that the assignment or demarcation of basic farmland protection zones was carried out in 2000, the value of "0" was assigned to all the grids for 1999. Other information relevant to the grids was also recorded and used to create explanatory variables. While longer is better for time series data, there are no comparable data for years previous to 1999. This creates a database containing only one year of data before the formal implementation of basic arable land protection planning and 9 years of data covering the time during which basic arable land protection planning was in place. Based on yearly converted arable land maps from 1999 to 2008, the dataset was created in a discrete-time fashion. For each grid, each year of the period constitutes a single row until it is converted, such that each grid is represented by multiple rows of data with a maximum of 10 rows per grid.

Methodology to assess the effect of land use planning

Assume a risk-neutral and price-taking land developer faces the choice of whether to convert a parcel from present agricultural use to non-agricultural uses. Based on current and historic values of relevant variables, the developer's conversion decision would be made to maximize the present discounted value of the stream of expected future net benefits from the land (Lubowski, Plantinga, & Stavins, 2008). For the developers, the present value of return for a parcel is the sum of the land rent once developed and the cost of developing the parcel, with the former viewed as positive and the latter negative. If the land developer is also a land owner, there would be another benefit derived from the land before the plot is developed – the discounted land rent in the undeveloped state – and this can be treated as one of the costs of development. The present value of returns to parcel can be expressed as:

$$V(X,L,T) = \int_{T}^{\infty} R(X,L,t)e^{-rt}\,dt - C(X,L)e^{-rT}\,dt$$

where $R(X,L,t)$ is land rent during time period t for the plot of land developed with the influence of X and L, $C(X,L)$ is the cost of developing the land with the influence of X and L (including arable land conversion costs), L is the factor denoting land use planning, X is the factors influencing V except for L, T is the time period during which the plot of land is developed, and r is the discount rate.

The developer maximizes V with respect to X, L and T, which yields the timing condition:

$$rC(X,L) = R(X,L,T)$$

So, the decision whether to develop and the development time T are related with X and L.

In this study, $R(X,L,t)$ and $C(X,L)$ were not directly observable and only some factors affecting $R(X,L,t)$ and $C(X,L)$ were observable, mainly X, L and t. The variable sets of X include such factors as physical condition, location, and neighborhood. The variable L is the parcel's attribute in land use planning, which is, concretely, whether it is classified as basic arable land. The detail about the variable sets of X, L and t and their variables selected by this study are presented in the section on explanatory variables. V is also not directly observable; however, when a plot of arable land is converted to non-agricultural use or developed, it could be said that the objective function of V obtains its maximum value. Thus, the decision regarding arable land conversion can be reduced to a dichotomous choice conditioned on the time period t, with arable land conversion assumed to be an indicator of the highest net present value of returns for a plot. Therefore, a dummy variable Y was introduced:

$$Y_{it} = \begin{cases} 1, & \text{if the plot } i \text{ was converted} \\ 0, & \text{otherwise} \end{cases}$$

Given this theoretical framework, the empirical model attempts to explain the effect of basic farmland protection planning on farmland development or conversion to non-agricultural use. A survival model is suitable for this purpose because survival analysis has been used to analyze the occurrence and timing of arable land conversion. This analysis is a collection of statistical procedures for which the outcome variable of interest is time until an event occurs. This model originated in bio-medical sciences studies and has been become popular in other disciplines, such as engineering and the social sciences. However, survival analysis has been applied in only a few pioneering articles related to geographical land change. These studies include investigations of forest fallowing behaviors among swidden cultivators in an Amazonian community in Peru (Coomes, Grimard, & Burt, 2000), estimating the impacts of demographic, biophysical and policy factors on forest clearance processes among smallholder farmers on an agricultural frontier of southern Mexico (Vance & Geoghegan, 2002), identifying the effect of neighborhood development spill-overs on the conversion rate of parcels from undeveloped to residential use (Irwin & Bockstael, 2002), researching integrating survival analysis with GIS science to address temporal complexities of land change (An & Brown, 2008), and studying the dynamic optimization problem of land use (De Pinto & Nelson, 2009). As the data were collected for the same set of geographical units for the years 1999–2006, the discrete-time survival model is proper, and the discrete-time hazard that was defined as the probabilities of the conversion occurring can be estimated by using a logistic regression model called the logistic discrete-time hazards model (Sophia & Anders, 2008), the form of which is:

$$\text{logit}\{\text{Prob}\ (Y_{it} = 1))|d,X\} = a + \varphi d + \sigma L + \beta X$$

where, a is the constant, d are a vector of dummy variables for year 2000–2006, φ, σ andβ are vector of coefficients for d, L and X respectively.

There are two crucial questions regarding the effects of basic farmland protection planning. The first question is whether basic farmland protection planning has saved farmlands from conversion, and the second is how much farmland was saved if the basic farmland protection planning did preserve farmland. The former can be judged from the estimated coefficients related with L: if the estimated coefficients related with L are consistent with their expected signs and statistically significant, we can conclude that the basic farmland protection plan has been effective in saving farmland from development.

The area of farmland saved from development due to basic farmland protection planning can be computed by comparing the predicted area of farmland converted to non-agricultural use with and without basic farmland protection planning. As logistic discrete-time hazards model estimated by using a logistic regression model, the prediction for any observation is a probability of an event occurring; this is different from prediction in a regression model. The predicted probability for each observation ranges from 0 to 100%, and this leads to the question: what is the threshold value of the percent for a plot or pixel to be counted as a converted grid? 50% or 0.5 was the most common value taken as the critical threshold for predicted probabilities, and the observations with predicted probabilities higher than 50% were regarded as presence (Geoghegan et al., 2001; Hosmer & Lemeshow, 2000; Lakes, Muller, & Kruger, 2009). However, the cut-off value of 50% might not work in some circumstance and is most likely not the optimal cut-point, especially when events or non-events are rare (Hein & Weiskittel). The lowest degree of misclassification of outcomes is incurred by the optimal threshold, where misclassification is quantified as the proportion of individuals incorrectly classified (Eric Vittinghoff, Glidden, & McCulloch, 2005). Sensitivity and specificity are often used as complementary measures to assess the prediction rules for logistic regression, sensitivity is the proportion of correctly classified events and specificity is the proportion of correctly classified non-events (Eric Vittinghoff et al., 2005). The point which maximizes both specificity and sensitivity is suggested as the cut-point (Hosmer & Lemeshow, 2000). The point where the value of sensitivity and that of specificity are equivalent is potentially one of the best cut-points. It is a feasible means for optimal threshold choice when sensitivity and specificity curves have the same slope, but this requirement is not always met. Fortunately, there are three methods that can be used to determine the optimal cut-off point from the receiver operating characteristic (ROC) curve; the Youden index is the commonly used criterion (Kumar & Indrayan, 2011). The Youden index is defined as the sum of sensitivity, specificity and −1, which means the better the classification at the cut-point, the higher the value of the Youden index (Agarwal et al., 2008). Because the minimum point of misclassification rate can coincide with the point where the curve of the sum of sensitivity and specificity has its maximum value, the optimal cut-off value is the probability with the maximum Youden index (Hein & Weiskittel, 2010). The Youden index was used to choose an optimal cut-off point in this study. Predicted probabilities were calculated by applying the estimated coefficients with and without basic farmland protection planning, and the classification was made with cut value determined by using the Youden index. Based on the classification, the corresponding predicted area of converted farmland was computed.

The explanatory variables

There are several factors that could influence the occurrence and timing of farmland conversion. Table 1 provides an overview of the definitions and the expected sign for each independent variable. The first set of variables listed in Table 1 is the year dummy variables. The variables of $d1$, $d2$, $d3$, $d4$, $d5$, $d6$, $d7$, $d8$ and $d9$ are dummy variables for year 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007 and 2008. The exponentials of coefficients for year dummy variables represent the odds ratio of conversion in a given year compared with the year 1999. The Chinese economic situation changed from 1999 to 2008, which unavoidably influenced Fuyang County's economic growth. The changing economy led to different demands for farmland conversion for construction purposes in different years. As far as farmland preservation policy is concerned, besides laws and rules on land use administration, the Chinese central government often issued policy documents, such as notices to intensify farmland protection, which made every year's actual rigidity of farmland protection different. Therefore, the signs of coefficients for year's dummy variables may be different.

Table 1
Definitions and expected signs for explanatory variables used in the models.

Set	Explanatory variable	Variable definitions	Expected signs
d	$d1$	Year dummy variable, $d1 = 1$ for 2000, $d1 = 0$ for otherwise	+/−
	$d2$	Year dummy variable, $d2 = 1$ for 2001, $d2 = 0$ for otherwise	+/−
	$d3$	Year dummy variable, $d3 = 1$ for 2002, $d3 = 0$ for otherwise	+/−
	$d4$	Year dummy variable, $d4 = 1$ for 2003, $d4 = 0$ for otherwise	+/−
	$d5$	Year dummy variable, $d5 = 1$ for 2004, $d5 = 0$ for otherwise	+/−
	$d6$	Year dummy variable, $d6 = 1$ for 2005, $d6 = 0$ for otherwise	+/−
	$d7$	Year dummy variable, $d7 = 1$ for 2006, $d7 = 0$ for otherwise	+/−
	$d8$	Year dummy variable, $d8 = 1$ for 2007, $d8 = 0$ for otherwise	+/−
	$d9$	Year dummy variable, $d9 = 1$ for 2008, $d9 = 0$ for otherwise	+/−
L	*Planning*	Dummy variable for basic farmland protection planning, *Planning* = 1 if the grid determined as basic farmland, and *Planning* = 0 for otherwise	−
X	*Elevation*	The elevation of grids (m)	−
	Slope	The slope of grids (%)	−
	Road	Distance from grid to road (m)	−
	Ynmr	Dummy variable for the kind of road, *Ynmr* = 1 for major road, *Ynmr* = 0 for otherwise	+
	City	Distance from grid to city (m)	−
	Town	Distance from grid to town (m)	−
	Village	Distance from grid to village (m)	−
	Factory	Distance from grid to industrial land (m)	−
	Construction	The distance from the grid to nearest construction land (m)	−

The second set of variables is the factor denoting land use planning, and a dummy variable of *Planning* was used for this purpose, which takes the value of "1" for the grids belonging to basic farmland districts and "0" for otherwise. Because more rigorous regulation of conversion and expropriation had been imposed on basic farmland than ordinary farmland, if the basic farmland protection plans have been implemented vigorously, the probability of conversion of basic farmland would be lower than that of ordinary farmland. Thus, the variable *Planning* is expected to have a positive sign if basic farmland protection planning performed well and the regulations protecting basic farmland protection have been thoroughly implemented.

