Agricultural Land Development in Lee County, Florida: Impacts of Economic and Natural Risk Factors in a Coastal Area

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, Orlando, Florida, 3-5 February 2013.

Abstract:

Farmland in Florida has undergone extensive conversion into residential and commercial uses. A censored survival model is applied to examine the timing of land use change using parcel-level data from Lee County, 1988-2008. Results suggest that flood and hurricane risks affect conversion timing while controlling for economic and demographic factors.

Keywords: Land use change, flood risk, agricultural land, economic development

Introduction

Farmland is a major resource used in production of food and raw materials for industry and. As land becomes increasingly valuable for economic development, agricultural land is converted to non-farm uses. The conversion is usually faster in coastal areas where urban sprawl is rapidly gobbling up prime agricultural land to meet the pressures of population growth and the increasing demand for development. In the U.S., almost three-quarters of the cropland were converted to other uses in between 1982 and 1997, resulting in a net decline of 43 million acres in cultivated cropland (Lubowski et al, 2006). Over time, urbanization and loss of agricultural land have dominated the land use change.

Frequent extreme weather events in coastal areas have spurred an ongoing discussion about the issues of land use in a watershed (Wagner, 2009). In the last decades, many inundations, which have been aggravated, in several cases, by the intense urbanization of flood prone areas, have occurred in coastal regions causing loss of human lives and financial damages (Brath, 2006). Moreover, the frequency of heavy precipitation has increased for most regions and is expected to continue in the future(Huber 2004; Posthumus , 2009). Destructive damages such as devastation of housing, agricultural production, and other production assets, and disruption of social and economic activities change the land use and land cover in a region. This attracts much discussion on the impacts of natural risks on land conversion and the implementation of related policies in coastal areas. Significant local efforts and federal policies and regulations have been applied to mitigate flood hazards and regulate development in flood-prone areas. Policy instruments (e.g., compensatory payments, hazard subsidies, and catastrophic insurance) are employed to control the land distribution and land conversion.

In the coastal zone, land use change is both a response and a consequence of the natural risks, which have different impacts on the profitability of different land uses . A large number of studies have been conducted during the last decades to identify the drivers of land conversion (Irwin et al., 2001; Ruben et al., 2008). The net return to land use is the major factor that determines the timing of land use change. For example, return on agricultural land traditionally is dependent on the potential value of products which might be affected by productivity and input and output prices.

Unlike industrial production, agricultural yield is largely related to some unexpected factors, such as natural disasters (Parks, 1995). But those disasters, such as floods, are always low-probability, although they have potential large-scale consequences (Bin and Kruse, 2006). In the case of a flood, it is possible that many regions are in a flood hazard zone but the owners have never experienced a flood or experienced a flood in a long time. Because of the lack of flooding experience, it is likely that land owners in floodplains are not aware of or are indifferent to the risk of being in a flood prone area. Imperfect information about natural hazards may cause the land owner to under- or over-estimate the expected losses, which impacts the timing of land conversion.

Various landowners have different perceptions of risk. In a sufficiently low risk zone, intensive development will occur along the coasts gradually, as the land values rise. At the same time, these increasing land values may motivate higher levels of flood protection leading in turn to reduced risk perceptions and further coastal development by the government leading to significant losses of rural land.

Existing studies prefer predicting the effects of land use change according to the climate or environmental change (Dale, 1997). Only some of the literature focuses on the influence of disasters on agricultural land conversion. Bin (2008) develops a study to estimate the effects of flood hazards on coastal housing prices, but fails to consider the agricultural sector. Brath (2006) assesses the impacts on flood frequency of land use change in a river basin, while Tollan (2002) analyses a relationship between flood and land cover.

In this study, we specify the natural risk as flood risk. A theoretical model is specified to show how flood risk on the coast influences the timing of agricultural land conversion. An empirical analysis is then conducted using survival analysis to explore the impacts on land development. The empirical model examines the explanatory variables that influence the time to conversion of agricultural land to developed (residential and commercial) uses. We also compare conversion patterns of cropland, forestland, and rangeland.

