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Exploration spatial analysis of factors influencing farmland conversion in Tainan, Taiwan

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Outline

- Issues Identified

- Current status in Taiwan

- Farmland Conversion

- Study area & Methodology

- Result

- Conclusion

Issue Identified

✓ Global environmental change

Food price

Food production

By 2050
Population=9.1 billion,
34 percent higher than today

http://www.telegraph.co.uk/news/politics/2967374/England-is-most-crowded-country-in-Europe.html
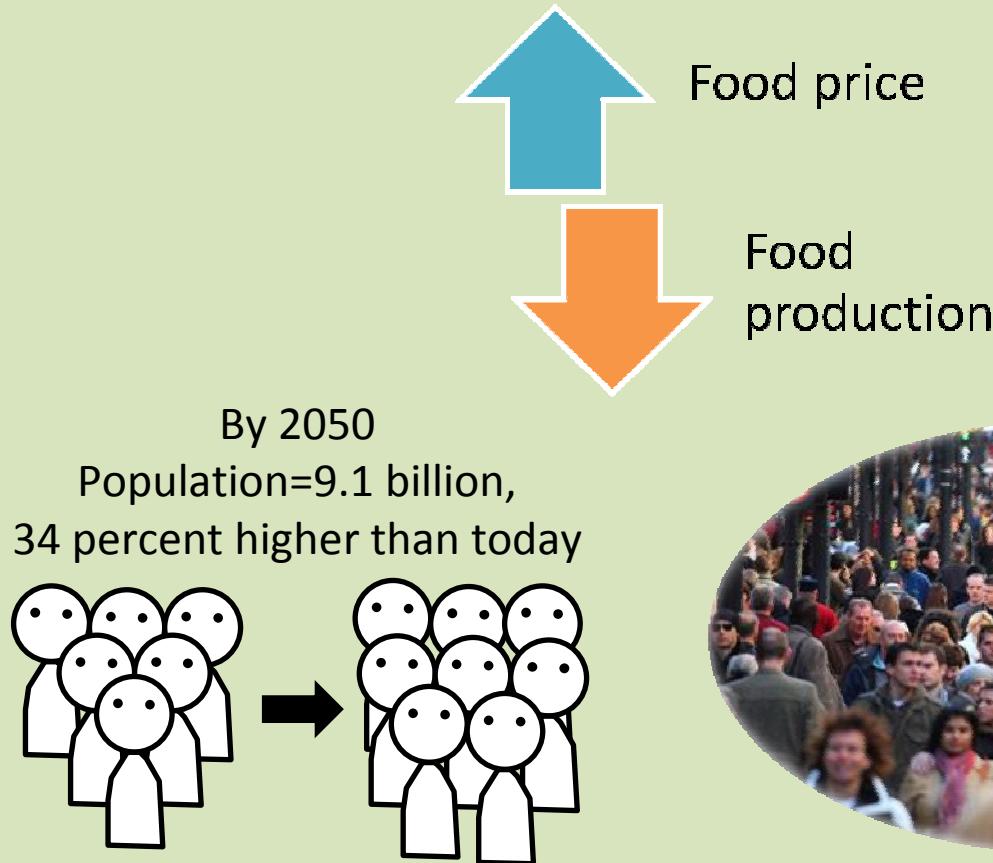
✓ Food production must increase by 70 percent. Annual cereal production will need to rise to about 3 billion tonnes from 2.1 billion today.

Issue Identified

✓The rate of growth in yields of the major cereal crops has been steadily declining, it dropped from 3.2 percent per year in 1960 to 1.5 percent in 2000.

✓Many countries will continue depending on international trade to ensure their food security.

✓**Causing the attention to demand and provision of food.**
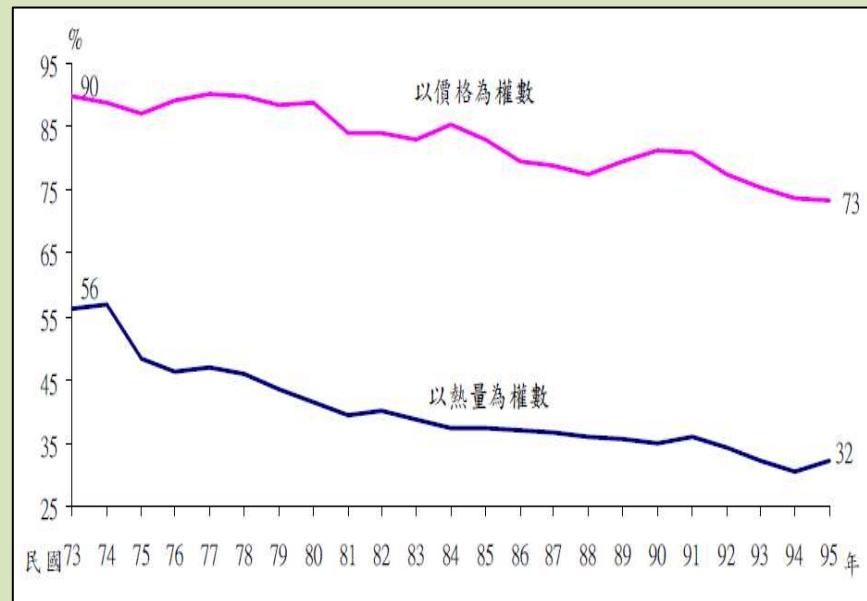
The decline of grain self-sufficient ratio in Taiwan(1984~2006)

✓ Food provisions depend on farmland resource.

Issue Identified

✓ 1998 ~2009: farmland area in Taiwan had decrease 43295.72 hectare.

✓ Issues of farmland conversion and superior farmland loss.

