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Comparative Analysis of Influence Factors on Arable Land Use Intensity at Farm Household Level: A Case Study Comparing Suyu District of Suqian City and Taixing City, Jiangsu Province, China

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Abstract: Using data from the farm household survey conducted in 2009, arable land use intensity (ALUI) and its influence factors at farm household level were investigated by the Tobit model. Suyu District of Suqian City and Taixing City of Jiansu Province, China were chosen as the regions for comparison. The results show that: 1) On the average, the ALUI, labor intensity, yield-increasing input, and labor-saving input are 15 238.14 yuan (RMB)/ha, 192 d/ha, 7233.01 yuan/ha, and 2451.32 yuan/ha in the less economically developed Suyu District, and 13 020.65 yuan/ha, 181 d/ha, 5871.82 yuan/ha, and 2625.97 yuan/ha in more economically developed Taixing City. The figures indicate that Suyu District has higher ALUI and labor intensity input but lower labor-saving input. 2) Comparing all the influence factors, the total arable land area in available and average plot size have bigger effects on arable land intensive use; to a small degree, family′s non-farm income affects labor intensity, yield-increasing input, and labor-saving input; the yield-increasing input decreases significantly when the householder has higher education attainment; the commercialization rates of agricultural products and the planting proportion of cash crops both have unstable influence on ALUI; the share of arable land rented in has few impacts on labor intensity, yield-increasing input, and labor-saving input. 3) There are no differences found in the internal impact mechanism of influence factors on the arable land intensive use behaviors of farm households. However, there are conspicuous disparities in the impact degrees and statistical significance based on varying economic levels. 4) Using the results as bases, this study proposes that the government should implement land management and agricultural policies according to local condition. And these policies should decrease land fragmentation to promote scale management of land and arable land use intensification.
Keywords: arable land use intensity (ALUI); labor intensity; yield-increasing input; labor-saving input; comparative analysis; farm household

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1 Introduction

Since a review of the growing literature shows that a rapid economic growth has always been accompanied by shifting land use patterns from agricultural land to industry, infrastructure, and residential land (Ramankutty *et al.*, 2002; Chen *et al.*, 2010; Zhong *et al.*, 2011), China could not make an exception. Although the loss of arable land is inevitable, agricultural land use intensification, which can bring a dramatic increase of the yield per unit area that has outpaced population growth, has been playing an important role in fulfilling rigid

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expansion of the demand for food (Chen *et al.*, 2009). Hence, in the last few decades, scholars have actively conducted research on arable land use intensity (ALUI) since they believed that agricultural intensification is the best option for China owing to the limited arable land reserve in the country (Long and Zou, 2010; Hao and Li, 2011). However, there are significant regional differences in terms of natural and socio-economic conditions. In order to formulate feasible policies for the sustainable use of arable land in different regions, it is important to analyze the diversities of ALUI and its influence factors.

In recent studies, scholars have focused on the concept and measurement of ALUI (Lambin *et al.*, 2000; Shriar, 2005; Temme and Verburg, 2011), whereas others have studied the holistic situation and its spatial and temporal variability (Kerr and Cihlar, 2003; Liu and Li, 2006; Zhu *et al.*, 2007; Zhang *et al.*, 2008b; Chen *et al.*, 2009; Persson *et al.*, 2010) using different methods and multiple evaluation scales. Concurrently, researchers have also analyzed the influence of ALUI and its change on grain production (Tranter *et al.*, 2007), soil and water degradation issues (Brown *et al.*, 1999; Brown and Shrestha, 2000; Hati *et al.*, 2007), biodiversity (Zechmeister and Moser, 2001; Vermaat *et al.*, 2007; Armengot *et al.*, 2011), and landscape structure (Baessler and Klotz, 2006). Moreover, the influence factors of ALUI and its modelling have been explored (Brown and Shrestha, 2000; Pan *et al.*, 2004; Zhao and Yang, 2010; Hao and Li, 2011). Determining the effect of driving factors on ALUI has been examined on two levels, namely, macro-scale and micro-scale. On the macro-scale, most researchers have focused on the level of economic development, population density, agricultural technology, policies, and others. And some researchers conducted comparative analyses on varied ALUI between the different levels of economic development using the data from relevant statistical yearbooks to draw useful conclusions (Zhang *et al.*, 2008a; Cao *et al.*, 2010; Chen *et al.*, 2011a). On the micro-scale, ALUI is mainly influenced by farm households′ family characteristics, willingness of production, labor allocation, land resource endowment, income, *etc*. However, existing studies have employed relevant statistical yearbook data to study the changes of the ALUI and its influence factors at the macro-scale. As such, micro-scale studies using data obtained from farm households are limited. For a better understanding of ALUI at the micro-scale, a comparative study on the regional diversity of ALUI and its influence factors under the different levels of economic development is essential.