Theoretical Framework

Theoretically, an owner of land who is considering converting to a new land use must maximize the net return. This requires two decisions: whether to convert and when to convert. The former emphasizes an individual's choice which is a static process; while the latter focuses on the dynamic aspect. The purpose of this study is to estimate how flood risks in the coastal areas impact agricultural land conversion to residential and commercial uses. We are particularly interested in examining the dynamics of land use change (when to convert) rather than the static process (where to convert). The dynamics involve an individual landowner's optimal timing decision regarding the conversion of a land parcel from cropland, forestland, and rangeland to residential, commercial and service, and industrial uses).

Conversion of parcel *i* from use *j* to use *k* at time *T* is a result of maximizing the present value of net returns from the parcel before and after time *T*:

$$\text{Max} \int_0^T [R_{ijt}(l,s,a,t) - \rho_i L_{ij}] e^{-\delta t}\,\text{dt} + \int_T^\infty [R_{ikt}(l,s,a,t,t) - \rho_i L_{ik}] e^{-\delta t} dt \qquad (2)$$

where the returns from the land before and after conversion time *T*, $R_{ijt}(l,s,a,t)$ and $R_{ikt}(l,s,a,t,T)$, are functions of location (*l*), soil quality (*s*), and site attributes (*a*). $\rho_{ik}L_{ij}$ and $\rho_{ij}\ L_{ik}$ are flood risk effects, where $\rho_i$and ρ_i are the probabilities of flood at location *i* and $L_{ij}$and L_{ik} are the losses from flood in land use *j* or *k* (before and after conversion).

The first order condition with respect to conversion time *T* is:

$$[R_{ijt}(l,s,a,T) - R_{ikt}(l,s,a,T)]e^{-\delta T} + \int_0^\infty \partial[R_{ikt}(l,s,a,t,T) - \rho_i L_{ik}]/\partial T e^{-\delta(t-T)} dt - [\rho_{ij}L_{ij}(l,s,a,T) - \rho_{ik}L_{ik}(l,s,a,T)]e^{-\delta T} = 0 \qquad (3)$$

where first two terms are conditions of simple static allocation model; the third term is discounted value of further changes in net return to use *k;* the forth term is related to flood loss and is positive. Optimization suggests that the impact of flood probability on land conversion depends on the relative in flood risks and losses under alternative land uses (sign of $\rho_{ik}L_{ik}$-$\rho_{ij}L_{ij}$).

A Hazard Model Application of the Timing of Land Conversion

Most of the traditional empirical studies on land conversion decisions prefer using static empirical models. A common approach is to specify the development decision as a discrete choice (Bell 1974; Bockstael and Irwin 2000; Brady and Irwin 2011; R.N. Lubowski 2002).This method provides an insight to explain the probabilities of land conversion from an individual's decision perspective, but fails to account for the dynamic aspect (Bella and Irwin 2002; Irwin, et. al, 2003; Irwin and Geoghegan 2001). In high-developing areas, for example, the more interesting issue is when a parcel is converted rather than whether a parcel is converted. In contrast, duration (survival) models are better able to investigate the timing of the development decision and is increasingly being applied in the land use context(Nickerson 2000; Hite, Sohngen, and Templeton 2003; Irwin and Bockstael 2004; Greenberg et al. 2005). In this study, a duration model is employed to analyze whether flood risk will speed up or slow down the optimal timing of land development. Theoretically, the timing of conversion is treated as a realization of a random process, and the unobservable attributes by a stochastic variable ε_i; the probability of conversion of parcel *i* in period *T* can be expressed as

$$h(t) = \lambda_0(t) exp\left\{[R_{ijt}(l,s,a,T) - R_{ikt}(l,s,a,T)]e^{-\delta T} + \int_0^{\infty} \partial[R_{ikt}(l,s,a,t,T) - \rho_i L_{ik}]/\partial T e^{-\delta(t-T)} dt - [\rho_{ij} L_{ij}(l,s,a,T) - \rho_{ik} L_{ik}(l,s,a,T)]e^{-\delta T}\right\} \quad (4)$$

where $\lambda_0(t)$ is the baseline hazard rate which describes the probability of failure, holding covariates constant, and may or may not vary over time. To solve the interval censored problem (time of land conversion is always only known to occur between two potentially large and irregularly spaced dates, but the actual date of the event is unknown) due to the data restriction, the model is estimated by an interval survival model introduced by Desmarais (2010), where the likelihood of a sample of discrete measured durations conditional on independent variables *X* is:

$$\ln L(\mathrm{t}, \mathrm{X}, \vartheta) = \sum_1^n \left\{\delta_i log \int_t^{t+1} f(z|X,\theta) \mathrm{dz} + (1-\delta_i) log\, S(t|X,\theta)\right\} \quad (5)$$

where $f(\cdot)$ is a probability density function and $S(\cdot)$ is a survival function. δ_i is a right-censoring indicator with 1 if no censoring or 0 if right-censoring.[1]