✓ The farmland area in Tainan county is the most in Taiwan, that makes Tainan area play a significant role in food provisions in Taiwan.

http://www.cuisineonline.pk/articles/news/food-security-needs-to-be-addressed-on-priority-president/

Issue Identified

- ✓ The land is limited by geography in Taiwan thus the importance of farmland resource is obvious.
- ✓ Total farmland area :1 billion →0.82 billion hectares


Agriculture use   **Industrial or commercial use**
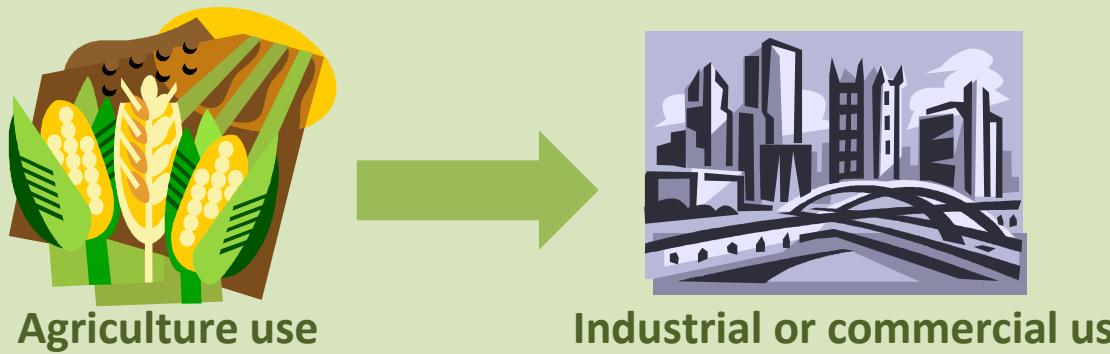
- ✓ **Private landowning**
    - ✓ The farmland policies had untied the restriction on farmland trades leading a more directly spatial transition of farmland.
- ✓ This study tries to examine the factors influencing farmland conversion and the impact level of related policies using GIS, Patch analyst and linear regression.

Current status in Tainan, Taiwan

- ✓ Farmland ecological footprint in Taiwan in 2004 gave 2.137 global hectares per person (Chen Chin-Tzu and Lee Yung-Jaan, 2007).

- ✓ Compared with average of high-income countries, the overshoot is 1.037 hectares.

- ✓ →**Demand of farmland is more than we thought we have and the natural resources we consumed have gone beyond its capacity.**

- ✓ The farmland area now in Taiwan is around 815 thousand hectares and the ratio between dry farmland and paddy field hasn't changed much.
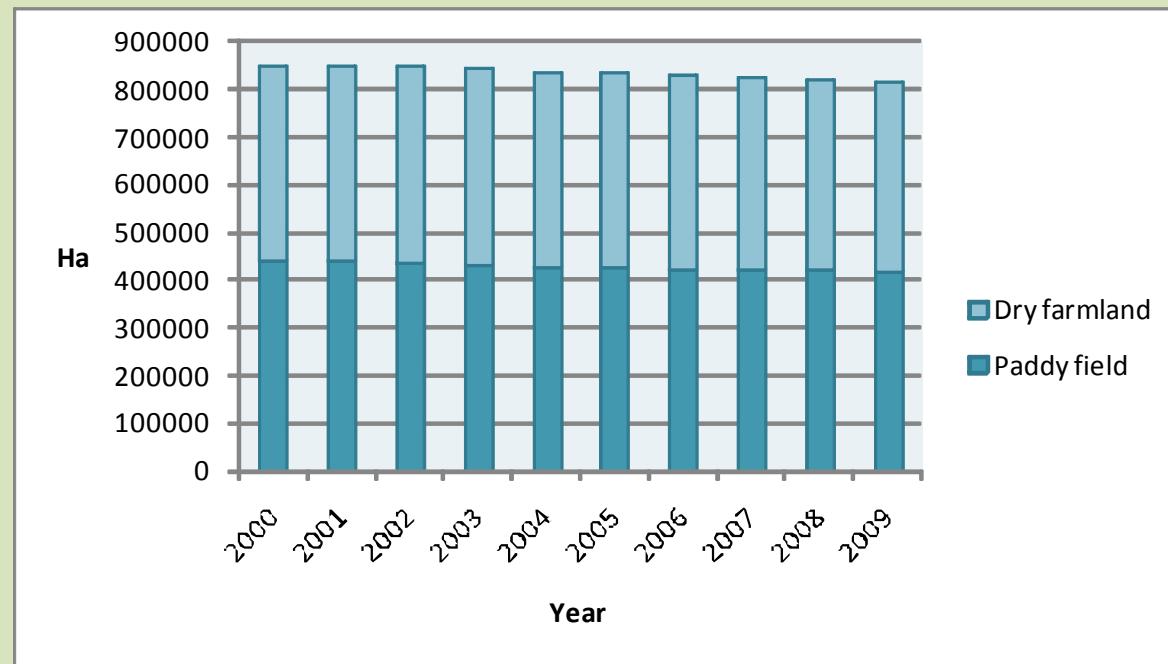
Dry farmland and Paddy field area from 2000 through 2009 in Taiwan.