This study aims to 1) analyze the ALUI and its influence factors employing econometric methods based on data obtained from farm households; and 2) investigate the regional diversity of ALUI and its influence factors between two areas representing different economic levels. The study results are expected to provide scientific reference for revealing arable land intensive use mechanism and laws to regulate the land use behaviors of farm households. The results can also put forward meaningful advices for agricultural policy-making and agricultural sustainable development.

2 Materials and Methods

2.1 Study areas

In conducting a comparative analysis, it is important to select two areas that have similar natural conditions and obvious economic gradient differences, which exclude the influence from natural conditions acting on ALUI. In the study, the selected county-level administrative regions include Suyu District of Suqian City and Taixing City (Fig. 1), located in the northern and central Jiangsu Province, respectively. Both of them have consistent cultivation system and sunshine conditions for rice-wheat double cropping annually. In addition to these, the different levels of economic development make them ideal study areas for the current comparative study.

Taixing City has higher economic development level and better location compared with Suyu District of Suqian City. Moreover, efficient air, land, and water transportation networks are present in Taixing City. The Beijing–Shanghai, Nanjing–Nantong, and Yancheng–Jingjiang highways pass through Taixing City. The Jiangyin Changjiang River Bridge links Taixing to Shanghai and south of Jiangsu Province together. In 2009, Taixing City ranked the 47th in the top 100 counties (cities) of China, and its GDP amounted to 3.37×10^{10} yuan (RMB) for that year. The ratio of the primary industry to secondary industry to tertiary industry was 8.0 : 57.3 : 34.7. Per capita GDP was 28 155 yuan, per capita disposable income of urban household and per capita net income of rural household were 17 849 yuan and 8179 yuan, respectively.

As the main urban zone of Suqian City, Suyu District

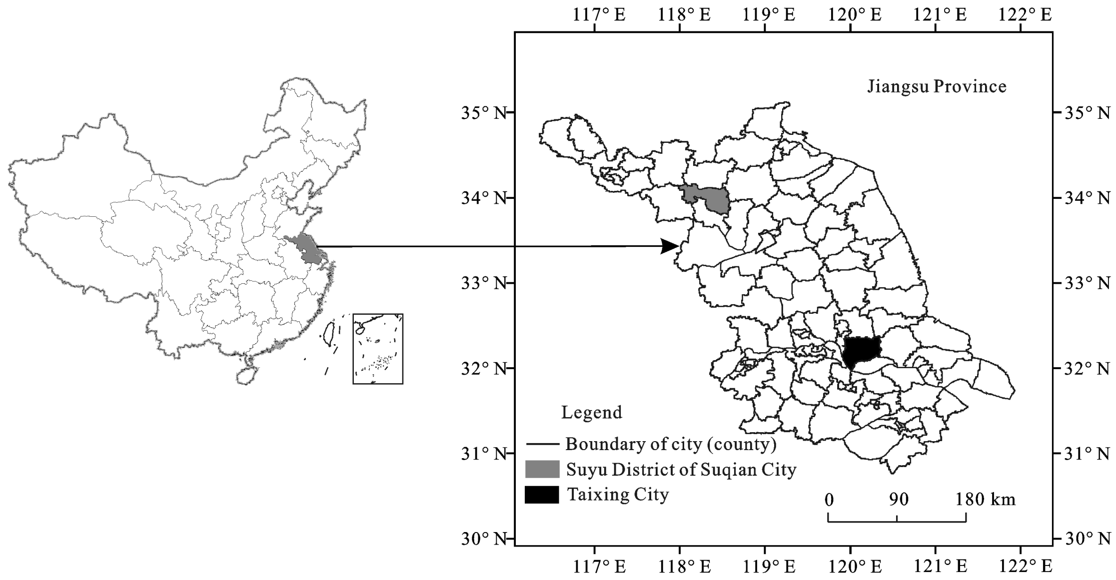

Fig. 1 Location of study areas

was set from Suyu County in 2004. The distances from Suyu District to Nanjing and Shanghai are 260 km and 380 km, respectively. In 2009, Suyu District′s GDP was 1.26×10^{10} yuan, the ratio of the primary industry to secondary industry to tertiary industry was 16.5 : 58.6 : 24.9. Per capita GDP was 17 934 yuan, and per capita disposable income of urban household and per capita net income of rural household were 10 850 yuan and 6120 yuan, respectively.