The third set is variables regarding parcel-level characteristics and includes these variables: *Elevation*, *Slope*, *Road*, *Ynmr*, *City*, *Town*, *Village*, *Factory* and *Construction*. Many studies have shown that elevation is an important factor influencing land use decisions in mountainous regions (Mottet, Ladet, Coque, & Gibon, 2006; Tasser, Walde, Tappeiner, Teutsch, & Noggler, 2007). For a land development project, especially for land use conversion in a hilly region, the elevation of the plot to be developed is usually included with the development cost and has a negative effect on land development because higher elevation may cause higher development costs. Thus, plots with higher elevations are less likely to be converted. The slope of plots is also an important factor that influences land use choice, as various studies have shown (Mottet et al., 2006; York & Munroe, 2010). As far as land conversion for non-agricultural use is concerned, the volume of earthwork is positively corrected with the slope of the plots to be developed. Therefore, the slope of plots has a negative impact on the probability of being converted.

A great deal of research has shown the importance of location and accessibility in determining land use. According to Johann von Thünen's land use theory, land location influences the relative rent to alternative land uses and, therefore, affects land use patterns (Polyakov & Zhang, 2008). In a similar vein, accessibility has been included in the land use decision models by a large body of literature because it represents a cost in land use decisions (Braimoh & Onishi, 2007). Accessibility can be expressed in terms of any concept of cost, such as money, time, and so on (Braimoh & Onishi, 2007; Lakes et al., 2009). In numerous studies, the distance to the specific site was used to denote the accessibility of land (de Espindola, de Aguiar, Pebesma, Camara, & Fonseca, 2012; Millington, Perry, & Romero-Calcerrada, 2007; Mottet et al., 2006; Serneels & Lambin, 2001; Van Doorn & Bakker, 2007). As a matter of fact, distance would impose some influence on land use costs (Gellrich, Baur, & Zimmermann, 2007), and land use costs, especially the cost of land development and the transportation cost relevant with land use, are positively correlated with the distance, which makes the land price decrease as distance increases. Previous research has indicated that road development is one driving force of land use and cover change (de Espindola et al., 2012; Patarasuk & Binford, 2012). Urbanization also has significant measurable relation with land use, landscape and agricultural land shrinkage (Huang, et al. 2012; Miller, 2012; Su, Xiao, & Zhang, 2012; Tavares, Pato, & Magalhães, 2012; Verburg, Veldkamp, & Fresco, 1999). Given the relationship between land use and such factors as urbanization and road development, variables such as *Road*, *City* and *Town* were used to measure the location and accessibility in this study, with *Road* representing the distance from grid to road, *City* and *Town* representing the distance from the parcel to the town where the People's Government of Fuyang

County is located, and the distance from the parcel to nearest town, respectively. In consideration of the different weight of different roads, the variable of *Ynmr* was generated to denote if the road closest to the grid is a major road, taking the value of "1" for the grids close to a major road in Fuyang County and "0" for otherwise. Because the probability of being converted for the grid close to major roads would be higher than a parcel far from a major road, the variable *Ynmr* is expected to have a positive sign. Plots closer to the road or town are expected to have relatively higher rent for non-agriculture use than agriculture use, as well as higher rent than plots further away. Thus, plots further from the road or town are less likely to be developed, or will be developed later than those near the road or town. This leads us to expect the signs for the variables *Road*, *City* and *Town* to be negative.

As neighboring parcels might have similar properties and be related, the use of a plot might be influenced by its adjacent parcel's use (Cho & Newman, 2005; Zhou & Kockelman, 2008). Therefore, variables such as *Village* and *Factory* were used to represent a plot's neighborhood, namely the distance from the parcel to a village or industrial land, respectively. The variable of *Construction* was used to represent the distance of the grid to the nearest construction land, excluding roads; construction land mainly includes rural residential land, land used by a factory, land used for water resource facilities, and so on. These variables, including *Village*, *Factory* and *Construction*, were added as explanatory variables in the equations to capture spatial associations. The parcels with higher value for the distance to nearest construction land are expected to have a smaller possibility of being converted to other uses. It is the same for the variables of *Village* and *Factory*; these three variables are expected to have negative signs.

The definitions and expected signs for independent variables are shown in Table 1, and the descriptive statistics of variables used in this study are presented in Table 2.

A framework to assess the implementation of planning based on arable land protection

Effectiveness-based approaches are frequently adopted by academic research to evaluate land use planning. In other words, researchers ask whether land use planning is effective, and understandings of effectiveness are usually used to assess both the impact of land use planning and the results of its implementation. There is another issue relevant to assessing land use planning, namely, whether planning was successful when compared with its initial goals or objectives. This approach may be termed a goals-based assessment of the implementation of land use planning. Effectiveness-based and goals-based assessments were integrated here into one framework to evaluate the results of the implementation of basic arable land protection planning. It is also appropriate to combine these two dimensions to assess the impact of land use planning with regard to cultivated land preservation. In regard to the goals of farmland protection in land use planning, there are possible gaps between the goal of cultivated land protection and the actual results derived from implementing land use planning. The implementation of land use planning may be successful or unsuccessful. Similarly, land use planning itself may be effective or ineffective. Thus, one may conjecture that four outcomes can exist regarding the implementation of land use planning when assessments of both implementation and planning are integrated into one analytic framework (see Fig. 2).

In this study, goals are conceptualized in terms of amounts of cultivated land converted, and the actual amount of converted cultivated land was compared with the goal initially set by the land use planning documents. For the purpose of measuring the success of cultivated land protection, the smaller the amount of converted cultivated land, the better the result of planning. We are interested here in the gaps between the goals of cultivated land conversion and the actual amount of cultivated land that was converted. The rules to judge whether land use planning implementation was successful based on the goals of cultivated land protection are as follows: implementation is judged successful for those situations in which the amount of land actually converted is smaller than the goals for conversion that were set, and unsuccessful for the situations in which the amount of land actually converted was the same as or larger than the conversion goals. Econometric methods are used here to evaluate the effectiveness of basic arable land protection planning given these definitions. These methods were presented in the previous section in relation to the assessment of the effectiveness of basic arable land protection planning.

Results and discussions

Estimation result

It is possible that correlations exist among the variables *Elevation*, *Slope*, *Road*, *City*, *Town*, *Village*, *Factory*, and *Construction* used here. The correction coefficients between these variables were calculated, and the results showed that there is high correlation between the variables *Construction* and *Village*, with a correlation coefficient of 0.750. Furthermore, the variable *Elevation* has a high correlation with the variables *Slope*, *Factory* and *City*, with a correlation coefficient of 0.651, 0.571 and 0.506, respectively. If variables with high correlation are included in a single model, it will cause multicollinearity (Wooldridge, 2005). Therefore, different models including different explanatory variables were estimated and the variable *Elevation* was excluded from any models that included

Table 2
Descriptive statistics of variables used in the study.

Explanatory variable	*N*	Minimum	Maximum	Mean	Std. deviation
Planning	12,106,350	0.00	1.00	0.68	0.47
Elevation	12,106,350	0.00	826.00	71.51	85.53
Slope	12,106,350	0.00	89.90	6.45	7.81
Road	12,106,350	0.00	7577.98	512.71	601.78
Ynmr	12,106,350	0.00	1.00	0.28	0.45
City	12,106,350	0.00	45,710.21	11,832.78	8789.80
Town	12,106,350	0.00	14,451.95	4165.80	2846.04
Village	12,106,350	0.00	1959.21	160.91	156.25
Factory	12,106,350	0.00	5571.69	681.06	652.60
Construction	12,106,350	0.00	1780.71	121.08	116.03

Note: *N* is the number of grids.

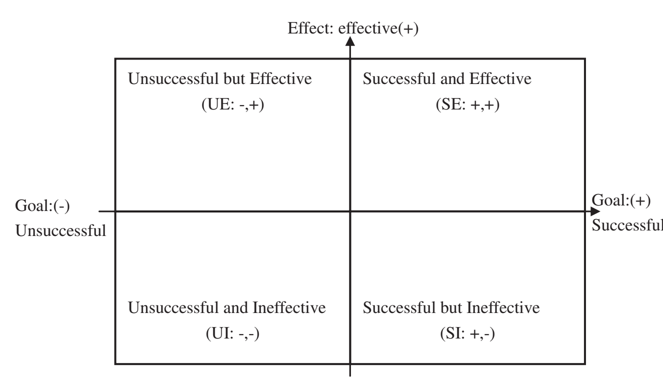

Fig. 2. The framework to assess the implementation results of land use planning based on cultivated land protection.

variables with which it shares a high correlation coefficient. The estimated results are presented in Table 3, which contains two models that include different variables. Model I includes such variables as *Planning*, *Slope*, *Road*, *Ynmr*, *City*, *Town*, *Village*, *Factory* and the dummy year variables. Taking into consideration the correlation between the variables *Construction* and *Village*, Model II includes the variable of *Construction* instead of *Village* and *Factory*. The two estimated models are shown in Table 3.

The estimated equations perform satisfactorily in terms of goodness of fit. The two models' values of the log likelihood at convergence are −254,266.83 and −259,052.40, respectively. The likelihood-ratio chi-squared values for the two models are 161,337.96 and 151,766.81, respectively, and the estimated models are highly significant with *p*-values of less than 1%. Moreover, all coefficients are statistically significant at the 1% level. The correct classification values are 99.57% for both estimated models with a cut-off of 0.5.

Akaike information criterion (AIC), Schwartz or Bayesian information criterion (BIC), and Pseudo R^2 were calculated to assess and choose models, as presented in Table 3. Model I has the smaller value of AIC and BIC and larger value of Pseudo R^2, which suggests that Model I was statistically superior to Model II.

The estimated equations suggest that the conversion of arable land to other uses is influenced by a plot's physical elements, location, neighborhood, and the policy of basic arable land protection. The estimated coefficients for *Slope* are significantly negative and their signs are consistent with expectations. The negative sign of *Slope* shows that the slope of a parcel has a negative influence on cultivated land conversion. The effect of the independent variable can be interpreted in terms of changes in odds. The value for the coefficient of *Slope* in model is −0.0752, the estimated odds ratio for an increase of 1 m in elevation is 0.9276 ($e-^{0.0752}$), which means that for every increase of 1 percent in slope gradient, the risk of being converted deceases by a factor of 0.9276. Moreover, the estimated odds ratio for an increase of 10 percent in slope gradient is 0.4714; this indicates that the odds are expected to change by a factor of 0.4714 for a 10 unit change in slope gradient.