Current status in Tainan, Taiwan
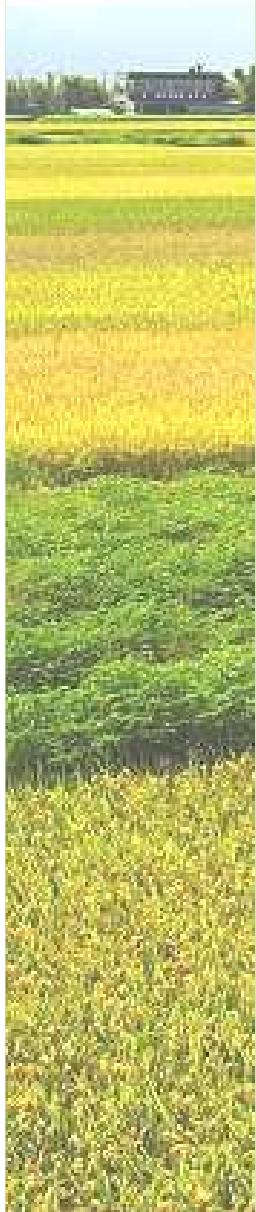
✓In the context of farmland kept decreasing, the productivity of farmland had been higher than the world average productivity in the last ten years.
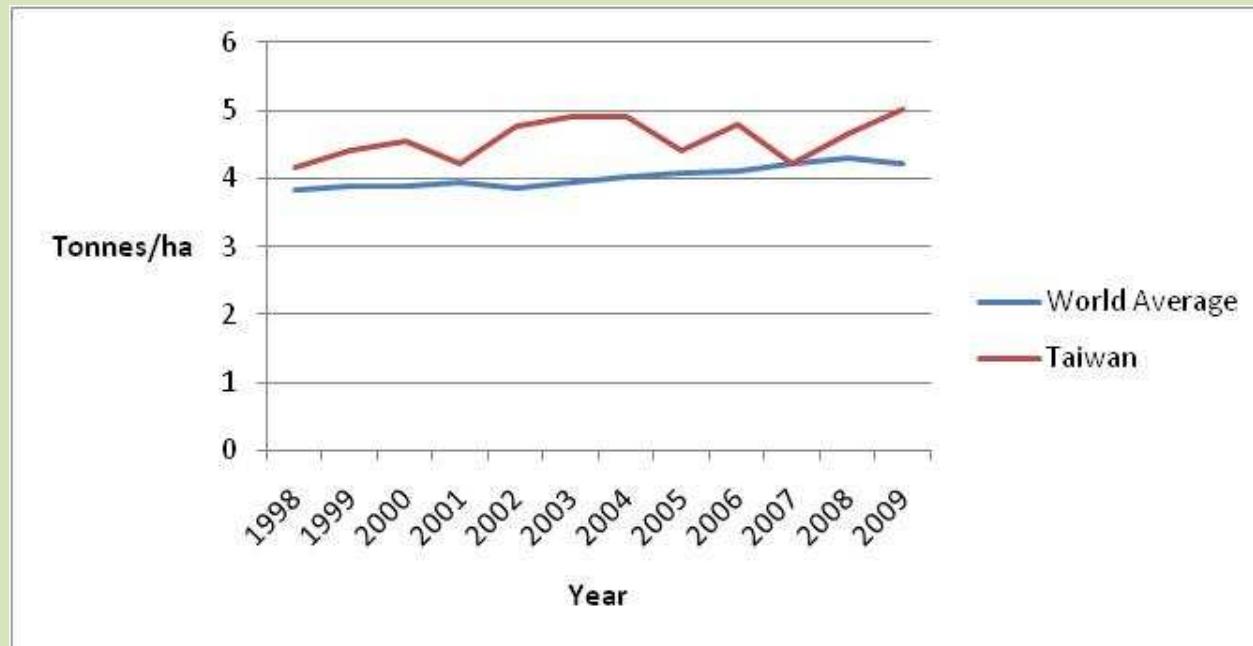
Comparison of farmland (Rice) productivity between the world and Taiwan from 1998 through 2009.

Farmland Conversion

✓ **Most trade of farmland located outside urban fringe or along the artery**.

✓ Urbanization and traffic accessibility had became the main factor of the farmhouse location.

✓ From 1995 through 2003, 8 years practice of Farmland Releasing Policy, farmland had released 38 thousand hectares.

① First part
  ✓Main purposes were the urban expansion plans and new non-urban plans.
② Second
 ✓Public constructions such as freeway. The other part was self-sponsored
  ✓Residential mainly.
③ Recent years
  ✓Social welfare, waste disposal and gas station use piecemeal.
  ✓Taking little ration of released farmland but fragmental spatially.

Farmland Conversion

✓The reasons why the issue of farmland conversion being emphasized
   ✓Conflict between farmland and habitat,
   ✓Economic growth bringing the demand of industrial land
   ✓ Level of knowledge raises
✓**Farmland conversion becomes fragmental**
   ✓A loss of sufficient farm support operations and facilities = raise operating costs. Farming such scattered plots is problematic.
   ✓For example, field surveillance to monitor crop growth.
   ✓Under these conditions consolidation of landholdings to achieve efficient scales of operation is nearly impossible (Elizabeth Brabec,2002).
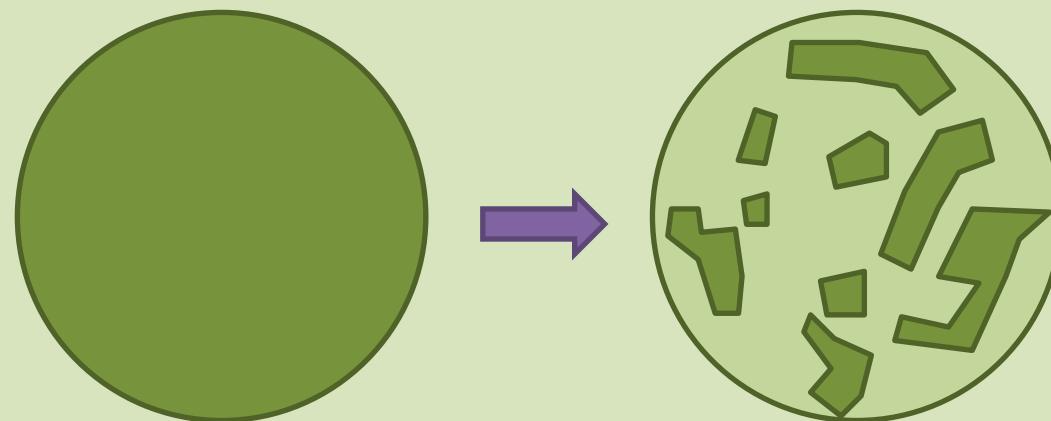
Farmland Releasing Policy (1995~2003) in Taiwan

- ✓ The impact from free trade in 1980s and the great demand of residential and industrial land in the circumstance trying decreasing the development on hillside.

