Empirical Study

Determinants of agricultural water saving technology adoption: an empirical study of 10 provinces of China

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Abstract: *In recent years, China has been faced by an increasingly severe water shortage due to the continual growth of demand on water resources. Although the Chinese government has been actively promoting the agricultural water-saving technology adoption, it is ill-informed of the adoption degree of the current agricultural water-saving technologies as well as the function of the governmental policies. Therefore, this paper analyzes the aforesaid problems based on investigative data of 10 provinces in China. The results demonstrate that although there is a rapid increase of adopted agricultural water-saving technologies, the actual adoption area is rather limited. Moreover, the governmental policies and scarcity of water resources are the determinants of agricultural water-saving technology adoption. Ultimately, the paper proposes some policy suggestions.*

Keywords: *Agriculture; Water saving technology; Water resource; Water shortage*

1. Introduction

China is confronted with severe shortage of water resources. On the one hand, the supply of water resources is constantly decreasing. Although the national water resources total 2.5 trillion m^3, listed as No. 6 in the world [1], the water resource per capita is merely 1,945 m^3, less than 1/4 of the average world per capita [2] listed among the 13 water-poor countries. Furthermore, the shortage is aggravating, especially the total underground water resources tends to decrease [3]. On the other hand, the total demand for water resources is dramatically increasing. Since the establishment of the People's Republic of China, the total demand for water resources has been growing rapidly. Total water consumption of China increased from 103.1 billion m^3 in 1949 to 543.5 billion m^3 in 2005 [1, 4].

The shortage of water resources and fierce competition between various departments result in decreasing water consumption rate of agricultural sectors. Back to the early period after establishment of P.R.C., the water consumption rate of China's agricultural sectors was up to 97%; however, by 2005, that rate had decreased to 69% and the water consumption rate of non-agricultural sectors had exceeded 30% [5]. It can be foreseen that the water consumption rate of agricultural sectors in China will further decrease along with the rapid economic development.

Nevertheless, the use efficiency of China's agricultural irrigation water is rather low. Researches demonstrate that the use coefficient of agricultural irrigation water is merely 0.3-0.4, with a difference of 0.4-0.5 compared with 0.7-0.9 of those developed countries; and the water use efficiency of crops averages 0.87 kg/m^3, with a difference of 1.45 kg/m^3 compared with Israel's 2.32 kg/m^3 [6]. From similar studies we have found that the use efficiency of irrigation water in China is far lower than that of developed countries [7, 8]. In addition, studies of Wang Jinxia et al. [9] and Lohma et al. [10] have found that the shortage of investment, dilapidated condition without repair and improper management have resulted in the low use efficiency of irrigation water.

Confronted with increasingly severe condition of agricultural irrigation water, the Chinese government has been continuously increasing investment

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in agricultural water-saving technologies. Starting from 1985, Ministry of Finance, in active collaboration with sectors of water resources and banking, has granted a total of 1.69 billion yuan of discount interest loan for water-saving irrigation in successive years; finances at all levels has accumulated discount interest of approximately 0.2 billion yuan and attracted investment of 1.6 billion yuan from various parties, developing over 15 million mu of water-saving irrigation area. For the purpose of enhancing the water-saving irrigation technology of China, in 1996 and 1997, the Central Finance listed the technology of water-saving irrigation among State Imported 1000 Advanced Agricultural Technologies Project, as a key funding program. Meanwhile, to popularize advanced and practical water-saving technologies, Ministry of Finance allocated technology extension outlay for technology publicity and personnel training. Besides, the state has increased investment in the infrastructure of farmland irrigation [11].

Although the government has been actively promoting water-saving technology adoption, it is ill-informed of the status of this adoption. Simultaneously, researches on water-saving technology adoption in China by the academic circles are quite limited. The scarce documents available, which study the water-saving technology adoption, are mainly cases study and qualitative analysis, lacking in quantitative analysis.

Therefore, this paper employs data from ten provinces in China to carry out a quantitative analysis of the status quo of agricultural water-saving technology adoption and its determinants. What on earth is the current adoption extent of water-saving technology in China? Which factors may have remarkable effect on its adoption? What roles do shortage of water resources and governmental policy play? Specifically speaking, this paper has two purposes: firstly to describe the changing tendency of water-saving technology adoption and secondly to identify the determinants affecting this adoption.