Based on the estimated equations, the location and accessibility of plot also have a significant negative influence on arable land's conversion to other uses. The coefficient for the independent variable *City* (−2.3600E−05) is of statistical significance in Model I. This result suggests that for every increase of 1 m, the risk of being converted decreases by a factor of 0.9999. The estimated odds ratio for increases of 100 and 1000 m in the distance from plot to town are 0.9976 and 0.9767, respectively. The coefficient for the independent variable *Town* (−0.0001) is also statistically significant in Model I, which suggests that for every increase of 1 m, the risk of being converted decreases by a factor of 0.9999. The estimated odds ratio for increases of 100 and 1000 m in the distance from plot to town are 0.9917 and 0.9202, respectively.

The estimated coefficient of *Road* is also negative and statistically significant. The coefficient of the variable *Road* is −0.0007; this indicates that, holding all other variables constant, the odds of conversion change by −0.9993 for a unit change in the distance from plot to road. Being 100 m farther from the road decreases the odds of conversion by a factor of 0.9359. The estimated odds ratios are 0.8758, 0.7179 and 0.5154, respectively, for increases of 200, 500, and 1000 m in the distance from plot to road. It is also worth noting that the coefficient of the variable *Ynmr* is 0.2809, which means that there was a significant difference between the odds of being converted for the grids close to major roads and the grids far from major roads. Compared with the grid far from a major road, a grid close to a major road has a larger probability of being converted to non-agriculture use. The estimated coefficient for the variable suggests that the odds of being converted increase by a factor of 1.3243 ($e^{0.2809}$) for the grids close to a major road, holding all other variables constant.

Table 3
Estimated results of logistic discrete-time hazards model for arable land conversion.

Explanatory variable	Model I				Model II			
	Coef.	Std. err.	z	$P > \|z\|$	Coef.	Std. err.	z	$P > \|z\|$
*d*1	0.2429	0.0534	4.5500	0.0000	0.3476	0.0534	6.5000	0.0000
*d*2	2.6225	0.0350	75.0300	0.0000	2.7272	0.0349	78.0400	0.0000
*d*3	2.4127	0.0354	68.0800	0.0000	2.5638	0.0354	72.3700	0.0000
*d*4	3.1595	0.0339	93.1100	0.0000	3.3279	0.0339	98.1300	0.0000
*d*5	−0.6189	0.0729	−8.4900	0.0000	−0.4292	0.0728	−5.8900	0.0000
*d*6	2.8501	0.0345	82.6200	0.0000	3.0029	0.0345	87.0500	0.0000
*d*7	1.7662	0.0380	46.5100	0.0000	1.9216	0.0380	50.6200	0.0000
*d*8	2.3948	0.0356	67.3500	0.0000	2.5750	0.0355	72.4600	0.0000
*d*9	3.4876	0.0337	103.5400	0.0000	3.6785	0.0337	109.3100	0.0000
Planning	−2.2319	0.0123	−180.7700	0.0000	−2.3607	0.0124	−190.9100	0.0000
Slope	−0.0752	0.0015	−50.6600	0.0000	−0.0885	0.0015	−58.3200	0.0000
Road	−0.0007	0.0000	−33.0300	0.0000	−0.0012	0.0000	−58.6000	0.0000
Ynmr	0.2809	0.0101	27.9100	0.0000	0.4594	0.0099	46.6300	0.0000
City	−2.3600E−05	0.0000	−24.7500	0.0000	−3.5900E−05	0.0000	−38.2600	0.0000
Town	−0.0001	0.0000	−40.4100	0.0000	−0.0001	0.0000	−46.3700	0.0000
Village	0.0013	0.0000	48.0900	0.0000				
Factory	−0.0017	0.0000	−77.7400	0.0000				
Construction					0.0012	0.0001	21.8300	0.0000
Constant	−5.6207	0.0354	−158.6900	0.0000	−5.9858	0.0351	−170.7100	0.0000
Log likelihood	−254,266.83				−259,052.40			
Number of observations	12,106,350				12,106,350			
LR chi^2	161,337.96				151,766.81			
Prob > chi^2	0.0000				0.0000			
Pseudo R^2	0.2408				0.2266			
Correctly classified	99.57%				99.57%			
AIC	508,569.70				518,138.80			
BIC	508,827.20				518,382.10			

The neighborhood is another factor influencing arable land conversion to non-agricultural use. The estimated coefficient for *Factory* is −0.0017 and significantly negative. This result suggests that the risk of being converted is higher for plots near industrial land than plots far from the industrial land. The coefficient for *Factory* suggests that the odds of being converted decrease by a factor of 0.9983 for an increase of 1 m in distance between a plot and industrial land. The estimated odds ratios are 0.9828, 0.8405, 0.4194, 0.1759, and 0.0309, respectively, for increases of 10, 100, 500, 1000, and 2000 m. Another explanatory variable, *Village*, (the distance from a grid to a village) is also statistically significant. It is expected that there is a larger possibility of being converted to non-agricultural use for those plots that are near a village than those far from a village. However, the estimated coefficient of *Village* is significantly positive and, thus, not in concordance with expectations. When compared with *Factory*, which has a significantly negative estimated coefficient in line with expectations, this result appears strange. However, this result reflects the actual circumstances in Fuyang. China's rural development has experienced an episode of universal transition since 2000 (Long, Zou, Pykett, & Li, 2011) and rapid urbanization and industrialization in China have caused the phenomenon of "village-hollowing" (Long, Li, Liu, Woods, & Zou, 2012), which has caused the extensive use of rural construction land. The policy of central and local governments, especially local governments' policy, has responded to these transitions. Policies accelerating the urbanization of Hangzhou, which is a prefecture-level city and has jurisdiction over Fuyang County, led to different land use policies and agricultural land conversion permits. The document "Circular on Some Policies about Accelerating the Progress of Urbanization" was issued by the Zhejiang Provincial Government in September 2000. This circular encouraged rural residential concentration and stated that core towns have priority in using the quota of arable land conversion. Actually, some other cities in Zhejiang Province had implemented a plan for dispersing rural residential concentrations before this circular was issued (Skinner et al., 2001). Another policy file, "Some Policies on Experimental Measures to Speed up the Reform of Core Towns" was issued by the government of Hangzhou in December 2001. This publication also guaranteed the core towns' priority in using the arable land conversion quota. The quota for converting arable land to construction use is 1160 ha over 14 years, which is allocated by the land use plan of Hangzhou for the term from 1997 to 2010. Due to these policies, there is little likelihood that farmers will receive permission from the local agency for land administration to convert arable land to non-agricultural uses near their current villages, a situation which most likely accounts for the positive coefficient for *Village*.

The estimated coefficients for year dummy variables are all of statistical significance. Regarding the coefficients of the dummy variables for the years 2000 to 2008, their exponentials represent the odds ratio of conversion in a given year compared with the year 1999. The coefficients of the dummy variables are positive except for 2004, which suggest that the odds of arable land being converted were greater in 2000, 2001, 2002, 2003, 2005, 2006, 2007, and 2008 than they were in 1999, and the odds of being converted were smaller in 2004 than in 1999. This can be explained by a change of land use policy of China, which saw more rigorous land use conversion regulations in the year 2004 (Zhong, Huang, Zhang, & Wang, 2011).

The effectiveness of basic farmland protection planning

Effectiveness of basic farmland protection planning

The estimated coefficient of the variable *Planning* was used to judge whether basic farmland protection planning had been effective in decreasing arable land conversion. If the estimated coefficients of *Planning* are consistent with its expected sign and statistically significant, the conclusion would be that the basic farmland protection plan had been effective in saving arable land from being developed for non-agricultural use. In other words, basic arable land protection planning can be judged effective if there are significant differences between the odds of being converted for basic arable land and ordinary, non-basic, arable land, and ineffective if there is no significant difference. The estimated coefficient for the variable of *Planning* is negative and statistically significant, thus consistent with the expected sign. The significantly negative coefficient for *Planning* indicates that there was a significant difference between the odds of being converted between basic arable land and ordinary, non-basic arable land. Compared with ordinary arable land, there is a smaller probability of basic arable land being converted to non-agriculture use. The estimated coefficient for the variable of *Planning* is −2.2319, which suggests that the odds of being converted decrease by a factor of 0.1073 ($e^{-2.2319}$) for basic arable land, holding all other variables constant. In other words, the odds of being converted decrease by 89.27% ($e^{-2.2319} - 1$). In terms of farmland preservation, the odds of not being converted increase by a factor of 9.32 ($1/e^{-2.2319}$), namely increase 832% ($1/e^{-2.2319} - 1$), holding all other variables constant. The result shows that the basic arable land protection planning used and its relevant policies were effective in decreasing arable land loss. Because the larger absolute value of the negative coefficient of the variable *Planning* means a larger decrease in the odds of being converted, we can argue that basic arable land protection was effective in preserving arable land.

Degree of protection of basic farmland protection planning to arable land

The estimated Model I was used to compute the probability of arable land being converted. The probability of being converted was computed with and without the basic arable land protection policy in place. The ROC curve (shown in Fig. 3) is the plot of sensitivity versus 1 − specificity for all cut-off values (Hosmer & Lemeshow, 2000). The area under the ROC curve is 0.9145, which is considered excellent discrimination according to the general rules (Hosmer & Lemeshow, 2000). The plot of sensitivity versus specificity versus all possible cut-points is shown in Fig. 4.

The summary of sensitivity, specificity, and the Youden index based on Model I is presented in Table 4. The cut-point was chosen based on the Youden index. The Youden index reaches its

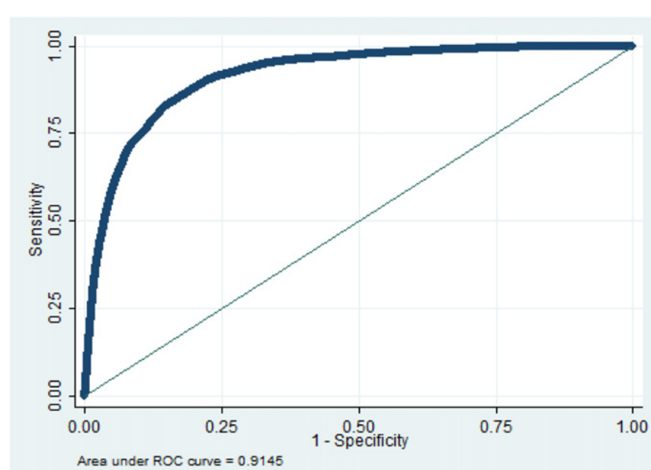

Fig. 3. The ROC curve for Model I.