2.2 Data collection

Our data were from a survey of rural households′ livelihoods and their land use conducted in Suyu District of Suqian City and Taixing City during August 2009 by the School of Geographic and Oceanographic Sciences, Nanjing University. Six villages were involved in the survey, which includes Wangji Village, Tangxu Village and Zhuhai Village of Suyu District in Suqian City, and Yeqin Village, Jiaobao Village and Zhanghe Village in Taixing City. In every village, about 60 farm households were randomly selected and interviewed. The data relating to farm households were obtained through structured interviews, informal discussion with village elders and local government leaders. The following information was included in the questionnaires: family characteristics, agricultural production, resources of household, land uses, labor transfer, credit and saving, land market, locations, and so on. In total, we obtained 356 questionnaires, among which 316 were valid. There were 161 and 155 valid questionnaires in Suyu District of Suqian City and Taixing City, respectively (Table 1).

Table 1 Investigated villages and samples

Areas	Town	Village	Number of valid questionnaire
Suyu District of Suqian City	Wangguanji	Wangji	52
	Wangguanji	Tangxu	51
	Wangguanji	Zhuhai	58
Taixing City	Hengduo	Yeqin	54
	Zhangqiao	Jiaobao	66
	Xuanbao	Zhanghe	39

2.3 Methodology

2.3.1 Calculation method for arable land use intensity

Arable land use intensity (ALUI) is defined generally as the total quantity of capital, labor, and capital interest consumed per unit area of land during a production cycle (Liu and Li, 2006). In the present study, the production cycle represented the time cost for rice-wheat double cropping. In order to simplify the issue and considering the low interest of the capital consumed per unit area of arable land, the interest of the capital was ignored and ALUI was denoted by the sum of the material inputs and labor inputs per unit area of arable land in one year. Material inputs referred to the means of agricultural production, such as seed, farmyard manure, chemical fertilizer, pesticide, mulching film, machinery, and all other direct inputs. This part of input per unit area was defined as the capital intensity of arable land use, whereas labor input was considered as the sum of family labor and hired labor during agricultural production. The labor input per unit area was defined as labor intensity of arable land use. Based on the main purpose of the study, material input was further divided into yield-increasing input and labor-saving input. For example, farmers usually invest on seed, farmyard manure, chemical fertilizer, and mulching film to increase the yield per unit area; however, they also invest in machinery and herbicide inputs for the purpose of replacing labor input.

2.3.2 Evaluation model for factors influencing arable land use intensity

(1) Model specification: The specific form and estimation method may be different due to the influence of data types and structure. Considering the ALUI values range from 0 to +∞, the Tobit model is used to study the relationship between ALUI and its influence factors. The primal for Tobit is described as follows:

$$y^* = \beta_0 + \beta x + u, u \big| x \sim N(0, \partial^2)$$
$$y = \max(0, y^*) \tag{1}$$

where y is ALUI at farm household level, including labor intensity, yield-increasing input and labor-saving input; x represents a group of vectors affecting the arable land use of farm households; β_0 and β are the intercept and coefficient, respectively; u is a random disturbance, and it following a normal distribution with mean zero and standard deviation σ. As latent variable, y^* satisfies with classical linear assumption. The model shows that: when $y^* \geq 0$, $y = y^*$; and when $y^* < 0$, $y = 0$.

(2) Analytical variables: The ALUI, labor intensity, yield-increasing input, and labor-saving input of arable land use are considered as dependent variables in the model. Based on previous research and the questionnaire survey, ten influence factors were selected as the explanatory variables. Details about the variables are all described in Table 2.

According to the theory of rural household behavior, the intent of rural household land use is to pursue maximal profits under a series of constrained conditions, including family characteristics, land endowment, non-farm employment situation, and agricultural product market development. As the decision maker of agricultural production, householders play an important role in land input decision making. Specifically, their age and

Table 2 Measurement methods of variables

	Variable	Measurement method	Unit
Dependent variable	Labor intensity	Cost of family labor, exchange labor, and hired labor / total arable land area in available	d/ha
	Yield-increasing input	Cost of seed, chemical fertilizer, pesticide, mulching film, and irrigation water / total arable land area in available	yuan/ha
	Labor-saving input	Cost of machinery and herbicide / total arable land area in available	yuan/ha
	ALUI	Monetization value of labor intensity* + capital intensity	yuan/ha
Independent variable	Age of householder	Came directly from questionnaires	years
	Educational level of householder	Came directly from questionnaires	years
	Index of savings deposits	1 represents deposit being 0; 2 represents deposit ranging from 0 to 5000 yuan; 3 represents 5000–10000 yuan; 4 represents 10000–20000 yuan; 5 represents 20000–50000 yuan; 6 represents deposit greater than 50000 yuan	dummy variable
	Total arable land area in available	Came directly from questionnaires	ha
	Average plot size	Total arable land area in available / number of plots cultivated by household	ha
	Share of arable land rented in	Area of land rented in / total arable land area in available	%
	Family's non-farm income	Came directly from questionnaires	yuan
	Commercialization rate of agricultural products	Sales of agricultural products / total output of agricultural products	%
	Planting proportion of cash crops	Acreage sown to cash crops / total sown area	%