All of the familiar distributions, such as the Weibull, Exponential, and Log-normal can be implemented within this framework if the specification is correct (Odell, et. al, 1992; Kim, 1997; Betensky, et. la, 2001). But estimation is not as straightforward in the case of the Cox proportional hazards model because the likelihood function is not fully specified. The methods developed to resolve this restriction (Sun et al., 1999; Pan et al., 2002) still have some limitations. Thus, we assume a Weibull distribution in the interval censoring survival model.

Data

To explore the potential effects of flood risk on land conversion timing, we conducted an analysis of parcel-level data on land use change (conversion) in Lee County, Florida, over the

[1] For interval censored models, particularly in the case of piecewise constant hazard specification, the log-likelihood function is different. Here, we provide a general form for illustrative purposes.

period from 1988 to 2008. Lee County is one of the fastest growing counties in Florida that is under a relatively higher risk of natural disasters. The tornado index value in this area is 142.76 (higher than the national level), floods occurred 275 times in the past 60 years[2], and approximately 12,000 parcels are located in the high risk flood zones[3]. Other extreme climactic events, like hurricanes, storms, and hail, are also common in this area.

The data for this analysis consist of 22,170 parcels classified as being in agricultural use in 1988 from two databases: South Florida Water Management District (SFWMD) and Lee County Property Appraiser (LCPA). More information on parcel conversion between 1988 and 2008 was also obtained from the SFWMD (including land cover in 1988, 1995, 2004, and 2008). The LCPA database includes a description and categorization of parcel zoning, size, current use, transition price, and the initial record date.

From the data, urbanization has been predominant over the last decades (Table.1). Of the 14,200 acres that were in agricultural use in 1988, 11,410 acres (80%) have been converted to developed uses by 2008. In 2007, the average size of a farmland parcel was only 91 acres compared to 320 acres in 1987), which is much lower than the national level (418 acres in 2007) as well as the state level (195 acres)[4]. In addition, 89% of forested land and 60% of rangeland were developed by 2008.

[Table 1]

Flood hazard zones and risk are measured by using data from the Federal Emergency Management Agency (FEMA) where the land is specified as Special Flood Hazard Area (SFHA). According to FEMA, SFHAs are defined as areas that will be inundated by a flood event having a 1-percent (0.2-percent) chance of being equaled or exceeded in any given year. The 1-percent (0.2-percent) annual chance flood is also referred to as the base flood or 100-year (500-year) flood. Based on this definition, 664,430 acres of land (73%) outside the floodplain was converted to developed land. 220,390 acres (94%) in the 100-year floodplain and 16,989 acres (91%) in the 500-year floodplain were converted to developed land use by 2008(Table 2).

Empirically, significant land conversion has been observed following an extreme event such as a strong flood. Flooding in the coastal regions of the study area primarily results from hurricanes and tropical storms. Hurricanes passing through this area will produce severe floods as well as structural damage. During the study periods, two big hurricanes fell on the Lee County. The two

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[2] Data sources: http://www.usa.com/lee-county-fl-natural-disasters-extremes.htm

[3] Data source: http://www.cityftmyers.com/Departments/CommunityDevelopment/Divisions/BuildingPermitsInspections/Information/FloodInformation/tabid/265/Default.aspx

[4] Data source: census of agriculture 1987 and 2007, USDA.

largest hurricanes that struck the county were Hurricane Andrew in 1992 and Hurricane Charley in 2004. Both events are incorporated in the model as dummy variables.