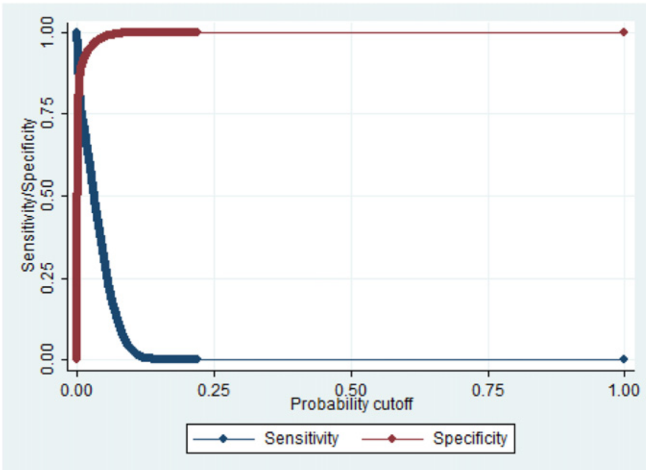

Fig. 4. The plot of sensitivity versus specificity versus all possible cut-points in Model I.

maximum at the cut-point of 0.0044. The specificity is very high at the cut-point of 0.5 with the value of 100%; however, the sensitivity is 0.00%. The sensitivity rises as the cut-points decrease. At the optimal point, the specificity is still high with a value of 84.56% and sensitivity improves to 83.49%. The rate of correct classification is 84.56 percent for the cut-point of 0.0044. The classification table is presented as Table 5. A value of sensitivity of 83.49% means that the proportion of correctly classified events is 83.49% and the value of specificity of 84.56% indicates that the proportion of correctly classified non-events is 84.56%.

Therefore, the value of 0.0044 was used as the threshold to derive the dichotomous variable. The estimated probabilities were compared with this threshold. If the estimated probability exceeds 0.0044, then the derived variable is equal to 1; namely, the predicted probability was viewed as the occurrence of conversion. Otherwise, its value is 0.

The types of estimated probabilities were computed, one of which is the estimated probabilities with the variable *Planning*'s value at 1, and another is with the variable *Planning*'s value at 0. The estimated probabilities with and without basic arable land protection were compared with 0.0044. If the estimated probability exceeds 0.0044 for a grid, then the grid is counted as conversion. Predicted conversion rather than the actual conversion was used, so that model error present in the predictions without basic arable land protection in place is counted in the predictions with basic arable land protection policy in place. Therefore, these grids are counted as the effect of basic arable land protection, whose estimated probability without basic arable land protection exceeds 0.0044 and estimated probability with basic arable land protection is less than 0.0044. $N1$ represents the number of grids counted by this means for the effect of basic arable land protection in Table 6. However, conversion from arable land to construction use is not a repeated event for a grid. If a grid is predicted as a conversion for several years, all but the first year of predicted conversion were dropped. $N2$ represents the number of the grids counted by this means for the effect of basic arable land protection in Table 6. The area saved by the basic arable land protection is calculated as follows:

$$A1 = N1 \times \frac{15 \times 15}{10^4}$$

$$A2 = N2 \times \frac{15 \times 15}{10^4}$$

The effects of basic arable land protection are shown in Table 6.

The value of $N1$ is larger than that of $N2$ except for 2001, and it is same for $A1$ and $A2$. Given that the conversion of arable land to other uses is not a repeated event, it is more reasonable for the estimated number and the area of grids saved by basic arable land protection policy to be represented by $A2$ and $N2$ than $A1$ and $N1$. As shown in Table 6, the estimated number and area of the grids saved by arable land protection policy are different for every year. The estimated area of conversion is the largest in 2001. Phenomena such as industrial park setup, town sprawl, and transportation development were observed from 1999 to 2003 (Zhong et al., 2011). New plants, road construction, and town development changed these variables' values, which include the variables *Road*, *City*, *Town* and *Factory* in those years. These changes influenced the predicted probabilities of the grids and caused fluctuations between the estimated conversion areas of arable land from 2000 to 2008. The ratios of the predicted conversion grids to the total grids of arable land fluctuated between 2000 and 2008, the highest is 40.92% in 2001, the lowest is 0.05% in 2006 (except for 2004) and the average is 5.83%. The relative effect was also computed and is shown as *NR* and *NNR* in Table 6. The relative effect is the ratio of the number of grids counted as the effect of basic arable land protection to the predicted number of conversion grids without basic arable land protection. Its value fluctuated from 2000 to 2008, with the highest fluctuation of 90.79% occurring in 2006, the lowest of 36.58% occurring in 2000 (the exception being 2004) with an average of 72.30%. This result also suggests that the policy of protecting basic arable land was effective in Fuyang County.

Table 4
Summary of sensitivity, specificity and Youden index based on model using a cut-point of 0.0030–0.0050 in increments of 0.0001.

Cut-point	Sensitivity	Specificity	Youden index
0.0030	88.09%	79.78%	67.87%
0.0031	87.68%	80.26%	67.94%
0.0032	87.27%	80.71%	67.98%
0.0033	86.85%	81.13%	67.98%
0.0034	86.44%	81.54%	67.98%
0.0035	86.05%	81.91%	67.96%
0.0036	85.72%	82.27%	67.99%
0.0037	85.37%	82.62%	67.99%
0.0038	85.04%	82.94%	67.98%
0.0039	84.74%	83.25%	67.99%
0.0040	84.46%	83.53%	67.99%
0.0041	84.20%	83.81%	68.01%
0.0042	83.93%	84.07%	68.00%
0.0043	83.68%	84.32%	68.00%
0.0044	83.49%	84.56%	68.05%
0.0045	83.25%	84.79%	68.04%
0.0046	83.01%	85.01%	68.02%
0.0047	82.79%	85.21%	68.00%
0.0048	82.53%	85.41%	67.94%
0.0049	82.27%	85.60%	67.87%
0.0050	81.99%	85.78%	67.77%

Table 5
Classification table based on Model I using a cut-point of 0.0044.

Classified	Observed		
	$Y = 1$ converted	$Y = 0$ unconverted	Total
$Y = 1$	43,357	1,860,973	1,904,330
$Y = 0$	8576	10,193,444	10,202,020
Total	51,933	12,054,417	12,106,350

Note: the number is the number of grids.

Table 6
The estimated effects of basic arable land protection.

Year	*N*1	*N*2	*A*1	*A*2	*NW*		Relative effect	
					NR	*NNR*	*N*1/*NR* (%)	*N*2/*NNR* (%)
1999	0	0	0.00	0.00	7467	7467	0.00	0.00
2000	8563	5975	192.67	134.44	23,653	16,332	36.20	36.58
2001	501,638	501,638	11,286.86	11,286.86	735,677	712,046	68.19	70.45
2002	483,373	11,262	10,875.89	253.40	698,127	14,119	69.24	79.76
2003	532,818	101,588	11,988.41	2285.73	861,906	122,349	61.82	83.03
2004	31	0	0.70	0.00	178	0	17.42	–
2005	567,763	13,752	12,774.67	309.42	837,265	17,162	67.81	80.13
2006	372,916	552	8390.61	12.42	541,055	608	68.92	90.79
2007	531,727	2211	11,963.86	49.75	740,824	2596	71.78	85.17
2008	484,713	69,192	10,906.04	1556.82	941,720	84,046	51.47	82.33
Total	3,483,542	706,170	78,379.70	15,888.83	5,387,872	976,725	64.66	72.30

Note: ① *NW* is the predicted number of conversion grids without basic arable land protection; ② *NR* is the predicted number of conversion grids without basic arable land protection, including repeated occurrences; ③ *NNR* is the predicted number of conversion grids without basic arable land protection dropping repeated occurrences.

Policies and institutions ensuring the effectiveness of basic arable land protection planning

Basic farmland protection planning per se does not compel compliance; it is, rather, farmland protection policies along with basic farmland protection plan enforcement that makes planning effective. Furthermore, relevant laws, regulations, and policies are usually integrated into land use planning, and local governments usually take these laws, regulations, and policies from the text of land use planning documents created by higher lever governments for their land use planning. Moreover, basic arable land protection is a nation-wide issue, and the central and provincial governments frequently issue relevant policies that require governments at all levels to enforce basic arable land protection. China has a top-down land use planning system, and some objectives of local land use planning are restricted by higher-level land use planning on local governments. The objectives of arable land protection and basic arable land protection are restricted by higher-level land use planning. The amount of arable land retention and basic arable land preservation in land use planning are required to be not less than the amount assigned by the next higher-level government's land use planning decisions. Local land use planning has the right to decide the spatial distribution of basic arable land and concrete amounts based on higher-level land use planning. All these factors have made it difficult to completely and comprehensively understand or explain the effect of arable land protection planning without mention of relevant institutions and policies.

Relevant laws regarding basic arable land protection

As far as policies for farmland protection are concerned, there are two principal laws governing arable land protection in China (Lichtenberg & Ding, 2008). One is the Land Administration Law, issued in 1986. This law has been revised three times, in 1988, 1998, and 2004. The revisions in 1988 and 2004 had nothing to do with farmland protection; however, farmland protection is the most important issue in the 1998 revision. According to the Land Administration Law of 1986, county-level, prefecture-level, province-level, and the central government have the right to approve the conversion and expropriation of arable land to non-agricultural use. The county-level government has the right to approve the conversion and expropriation application of arable land of less than 3 mu (1 mu = 1/15 ha), the province-level government has the right to approve the conversion and expropriation application of arable land larger than 3 mu and less than 1000 mu, and the rights of prefecture-level government are determined by its province-level government. Conversions of arable land larger than 1000 mu should obtain approval from the State Council. The Land Administration Law was revised in 1998 and enacted in 1999; this revised edition is commonly called the New Land Administration Law in China. This revision adjusted the allocation of rights for approval of arable land conversion and expropriation. The New Land Administration Law created a new system called land use regulation, and classified land into three types, namely agricultural land, construction land, and unused land. Arable land, grass land and wood land are classified as agricultural land. Conversion of agricultural land to construction use must be approved, as required by Article 44 of the Land Administration Law.