- ✓ Location of releasing region in Farmland Releasing Policy and the land industrial or commercial use needed were very different.

Promote efficiency and to distribute national land resource in equity

Protect integrity of agricultural environment to ensure the function of production, living and ecology

Answer social justice in sharing the benefit of land.

Policy goals
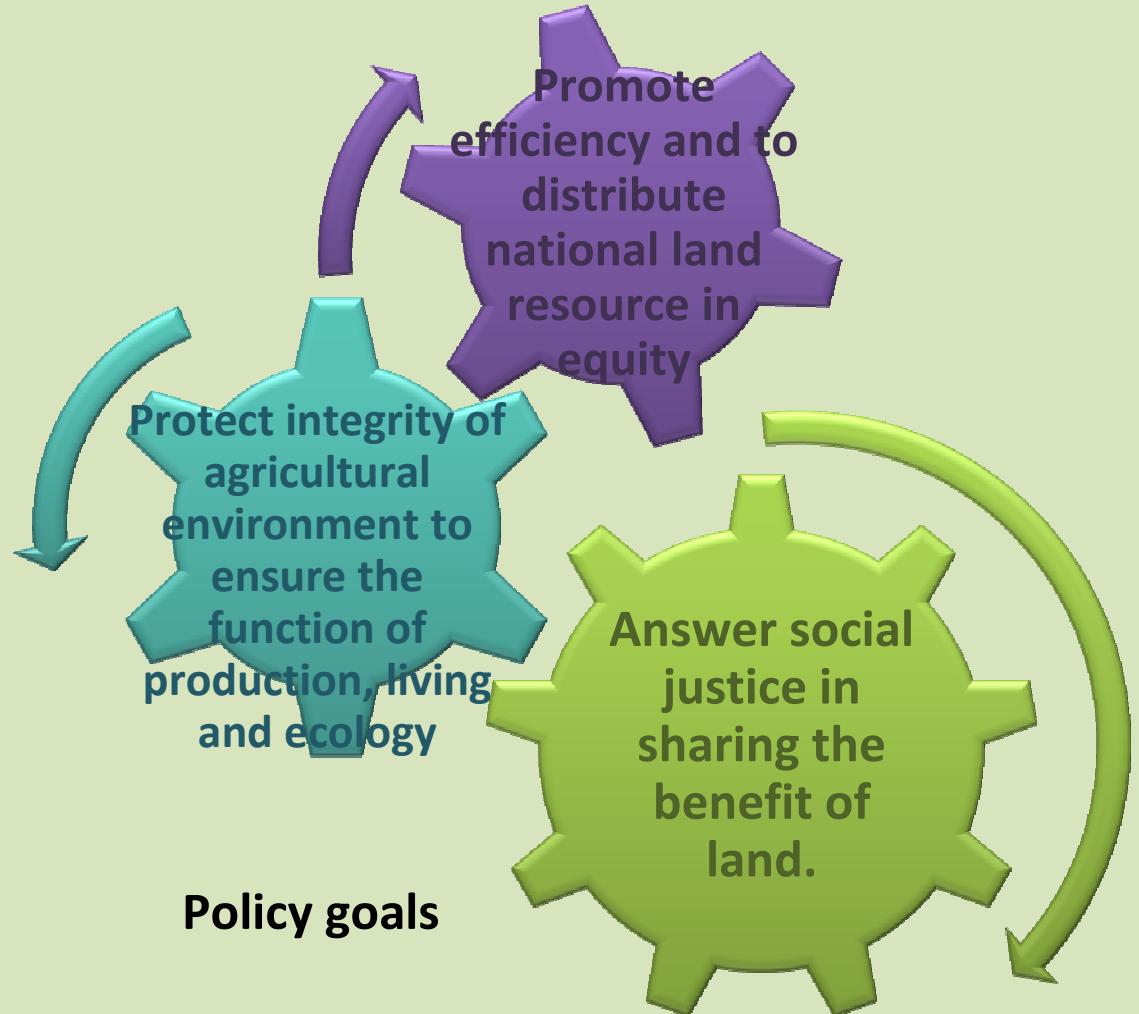
Study area

Tainan County
- ✓ Southwest part of the island .
- ✓ Warm climate
- ✓ Average density of 547.79 persons/km.
- ✓ Total area 2016 km^2.
- ✓ Amount of rice production taking 10% in Taiwan.