[Table 2]

In order to account for the variation in net returns to land at the parcel-level, soil information data were collected from the United States Geological Survey (USGS). Three variables were selected indexing the soil quality to approximate the land profitability. Land Capability Class (*LCC*) of the parcel is a summary measure of the suitability of the land for agricultural production. In general, *LCC* is classified in eight grades, with higher LCC ratings indicating poorer soils for crop production. Farmland Classification (*FC*) identifies land as prime farmland, farmland of statewide importance, or farmland of local importance. Drainage Class (*DC*) identifies the natural drainage conditions of the soil and refers to the frequency and duration of wet periods.

A number of parcel attributes that are time invariant were identified by the GIS data from the Florida Geographic Data Library (*FGDL*). Parcels are expected to have more development potential when they are closer to cities and schools, main roads, and beaches. Proximity to water bodies has two impacts on property values: positive from amenity view and negative from higher flood risk. Parcels of small size also are expected to be developed sooner.

In the analysis, we also control for demographic and economic characteristics locational attributes. Population density, housing price index (HPI), and interest rate (INTEREST) data are collected from the U.S. Census Bureau in a GIS format at the tract scale. The first two variables are expected to have speed up land conversion from agricultural to developed uses. Table 3 defines the variables used in the empirical model and provides summary statistics (in log form).

[Table 3]

Results

The model in equation 5 is estimated using annual parcel data from 1988 to 2008 broken into four intervals. All the parcels in the sample were in agricultural use in 1988; they may or may not have been converted by 2008. Table 4 presents the empirical results from the estimation of land conversion in the study area. Negative coefficients represent factors/variables associated with earlier land conversion, while positive coefficients indicate variables associated with later conversion. In Model 1, hazard ratios are estimated using a parametric model, Cox proportional model, and Interval Censoring survival model respectively. Model 2 incorporates the two extreme events as dummy variables (*YEAR92* and *YEAR04*). The interaction terms between the floodplain variable (*FLOOD100* or *FLOO500*) and event year (*YEAR92 or YEAR04*) are interpreted as how the flood risk affected the timing of conversion in the 100-year and the 500-year floodplain after the 1992 flood and 2004 floods. Model 3 replaces the dummy variable of event year by a time trend variable (*LASTYEAR92*). *LASTYEAR92* is a time trend that describes the number of years after the 1992 flood. The interaction term estimates how the risk premium changed over time after the 1992 flood.

[Table 4]

Flood risks, the factors we are particularly interested in, are found to slow down the land transition in 100-year floodplain, but speed up the time in 500-year floodplain, which is consistent with the analysis of Equation 3. The sign of flood risk relies on the relative expected loss caused by flooding. A negative sign of the coefficient at the 100-years floodplain variable means that higher flood risk postpones land conversion to developed uses, which implies that the flood risk impacts before conversion (cropland) are smaller than after conversion (developed land). The expected loss from the flood hazard in the higher risk areas depreciates the land value of developed parcels more than the value of cropland which slows down the conversion. Studies suggest that natural disasters depreciate the value of property (Tollan 2002; Brath, Montanari, and Moretti 2006; Okmyung Bin et al. 2008; Tollan 2002) as well as have a negative impact on agricultural production (Chmielewski and Potts 1995; Tiongco and Dawe 2002; Chen and Chang 2005). In this case, the flood risk accelerating or postponing the time of cropland conversion is determined by the relative net values of property facing flood risk.

In Model 3, the signs of the two event dummy variables (*YEAR92 AND YEAR04*) are positive, suggesting land earlier conversion after a strong flood event. The interaction terms (*F100Y92, F100Y04*, *F500Y92 and F500Y04*) between the floodplain designation and event year have positive positive signs indicating the flood risk might accelerate conversion of lands that are in the floodplain after the 1992 flood or the 2004 flood. The time trend (*LASTYEAR92*) in model 3 is predicted to have a negative impact on land conversion, which suggests the effects from big events decrease gradually as time passed. The interaction terms of 100- and 500-year floodplain and *LASTYEAR92* (*F100YL92* and *F500YL92*) are positive and negative, respectively, showing the different impacts on land conversion in more and less risky areas following a major hurricane event. However, these do not offset the much larger impacts of flood risk (*FLOOD500*) on the timing of conversion.