There are two types of land ownership in the Chinese land tenure system, namely, collective ownership and state ownership. Arable land is either collectively owned land or state-owned, with the vast majority collectively owned. According to the Constitution of the People's Republic of China and the Land Administration Law, rural and suburban land belongs to village collectives in general, rural collectives have the authority to allocate farmland to households, and farm households have the use rights of arable land for a term of 30 years. Although county-level government has the right to approve agricultural land conversion, the New Administration Law requires that arable land be expropriated before it is converted to construction use if the arable land to be converted is collectively owned. The rights allocation of arable land acquisition or expropriation is defined by Article 45; this assignment of rights was termed the "recentralization"of land management in China (Wu, 2009). As mentioned above, the local governments below province-level have no rights to approve arable land expropriation. The province-level governments have the right to approve ordinary arable land expropriation less than 35 ha (525 mu) and other land less than 70 ha. These conversions require approval from the State Council, including conversion of basic arable land, ordinary arable land expropriation exceeding 35 ha, and other collectively owned land exceeding 70 ha.

The data mentioned above indicate that basic arable land protection planning reduced the occupation of arable land to a remarkable degree. The change in the arable land protection regime provides a good explanation for this. One of the bottlenecks is the adjustment of approval rights for basic arable land conversion. The central government centralized approval rights over basic arable land conversion by revising the Land Administration Law. Since 1999, when the new Land Administration Law came into effect, any conversion of basic arable land to non-agricultural use must obtain the permission of the State Council. This adjustment of approval rights over basic arable land conversion makes it more difficult to obtain approval for basic arable land conversion.

Table 7
Policies regarding basic arable land protection in China issued between 1999 and 2008.

Year	Name of policy	Issued by
1999	Basic Arable Land Protection Regulation (Revised in 1998)	State Council
1999	Circular on Enforcing "the Basic Arable Land Protection Regulation" and Reinforcing basic Arable Land Protection	Ministry of Land and Resources and Ministry of Agriculture
2000	Circular on Inspection of Land Law Enforcement Based on Remote Sensing Technology	Ministry of Land and Resources
2000	Circular on Inspection of Land Law Enforcement Based on Remote Sensing Data of 2000	Ministry of Land and Resources
2000	Measures for the acceptance of Basic Arable Protection District Readjustment	Ministry of Land and Resources
2001		
2002	Circular on Inspection of Land Law Enforcement Based on Remote Sensing Data of 2001	Ministry of Land and Resources
2003	Circular on Strictly Prohibiting Conversion of Basic Arable Land to Non-agricultural Us	Ministry of Land and Resources
2003	Circular on Strengthening Farmland Protection	Ministry of Land and Resources
2004	Circular on Inspection on Basic Arable Land Protection	Ministry of Land and Resources and Ministry of Agriculture
2004	Urgent Notice on Land Market Consolidation & Tightening Land Administration	General Office of the State Council
2004	Requirement on the Correction of the Problems in Basic Arable Land Protection	Ministry of Land and Resources
2004	Decision on the Deepening Reform and Tightening Land Administration	The State Council
2004	Circular on the Reform of Land and Resources Administrative System below the Province-level	The State Council
2005	Assessment Approach on Province-level Government's Target Responsibility of Farmland Protection	General Office of the State Council
2005	Circular on Setting up Demonstration Zone of Basic Arable Land	Ministry of Land and Resources
2005	Circular on the Fifth Inspection of Land Law Enforcement Based on Remote Sensing Data	Ministry of Land and Resources
2005	Requirements on Enforcing Basic Arable Land Protection	Ministry of Land and Resources
2006	Circular on Setting up the System of Supervision of State Land	General Office of the State Council
2006	Circular on the Sixth Inspection of Land Law Enforcement Based on Remote Sensing Data	Ministry of Land and Resources
2007	Circular on the Seventh Inspection of Land Law Enforcement Based on Remote Sensing Data	Ministry of Land and Resources
2008	Urgent Circular on Administration of dynamic balance of Arable Land	Ministry of Land and Resources
2008	Circular on the eighth Inspection of Land Law Enforcement Based on Remote Sensing Data	Ministry of Land and Resources

Source: summarized by authors.

In addition to the adjustment of approval rights of arable land conversion and expropriation, the New Land Administration Law also raised the standard of arable land expropriation in Article 47. According to Article 47, compensation for land expropriated includes land compensation, compensation for resettlement and compensation for attachments to or green crops on the land. The land compensation is 6–10 times the average output value of the three years preceding the expropriation of the cultivated land. The compensation for resettlement of each agricultural person is 4–6 times the average annual output value of the three years, and the resettlement compensation per ha shall not exceed 15 times the average annual output value. The compensation for resettlement may be increased with the approval of the people's governments of provinces, autonomous regions, and municipalities in situations in which the land compensation and resettlement compensation paid are not enough to maintain the farmers' original standard of living. In addition, the combined total of land compensation and resettlement compensation shall not exceed 30 times the average output value. Furthermore, the Decision on the Deepening Reform and Tightening Land Administration issued by State Council in 2004 required that the expropriation of basic arable land should be compensated according to the highest standards for land compensation and resettlement compensation. Those compensation standards are much lower in the Land Administration Law passed in 1986, when the standards for land compensation and resettlement compensation were 3–6 times and 2–3 times the average annual output value, respectively. The maximum for resettlement compensation per ha is 10 times, and the maximum of the combined total of land compensation and resettlement compensation is 20 times that contained in the Land Administration Law from 1986.

In addition to the New Land Administration Law, there is a special law on basic arable land protection entitled "Basic Arable Land Protection Regulation". This law was passed in 1994 and revised in 1999 due to the Land Administration Law revision in 1998. Article 9 of the Basic Arable Land Protection Regulation and Article 34 of the New Land Administration Law require that the area of basic land shall account for over 80% of the cultivated land in provinces, autonomous regions, and municipalities. The area of basic arable land in one region is assigned by its higher-level government, usually as a result of the master land use planning of its higher-level government. The quota of basic arable land for Fuyang County is 24,773 ha as assigned by the Master Land Use Planning of Hangzhou City from 1997 to 2010, representing 84.46% of the area of Fuyang County's arable land in 1996. Article 14 of the Basic Arable Land Protection Regulation requires that there be no net decrease or loss of basic arable land during the planning period. According to Article 15 of the Basic Arable Land Protection Regulation and Article 11 of the Basic Arable Land Protection Regulation of Zhejiang Province, only some special conversions for non-agricultural purposes could be approved. These include arable land conversion for the purpose of military installations, energy purposes, communications, water conservancy, and other infrastructure projects approved by the State Council and the government of Zhejiang Province.

Also required is that the basic arable land protection zone be designated when town-level and county-level master land use planning is conducted in accordance with Article 8 of the Basic Arable Land Protection Regulation. Furthermore, Article 11 of the Basic Arable Land Protection Regulation requires that local governments set up on-site posts demarcating the basic arable land protection zone.

Changes of policies relevant for basic arable land protection

In addition to adjusting the allocation of arable land conversion approval rights, the Chinese central government has, since 1999, steeped up its supervision of local land use and local governments' administration, in response to illegal land use and local governments' passive reactions. Specifically, new technology was used in the supervision of land use and its administration. Illegal farmland conversion occurs in China's urban periphery that bypasses the process of land expropriation approval (Wang & Scott, 2008). Because local divisions of land administration departments had reacted passively to this illegal land conversion prior to 1999, when the new Land Administration Law was put into place, the Ministry of Land and Resources of the People's Republic of China

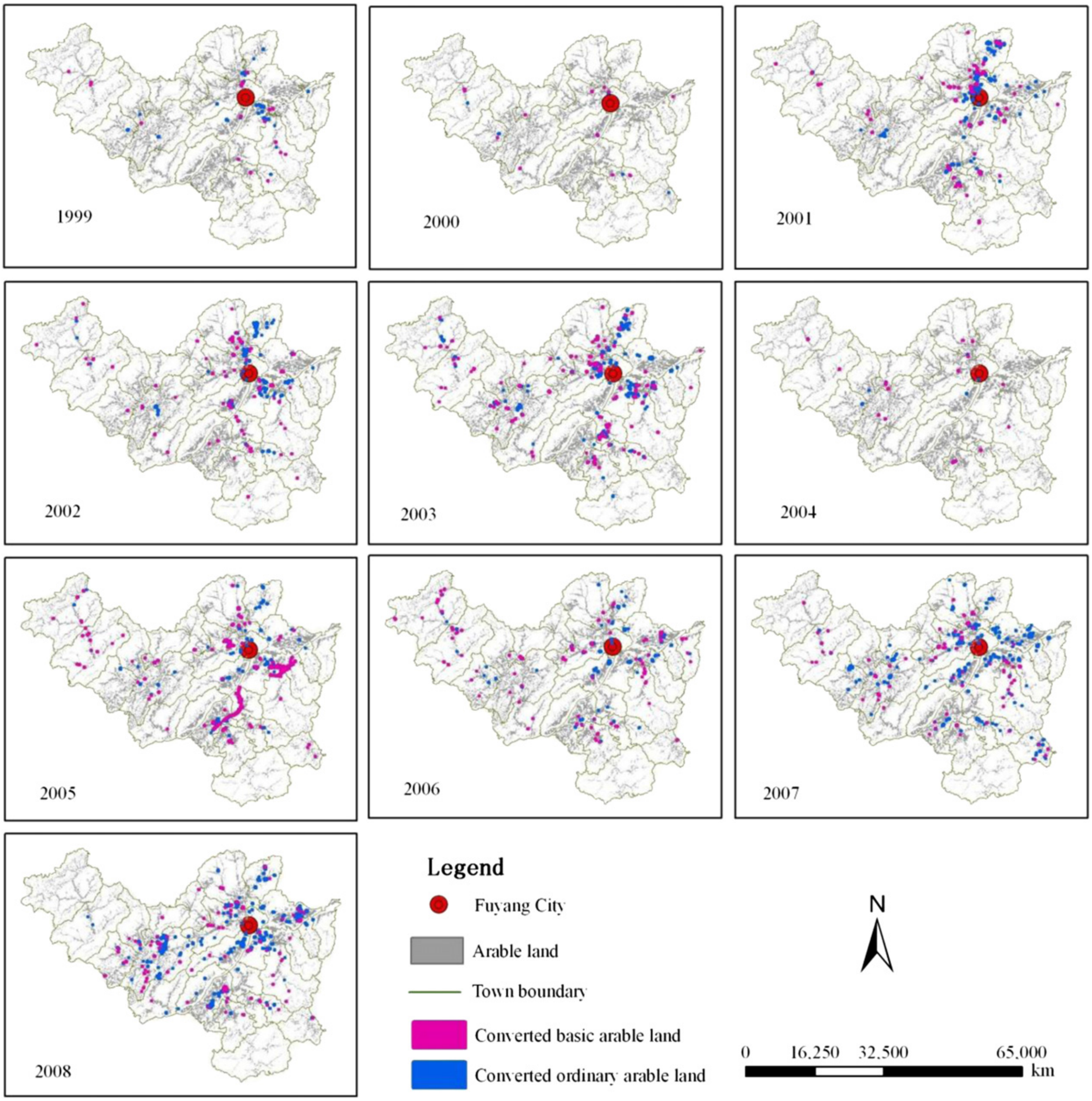

Fig. 5. Annual conversion of arable land between 1999 and 2000.