Notes: *, The monetization value of labor intensity = (Family labor wages × Number of family labor) + (Employment wages × Number of employees); Family labor wages = (Per capita annual net income of local rural households × Rural population) / (Employed persons in rural × whole year working days), based on Pricing Section of National Development and Reform Commission (2010) educational levels reflect different human capital acting on agricultural production decision. Considering the significant influence of economic capability on land input, the model includes family features of farm households with the age of householder, educational level of householder, and index of savings deposits.

Arable land area, arable land quality, location, and land fragmentation are all important parameters representing arable land resource endowment. On one hand, with the difficulty of objective expression on land quality, chronicity of land quality, equal allocation of land quality and location in the process of land redistribution in the village, the current study did not take arable land quality and location into account. On the other hand, the average plot size was included because of the importance of arable land fragmentation.

Non-farm employment, land transfer, and commercialization of agricultural products, have certain differences and are likely to have an impact on arable land input in diverse ways at different economic development levels. The following relevant variables were represented in the model: family′s non-farm income, the share of arable land rented in, the commercialization rate of agricultural products, and the planting proportion of cash crops.

3 Results and Analyses

3.1 General conditions of arable land use intensity

Table 3 shows the differences in arable land intensive use between Suyu District of Suqian City and Taixing City. The mean, maximum, and minimum values of ALUI in Suyu District of Suqian City are significantly higher than those in Taixing City, indicating that farm households have less input on arable land in more developed areas. In particular, the minimum value of ALUI in Taixing City is 1031.25 yuan/ha, which is too little to be considered going out of cultivation. Labor-intensity in Suyu District of Suqian City has higher mean, maximum, and minimum values than Taixing City. This is attributed to more non-farm employment opportunities provided for farm households, less labor inputs into agricultural planting, and relatively more labor-saving inputs resulting from the increase of farming opportunity cost in more developed areas. This basically corresponds with the observation, in which the labor-saving inputs of farm households in Suyu District of Suqian City are much lower than those in Taixing City. Contrary to the observation of labor-saving input, yield-increasing input in Suyu District of Suqian City is apparently higher than those in Taixing City, which is basically identical with the conclusion draw by some scholars based on an analysis of province-level statistical data, that is ′with the development of regional economy, and influenced by low comparative returns, there is a decrease in the attraction of the increase in agricultural production for farm households, accordingly resulting in a reduction in the incentive to increase the output of arable lands via input during the use of arable land′ (Chen *et al.*, 2011b). Moreover, to analyze the differences between yield-increasing input and labor-saving input found in counties with different levels of economic development, the current study further divided yield-increasing input and labor-saving input into three different grades (i.e., high, medium, low) carried through regional comparison based on the samples′ overall situation. The aim is to show the regional differences of capital intensity on the different levels of economic development.

As shown in Table 4, farm households are divided

Table 3 Differences of arable land use intensity (ALUI) between Suyu District of Suqian City and Taixing City

		ALUI (yuan/ha)	Labor intensity (d/ha)	Capital intensity (yuan/ha)	Yield-increasing input (yuan/ha)	Labor-saving input (yuan/ha)
Suyu District	Mean	15238.14	192.00	9684.32	7233.01	2451.32
	S.D.	6461.39	168.00	3160.23	2485.53	876.62
	Maximum	48300.00	1350.00	29160.00	20748.00	8412.00
	Minimum	9210.00	17.00	1715.00	1115.00	389.00
Taixing City	Mean	13020.65	181.00	8497.07	5871.12	2625.97
	S.D.	4261.82	66.00	3390.65	2482.01	1209.27
	Maximum	28246.32	390.00	21188.00	16577.00	7269.00
	Minimum	1031.25	23.00	250.00	250.00	0.00

Table 4 Diversity of capital intensity in different grades between Suyu District of Suqian City and Taixing City

		Yield-increasing input			Labor-saving input		
		Low (< 5026 yuan/ha)	Medium (5026–10710 yuan/ha)	High (> 10710 yuan/ha)	Low (< 2025 yuan/ha)	Medium (2025–3500 yuan/ha)	High (> 3500 yuan/ha)
Suyu District	Number of farm households	24	125	12	35	116	10
	Ratio	14.91%	77.64%	7.45%	21.74%	72.05%	6.21%
Taixing City	Number of farm households	57	92	6	49	74	32
	Ratio	36.77%	59.35%	3.88%	31.61%	47.74%	20.65%

