

## Conceptual model on urbanization and sustainable development of agriculture — A case study of Chengdu city\*

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**Abstract.** Urbanization is an inevitable process in socio-economic development. During its process characterized by the rapid rise of the second and third industry proportion of the urban industry, the proportion of the primary industry (i.e. agricultural industry) drops drastically. But such drops in the ratio of agriculture in the national productivity do not necessarily mean that agriculture is no longer significant. On the contrary, the special roles of the agriculture in the urbanization process ask for more attention to its sustainable development. This paper took the urbanization and the sustainable development of agriculture in Chengdu City as an example to expound their mutual relationship by a conceptual model.

**Keywords:** urbanization, sustainable development of agriculture, conceptual model, Chengdu City

### 1 Introduction

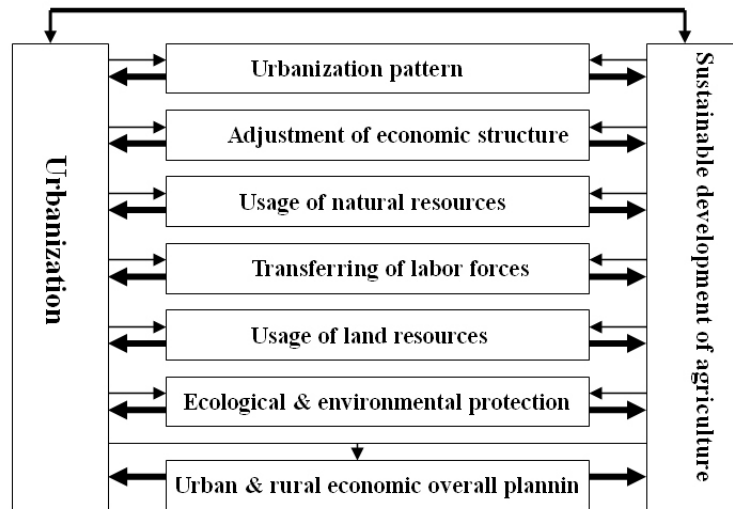
Urbanization is an inevitable process in socio-economic development<sup>[2, 4, 7, 8, 10, 16, 17, 20]</sup>. During the process characterized by the rapid rise in the proportions of the second and third industries of the urban industries, the proportion of the primary industry (i.e. agriculture industry) in the rural areas dramatically drops<sup>[3, 5, 6, 11, 14, 15, 19]</sup>. But such drops in the proportion agriculture, does not mean that agriculture is no longer significant. On the contrary, because of the special position of agriculture in urbanization, even more attention has to be paid to its sustainable development. In fact, there are mutual relationships of promotion and constrain between urbanization and sustainable development of agriculture. The sustainable development of agriculture is helpful to promote the urbanization process whereas the non-sustainable development of agriculture hinders urbanization such process, and vice versa. Their mutual relationships can be described by the following conceptual model (see Fig. 1)<sup>[12, 13]</sup>:

This figure shows the relationships between urbanization and sustainable development of agriculture through the urbanization patterning, economic structure adjustment, usage of land and other natural resources, labor force transferring, ecological and environmental protection. Urban and rural economic overall planning was effective on all other factors of policy-making. Actually the thoughts reflected in this conceptual model implied the necessity and the methods for the coordination of both urbanization and sustainable development of agriculture. In order to explain more clearly the relationships between urbanization and the sustainable development of agriculture, Chengdu City was taken as an example to depict this conceptual model in the followed texts.

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**Fig. 1.** The conceptual model on urbanization and the sustainable development of agriculture

In this paper we mainly adopted regression analysis method to explain the mutual relationships between urbanization and sustainable development of agriculture according to statistical data from statistical yearbook of Chengdu.

## 2 General relationship between urbanization and agricultural development

The historical data concerning the urbanization process and agricultural development in Chengdu City were listed in Tab. 1<sup>[1]</sup>.