This paper is organized as follows: introduction; data sources, types, status quo and changing tendency of water-saving technology adoption; descriptive analysis on water-saving technology adoption; econometric analysis and results; conclusion and policy implications.

2. Data, types, status quo and changing tendency of water-saving technology adoption

The water-saving technology defined by us refers to perceptible water-saving irrigation technology at field level. Likewise, the definition of water use efficiency also means crop yield per unit water input measured at field level, for water-saving technology adoption is found not water-saving in some conditions when the net water use amount is measured in the overall irrigation system or on the drainage area scale. This is because the water-saving nature of each technology is not only determined by technological characteristics but also by factors like hydrological system and economic adjustment of output [12] [a].

2.1 Data source

Data employed in this paper derives from field investigation of three projects done by the Center for Chinese Agricultural Policy (CCAP).

The first project was investigation on China's water right system and management panel data. This investigation is divided into two phases: during the first phase, investigation was done in Henan, Hebei and Ningxia in 2001 and the investigation period was respectively 1990, 1995 and 2001; during the second phase, follow-up investigation was performed in Henan and Hebei in September, 2004. To add data to

[a] Did the water-saving technology real save water consumption? The answer to the question depends not only on feature of each technology, but also on the hydrology system used for the water-saving technology. If the irrigation water is withdrawn from the shallow aquifer and the water irrigating the farmland does not evaporate from both the surface of soil and with growing crops, the water will return to aquifer leading to no loss from the system. In such a case, (e.g. the research on Luancheng County of Hebei Province by Kendy [13]), actually, water-saving comes from the reduced total loss in soil moisture evaporation (ET). The water-saving technology by reducing seepage (underground piping system or lined channels) or applied water facilities (such as furrow irrigation, leveling of land, sprinkler irrigation) will not result in considerable water saving. Moreover, it is possible that recharge of water at one area may have effect on the amount of underground water used for another area in irrigation. If this is the case, reduction of water compensation by water saving may possibly cause negative impact on use of underground water at other areas.

2004, another follow-up investigation was completed in Ningxia in August, 2005. The investigation of this project randomly sampled 77 villages based on the scarcity degree of water resources.

The second project was investigation on water resources of Northern China in December, 2004. 6 provinces were investigated, including Henan, Hebei, Shannxi, Shanxi, Inner Mongolia, and Liaoning. The invested periods were 1995 and 2004 respectively. To make the research more representative, we adopted the way of randomly stratified sampling to select sample villages in Northern China. Firstly, we selected counties in each sample province and then divided them into 4 categories in accordance with their irrigation area, namely sever water shortage, partial water shortage, normal and absolute water shortage (mountain areas and deserts). We randomly sampled 2 townships in each county and 4 villages in each county. The second investigation collected 401 sample villages [b].

The third project was investigation on water-consuming consortiums of 3 provinces in July, 2006, including Gansu, Hubei and Hunan. We adopted the randomly stratified sampling based on scarcity degree of water resources in 1995 and 2005 respectively. Altogether 60 sample villages were selected.

Investigation of the first and second projects collected 478 sample villages and investigation of the third obtained 60 sample villages. Therefore, there are a total of 538 samples from the three investigations. As samples of the final investigation are data of 2005, we deal with all data of 2004 in accordance with those of 2005 in consideration of consistency [c].

2.2 Types of adopted water-saving technologies

Based on investigation of 538 villages in 10 provinces, we have found that there are various types of water-saving technologies in the rural area. To facilitate analysis, we categorize them into three types in accordance with capital needed, separability and time of adoption.

The first type is traditional water-saving technologies including border irrigation, furrow irrigation and land leveling. We categorize these technologies into the same type as they were adopted rather early and some were adopted in 1980s prior to agricultural reform as most village leaders reflected. Besides, these technologies have relatively low fixed cost and are separable for each household to operate independently.

The second type is household-based water-saving technologies which include ground pipes (film plastic pipe or water bags), plastic film cover, leaving stubble to avoid plough (wheat straw covering), intermittent irrigation and anti-drought breeds [d]. Normally this type of technologies can be adopted by a single household (rather than village committees or farmer household group). In addition, they have relatively low fixed cost but high separability. In comparison with traditional technologies, these types of technologies were adopted later.