Note: 'Ratio' is the ratio of farm households with low/medium/high yield-increasing input (or labor-saving input) to the total local farm households who were interviewed

into three groups according to the intervals of yield-increasing input: 1) households with yield-increasing inputs lower than 5026 yuan/ha; 2) households with medium yield-increasing inputs ranging from 5026 yuan/ha to 10 710 yuan/ha; and 3) households with high yield-increasing inputs of more than 10 710 yuan/ha. There are 125 households (77.64%) belonging to the medium group and 12 households (7.45%) belonging to the high group in Suyu District of Suqian City. These figures are higher than those found in Taixing City. The number of households of each group indicates that most households cultivated their land with a medium level of yield-increasing input, whereas there are more households with low yield-increasing inputs in more economically developed areas than those in the less developed areas.

Similarly, farm households are divided into three groups according to the intervals of labor-saving input: 1) households with labor-saving inputs lower than 2025 yuan/ha; 2) households with medium labor-saving inputs ranging from 2025 yuan/ha to 3500 yuan/ha; and 3) households with high labor-saving inputs at more than 3500 yuan/ha. There are 35 households (21.74%) belonging to the lowest group, and 10 households (6.21%) belonging to the highest group in Suyu District of Suqian City, which are lower than those found in Taixing City. This indicates that, households' behavior of labor-saving input would be different with the developing of economy and increasing of non-agricultural opportunities.

The level of regional economic development influences household land use behaviors. The way farm households respond to factors that bring about changes, such as resources and environment, social policy and others, shape the different characteristics of their land use behaviors (Kong *et al.*, 2010). Given that land use behavior is the significant micro-level driving force causing the differences in ALUI at the micro-scale, it is necessary to conduct an in-depth analysis of the impact of various factors (e.g., family characteristics of farm households, land resource endowment, situation of non-farming employment, development degree of agricultural market, and others) on ALUI, while considering the different levels of economic development.

3.2 Comparative analysis of factors influencing arable land use intensity

Existing studies have found that age, gender, and the educational level of farmers influence their behaviors and participation in non-farm work (Xin and Jiang, 2009; Wang, 2010). An increase in non-farm income can have a significant influence on household savings. In the mainland of China, elder farmers usually do not receive education as much as young farmers do (Zhong *et al.*, 2008). However, if there are strong correlations among independent variables, they can lead to the problem of multicollinearity. Thus, the independent variables should remove redundancies prior to simulations. The standard error increases with an increase in correlation, and this has much effect on the results (Zhong *et al.*, 2009). The current study calculated the correlation coefficients using the respective samples from Suyu District of Suqian City and Taixing City and found that the correlations of the age and educational level of householder in Suyu District of Suqian City and Taixing City are –0.2763 and –0.3148, respectively; whereas those for family's non-farm income and the index of saving deposits are 0.4088 and 0.2291 for Suyu District of Suqian City and Taixing City, respectively. Afterwards, the independent variables were determined, considering the correlation coefficients among independent variables, their links, and the number of samples. Finally, only seven variables were selected for model estimation, including the educational level of the householder, the total arable land area in available, average plot size, the share of arable land rented in, family′s non-farm income, the commercialization rate of agricultural products, and the planting proportion of cash crops.

Furthermore, ALUI was divided into different forms such as the labor intensity, yield-increasing input, and labor-saving input based on the different input types and purposes. The influence factors were comparatively analyzed based on the overall situation and subdivision of ALUI. This strategy facilitated a better understanding of the internal mechanism of arable land intensive use. With the assistance of Stata (Version 11.0), the Tobit model was applied to analyzing the survey data of farm households in both Suyu District and Taixing City to simulate the influence of above-mentioned seven variables on ALUI, labor intensity, yield-increasing input, and labor-saving input.

3.2.1 Arable land use intensity

The simulated results of the influence of above-mentioned seven variables on ALUI are listed in Table 5. The chi-square values of likelihood ratio test for samples collected from Suyu District and Taixing City are 9.94 and 34.55, with significance test values recorded at 0.1161 and 0.0000, respectively. These values indicate that the overall test of the models is significant at the 10% and 1% levels, respectively.