Soil quality largely determines agricultural productivity and returns on farmland: higher soil quality slows down farmland conversion. Parcel location significantly influences the land conversion: parcels closer to some particular sites, e.g., city centers, roads, schools and beaches, are expected to have higher value in development and are associated with earlier conversion. In particular, distance to main roads and cities has negative and significant impacts on the timing of land development. These results are consistent with previous studies (Irwin and Bockstael, 2002, 2004; Hite et al., 2002). Similarly, parcels located near beaches are converted sooner, consistent with previous studies confirming that the amenity appreciates the value of the property (Batty 2001; Germino et al. 2001; Llobera 2003; Paterson and Boyle 2002). Similarly, parcels near water bodies are also predicted to be positively correlated with land conversion, suggesting increased value from amenity views can compensate expected loss from higher flood risks.

As expected, population density is found to have a positive influence on land conversion (the hazard ratio), since population growth is always considered an endogenous factor affecting development of rural lands and transition (Meyer and Turner 1992; Polyakov and Zhang, 2008). Housing price index and long term interest rates are found to affect hazard ratio in opposite directions. House price index has a significantly positive effect, since a higher house price in the area increases the value of land in development. Long term interest rates negatively affect the time of conversion since higher interest rates discourage investment.

[Table 5]

Insurance rates, as the most important form of compensation, may significantly impact land conversion in coastal areas. Assuming that higher insurance rates are associated with larger coverage, we expect a negative association between them and conversion timing. Table 5 represents the risk effect on timing of agricultural land conversion in areas with different levels of insurance rate. Flood risks do not significantly impact the time of land conversion in lower insurance rate areas. In contrast, in higher insurance rate areas, the conversion time is slowed by higher flood risk (*FLOOD100*) but accelerated by lower flood risk (*FLOOD500),* which is consistent with the pooled data model. But the positive impacts are slightly smaller NOT IN THE TABLE. This suggests that (presumably) higher insurance coverage encourage conversion in in the lower flood risk areas (*FLOOD500*) but still cannot match the large damages in the higher risk districts (*FLOOD100*).

In addition to cropland conversion, we are also interested in the impacts of flood risk on other rural lands, such as forest land and rangeland. Table 6 shows the results of preliminary analysis of forest land and rangeland databases. The findings are slightly different from the analysis of agricultural land conversion. Given the higher risk level (*FLOOD100*), flood risk postponed the time of conversion of forest land but sped up conversion of the rangeland. The impacts are inversed in the lower flood risk areas (*FLOOD500*). Unlike agricultural land and forestland, rangeland is more likely to convert earlier, possibly because of relatively low returns which outweigh the higher expected losses in developed uses.

[Table 6]

Conclusion

This paper explores how natural hazards affect the timing of land use change decisions in a coastal area in Florida (Lee county).

A theoretical model suggests that flood risks can have positive or negative impacts on the timing of land conversion from agricultural uses to development. An empirical model is developed to investigate the influence of uncertain hazards on farm land conversion. By incorporating the landscape attributes and macro-economic features, a hypothesis formulated that the uncertain natural risk significantly affects farm land conversion. Empirical evidence of flood risk that influenced the timing and pattern of agricultural land development is provided. Controlling for other variables, flood risk accelerates farmland conversion in low risk areas but slows it down in high risk areas. This also implies that loss in developed land is more elastic to higher flood risk while loss in agricultural land is more elastic to lower flood risk.

Empirical analysis also shows that insurance rates have heterogeneous influences on conversion timing: flood risks have larger impacts on conversion time in high insurance rate regions but insignificant impacts in low insurance rate regions which may have policy implications.

These results are preliminary and limited by potential problems of econometric identification. The issues of endogeneity between flood risk and land conversion may violate consistency of the results. Censoring data, as an everlasting problem in the duration analysis, may also lead to biases. Several assumptions and model specification itself need further work.