The third type is community-based water-saving technologies which include underground pipes, sprinkler irrigation, drip irrigation and anti-seepage channel. These types of technologies are usually adopted by the community or farmer group instead of individual farmer household as they demand equipment with relatively high fixed cost and require cooperation of the collective or the majority of farmer households. Compared with the previous two types, these technologies were not adopted by farmers until recent years.

2.3 Status quo and changing tendency of adopted water-saving technology

Generally speaking, villages adopting water-saving technologies in China are distributed widely and scattered rapidly. It can be seen from Table 1 that 79% villages adopted water-saving technologies in 1995 and that number increased to 95% in 2005,

[b] At Dadeng Town, Xiangfen County, Shanxi Province, our investigation team has investigated an additional village (Qianhe Village) which was also included in the paper as effective sample.

[c] Due to only one year's interval between 2004 and 2005 and no big change in real conditions thereof, they were incorporated in the treatment.

[d] Here, it does not mean draught-resistant species in real sense and it only means that such species has property of draught-resistance in itself because the genuine draught-resistant species is just found by research, which is not spread and publicized massively.

increasing by 16%. From 1995 to 2005, the adoption rate of water-saving technologies averaged 87%, that is to say, only 13% villages did not adopt any kind of water-saving technology during the 10 years.

However, the actual adoption area of water-saving technologies in each village was rather small. In 1995 the rate was 11% and merely 16% in 2005. Although there is a growth to some extent, the adoption area of water-saving technologies was still quite low, by far lower than the rate of villages adopting water-saving technologies. This indicates that the area which actually adopted water-saving technologies is very small in spite of the wide spatial distribution of adopted water-saving technologies in China. This also signifies that there is great development space for the adoption of water-saving technologies.

As the same of the overall adoption, the adoption degree of the three types of water-saving technologies is very low. It can be seen from Table 2 that even for the traditional water-saving technologies which were adopted the earliest and the most widely, the adopted area merely accounted for 28% arable area in 2005; let alone the household-based and community-based technologies, which merely accounted for 12% and 9% respectively in 2005, accounting for 1/10 arable area in average, far below the adoption rate of developed countries like America and Israel.

But there is a remarkable difference in the growth tendency and status of these three types of water-saving technologies. On the one hand, the growth of traditional technologies is slower than that of household-based and community-based types. From 1995 to 2005, the traditional technologies merely increased by 47% whereas the household-based and community-based technologies increased respectively by 200% and 300%. This indicates that modern water-saving technologies are developing rapidly. On the other hand, though traditional technologies witness low increase, they are still significant in terms of adopted area. In 2005, the adopted area of traditional technologies was 28% whereas those of household-based and community-based technologies were less than 15%. This implies that water-saving technologies adopted in China are still rather backward. In similar studies done by Lohmar et al. [10], similar conclusion was drawn.

Table 1
Raito of villages adopting water-saving technologies and of adopted area in 1995 and 2005

Whether to adopt water-saving technology	Number of villages		Ratio of villages (%)		Area	
	1995	2005	1995	2005	1995	2005
Adopted	426	510	79	95	11	16
Not adopted	112	28	21	5	89	84

Table 2
Raito of villages adopting three types of water-saving technologies and of adopted area in 1995 and 2005

Water-saving technology	Number of villages		Ratio of villages (%)		Area (%)	
	1995	2005	1995	2005	1995	2005
Traditional						
Adopted	369	443	69	82	19	28
Not adopted	169	95	31	18	81	72
Household-based						
Adopted	319	451	59	84	6	12
Not adopted	219	87	41	16	94	88
Community-based						
Adopted	134	284	25	53	3	9
Not adopted	404	254	75	47	97	91

3. Descriptive analysis on factors affecting water-saving technology adoption

We analyze the correlation between water-saving technology adoption and the two types of factors in this paper and classify the three types of water-saving technologies into five groups in accordance with rate of the adoption area in a method of sample-based isometric grouping (An exception is that the first group includes all samples with an adopted area of 0 and all the others are isometrically grouped based on samples. Refer to Line 2-3 of Table 3).