1995

2006

Farmland Conversion

Farmland conversion location in Tainan county.
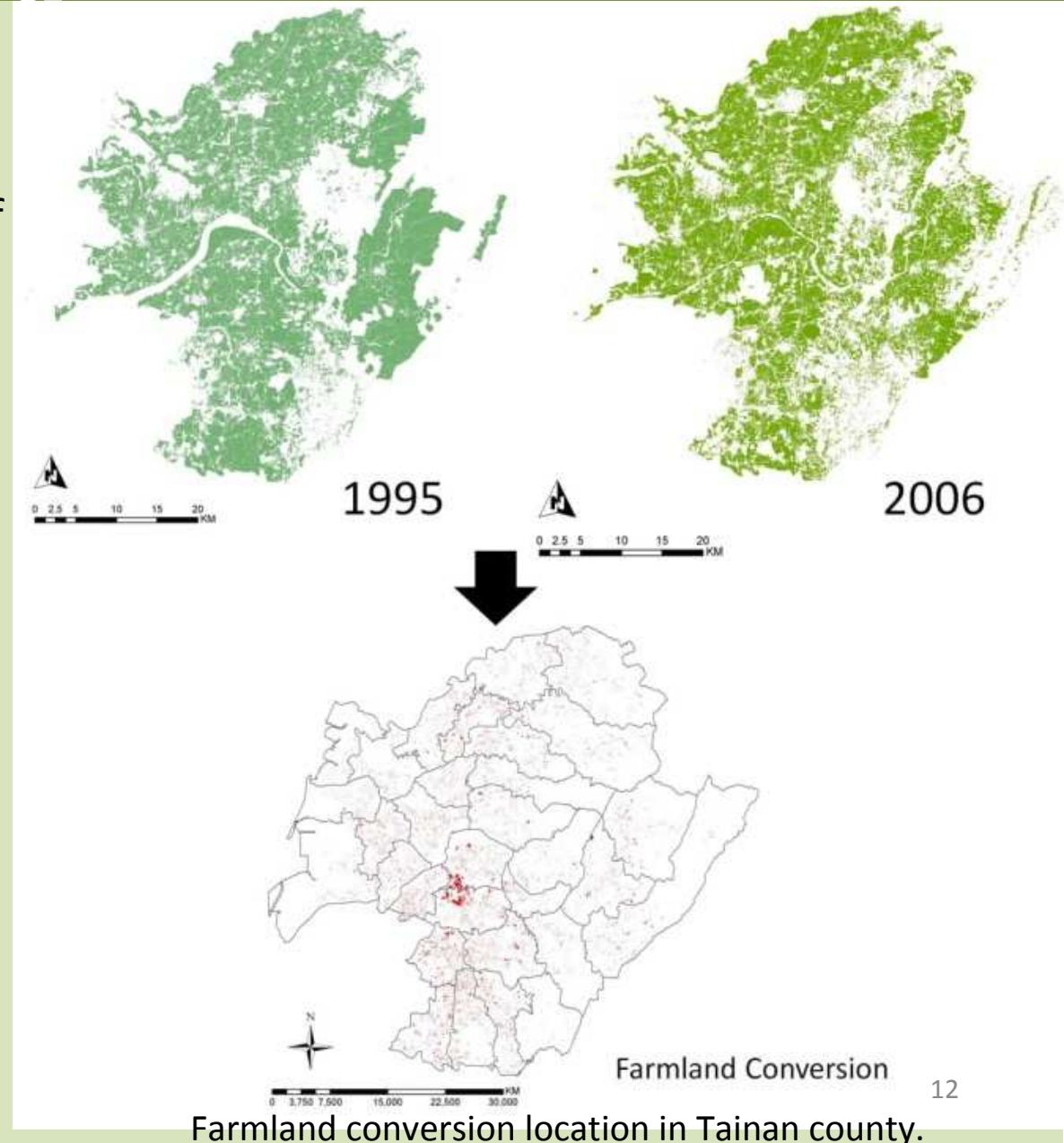
Methodology—Patch analyst

✓ **Function**

   ✓ An extension to ArcGIS

   ✓ Facilitates the spatial analysis of landscape patches and the modeling of attributes associated with patches.

   ✓ This study used Patch Analyst to calculate related farmland attributes in 1995 and 2006 such as Mean Shape Index(MSI), Mean Patch Fractal Dimension(MPFD), Mean Patch Size(MPS) and Number of Patches(NumP).

Methodology— Patch analyst

✓ **Mean Shape Index(MSI)**

    ✓ Indicates the change of farmland shape.

    ✓ The shape is more regular(round or square)when MSI is closer to 1. The more irregular the shape is , the more ecological benefit and interaction between surrounding and species have(Chen-Fa Wu, 2006).

✓ **Mean Patch Fractal Dimension(MPFD)**

✓ Measures characteristic of farmland shape. MPFD is between 1and 2 . The larger the MPFD is, the more irregular the farmland shape is and the ecological marginal benefit is larger, too.

$$MSI = \frac{\sum_{i=1}^{n}\left(\frac{0.25 p_i}{\sqrt{a_i}}\right)}{n_i} \qquad MPFD = \frac{\sum_{i=1}^{n}\left(\frac{2\ln(0.25) p_i}{\ln a_i}\right)}{n_i}$$

a_i :Farmland area for i(m²),
n_i :Number of farmland for i
p_i :is the farmland perimeter for i (m).