Table 5 shows significant differences in the orientation, degree, and significance level of the impact of various factors on ALUI in the two study regions. First, from the impact direction, the four variables (educational level of the householder, family′s non-farm income, the commercialization rates of agricultural products, and the planting proportion of cash crops) show differences between the two regions. Second, regarding the impact degree, average plot size, the total arable land area in available, and the share of arable land rented in all have a significant influence on ALUI in Suyu District of Suqian City. In comparison, in Taixing City, average plot size, the total arable land area in available and educational level of the householder all exert great influence on ALUI. Finally, the significance levels of two factors (the total arable land area in available and average plot size) obtained in Suyu District of Suqian City, are 1% and 5%, respectively. In Taixing City, three factors (the total arable land area in available, the commercialization rates of agricultural products, and educational level of the householder) achieve significance levels of 1%, 1%, and 5%, respectively. Estimated results reveal that the same factors have different impacts on ALUI of farm household in the two regions with different levels of economic development. How does the influence occur? The subsequent sections comparatively analyze the influence factor based on the subdivision of ALUI.

3.2.2 Labor intensity

The simulated results of the influence of above-mentioned seven variables on labor intensity are listed in Table 6. The chi-square values of likelihood ratio test for samples collected from Suyu District and Taixing City are 10.45 and 11.80, with the significance test values recorded at 0.1046 and 0.1074, respectively. These values indicate that the overall tests of the models are both basically significant at the 10% level.

Estimated results reveal that there are certain differ-

Table 5 Estimated results of influence factors on arable land use intensity in Suyu District of Suqian City and Taixing City

Influence factor	*b* (*t*-value) for Suyu District	*b* (*t*-value) for Taixing City
Intercept parameter	17093.2708*** (8.80)	15759.2120*** (12.94)
Educational level of householder	16.4235 (0.12)	–213.4194** (–2.01)
Total arable land area in available	–850.3245*** (–2.98)	–893.8798*** (–4.11)
Average plot size	961.9821** (1.98)	417.9501 (1.12)
Share of arable land rented in	31.9700 (0.79)	27.6277 (0.62)
Family′s non-farm income	–0.0103 (–0.44)	0.0077 (0.89)
Commercialization rate of agricultural products	–2.9725 (–0.14)	41.4551*** (3.45)
Planting proportion of cash crops	18.7587 (0.74)	–25.8199 (–1.51)

Notes: *b* means regression coefficient; figure in bracket means *t*-value of *t*-test ; *, **, and *** means the significant levels of 10%, 5%, and 1%, respectively

Table 6 Estimated results of influence factors on labor intensity in Suyu District of Suqian City and Taixing City

Influence factor	*b* (*t*-value) for Suyu District	*b* (*t*-value) for Taixing City
Intercept parameter	242.3782*** (4.83)	214.9378*** (9.41)
Educational level of householder	–0.4599 (–0.13)	–1.3576 (–0.69)
Total arable land area in available	–19.3368*** (–2.63)	–5.7844* (–1.42)
Average plot size	28.1301** (2.27)	–6.5770* (–1.05)
Share of arable land rented in	0.5396 (0.52)	0.0573 (0.08)
Family′s non-farm income	–0.0002* (0.18)	–0.0002*** (2.07)
Commercialization rate of agricultural products	–0.4637 (–0.82)	0.1274 (0.58)
Planting proportion of cash crops	0.9668* (1.49)	–0.0845 (–0.33)

Notes: *b* means regression coefficient; figure in bracket means *t*-value of *t*-test; *, **, and *** means the significant levels of 10%, 5%, and 1%, respectively

ences in the orientation, degree, and significance level of the impacts of various factors on labor intensity of farm households in these two regions. Factors such as the total arable land area in available and average plot size have the greatest impact on the labor input of farm households into arable lands. However, with different levels of economic development, the impact degree is different, and changes occur to the orientation of the impact of average plot size on labor input. The results imply that in developed areas, farming opportunity cost is high, that is, the larger the average plot size, the bigger the possibility of mechanized farming that require less labor inputs. If the average plot size is small, mechanized farming would not be feasible, and the farm households have to cultivate arable lands through relatively more labor inputs. In different levels of economic development, family′s non-farm income always influences arable land labor inputs negatively, but the estimated results reveal a relatively low impact degree. Jiangsu Province boasts of a high level of overall economic development and numerous job opportunities. With these characteristics, it is difficult to differentiate the influence of family′s non-farm income on arable land labor input in these two areas. The planting proportion of cash crops positively affects the arable labor input of farm households in less developed Suyu District, but not in the more developed Taixing City, because farm households in Taixing City do not customarily grow cash crops.

3.2.3 *Capital intensity*: *Yield-increasing input*

The simulated results of the influence of abovementioned seven variables on yield-increasing input are listed in Table 7. The chi-square values of likelihood ratio test for samples collected from Suyu District of Suqian City and Taixing City are 10.93 and 40.43, with significance test values recorded at 0.1015 and 0.0000, respectively. These values indicate that the overall test of the models is significant at the 10% and 1% levels, respectively.