3.1 Correlation between scarcity of water resources and water-saving technology adoption

Theoretically speaking, the scarcer a resource becomes, the more likely it is to adopt technologies to save this resource [14]. Previous empirical studies also demonstrate that scarcity of water resources is in positive correlation with water-saving technology adoption [15-22]. Our investigative data reveals that the three variables reflecting scarcity of water resources are basically in positive correlation with the three types of water-saving technologies (Refer to Line 4-6 of Table 3). For instance, as the ratios of irrigation water from underground water were increased to 43% and 45% from 12% and 24% respectively, the adopted area of traditional and household-based technologies increased correspondingly. Although the correlation between scarcity of water resources and adopted area of community-based technologies is first positive and then negative, the overall correlation is positive. The other two variables, inadequacy rates of surface water and underground water are also in positive correlation with adoption of the three types of technologies.

Table 3
Correlativity between adoption of three types of water-saving technologies and scarcity of water resources and policy support from 1995 to 2005

Types of water-saving technologies	Number of observation (1076)	Adopted area of water-saving technologies (%)	Scarcity of water resources			Policy support		
			A	B	C	D	E	F
Traditional								
Group 1	264	0	12	17	5	22	4	9
Group 2	203	7	33	20	19	39	13	17
Group 3	203	23	37	21	20	35	9	16
Group 4	203	35	38	21	16	41	9	19
Group 5	203	59	45	25	16	45	13	29
Household-based								
Group 1	306	0	24	14	7	24	5	10
Group 2	193	2	24	25	15	46	12	20
Group 3	193	7	31	22	15	38	8	18
Group 4	193	14	41	19	23	33	12	20
Group 5	191	30	43	24	17	45	13	24
Community-based								
Group 1	658	0	27	19	11	28	5	12
Group 2	105	2	45	21	26	37	15	19
Group 3	105	8	42	22	25	50	19	27
Group 4	104	17	49	17	14	45	16	28
Group 5	104	28	26	27	14	62	17	31

Note: A: Irrigation water totally from underground water (%); B: Inadequacy rate of surface water (%); C: Inadequacy rate of underground water (%); D: Whether the government popularizes the technologies (%); E: Whether the government offers fund support (%); F: Whether the government establishes demonstration villages (%).

3.2 Correlation between support of governmental policy and water-saving technology adoption

Generally speaking, the more support policies by government on water-saving technology adoption, the more likely it is to adopt them. However, it is difficult to analyze governmental support policies one by one as there are too many relevant policies and it is not necessary to do so. So we classify these policies into three aspects as required, namely, popularization, funding and demonstration. The existing studies demonstrate that extension of water-saving technologies has a great positive effect on their adoption [23], and policy support has positive impact on its adoption [24-27]. Data shows that governmental policy support is likely to have conspicuous impact on the water-saving technology adoption (Refer to Line 7-9 of Table 3). As the variable of governmental extension increased to 45%, 45% and 62% respectively from 22%, 24% and 28%, adoption area of the three types of water-saving technologies also increased, which demonstrates great positive relation between them. Likewise, the increase in variable of governmental funding support to 13%, 13% and 17% respectively from 4%, 5% and 5%, also demonstrated the obviously positive relationship with the adoption area of the three types of water-saving technologies. Moreover, the variable of establishment of demonstration villages is also in positive relationship.

It is certain that water-saving technology adoption might be affected by other factors (ratio of economic crop area, agrotype, non-agricultural employment rate, educational level, arable land per capita) in addition to the above-mentioned two types of variables.

The previous analyses demonstrate that water-saving technology adoption is in highly positive relation with scarcity of water resources and governmental policy support. However, the analyses above merely reflect the simple correlativity between variables but fail to consider other affecting factors. Further analysis based on econometrical model is needed to figure out the outcomes after control of other factors.

4. Econometric model and results

For the purpose of an accurate analysis on the inherent relationship between the above-mentioned phenomena, we establish the following econometric model to analyze the determinants for water-saving technology adoption by employing data of 538 villages in 1995 and 2005.

4.1 Establishment of the econometric model

Water-saving technology adoption degree=F (Whether the irrigation water is completely from underground water, inadequacy rate of surface water and underground water; whether the government has offered funding support to this village for adopting water-saving technologies; whether the county has set up demonstration villages or experimental bases for adopting water-saving technologies, control variables and other factors.)

We select the percentage of adoption area of water-saving technologies (%) to reflect the adoption degree of these technologies. This index means the ratios between the areas respectively adopting the three types of water-saving technologies against total arable area.