**Table 1.** Historical data concerning urbanization and agricultural development in chengdu city

Years	Level of urbanization (%)	Agricultural GDP proportion (%)	Total agricultural output value rate of increment (%)	Agricultural commodity output value rate (%)	Agriculture labor productivity (yuan/person)	ADI*	average net income of farmer (yuan/year)
1949	20.29	73.37	/	/	/	/	32
1950	19.95	72.84	/	/	/	1.28	40 (in 1952)
1960	30.08	23.81	19.60	/	/	1.41	44 (in1962)
1970	23.75	33.36	10.87	/	/	1.48	82
1980	23.35	27.22	0.95	/	507	1.68	223
1990	27.30	20.90	15.56	59.3	1347	1.98	773
1995	30.97	14.61	17.60	63.6	3678	2.01	1649
2000	34.13	9.56	2.16	70.4	5127	2.00	2926
2001	34.79	8.83	7.29	71.1	5813	2.05	3111**

Note: \*: Agricultural diversification indexes (ADI) =  $1 \div \sum$  The proportion of output value of farming, forestry, animal husbandry and fishery to gross output value of agriculture respectively.

\*\* : The per capita net income of the farmers in 2001 is the data disposable income.

While urbanization level rose, the contribution of agriculture to the whole national economy dropped gradually during 1949-2001, which was characterized by the drops in the proportion of agricultural GDP in the period. The correlation efficient between the urbanization level and agricultural GDP was -0.8821.

Urbanization process and agricultural development was closely related. When the effects of arbitrary policies on urbanization and that of special years of natural disasters on the agricultural development were ex-

cluded, it was obvious that the greater increase in agricultural output was accompanied by the greater increase in the urbanization level and vice versa.

The positive correlations between urbanization level and the levels of commoditization or marketing agriculture indicated that the improvement of the urbanization offered more markets for agricultural products and promoted the commoditization and mercerization of agriculture<sup>[18]</sup>.

The positive correlation between urbanization and the overall agricultural labor productivity was observed in the period of 1949-2001 but the labor productivity of grains dropped gradually in contrast to the gradual rise in the labor productivity of products other than grains. This was mainly because of the promotion of adjustment of the agriculture structure by urbanization process. The correlation between urbanization level and agricultural diversification indexes (ADI) also supported such conclusion. The correlation coefficient was 0.7425 for the period.

During 1949-2001, there was a positive correlation between farmer's income level and urbanization level and the coefficient of correlation was 0.8528.

### 3 Regression model of the urbanization level

According to actual data about industrialized level and urbanization level of Chengdu City<sup>[11]</sup> (see Tab. 2), the scatter diagram between the urbanization rate ( $y$ ) and industrialization rate ( $x$ ) assumed an exponentially curved relationship:  $y = ae^{bx}$ . After linear treatment to the equation,  $\ln y = \ln a + bx$ . After the regression analysis of the data in Tab. 2<sup>[11]</sup>, we can get the curve equation (i.e. the theory model of the urbanization level) as follows:  $\ln y = 2.924873 + 0.010514x$

**Table 2.** The relationships between rates of industrialization ( $x$ ) and urbanization ( $y$ ) of chengdu city

Years	Industrialization rate(%)*	Urbanization rate(%)**
1949	9.68	20.29
1950	9.61	19.95
1960	52.48	30.08
1970	44.51	23.75
1980	49.63	23.35
1990	39.71	27.30
1995	43.40	30.97
1996	44.31	31.63
1997	45.32	32.20
1998	45.10	32.83
1999	44.74	33.50
2000	44.71	34.13
2001	45.32	34.79

Note: \*: The industrialization rate can be approximately expressed with the rate of second industrial output in whole national economy, i.e. industrialized rate or industrialized level= GDP of the secondary industry  $\div$  GDP  $\times$  100%.

\*\* : Urbanization rate can be expressed with the proportion of urban population, i.e. urbanization rate or urbanization level= Non-agricultural population  $\div$  Total population  $\times$  100%.

The result of this model simulation was statistically significant (Tab. 3) and could be used for explaining the relationship between urbanization and industrialization in Chengdu city. In the table, Dependent Variable:  $Y$ ; Method: Least Squares; Sample: 1949–2001; Included observations: 13.