Estimated results reveal that various factors have identical impacts on orientation but different impacts in terms of degree and significance level on the yield-in-

Table 7 Estimated results of influence factors on yield-increasing input in Suyu District of Suqian City and Taixing City

Influence factor	*b* (*t*-value) for Suyu District	*b* (*t*-value) for Taixing City
Intercept parameter	10233.3600*** (8.77)	7427.3760*** (10.66)
Educational level of householder	–48.4995*** (–2.62)	–165.6873*** (–2.77)
Total arable land area in available	–207.2152* (–1.89)	–516.4790*** (–4.15)
Average plot size	75.3324 (0.41)	308.6364* (1.45)
Share of arable land rented in	8.2422 (0.54)	28.1231 (1.10)
Family′s non-farm income	0.0087* (1.60)	0.0034* (1.67)
Commercialization rates of agricultural products	8.0585 (0.96)	29.2293*** (4.25)
Planting proportion of cash crops	–5.8351 (–0.61)	–13.7443 (–1.40)

Notes: *b* means regression coefficient; figure in bracket means *t*-value of *t*-test; *, **, and *** means the significant levels of 10%, 5%, and 1%, respectively creasing input in these two areas. Regarding the impact degree, the total arable land area in available has the largest and significant influence on the arable land yield-increasing input of farm households. However, this is negatively significant, in which the households use less yield-increasing inputs, such as chemical fertilizer and insecticide, given the larger total arable land area in available. Large-scale management of arable land could lower the inclination of farm households to blindly adopt yield-increasing inputs. The average plot size also shows significant impact, but it is not remarkable in the estimated results of Suyu District of Suqian City. In contrast, the results of Taixing City reveal that large average plot size drives farm households to increase yield-increasing input. The educational level of the householder also present a significant negative effect on yield-increasing input, indicating that with the increase of educational level, the inclination of the householder tends to decrease yield-increasing inputs, such as chemical fertilizer and insecticide. In these two research regions, family′s non-farm income exerts a positive but low degree influence on yield-increasing input; specifically, the impact degree of family′s non-farm income is higher in Suyu District of Suqian City than that in Taixing City. This shows that farm households in less developed areas tend to invest in agricultural production when their incomes increase. Meanwhile, the impact of the commercialization rate of agricultural products on yield-increasing input is quite different in the two comparative regions. The impact is not significant in the estimated results for Suyu District of Suqian City, but positively significant for Taixing City, indicating that although farming opportunity cost in developed areas is higher, the higher commercialization rate of agricultural products and income brought by commercialization drive farm households to increase their respective yield-increasing inputs.

3.2.4 Capital intensity: Labor-saving input

The simulated results of the influence of abovementioned seven variables on labor-saving input are listed in Table 8. The chi-square values of likelihood ratio test for samples collected from Suyu District of Suqian City and Taixing City are 13.19 and 23.21, with significance test values recorded at 0.0606 and 0.0016, respectively. These values indicate that the overall test of the models is significant at the 10% and 1% levels, respectively.

Estimated results reveal that various factors have identical impacts on orientation but different impacts in terms of the degree and significance level on the labor-saving input in these two regions. Compared with the other factors, the total arable land area in available, and average plot size both have the largest and notable influence. The larger the total arable land area in available, the larger the average plot size, thus resulting in increased labor-saving inputs from farm households. However, the range of increase is much smaller in less developed Suyu District of Suqian City than that in more developed Taixing City, indicating that despite different economic development conditions, arable land resource endowment factor exerts certain impact on labor-saving input. Family′s non-farm income and the commercialization rate of agricultural products have positive impact on labor-saving input, with impact degree lower in Suyu District of Suqian City than that in Taixing City. The planting proportion of cash crops also has negative and significant influence on labor-saving input, although impact degree is lower in Suyu District of Suqian City than that in Taixing City. Under different

Table 8 Estimated results of influence factors on labor-saving input in Suyu District of Suqian City and Taixing City

Influence factor	*b* (*t*-value) for Suyu District	*b* (*t*-value) for Taixing City
Intercept parameter	2476.0570*** (9.54)	2990.9950*** (8.30)
Educational level of householder	–1.2912 (–0.07)	–18.7341 (–0.61)
Total arable land area in available	118.4898*** (3.12)	230.1153*** (3.57)
Average plot size	124.2979** (1.94)	266.8578** (2.42)
Share of arable land rented in	6.7037 (1.24)	–1.8980 (–0.14)
Family′s non-farm income	0.0022* (1.71)	0.0062* (1.62)
Commercialization rate of agricultural products	4.6782* (1.61)	9.1695** (–2.58)
Planting proportion of cash crops	–3.5287* (–1.55)	–9.9432** (–1.96)

Notes: *b* means regression coefficient; figure in bracket means *t*-value of *t*-test; *, **, and *** means the significant levels of 10%, 5%, and 1%, respectively economic development conditions, the mechanisms for those above-mentioned factors influencing the arable land labor-saving input of farm households are basically similar, although differences exist in terms of the degree of influence.