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Table 1. Land transition matrix by area, Lee County, 1988-2008

	Area change (100 acres)							Percentage change (%)					
	C	**F**	**R**	**D**	**O**	**Total**	**Share (%)**	**C**	**F**	**R**	**D**	**O**	**Total**
C	18.4	3.0	6.4	114.1	0.4	142	3.3	12.9	2.1	4.5	80.2	0.3	100
F	1.8	8.3	3.6	129.5	1.1	144	3.3	1.2	5.8	2.5	89.8	0.7	100
R	1.5	1.8	4.7	13.1	0.7	22	0.5	6.7	8.4	21.7	60.2	3.0	100
D	6.6	90.3	193.0	643.2	5.9	939	21.6	0.7	9.6	20.6	68.5	0.6	100
O	20.1	17.3	19.6	3022.9	11.5	309	71.2	0.7	0.6	0.6	97.8	0.4	100

Note: C is crop land; F is forestland; R is rangeland; D is developed land; O is other land.

Table 2. Land conversion by flood zone: Lee County, FL, 1988-2008

	Area change (100 acres)			
	Developed	**%**	**Undeveloped**	**%**
OUTSIDE FLOODPLAIN	6644.3	73	2403.1	27
100-YEAR FLOODPLAIN	2203.9	94	149.38	6
500-YEAR FLOODPLAIN	169.89	91	17.108	9

Table 3. Variables definition and statistics used in the analysis (logarithmic)

	Definition	Mean	S.D
FLOOD100	parcel in 100-year flood zone	0.26	0.44
FLOOD500	parcel in 500-year flood zone	0.02	0.14
LCC	Capability Class: 1-8 (class 1 has the least limitations/highest capability, and class 8 has the greatest limitations/lowest capability)	4.01	1.02
DC	Drainage Class:1-3 (lower class with higher drainage conditions)	2.06	0.33
FC	Farmland Classification:1-3(lower class is more suited to use as prime farmland)	1.51	0.71
DS_ROAD	Distance to the nearest road (foot)	6.87	1.16
DS_BEACH	Distance to the nearest beach (foot)	11.00	0.56
DS_CITY	Distance to the nearest city (foot)	9.56	0.71
DS_SCHOL	Distance to the nearest school (foot)	8.51	0.88
DS_WATEBY	Distance to the nearest water body (foot)	6.41	1.01
DENSITY	Population density (by tract)	-8.72	1.24
LOTSIZ	Size of parcel (m^2)	6.86	1.01
HPI	House price index (1980=1)	241.7	107.8
INTEREST	Long-run interest rate (5 year average)	8.91	0.49

Table 4.Estimation results for agricultural land conversion (hazard rate)

	Model 1			Model 2	Model 3
VARIABLES	Parametric	Cox	Interval censoring		
Flooding risks					
FLOOD100	-0.0565***	-0.048***	-0.0591***	-0.182***	-0.218***
	(0.0130)	(0.0129)	(0.0170)	(0.0220)	(0.0241)
FLOOD500	0.0205	0.0551	0.129**	0.152***	0.148***
	(0.0450)	(0.0450)	(0.0626)	(0.0436)	(0.0518)
YEAR04				0.739***	
				(0.0211)	
YEAR92				0.421***	
				(0.0133)	
F100Y92				0.135***	
				(0.0231)	
F500Y92				-1.406***	
				(0.216)	
F100Y04				0.286***	
				(0.0301)	
F500Y04				1.465***	
				(0.214)	
LASTYEAR92					-0.0167***
					(0.00255)
F100YL92					0.0226***
					(0.00225)
F500YL92					-0.0381***
					(0.00543)
Soil qualities					
LCC	0.0447***	0.0493***		0.0391***	0.0415***
	(0.0107)	(0.0105)		(0.0107)	(0.0107)
DC	-0.292***	-0.306***	-0.326***	-0.289***	-0.298***
	(0.0267)	(0.0260)	(0.0296)	(0.0274)	(0.0274)
FC	0.150***	0.146***	0.169***	0.155***	0.154***
	(0.0108)	(0.0107)	(0.0131)	(0.0108)	(0.0108)
Location variables					
DS_ROAD	-0.0182***	-0.023***	-0.0854***	-0.017***	-0.0173***
	(0.00544)	(0.00532)	(0.00678)	(0.00545)	(0.00546)
DS_BEACH	-3.284***	-0.140***	-0.603***	-3.728***	-3.453***
	(0.441)	(0.0146)	(0.0179)	(0.456)	(0.451)
DS_BEACHSQ	0.144***			0.164***	0.151***
	(0.0202)			(0.0209)	(0.0207)
DS_CITY	0.0841***	0.0590***	-0.231***	0.0793***	0.0812***
	(0.0103)	(0.00966)	(0.0122)	(0.0105)	(0.0105)
DS_CITYSQ	-0.066***	0.0787***	0.0783***	-0.058***	-0.0595***
	(0.0018)	(0.0116)	(0.0116)	(0.0117)	(0.0018)
DS_SCHOL	-0.0328***	-0.023***	-0.103***	-0.038***	-0.0359***