implemented a new supervision method in 2000 to inspect local land use and local governments' land use administration. This supervision included inspecting land law enforcement by using remote sensing technology and monitoring the land use dynamic. Since 2001 the inspections and monitoring have been carried out once a year. One of the key points of land law enforcement inspection is the conversion of arable land, especially basic arable land. The adoption of remote sensing technology has brought pressure on local governments (Ho & Lin, 2004a), and the inspections of land law enforcement have heightened the central government's authority because the accuracy of land use data, especially data on illegal land use, has been greatly improved. The Ministry of Land and Resources of the People's Republic of China issued the "Circular on Strictly Prohibiting Conversion of Basic Arable Land to Non-agricultural Use" in August of 2003, and launched a special inspection on basic arable land protection in February of 2004.

Furthermore, farmland protection was integrated into local government performance assessment, a development which has forced local governments to put more effort into controlling farmland loss. The General Office of the State Council of the People's Republic of China issued a circular entitled "Assessment Approach on Province-level Government's Target Responsibility of Farmland Protection" in 2005; basic arable land protection is an important item in the quantitative performance assessment system outlined in this circular. This assessment system has exerted pressure on local governments and their chief executives instead of ministries and commissions under the State Council, as had been the case in the past.

Last but not least, the structural reform of governance and inspection of land use administration has raised the level of basic farmland protection planning enforcement and compliance. The "Circular on the Reform of Land and Resources Administrative System below the Province-level" issued by the State Council in

2004 led to the readjustment of local land and resources administrative systems. The administrative rights over land, resources, and construction land use approval have been concentrated. In addition to these developments, a new regime entitled the land supervisor system was set up by State Council of China and a new inspection organization, the Supervisor of State Land, was established in 2007 and placed directly under the Ministry of Land and Resources. One of the tasks of the Supervisor of State Land is supervising the province-level efforts regarding arable land protection, especially basic arable land protection. These changes, listed in Table 7, have made basic arable land planning more effective and saved much arable land in comparison with the older policy that neglected basic arable land protection. Changes to relevant policies, combined with the implementation of a basic arable land protection plan, caused fluctuations in arable land conversion between 1999 and 2008, as illustrated in Fig. 5.

Comprehensive evaluation of basic arable land implementation

Using the combined framework of effectiveness-based and goals-based assessment, this paper evaluated the results of implementing basic arable land protection planning. The results of the assessment, based on effectiveness criteria provided in the previous sections, indicated that basic arable land protection planning and its implementation created a positive effect, namely, basic arable land protection planning and its implementation did reduce the loss of arable land in Fuyang County. The quota of arable land conversion to non-agricultural use is 1160 ha for the years from 1997 to 2010, which was the objective of arable land conversion control. There were approximately 1169 ha of arable land converted to non-agricultural use between 1999 and 2008, which exceeded the control target of arable land conversion in the planning. This result belongs in the category of unsuccessful but effective planning when we combine considerations of both effectiveness-based and goals-based assessment dimension. This result looks strange, but there are several root causes for this result. First, the top-down administrative system of land use planning leaves local government less space for its own arable land conversion plan. The bottom-up method of land use planning, especially for arable land protection planning, has been almost completely ignored in the current system of arable land protection planning and administration. The lower-level governments are required to accept the quota of arable land conversion arranged by their next higher-level government, which means lower-level governments can set a goal of arable land conversion less than the quota set by its next higher-level government rather than exceeding the quota. Local government can determine the spatial distribution of basic land protection and the arable land to be converted. Second, there is a gap in interests regarding land administration, especially arable land protection, between the local and central governments. Local governments emphasize interests in urbanization, industrialization, and economic growth rather than food security. However, the central government must balance economic growth and food security. Local governments are tempted to convert arable land to non-agricultural use to promote local economic growth rather than preserving arable land. Faced with these impulses on the part of local governments, the central government has responded in the ways mentioned above. However, China's central government has focused on the tools of command and control rather than developing tools associated with positive incentives and compensation. These two factors have increased the likelihood of planning failure with regard to arable land protection. Third, the system for evaluating local government cadres' performance and promotion has made it impossible for local governments to ignore higher-level and central governments' requirements regarding arable land protection. The promotion of local government officials is in the hands of the relevant higher-level governments, and the central government has powerful influence over local government officials' promotion at and above the prefecture-level, especially officials' promotions at the province-level. This governance structure over cadre promotion and arable land protection has forced local governments to balance the demand for arable land conversion created by local economic growth with arable land protection objectives required by the higher-level and central governments. These circumstances create an effective but not successful regime of arable land protection.

Conclusions

The empirical results suggest that basic arable land planning did reduce the conversion of arable land to non-agricultural use. The likelihood of conversion of arable land in basic arable land protection district is notably different from that of arable land outside the basic arable land protection district. The results from the estimated model describing the arable land conversion of Fuyang County indicates that the odds of being converted decreased by 89 percent for basic arable land, compared with the arable land outside the basic arable land protection district, namely ordinary arable land. On average, the conversion of arable land decreased by 72 percent between 2000 and 2008 from what otherwise would be expected, due to the basic arable land protection planning that was in place in Fuyang County.

There are two pillars for the effectiveness of basic arable land protection planning, and three types of institutional transition have fostered positive effects. First, the adjustment of approval rights for arable land conversion allocation between the central government and local governments is the most important item for the effectiveness of basic arable land protection planning. The second pillar is the new technology used by the central government to inspect land use and land administration of local governments, especially the annual land law enforcement inspection based on remote sensing technology carried out by the Ministry of Land and Resources of China since 2000. Furthermore, three types of institutional transition or change have fostered the positive effect of basic arable land protection planning. One is the raising of the standard of arable land expropriation, which has increased the cost of occupation of arable land for non-agricultural uses. Performance assessment change is the second transition, and the setup of the regime called the Assessment on Province-level Government's Target Responsibility of Farmland Protection has made local governments pay attention to not only local economic growth but also arable land protection. The last institutional transition is governance structure reform of land administration in the form of the readjustment of the local land and resources administrative system in 2004 and the creation of a land supervisor system in 2007; the first mission and policy goal of the latter is to urge local government to pay more attention to arable land protection.

These institutional changes to the Chinese farmland protection regime drive the system in a different direction from those of many countries with private ownership of land, such as the United States. Market-based policy tools have been highlighted and encouraged in the US, for example, transaction of development rights (TDR), purchase of development rights (PDR), farmland trusts, and so on. However, China has strengthened the central government's supervision of local governments' land administration and tightened up the approval rights of farmland conversion. In particular, the technical support for the central government's supervision of local governments' land administration has been gradually strengthened over the past decade and is expected to be more powerful and effective in the near future. This appears to be a deviation from the more general market-based reform taking place in China's economy; however, it is an appropriate choice for China's land administration given consideration of two critical differences. One is China's public ownership of land, which has made local government the de facto owner of urban land. Farmers and farm households are just the users, not the owners, of farmland (Cai, 2003; Ho, 2001), with usage rights of 30 years with the leasing arrangement between farm households and their village collectives. Another is the local governments' dual roles of administrator and developer in land development (Lichtenberg & Ding, 2009), giving local governments and village leaders the impetus to develop farmland. China's central government has focused on strengthening the supervision of local governments' land use and land use administration to preserve farmland due to these factors. It is expected that basic farmland protection planning will be more effective in the future when one takes into account the Chinese system of land ownership and institutional change in the land administration regime.

The results derived from an integrated analysis framework for assessing planning implementation lead to more insightful analysis combining the two dimensions of effectiveness-base and goals-based assessment. Although the basic arable land protection planning was deemed effective, it was not deemed successful in comparison with the objective of arable land protection. Three key and interweaving causes made these results unsuccessful but effective; these causes include the lack of combination of top-down and bottom-up administration in the system of land use planning, unbalanced policies between command-control and incentives, the gap of interests regarding land administration between the local governments and the central government, and the system of local government cadres' promotion and performance evaluations.

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References

Agarwal, R., Metiku, T., Tegegne, G. G., Light, R. P., Bunaye, Z., Bekele, D. M., et al. (2008). Diagnosing hypertension by intradialytic blood pressure recordings. *Clinical Journal of the American Society of Nephrology, 3*(5), 1364–1372.

Alphan, H. (2003). Land-use change and urbanization of Adana, Turkey. *Land Degradation & Development, 14*(6), 575–586.

An, L., & Brown, D. G. (2008). Survival analysis in land change science: integrating with GIScience to address temporal complexities. *Annals of the Association of American Geographers, 98*(2), 323–344.

Braimoh, A. K., & Onishi, T. (2007). Spatial determinants of urban land use change in Lagos, Nigeria. *Land Use Policy, 24*(2), 502–515.

Bramley, G. (1993). The impact of land-use planning and tax subsidies on the supply and price of housing in Britain. *Urban Studies, 30*(1), 5–30.

Bureau of Statistics of Hangzhou City, NBS Survey Office in Hanghou, & Hangzhou Bureau of Socio-economic Survey. (2011). *Hangzhou statistical yearbook 2011.* China Statistics Press.

Cai, Y. (2003). Collective ownership or cadres' ownership? The non-agricultural use of farmland in China. *The China Quarterly, 175*, 662–680.

Chen, J. (2007). Rapid urbanization in China: a real challenge to soil protection and food security. *Catena, 69*(1), 1–15.