4 Discussion and Conclusions

4.1 Discussion

According to the existing macro-scale studies, it is inevitable for regional economic development to increase ALUI (Chen *et al.*, 2011b). With economic development, the overall trend of ALUI is to move upwards then peak at a certain level (Zhang *et al.*, 2008a). From the correlation analysis of the relationship between ALUI structure and economic development, the share of capital intensity has a significantly positive relationship with the economic development, whereas the share of labor intensity has a significantly negative relationship with the level of economic development (Zhang *et al.*, 2008b). Although these issues have been validated by using macro-level analysis, it is not yet clear whether or not the same rules on micro-scale apply to the arable land intensive use behavior at the farm household level. As the micro-main body of land use, the arable land intensive use behaviors of farm households are subject to the effects of local natural conditions and resource endowment. These behaviors have much to do with farm household characteristics and economic conditions, and largely depend on the local economic development level and development degree of the market (Zhong *et al.*, 2009; Hao and Li, 2011). Therefore, some regional differences are evident. Based on findings from previous works, the current study analyzed the micro-scale differences of ALUI and its influence factors by using survey data of farm households in two areas with different levels of economic development. And there are regional differences in the intensive land use behaviors of farm households in regions with different levels of economic development. The research results reveal the variation laws of ALUI on the micro-scale. The current research initiative also contributes to literature on land intensive use at the farm household level; however, the survey research period, which was only for one year, resulted in limited number of samples and inadequacies in the limited selection of indexes. To obtain robust empirical results, more data are needed to control the individual heterogeneity of farm households and various possible uncertain factors.

4.2 Conclusions

ALUI is influenced by many factors, and farm households adjust their land use strategies with changes in both the biophysical and socio-economic environment. Based on the above analysis using samples from Suyu District of Suqian City and Taixing City in Jiangsu Province, the following conclusions are obtained:

(1) ALUI is diverse in different regions with different levels of economic development. On average, ALUI, labor intensity, and yield-increasing input in the less economically developed Suyu District of Suqian City are 15 238.14 yuan/ha, 192 d/ha and 7233.01 yuan/ha, respectively. They are significantly higher than those found in the more economically developed Taixing City, which are 13 020.65 yuan/ha, 181 d/ha and 5871.82 yuan/ha, respectively, with the exception of labor-saving input, which is lower in Taixing City.

(2) The estimated results using the Tobit model indicated that two representational arable land endowment indexes, total arable land area in available and average plot size, consistently proved to be major factors influencing the arable land intensive use. Family′s non-farm income also has a significant impact on yield-increasing input and labor-saving input, although it shows a low impact degree. The educational level of the householders only notably influences their yield-increasing input, and this has little effect on labor intensity and labor-saving input. By comparison, the impacts of the commercialization rate of agricultural products and the planting proportion of cash crops on ALUI are not stable. Finally, the share of arable land rented in has positive but insignificant impacts on ALUI, labor intensity, yield-increasing input, and labor-saving input.

(3) Little difference has been found in the internal impact mechanism of influence factors on the arable land intensive use behaviors of farm households, but there are significant disparities in the impact degree and statistical significance due to different levels of economic development.

(4) Certain suggestions for improving arable land use are proposed based on the above-mentioned results. 1) The government should implement land management and agricultural policies that are suitable for each region. The economically developed areas, where farm house-

holds are less dependent on the agricultural income, have lower labor intensity and yield-increasing input. Although farm households in economically developed areas are given agricultural subsidies, they have less enthusiasm for agricultural production. Therefore, in these developed areas, the government should adopt appropriate measures accelerating the transfer of arable land, thus achieving economies of scale. Meanwhile, in the less developed areas, the government should increase the agricultural subsidies to increase the ALUI of farm households and develop efficient agriculture. 2) Yield-increasing input and labor-saving input increase significantly along with an increase in the average plot size, indicating that land fragmentation discourages the use of machinery and scale management of land. Therefore, government policies should decrease land fragmentation and promote scale management of land and arable land use intensification. 3) Finally, improving the educational level of the households is indispensable in enhancing scientific, technological, and management skills that ultimately promote arable land use intensification.

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