For the purpose of an overall reflection of the scarcity of water resources, we measure the scarcity of water resources from three various aspects, namely, irrigation water resources, reliability of surface water and reliability of underground water. (1) Whether the irrigation water is completely from underground water (0 represents No whereas 1 Yes); (2) Inadequacy rate of surface water (%), this index is calculated by investigating the years when water channels of the villages were short of water between 1993 and 1995 as well as that between 2002 and 2005. Likewise, we also choose three variables to reflect policies [e] which might affect water-saving technology adoption: (1) Whether the government has carried out activities to extend water-saving technologies (0 represents No whereas 1 Yes); (2) Whether the government has offered funding support to this village for adopting water-saving technologies (0 represents No whereas 1 Yes); (3) Whether the county has set up demonstration villages or experimental bases for adopting water-saving technologies (0 represents No whereas

[e] Generally speaking, the relevant policies to water saving technologies may be divided into that on surface water and that on underground. Here means the policies in the two aspects without division made, because in some cases, it is hard to clearly differ from the two kinds of policies.

1 Yes). In order to avoid any inherent problems these variables are respective information of two lag periods from 1990 to 1995 and from 2001 to 2005.

To control the effects of other factors, we add some control variables in the model. For instance, we add the ratio of economic crops (%), soil type (sand soil 0-1) and loam soil (0-1), with clay as the comparison group since they may affect the costs and benefits of adopting the water-saving technology. We also control some other village level variables, including arable land per capita(mu/person), irrigation area (%), net income per capita (yuan/person) [f], non-agricultural employment rate (%) [g], the ratio of villagers with middle-school or high-school education (%) and the distance from the village committee to the county government (km, Appendix A). The existing research shows that these variables have influences on the adoption of water-saving technology since adopting these technologies needs cost, information and knowledge. Moreover, the implementation of water-saving technologies is also related to the distance between the village and the upper level government since the larger the distance, the more difficult it is to monitor the use of the technology.

4.2 Selection of model estimation method

As the dependent variables are limited dependent variables, many observed values are zero. For instance, 658, 306 and 264 observed values are zero respectively in areas adopting community-based, household-based and traditional technologies. Thus the method of Ordinary Least Square(OLS)may result in invalidity-inclined results, so we use the Tobit estimation method. In addition, considering that each province has some uncontrolled factors, a provincial dummy variable is added in the model.

4.3 Estimation results and explanations

According to the estimation results of Table 4, the major factors affecting water-saving technology adoption are summarized as follows.

Firstly, generally speaking, the Chi^2 test of Tobit model is very conspicuous and the coefficient symbols of independent variables concerned are basically consistent with those anticipated. This indicates that it is acceptable to adopt Tobit model for estimation. Meanwhile, the co-linearity is also tested. As the condition number between variables is very small, merely 15.1, the model basically does not have co-linear problem.

Furthermore, the control variable also has remarkable impact on the adoption model of the three types of water-saving technologies. For instance, rate of irrigated area, education variables (ratio of villagers with middle-school education) and net income per capita all have remarkable positive effect in the model as anticipated theoretically. Also, the area proportion of economic crops has remarkable positive effect on household-based and community-based technologies. This might be explained by the fact that the high yields of economic crops can compensate the high input cost of household-based and community-based technologies [28].

It is worth mentioning that coefficients of arable land per capita and non-agricultural employment rate are negative in the traditional technology model, respectively reaching a significant level of 1% and 5% respectively statistically. This demonstrates that the two coefficients are in significant negative correlation with adoption of traditional technologies. This outcome might be due to the fact that the relatively backward traditional technologies tend to demand more labor force.

Secondly, scarcity of water resources has signification promotion on water-saving technology adoption.

The estimation result of the model demonstrates that the three variables indicating scarcity of water resources have significant effects on water-saving technology adoption and all their coefficients are positive values (Refer to Line 1-3 of Table 4). This is consistent with previous analysis. However, different types of water-saving technologies have different responses to the variable of scarcity of water resources.

Judging from the regression result, the coefficient of the variable of irrigation water completely from underground water is positive in models of the three

[f] It means the net income per capita after adjustment for consumer price index of rural residents taking 2005 as basic term.

[g] The non-farming employment proportion here means [number of villagers earning incomes in their own village number of villagers earning incomes from outside of their village (those out in the morning and back in the evening) + number of villagers numbers of villagers working outside]/total labor force.