Chen, Z. J., Chen, J., Shi, P. J., & Tamura, M. (2003). An IHS-based change detection approach for assessment of urban expansion impact on arable land loss in China. *International Journal of Remote Sensing, 24*(6), 1353–1360.

Cho, S. H., & Newman, D. H. (2005). Spatial analysis of rural land development. *Forest Policy and Economics, 7*(5), 732–744.

Coomes, O. T., Grimard, F., & Burt, G. J. (2000). Tropical forests and shifting cultivation: secondary forest fallow dynamics among traditional farmers of the Peruvian Amazon. *Ecological Economics, 32*(1), 109–124.

Daniels, T. (1990). Using LESA in a purchase of development rights program. *Journal of Soil and Water Conservation, 45*(6), 617–621.

Daniels, T. L. (1990). Policies to preserve prime farmland in the U.S.A.: a comment. *Journal of Rural Studies, 6*(3), 331–336.

Daniels, T. L., & Nelson, A. C. (1986). Is Oregon farmland preservation program working. *Journal of the American Planning Association, 52*(1), 22–32.

De Pinto, A., & Nelson, G. C. (2009). Land use change with spatially explicit data: a dynamic approach. *Environmental & Resource Economics, 43*(2), 209–229.

DeMers, M. N. (1988). Policy implications of LESA factor and weight determination in Douglas County, Kansas. *Land Use Policy, 5*(4), 408–418.

Demers, M. N. (1989a). The importance of site assessment in land-use planning – a re-examination of the SCS LESA model. *Applied Geography, 9*(4), 287–303.

Demers, M. N. (1989b). Knowledge acquisition for GIS automation of the SCS LESA model – an empirical-study. *AI Applications in Natural Resource Management, 3*(4), 12–22.

Deng, F. F., & Huang, Y. Q. (2004). Uneven land reform and urban sprawl in China: the case of Beijing. *Progress in Planning, 61*, 211–236.

Doos, B. R. (2002). Population growth and loss of arable land. *Global Environmental Change-Human and Policy Dimensions, 12*(4), 303–311.

Dung, E. J., & Sugumaran, R. (2005). Development of an agricultural land evaluation and site assessment (LESA) decision support tool using remote sensing and geographic information system. *Journal of Soil and Water Conservation, 60*(5), 228–235.

Eric Vittinghoff, S. C. S., Glidden, D. V., & McCulloch, C. E. (2005). *Regression methods in biostatistics linear, logistic, survival, and repeated measures models*. New York: Springer, c2005.

Esparza, A. X., & Carruthers, J. I. (2000). Land use planning and exurbanization in the rural mountain west – evidence from Arizona. *Journal of Planning Education and Research, 20*(1), 23–36.

de Espindola, G. M., de Aguiar, A. P. D., Pebesma, E., Camara, G., & Fonseca, L. (2012). Agricultural land use dynamics in the Brazilian Amazon based on remote sensing and census data. *Applied Geography, 32*(2), 240–252.

Fazal, S. (2000). Urban expansion and loss of agricultural land – a GIS based study of Saharanpur City, India. *Environment and Urbanization, 12*(2), 133–149.

Ferguson, C. A., Bowen, R. L., & Kahn, M. A. (1991). A statewide LESA system for Hawaii. *Journal of Soil and Water Conservation, 46*(4), 263–267.

Firman, T. (2000). Rural to urban land conversion in Indonesia during boom and bust periods. *Land Use Policy, 17*(1), 13–20.

Foster, J. H., & Macconnell, W. (1977). Agricultural land-use change in Massachusetts 1951–1971. *Massachusetts Agricultural Experiment Station Bulletin, 640*, 3–54.

Gao, J., Liu, Y., & Chen, Y. (2006). Land cover changes during agrarian restructuring in Northeast China. *Applied Geography, 26*(3-4), 312–322.

Gellrich, M., Baur, P., & Zimmermann, N. E. (2007). Natural forest regrowth as a proxy variable for agricultural land abandonment in the Swiss mountains: a spatial statistical model based on geophysical and socio-economic variables. *Environmental Modeling & Assessment, 12*(4), 269–278.

Geoghegan, J., Villar, S. C., Klepeis, P., Mendoza, P. M., Ogneva-Himmelberger, Y., Chowdhury, R. R., et al. (2001). Modeling tropical deforestation in the southern Yucatan peninsular region: comparing survey and satellite data. *Agriculture Ecosystems & Environment, 85*(1-3), 25–46.

Hein, S., & Weiskittel, A. (2010). Cutpoint analysis for models with binary outcomes: a case study on branch mortality. *European Journal of Forest Research, 129*(4), 585–590.

Ho, P. (2001). Who owns China's land? Policies, property rights and deliberate institutional ambiguity. *China Quarterly, 166*, 394–421.

Ho, S. P. S., & Lin, G. C. S. (2004a). Converting land to nonagricultural use in China's coastal provinces – evidence from Jiangsu. *Modern China, 30*(1), 81–112.

Ho, S. P. S., & Lin, G. C. S. (2004b). Non-agricultural land use in post-reform China. *China Quarterly, 179*, 758–781.

Hoobler, B. M., Vance, G. F., Hamerlinck, J. D., Munn, L. C., & Hayward, J. A. (2003). Applications of land evaluation and site assessment (LESA) and a geographic information system (GIS) in East Park County, Wyoming. *Journal of Soil and Water Conservation, 58*(2), 105–112.

Hosmer, D. W., Jr., & Lemeshow, S. (2000). *Applied logistic regression*. Hoboken, NJ, USA: Wiley.

Huang, J., Pontius, R. G., Jr., Li, Q., & Zhang, Y. (2012). Use of intensity analysis to link patterns with processes of land change from 1986 to 2007 in a coastal watershed of southeast China. *Applied Geography, 34*(0), 371–384.

Huddleston, J. H., Pease, J. R., Forrest, W. G., Hickerson, H. J., & Langridge, R. W. (1987). Use of agricultural land evaluation and site assessment in Linn County, Oregon, USA. *Environmental Management, 11*(3), 389–405.

Ihlanfeldt, K. R. (2009). Does comprehensive land-use planning improve cities? *Land Economics, 85*(1), 74–86.

Irwin, E. G., & Bockstael, N. E. (2002). Interacting agents, spatial externalities and the evolution of residential land use patterns. *Journal of Economic Geography, 2*(1), 31–54.

Kelly, P. F. (1998). The politics of urban–rural relations: land use conversion in the Philippines. *Environment and Urbanization, 10*(1), 35–54.

Kline, J. D. (2005). Forest and farmland conservation effects of Oregon's (USA) land-use planning program. *Environmental Management, 35*(4), 368–380.

Kline, J. D., & Alig, R. J. (1999). Does land use planning slow the conversion of forest and farm lands? *Growth and Change, 30*(1), 3–22.