## 4 Analysis of the relationship between urbanization process and agricultural development

### 4.1 Hypotheses

The following hypothesis was assumed when the analysis of the relationships between urbanization process and agricultural development in Chengdu city was made:

**Table 3.** The results of regression model on urbanization and industrialization

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>C</i>	2.924783	0.124806	23.43468	0.0000
<i>X</i>	0.010514	0.002970	3.539565	0.0046
R-squared	0.532482	Mean dependent var		3.344136
Adjusted R-squared	0.489981	S. D. dependent var		0.198122
S.E. of regression	0.141490	Akaike info criterion		-0.932541
Sum squared resid	0.220213	Schwarz criterion		-0.845626
Log likelihood	8.061516	F-statistic		12.52852
Durbin-Watson stat	0.487800	Prob(F-statistic)		0.004636

(1) All of population at the beginning of the urbanization was supposed to be agricultural population and the amount of food produced at the moment was supposed to equal to that demanded by the population.

(2) The consumption of food of an average urban people was supposed to the same as that of an average rural people.

(3) The trade of food products between Chengdu city and other area was supposed to be zero.

(4) Food products were supposed to be only in the form of grain.

#### 4.2 The analysis of mutual dependence between the urbanization and agricultural development

With the above hypotheses, there was a correlation between the increase rates of both labor productivity of food and urbanization:

Increase rate of food labor productivity ( $G$ ) =  $\frac{1}{(1-UR)} - 1$ <sup>[9]</sup>, in which, UR= urbanization level, i.e. proportion of urban population to total population (%).

The theoretical level of labor productivity of food could be calculated in accordance to the urbanization level (Tab. 4) and comparison of actual and theoretical increase in labor productivity of food could indicate whether the food production was sufficient during the period.

From Tab. 4, it could be observed that the increase in food production in Chengdu city failed to fulfill the requirement by the advances in urbanization.

#### 4.3 Constrains on the increase of agricultural productivity

The agricultural development level in Chengdu city, especially in the respect of food production, failed to keep up with the urbanization process largely due to the followed reasons.

(1) The decrease in agricultural investment resulted in the drops in the agricultural labor productivity.

Insufficient agricultural input directly affected the land output and led to the reduction in agricultural labor productivity. Although the value of the financial input from government has increased in past years but the proportion of agriculture expenditure dropped significantly from 10.36% in 1980 to 4.7% in 2001. The credit expenditure used for agriculture was continuously at low levels. The proportion of short loans from financial institution used in agriculture was only 1.92% in 1990 and did not exceeded 5.0% yet in 2001.

Government investment in agricultural infrastructure construction was extremely weak and had deteriorating effects on the farmer's investment enthusiasm. The investment of agricultural infrastructure construction accounted for 5.55% of the total infrastructure construction input by gobenment in 1978, the value was lowered to 2.53% in 1980 and less than 1% since 1990s. Meanwhile the cost of the agriculture activities, especially of plantations, has increased continuously during the period.

(2) The relatively low profit of agriculture products, especially of grain products, lowered the enthusiasm of the farmers and resulted in the reduction in the grain land productivity.

Tab. 5 shows the reduction in the profit of agricultural production and the grain production in 1978-2001. The low benefit failed to stimulate farmer's enthusiasm of input. As a rational reaction in a market economy, the tendency that the farmer household invested in the non-agriculture industry had become stronger in the past years while the agricultural investment especially that in grain production, gradually decreased.

**Table 4.** Food labor productivity and the increase rate in agriculture workforce in chengdu city

Year	Total output of grain 1×107 kg	Agricultural workforce (person)	Labor productivity of agricultural workforce (kg grain /person)	Actual increase in labor productivity of food (%)	Theoretical increase in labor productivity of food (%)*	Difference in between actual and theoretical increase in labor productivity of food (%)
1989	356.80	3004399	1188	/	36.99	/
1990	381.70	3051316	1251	5.30	37.55	32.25
1991	392.26	3153057	1244	0.56	38.12	38.68
1992	399.05	3167465	1260	1.29	39.80	38.51
1993	397.53	3004900	1323	5.00	41.14	36.14
1994	397.30	2870400	1384	4.61	43.47	38.86
1995	398.97	2826002	1412	2.02	44.86	42.84
1996	400.61	2723731	1471	4.18	46.24	42.06
1997	402.10	2682900	1499	1.90	47.49	45.59
1998	403.86	2671074	1512	0.87	48.88	48.01
1999	397.02	2530905	1569	3.77	50.38	46.61
2000	363.71	2440924	1463	6.76	51.81	58.57
2001	310.73	2402693	1371	6.29	53.35	59.64

Note: \*: Theoretical value was calculated according to the formula, increase in labor productivity of food ( $G = \frac{1}{(1-UR)} - 1$ ), in which urbanization level (UR) was the proportion of urban population to total population (%)

Source: “ *statistical yearbook of Chengdu* ” (relevant year).