The farmland shape was more irregular in 2006 and the ecological benefit and interaction between surrounding and species had decreased.
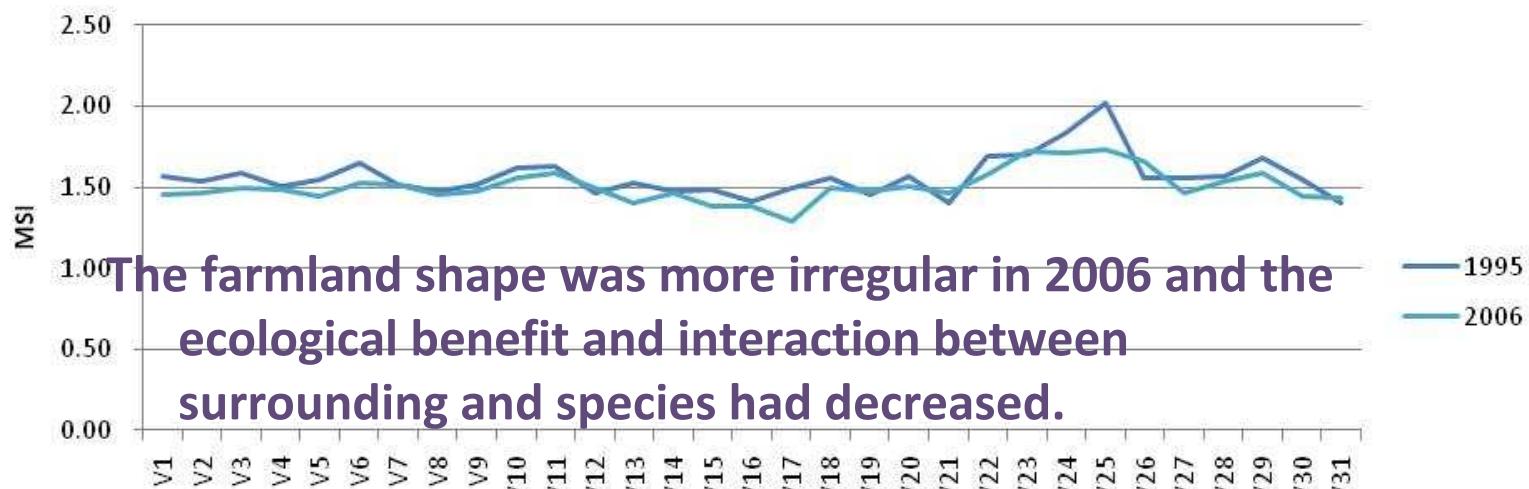
Comparison of MSI between 1995 and 2006 in Tainan county.
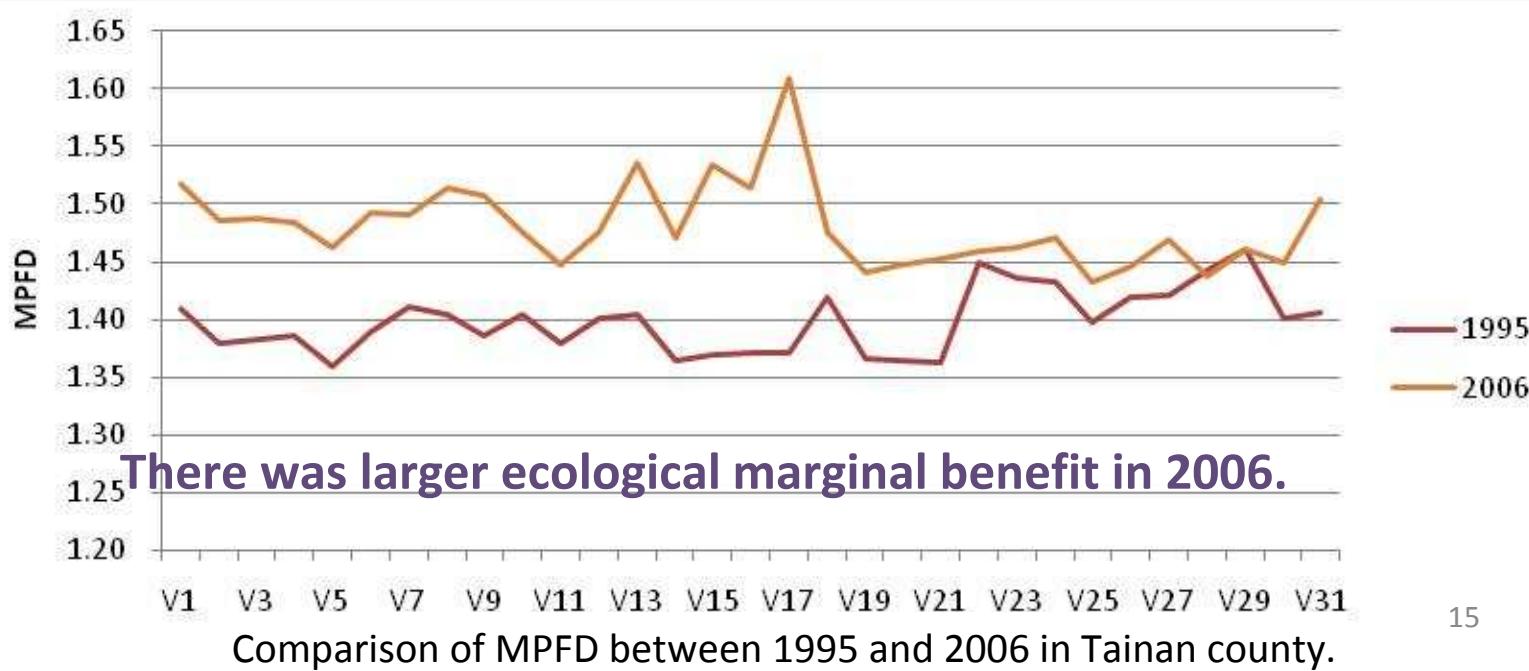
There was larger ecological marginal benefit in 2006.

Comparison of MPFD between 1995 and 2006 in Tainan county.

15

**Average size of farmland became smaller while the number of farmland patches increased.**


Comparison of MPS between 1995 and 2006 in Tainan county.

Comparison of NumP between 1995 and 2006 in Tainan county.