Table 4
Tobit estimated results of adoption area of the three types of water-saving technologies

	Rate of adoption are of water-saving technologies (%)		
Explanatory variables	Traditional	Household-based	Community
Scarcity of water resources			
Irrigation water completely from underground water	9.313	2.232	5.134
	(1.864)‡	(1.092)†	(1.541)‡
Inadequacy rate of surface water(%)	0.091	0.041	0.026
	(0.021)‡	(0.012)‡	(0.018)
Inadequacy rate of underground water(%)	0.030	0.036	0.044
	(0.022)	(0.013)‡	(0.018)†
Policy support			
Governmental extension of water-saving technologies	6.383	3.563	3.489
	(1.582)‡	(0.922)‡	(1.306)‡
Governmental subsidization of water-saving technologies	0.883	1.582	10.006
	(2.041)	(1.183)	(1.520)‡
Governmental establishment of demonstration villages adopting water-saving technologies	3.080	0.366	-0.524
	(2.010)	(1.172)	(1.561)
Crop structure			
Ratio of economic crop area(%)	-0.019	0.070	0.088
	(0.040)	(0.023)‡	(0.032)‡
Soil type(clay of comparison group)			
Sand soil	-0.511	0.370	1.419
	(2.188)	(1.283)	(1.825)
Loam soil	-1.352	-0.981	1.578
	(2.103)	(1.228)	(1.751)
Variables of village features			
Arable area per capita(mu)	-2.047	-0.107	-0.263
	(0.487)‡	(0.229)	(0.358)
Rate of irrigation area(%)	0.208	0.043	0.116
	(0.023)‡	(0.014)‡	(0.020)‡
Net income per capita(yuan)	0.000	0.001	0.003
	(0.001)	(0.000)	(0.001)‡
Non-agricultural employment rate(%)	-0.076	-0.006	-0.009
	(0.036) †	(0.021)	(0.029)
Ratio of villagers with middle-school education (%)	0.043	0.064	0.070
	(0.032)	(0.019)‡	(0.027)‡
Distance between the village committee to county government(km)	-0.053	-0.012	0.033
	(0.030)*	(0.018)	(0.024)
Province dummy variable [i]	NA	NA	NA
Intercept item	-31.339	-17.112	-24.821
	(6.040)‡	(3.375)‡	(4.383)‡
Chi^2 checked value	489.8	332.61	360.65
Sample number	1,076	1,076	1,076
Degree of freedom	1,049	1,049	1,049

[h] In brackets are standard deviation; *, † and ‡ respectively represent the significance level of statistical test is 10%, 5% and 1%.

[i] Due too many provincial dummy variables (9 dummy variables in 10 provinces), here omits the estimated coefficients and standard deviation for these dummy variables.

types of water-saving technologies and is conspicuous statistically. This demonstrates that villages with irrigation water from underground water, in comparison with villages with irrigation water from surface water, are more inclined to adopt water-saving technologies. Nevertheless, judging from simple coefficient decomposition, this explanation degree is not high, namely, 7.9%, 2.1% and 6.4% respectively.

The variable of inadequate surface water is also positive in the model of traditional water-saving technology and reaches 1% significance level statistically. This indicates that the scarcer the surface water is, the more likely it is to adopt traditional technologies. This might be explained by the fact that traditional water-saving technologies are greatly affected by surface water as water used by traditional technologies is mainly from surface water. But the explanation degree of traditional water-saving technologies is only 11.6%.

Likewise, the variable of inadequate underground water is positive in the model of community-based technologies and reaches a significance of 10% statistically. This demonstrates that villages with scarce underground water are more willing to adopt community-based water-saving technologies, which might be explained by the fact that water used by community-based water-saving technologies is mainly from underground water and therefore any change of underground water may greatly affect the adoption of community-based technologies. But the explanation degree is not higher than 12.6%.

Household-based technologies normally have two sources (surface water and underground water), so the variables of inadequate surface water and inadequate underground water are both positive in the model of household-based technologies and their coefficients reach a significant level of higher than 1%. This demonstrates that scarcity of surface water and underground water may both affect the adoption of this type of technology. But from the explanation degree, the explanation of inadequate underground water is better (with the explanation degree of inadequate underground water and inadequate surface water respectively being 7.8% and 5.7%).