**Table 5.** Change in the average income constitution of farmer households in chengdu city

Items		1978	1980	1990	1995	2000	2001
Total income per person (yuan)		168.56	262.06	1195.27	2811.08	4298.28	4663.34
Wages	Amount (yuan)	28.12	42.41	130.20	296.36	1006.78	1124.93
	Proportion to total income(%)	16.68	16.18	10.89	10.54	23.42	24.12
Income from farming and other activities	Amount (yuan)	117.83	190.57	1003.28	2398.33	2911.70	3134.80
	Proportion to total income(%)	69.90	72.72	83.94	85.32	67.74	67.22
Income from plantations	Amount (yuan)	66.88	111.16	491.52	1152.29	1210.01	1244.62
	Proportion to total income(%)	39.68	42.42	41.12	40.99	28.15	26.69
Grain yield (kg/hectare)		4010	4245	5433	5708	5902	5383

Source: “ *Chengdu Statistics Yearbook* ” (relevant year).

(3) The small land acreage of every farmer household limited the investment enthusiasm and affected the land productivity.

In the case of Chengdu city, The average area of cultivating land of each farmer was 667 m<sup>2</sup> in 2000, which was less than the averages of either whole China mainland (1047 m<sup>2</sup>) and western part China (1107 m<sup>2</sup>). The small cultivating land acreage of the farmers in Chengdu city had damaged the enthusiasm to a certain degree and had negatively affected the land productivity.

(4) The national economic development and the agricultural structure adjustment have brought about changes in the land utilization structure and accelerated the reduction of cultivated areas to surpass the speed at which the land productivity increased. By reducing the total output of the grain production, they have also hindered the increase in labor productivity of food.

During the process of the national economy development accompanied by the adjustment of the structure of wholesome national economy as well as that of agricultural, the structure of land utilization has also

changed with the characterization of the overall reductions in the areas of the cultivating lands. The speed of such reduction has surpassed the speed at which the land productivity was increased and has consequently resulted in the slower increase and even the reduction in grain yield and hindered the increase in the labor productivity of food.

(5) The deterioration of the agro-ecological environment has directly reduced the land quality for grain production and hindered the increase in the labor productivity of food.

The quality as well as the areas of cultivating land has dropped due to the environmental deterioration and natural disasters during the past years. The area of the cultivating destroyed by natural disasters increased to 32 hectares in 1999 and 64 hectares in 2000. The effects of such drops in the quality and areas of cultivating lands resulted in the decrease in the gain output and hindered the increase in the labor productivity of food.

## 5 Conclusions and suggestions

According to theoretical analysis on inherent links between urbanization and agricultural development based on the data from Chengdu city, it could be concluded that the agricultural development level in Chengdu city, especially in the respect of food production, failed to keep up with the urbanization process. To realize the further urbanization process of Chengdu city, more attention and investment should be paid to agricultural production to improve the labor productivity of food and other agricultural products. The followed measures were suggested.

(1) It has to be realized and taken as the guidance for every program that only the coordinated urbanization and agriculture development can be sustainable.

(2) Agricultural investment has to be increased to enhance the land productivity. At present, the land productivity of food can not meet the requirement of the urbanization of Chengdu city. Vigorous measures have to be taken to increase agricultural investment for the increase the productivity of food.

(3) Agricultural technology has to be advanced and extended to enhance the agricultural productivity. As the primary factor of the productivity, the advances of the science and technology, such as modern agrobiotechnology, can significantly promote the improvement of agricultural productivity.

(4) Agricultural production structure has to be adjusted and optimized to fulfill the requirement for agricultural products by the process of urbanization.

(5) Industrialize the agriculture to elongate the chains of the primary industry to the main industries of the city and to consequently elevate the levels of urbanization.

(6) Allocate the resources rationally in accordance to the current status of the resources to realize the optimal usage of the resources, the formation of the differently characterized modes for cities and towns to develop and the coordinated development of urbanization and agriculture.

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