16
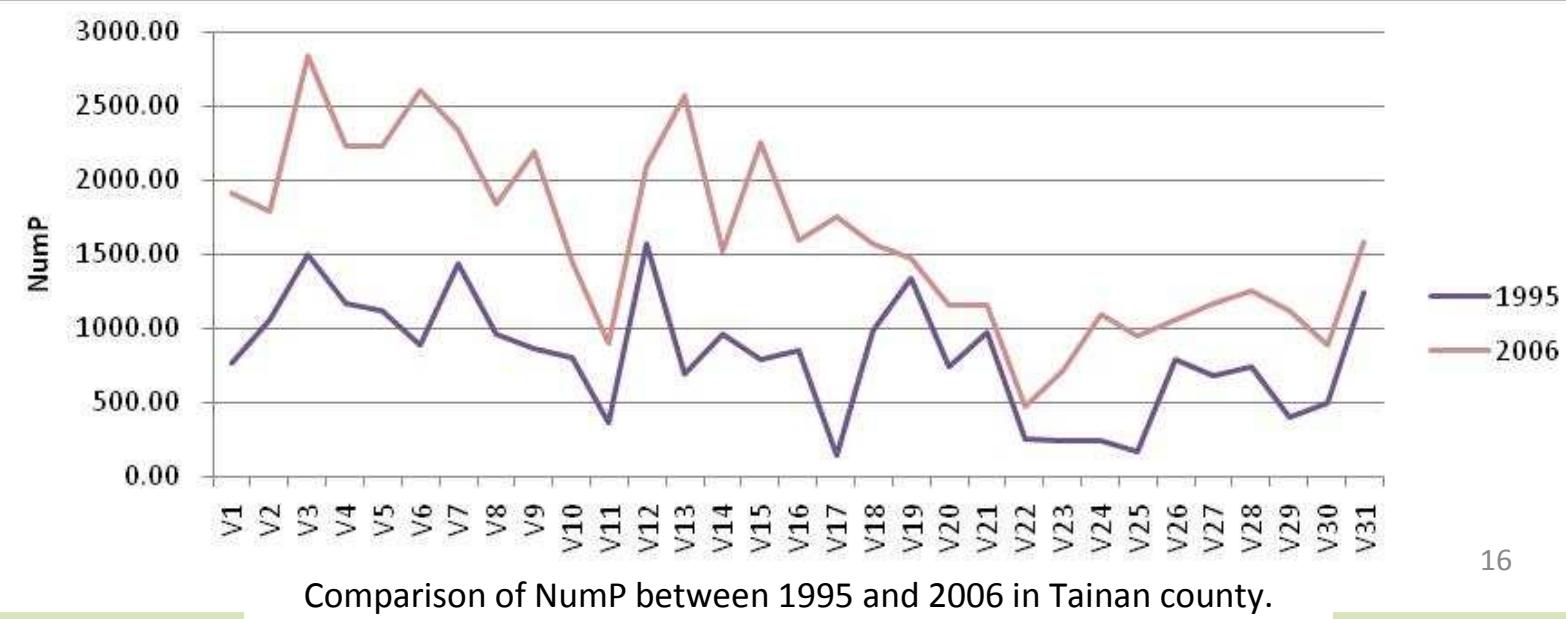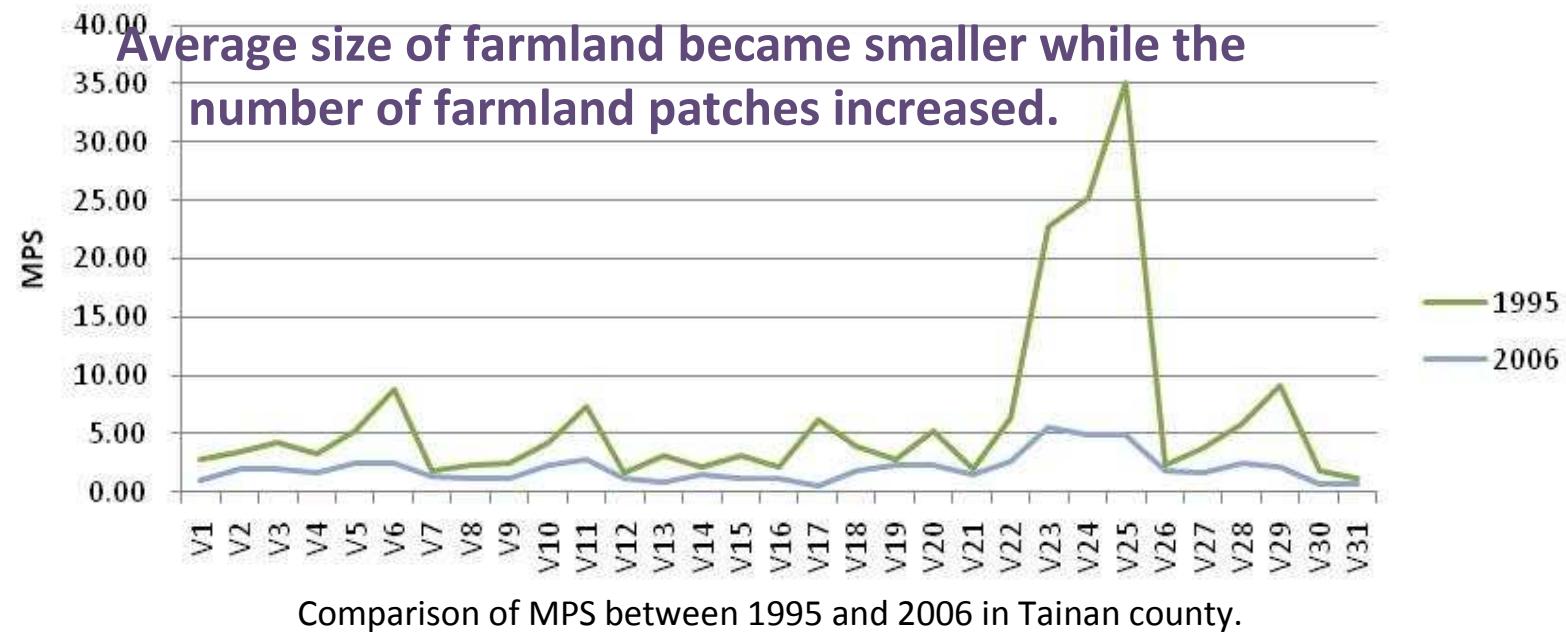
Methodology— Linear regression analysis

✓ There are many factors influencing the farmland conversion. Besides spatial factors, this study also tries to consider the effect of policy.