Thirdly, policy support also has an obvious effect on water-saving technology adoption

It can be concluded from the estimation results that policy support also has a distinct effect on water-saving technology adoption and the coefficients are all positive (Refer to Line 4-6, Table 4).

The coefficients of the variable of governmental extension are all positive in the model of the three types of water-saving technologies and reach a significance level of over 5%, which demonstrates that villages with governmental extension, in comparison with those without it, are more inclined to adopt water-saving technologies. This might be explained by the fact that the information and technology the promotion personnel brings have promoted the adoption of water-saving technology. The explanation degrees of this variable reach 21.2%, 12.9% and 16.9% respectively in the three models, which explains approximately 20% changes of water-saving technology adoption.

The coefficients of the variable of governmental subsidization are positive in the model of community-based technology and reach a significant level of up to 1% statistically. This demonstrates that villages with governmental subsidization, in comparison with those without it, are more probable to adopt community-based technologies. This might be explained by the fact that community-based technologies tend to demand large investment of funds and are thus more sensitive to subsidizing policy. Likewise, the explanation degree of this variable is up to 24.8%, that is to say, the variable of governmental subsidization explains 1/4 changes of the adoption area of the community-based water-saving technologies.

Different from the two previous policy supports, governmental demonstration hardly has any effect on the model of the three types of water-saving technologies. This indicates that governmental demonstration policy does not affect water-saving technology adoption. This might be due to the failure of real implementation of this demonstration policy. However, generally speaking, governmental policy support, compared with effect from scarcity of water resources, has a greater effect on adoption area of water-saving technologies.

5. Conclusion and policy implications

The paper mainly analyzes the major impacts on agricultural water-saving technology adoption in

China. The field investigative data of the three projects done by Center for Chinese Agricultural Policy (CCAP) are applied for estimation and analyses on the basis of econometric model. The research results demonstrate that although there is rapid increase of water-saving technology adoption in China, the overall adoption level remains rather low; and the water-saving technology adoption in China is determined by multiple factors, among which scarcity of water resources and policy interference are the two main determinants affecting the water-saving technology adoption. In addition, crop structure, per capita arable area, non-agricultural employment rate and education are also affecting water-saving technology adoption to various extents.

The above-mentioned research results imply that if China desires to promote overall adoption of water-saving technology, extension of the water-saving technology is likely to be an effective policy tool; if China desires to vigorously develop community-based water-saving technology, the policy of subsidizing the water-saving technology might be more effective; the adjustment of crop structure to high value-added cash crops might encourage farmers and communities to apply modern water-saving technology; openness of household registration and less separation of urban and rural area in recent years, which have resulted in expansion of non-agricultural employment rate, might reduce adoption of traditional water-saving technology. Moreover, as the scarcity degree of water resources has a positive effect on adoption of water-saving technology, the establishment of water right market and perfection of water pricing policy might also promote the adoption of water-saving technology.

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Appendix A: Descriptive statistics for major variables

Variable	Observations	Mean	Std. Dev.	Min	Max
The share of adoption area of community technology (%)	1,076	5.4	9.4	0	58.3
The share of adoption area of household technology (%)	1,076	9.3	11.5	0	77.5
The share of adoption area of traditional technology (%)	1,076	23.6	22.3	0	100
Irrigation water only from ground water or not (0-1)	1,076	0.3	0.5	0	1
Percentage of surface water not enough (%)	1,076	20.3	35.8	0	100
Percentage of ground water not enough (%)	1,076	14.7	32.8	0	100
Government extension or not (0-1)	1,076	0.5	0.5	0	1
Government subsidy or not (0-1)	1,076	0.1	0.4	0	1
Government make the experimental spot in town or not (0-1)	1,076	0.2	0.4	0	1
Percentage of cash area account for total sown area (%)	1,076	19.9	20.3	0	100
Sand soil or not (0-1)	1,076	0.4	0.5	0	1
Clay soil or not (0-1)	1,076	0.5	0.5	0	1
Land area per capita (%)	1,076	2.3	2.4	0	44.8
Percentage of irrigated area (%)	1,076	59.3	38	0	100
Income per capita (yuan)	1,076	1,623.4	1,114.7	80	10,000
Percentage of nonagricultural employment (%)	1,076	11.9	9.8	0	72
Percentage of farmers in the village went to middle school (%)	1,076	47.4	23.1	0	100
Distance to county (km)	1,076	25.7	26.3	0	210

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