Kumar, R., & Indrayan, A. (2011). Receiver operating characteristic (ROC) curve for medical researchers. *Indian Pediatrics, 48*(4), 277–287.
Kurucu, Y., & Chiristina, N. K. (2008). Monitoring the impacts of urbanization and industrialization on the agricultural land and environment of the Torbali, Izmir region, Turkey. *Environmental Monitoring and Assessment, 136*, 289–297.
Lakes, T., Muller, D., & Kruger, C. (2009). Cropland change in southern Romania: a comparison of logistic regressions and artificial neural networks. *Landscape Ecology, 24*(9), 1195–1206.
Leishman, C., & Bramley, G. (2005). A local housing market model with spatial interaction and land-use planning controls. *Environment and Planning A, 37*(9), 1637–1649.
Levia, D. F. (1998). Farmland conversion and residential development in north central Massachusetts. *Land Degradation & Development, 9*(2), 123–130.
Lichtenberg, E., & Ding, C. (2009). Local officials as land developers: urban spatial expansion in China. *Journal of Urban Economics, 66*(1), 57–64.
Lichtenberg, E., & Ding, C. G. (2008). Assessing farmland protection policy in China. *Land Use Policy, 25*(1), 59–68.
Lichtenberg, E., Tra, C., & Hardie, I. (2007). Land use regulation and the provision of open space in suburban residential subdivisions. *Journal of Environmental Economics and Management, 54*(2), 199–213.
Liu, Y. S., Wang, L. J., & Long, H. L. (2008). Spatio-temporal analysis of land-use conversion in the eastern coastal China during 1996–2005. *Journal of Geographical Sciences, 18*(3), 274–282.
Long, H. L., Li, Y. R., Liu, Y. S., Woods, M., & Zou, J. (2012). Accelerated restructuring in rural China fueled by 'increasing vs. decreasing balance' land-use policy for dealing with hollowed villages. *Land Use Policy, 29*(1), 11–22.
Long, H. L., Tang, G. P., Li, X. B., & Heilig, G. K. (2007). Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. *Journal of Environmental Management, 83*(3), 351–364.
Long, H. L., Zou, J., Pykett, J., & Li, Y. R. (2011). Analysis of rural transformation development in China since the turn of the new millennium. *Applied Geography, 31*(3), 1094–1105.
Lubowski, R. N., Plantinga, A. J., & Stavins, R. N. (2008). What drives land-use change in the United States? A national analysis of landowner decisions. *Land Economics, 84*(4), 529–550.
McConnell, V., & Walls, M. (2009). US experience with transferable development rights. *Review of Environmental Economics and Policy, 3*(2), 288–303.
Miller, M. D. (2012). The impacts of Atlanta's urban sprawl on forest cover and fragmentation. *Applied Geography, 34*, 171–179.
Millington, J. D. A., Perry, G. L. W., & Romero-Calcerrada, R. (2007). Regression techniques for examining land use/cover change: a case study of a mediterranean landscape. *Ecosystems, 10*, 562–578.
Mori, H. (1998). Land conversion at the urban fringe: a comparative study of Japan, Britain and the Netherlands. *Urban Studies, 35*(9), 1541–1558.
Mottet, A., Ladet, S., Coque, N., & Gibon, A. (2006). Agricultural land-use change and its drivers in mountain landscapes: a case study in the Pyrenees. *Agriculture Ecosystems & Environment, 114*(2–4), 296–310.
Munroe, D. K., Croissant, C., & York, A. M. (2005). Land use policy and landscape fragmentation in an urbanizing region: assessing the impact of zoning. *Applied Geography, 25*(2), 121–141.
Nellis, L., & Maca, M. N. (1986). The effectiveness of zoning for agricultural lands protection – a case-study from Cache County, Utah. *Landscape and Urban Planning, 13*(1), 45–54.
Nelson, A. C. (1988). An empirical note on how regional urban containment policy influences an interaction between greenbelt and exurban land markets. *Journal of the American Planning Association, 54*(2), 178–184.
Nelson, A. C. (1999). Comparing states with and without growth management – analysis based on indicators with policy implications. *Land Use Policy, 16*(2), 121–127.
Nizeyimana, E. L., Petersen, G. W., Imhoff, M. L., Sinclair, H. R., Waltman, S. W., Reed-Margetan, D. S., et al. (2001). Assessing the impact of land conversion to urban use on soils with different productivity levels in the USA. *Soil Science Society of America Journal, 65*(2), 391–402.
Patarasuk, R., & Binford, M. W. (2012). Longitudinal analysis of the road network development and land-cover change in Lop Buri province, Thailand, 1989–2006. *Applied Geography, 32*(2), 228–239.
Pease, J. R., & Jackson, P. L. (1979). Farmland preservation in Oregon. *Journal of Soil and Water Conservation, 34*(6), 256–259.
Plaut, T. R. (1980). Urban expansion and the loss of farmland in the United States – implications for the future. *American Journal of Agricultural Economics, 62*(3), 537–542.
Polyakov, M., & Zhang, D. (2008). Property tax policy and land-use change. *Land Economics, 84*(3), 396–408.
Saizen, I., Mizuno, K., & Kobayashi, S. (2006). Effects of land-use master plans in the metropolitan fringe of Japan. *Landscape and Urban Planning, 78*(4), 411–421.
Serneels, S., & Lambin, E. F. (2001). Proximate causes of land-use change in Narok District, Kenya: a spatial statistical model. *Agriculture Ecosystems & Environment, 85*(1–3), 65–81.
Seto, K. C., & Kaufmann, R. K. (2003). Modeling the drivers of urban land use change in the Pearl River Delta, China: integrating remote sensing with socioeconomic data. *Land Economics, 79*(1), 106–121.
Seto, K. C., Woodcock, C. E., Song, C., Huang, X., Lu, J., & Kaufmann, R. K. (2002). Monitoring land-use change in the Pearl River Delta using Landsat TM. *International Journal of Remote Sensing, 23*(10), 1985–2004.
Shrestha, M. K., York, A. M., Boone, C. G., & Zhang, S. (2012). Land fragmentation due to rapid urbanization in the Phoenix metropolitan area: analyzing the spatiotemporal patterns and drivers. *Applied Geography, 32*(2), 522–531.
Skinner, M. W., Kuhn, R. G., & Joseph, A. E. (2001). Agricultural land protection in China: a case study of local governance in Zhejiang province. *Land Use Policy, 18*(4), 329–340.
Smith, M. D., & Giraud, D. (2006). Traditional land-use planning regulation and agricultural land conservation: a case study from the USA. *Planning Practice & Research, 21*(4), 407–421.
Sophia, R.-H., & Anders, S. (2008). *Multilevel and longitudinal modeling using Stata* (2nd ed.). StataCorp LP.
Stamm, T., Gill, R., & Page, K. (1987). Agricultural land evaluation and site assessment in Latah County, Idaho, USA. *Environmental Management, 11*(3), 379–388.
Steiner, F. (1987). Agricultural land evaluation and site assessment in the United States – an introduction. *Environmental Management, 11*(3), 375–377.
Steiner, F., Dunford, R., & Dosdall, N. (1987). The use of the agricultural land evaluation and site assessment system in the United States. *Landscape and Urban Planning, 14*(3), 183–199.
Steiner, F. R. (1994). The evolution of land evaluation and site assessment – introduction. In *Decade with LESA: The evolution of land evaluation and site assessment* (pp. 11–19).
Su, S., Jiang, Z., Zhang, Q., & Zhang, Y. (2011). Transformation of agricultural landscapes under rapid urbanization: a threat to sustainability in Hang-Jia-Hu region, China. *Applied Geography, 31*(2), 439–449.
Su, S., Xiao, R., & Zhang, Y. (2012). Multi-scale analysis of spatially varying relationships between agricultural landscape patterns and urbanization using geographically weighted regression. *Applied Geography, 32*(2), 360–375.
Tasser, E., Walde, J., Tappeiner, U., Teutsch, A., & Noggler, W. (2007). Land-use changes and natural reforestation in the Eastern Central Alps. *Agriculture Ecosystems & Environment, 118*(1–4), 115–129.
Tavares, A. O., Pato, R. L., & Magalhães, M. C. (2012). Spatial and temporal land use change and occupation over the last half century in a peri-urban area. *Applied Geography, 34*(0), 432–444.
Thapa, R. B., & Murayama, Y. (2010). Drivers of urban growth in the Kathmandu valley, Nepal: examining the efficacy of the analytic hierarchy process. *Applied Geography, 30*(1), 70–83.
Thorsnes, P. (2000). Internalizing neighborhood externalities: the effect of subdivision size and zoning on residential lot prices. *Journal of Urban Economics, 48*(3), 397–418.
Thorson, J. A. (1997). The effect of zoning on housing construction. *Journal of Housing Economics, 6*(1), 81–91.
Tong, C. L., Hall, C. A. S., & Wang, H. Q. (2003). Land use change in rice, wheat and maize production in China (1961–1998). *Agriculture Ecosystems & Environment, 95*(2-3), 523–536.
Tse, R. Y. C. (2001). Impact of comprehensive development zoning on real estate development in Hong Kong. *Land Use Policy, 18*(4), 321–328.
Tyler, M., Hunter, L., & Steiner, F. (1987). Use of agricultural land evaluation and site assessment in Whitman County, Washington, USA. *Environmental Management, 11*(3), 407–412.
Van Doorn, A. M., & Bakker, M. M. (2007). The destination of arable land in a marginal agricultural landscape in South Portugal: an exploration of land use change determinants. *Landscape Ecology, 22*(7), 1073–1087.
Vance, C., & Geoghegan, J. (2002). Temporal and spatial modelling of tropical deforestation: a survival analysis linking satellite and household survey data. *Agricultural Economics, 27*(3), 317–332.
Veldkamp, A., Verburg, P. H., Kok, K., de Koning, G. H. J., Priess, J., & Bergsma, A. R. (2001). The need for scale sensitive approaches in spatially explicit land use change modeling. *Environmental Modeling & Assessment, 6*(2), 111–121.
Verburg, P. H., Chen, Y. Q., & Veldkamp, T. A. (2000). Spatial explorations of land use change and grain production in China. *Agriculture Ecosystems & Environment, 82*(1–3), 333–354.
Verburg, P. H., Overmars, K. P., Huigen, M. G. A., de Groot, W. T., & Veldkamp, A. (2006). Analysis of the effects of land use change on protected areas in the Philippines. *Applied Geography, 26*(2), 153–173.
Verburg, P. H., Veldkamp, A., & Fresco, L. O. (1999). Simulation of changes in the spatial pattern of land use in China. *Applied Geography, 19*(3), 211–233.
Vermeulen, W., & van Ommeren, J. (2009). Does land use planning shape regional economies? A simultaneous analysis of housing supply, internal migration and local employment growth in the Netherlands. *Journal of Housing Economics, 18*(4), 294–310.
Wang, Y. M., & Scott, S. (2008). Illegal farmland conversion in China's urban periphery: local regime and national transitions. *Urban Geography, 29*(4), 327–347.
Ward, R. M. (1991). The US farmland protection policy act: another case of benign neglect. *Land Use Policy, 8*(1), 63–68.
Weng, Q. H. (2002). Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modelling. *Journal of Environmental Management, 64*(3), 273–284.
Williams, T. H. L. (1985). Implementing LESA on a geographic information-system – a case-study. *Photogrammetric Engineering and Remote Sensing, 51*(12), 1923–1932.
Wooldridge, J. M. (2005). *Introductory econometrics: A modern approach* (3rd ed.). Mason, OH: Thomson/South-Western.
Wright, L. E., Zitzmann, W., Young, K., & Googins, R. (1983). LESA – agricultural land evaluation and site assessment. *Journal of Soil and Water Conservation, 38*(2), 82–86.
Wu, F. L. (2009). Land development, inequality and urban villages in China. *International Journal of Urban and Regional Research, 33*(4), 885–889.

Wu, J., & Cho, S. H. (2007). The effect of local land use regulations on urban development in the Western United States. *Regional Science and Urban Economics, 37*(1), 69–86.
Wu, K.-y., & Zhang, H. (2012). Land use dynamics, built-up land expansion patterns, and driving forces analysis of the fast-growing Hangzhou metropolitan area, eastern China (1978–2008). *Applied Geography, 34*(0), 137–145.
Xiao, J. Y., Shen, Y. J., Ge, J. F., Tateishi, R., Tang, C. Y., Liang, Y. Q., et al. (2006). Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. *Landscape and Urban Planning, 75*(1-2), 69–80.
Xie, Y. C., Yu, M., Bai, Y. F., & Xing, X. R. (2006). Ecological analysis of an emerging urban landscape pattern-desakota: a case study in Suzhou, China. *Landscape Ecology, 21*(8), 1297–1309.
Xu, W. (2004). The changing dynamics of land-use change in rural China: a case study of Yuhang, Zhejiang province. *Environment and Planning A, 36*(9), 1595–1615.
Yeh, A. G. O., & Li, X. (1999). Economic development and agricultural land loss in the Pearl River Delta, China. *Habitat International, 23*(3), 373–390.
York, A. M., & Munroe, D. K. (2010). Urban encroachment, forest regrowth and land-use institutions: does zoning matter? *Land Use Policy, 27*(2), 471–479.
Yu, W., Zang, S., Wu, C., Liu, W., & Na, X. (2011). Analyzing and modeling land use land cover change (LUCC) in the Daqing City, China. *Applied Geography, 31*(2), 600–608.
Zhang, T. W. (2000). Land market forces and government's role in sprawl – the case of China. *Cities, 17*(2), 123–135.
Zhong, T. Y., Huang, X. J., Zhang, X. Y., & Wang, K. (2011). Temporal and spatial variability of agricultural land loss in relation to policy and accessibility in a low hilly region of southeast China. *Land Use Policy, 28*(4), 762–769.
Zhou, B., & Kockelman, K. M. (2008). Neighborhood impacts on land use change: a multinomial logit model of spatial relationships. *Annals of Regional Science, 42*(2), 321–340.