	(0.00758)	(0.00764)	(0.00964)	(0.00778)	(0.00771)
DS_WATERBODY	-0.205***	-0.209***	-0.246***	-0.202***	-0.204***
	(0.00664)	(0.00660)	(0.00859)	(0.00667)	(0.00663)
Demography and economic variables					
DENSITY	0.0211***	0.0204***	-0.324***	0.0207***	0.0213***
	(0.00660)	(0.00665)	(0.00948)	(0.00656)	(0.00659)
LOTSIZ	0.0430***	0.0562***	-0.0524***	0.0452***	0.0433***
	(0.00827)	(0.00788)	(0.00872)	(0.00826)	(0.00828)
HPI	0.00536***	0.0214			0.00574***
	(9.58e-05)	(0)			(0.000158)
INTEREST	-0.139***	-0.101			
	(0.0337)	(0)			
Constant	14.72***		2.132***	19.39***	16.98***
	(2.368)		(0.207)	(2.450)	(2.419)
Observations	28,018	28,018	28,018	28,018	28,018

Robust standard errors in parentheses;*** p<0.01, ** p<0.05, * p<0.1

Table 5. Estimation results for agricultural land conversion by different insurance rates

	All observation	Lower insurance rate	Higher insurance rate
FLOOD100	-0.172***	0.266	-0.127**
	(0.0217)	(0.356)	(0.0624)
FLOOD500	0.169***		0.449***
	(0.0429)		(0.0450)
YEAR92	-0.118***	0.102	-0.0588***
	(0.0176)	(0.342)	(0.0198)
F100Y92	0.189***	-0.0924	0.155**
	(0.0224)	(0.343)	(0.0669)
F500Y92	-0.597***		-0.797***
	(0.0597)		(0.0581)
CONSTANT	15.71***	20.09***	-7.665
	(2.396)	(4.850)	(5.467)
OBSERVATIONS	28,018	7,060	20,958

Note: Other control variables are similar to those in table 4. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 6. Estimation results for land development for different types of rural land

	Cropland		Forestland		Rangeland	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
FLOOD100	-0.18***	-0.218***	-0.11***	-0.063***	0.583***	0.613***
	(0.0220)	(0.0241)	(0.0200)	(0.0208)	(0.0396)	(0.0427)
FLOOD500	0.152***	0.148***	-0.063**	0.0269	1.434***	1.176*
	(0.0436)	(0.0518)	(0.0323)	(0.0328)	(0.492)	(0.622)
YEAR04	0.739***		1.322***		1.969***	
	(0.0211)		(0.0181)		(0.0445)	
YEAR94	0.421***		0.147***		-0.21***	
	(0.0133)		(0.0186)		(0.0462)	
F100Y94	0.135***		0.227***		0.389***	
	(0.0231)		(0.0257)		(0.115)	
F500Y94	-1.41***		0.142***		-13.6***	
	(0.216)		(0.0391)		(0.409)	
F100Y04	0.286***		-0.40***		-1.23***	
	(0.0301)		(0.0305)		(0.161)	
F500Y04	1.465***		-1.20***		13.19***	
	(0.214)		(0.108)		(0.502)	
LASTYEAR94		-0.017***		-0.068***		-0.21***
		(0.00255)		(0.00291)		(0.00925)
F100YL94		0.0226***		0.00282		-0.0181*
		(0.00225)		(0.00224)		(0.00989)
F500YL94		-0.038***		-0.022***		-0.0354
		(0.00543)		(0.00436)		(0.0465)
Constant	19.39***	16.98***	-4.521***	-5.456***	190.7***	209.4***
	(2.450)	(2.419)	(1.627)	(1.598)	(22.52)	(21.65)
Observations	28,018	28,018	25,030	25,030		

Note: Other control variables are similar to those in table 4. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1