✓ **Dependent variables**

✓ Four farmland attributes in 1995 and 2006 : Mean Shape Index(MSI), Mean Patch Fractal Dimension(MPFD), Mean Patch Size(MPS) and Number of Patches(NumP).

✓ **Independent variables**

✓ Farmland Releasing Policy(x1), population(x2), working population(x3), industrial zone area(x4), road area(x5), superior farmland area(x6), distance to interchange(x7) and distance to train station(x8).

✓ Farmland Releasing Policy ,as dummy variable, had practiced from 1995 through 2003 therefore takes the values 0(1995)and 1(2006) to indicate the absence or presence of Farmland Releasing Policy categorical effect.

-	Mean	Standard deviation	Number
MSI	1.53661	.117598	62
MPS	4.10516	5.815958	62
NmP	1209.20968	645.158365	62
MPFD	1.43968	.052883	62

Descriptive statistics

Result

The result of linear regression.

Model		coefficient estimated B value	Standardized coefficient Beta Distribution	t	Significance	VIF	R^2	Adjusted R^2
MSI	constant	1.505	-	56.799	.000	-	.217	.191
	x1	-.061	-.261	-2.269	.027	1.000		
	x7	0.000009.423	.386	3.351	.001	1.000		
MPS	constant	2.153	-	1.865	.067	-	.393	.372
	x1	-4.195	-.364	-3.584	.001	1.000		
	x7	.001	.511	5.033	.000	1.000		
NumP	constant	521.583	-	3.229	.002	-	.646	.608
	x1	802.864	.627	7.796	.000	1.007		
	x2	.012	.621	3.321	.002	5.443		
	x3	-.021	-.535	-2.894	.005	5.324		
	x5	0.000005317	.256	3.108	.003	1.055		
	x6	0.000002705	.186	2.220	.031	1.093		
	x7	-.023	-.172	-1.864	.068	1.330		

18

Result

✓ Distance to interchange is significant to Mean Shape Index(MSI), Mean Patch Size(MPS) and Number of Patches(NumP).

✓ **Standardized coefficient of Number of Patches (NumP) tells that the further the distance to interchange is, the larger the mean farmland size and ecological benefit is. And the nearer the distance to interchange is, the larger the number of farmland is.**

✓ Moreover, the Farmland Releasing Policy(x1) is significant to all dependent variables. **This may go against with the policy goal of "protecting integrity of agricultural environment to ensure the function of production, living and ecology."**

Conclusion

Agricultural sector will face more severe challenges in the future. Farmland conversion and its transformation pattern affect the issues of food security.

http://shuchuan7.blogspot.com/2009/06/blog-post_26.html

✓Agriculture was the economic base of Taiwan.
✓**Policy—From past to now**
    ✓Based on study: making planning practical.
    ✓How to achieve the effect of with sharing the benefit of land and releasing farmland efficiently instead of the negative influence on entire agricultural environment is going to be an issues requiring government to put more effort on.

Conclusion

Farmland

Value/ benefit

Other types of land use
(Industrial , commercial and residential etc.)
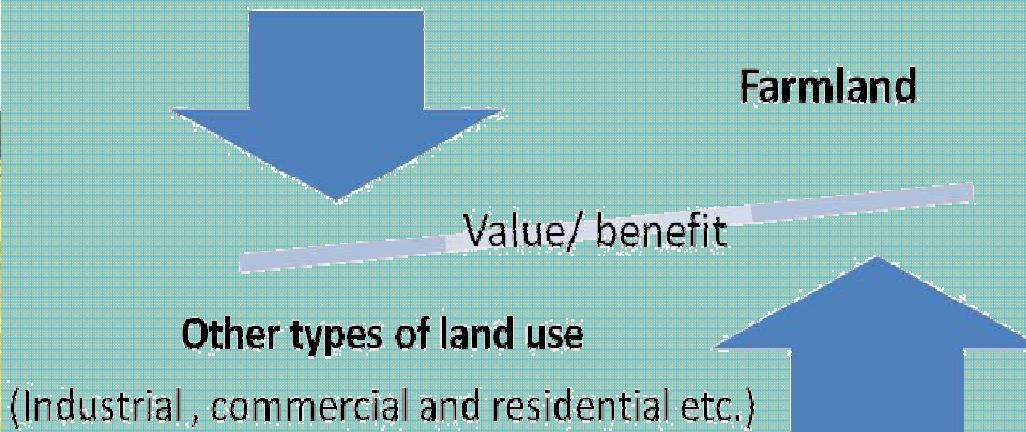
When the benefit of farmland can't exceed the benefit brought by changing into industrial or commercial use, the conversion will occur.

Increasing the benefit of farmland
- ✓ ex. promote local consumption of domestic rice to increase the demand to reduce fallow.

Decrease the benefit conversion
- ✓ Urban or high density development should take account of the influences on land nearby.
- ✓ To prevent types of land use triggering conversion from being located nearby,
- ✓ Planner should map out buffer zone around the superior farmland area in advance in order to lower the possibility of conversion.

21

Thanks for your attention.

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