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RESEARCH ARTICLE

Place attachment, environmental cognition and organic fertilizer adoption of farmers: evidence from rural China

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Abstract
For preventing the excessive consumption of agricultural resources, it is of vital importance to promote agricultural pro-environmental behavior of farmers. Despite the proven importance of psychological factors in encouraging farmers' adoption of organic fertilizer, the evidence is scarce. To fill this gap, this study aims to explore how place attachment and environmental cognition affect farmers' organic fertilizer adoption with a community sample of 944 rural farmers collected in Hubei province. Specifically, we firstly distinguish two dimensions of place attachment, namely, natural attachment and civic attachment, and then we explore the influence of those dimensions and environmental cognition on farmers' adoption of organic fertilizer. The results reveal that both place attachment and environmental cognition positively affect farmers' organic fertilizer adoption. Furthermore, the roles of place attachment vary across different groups divided by farmers' environmental cognition degree and age. Therefore, to promote green agricultural practices, policy-makers should enhance various farmers' place attachment and environmental cognition by strengthening infrastructure construction, organizing collective activities, and conducting animation propaganda.

Keywords Place attachment · Environmental cognition · Agricultural pro-environmental behavior · Organic fertilizer · Farmers

Introduction

Pollution from human activities has threatened rivers, air quality, and biodiversity (Archibald et al. 2018; Fernández-Martínez et al. 2020; Liu et al. 2019a), among which the overuse of chemical fertilizers has led to serious agricultural non-point source pollution problems in agriculture sectors (Shi and Shang 2018), particularly in China (Yang et al. 2019). According to the National Bureau of Statistics of China, the total amount of chemical fertilizer used in 2019 was 54.03 million tons, over 6 times of that used in 1978.[1] Hence, it is essential to put forward related strategies for reducing chemical fertilizer use. However, environmental concerns have increased over the past decades, and actions are still limited (Eom et al. 2016). Efforts have been made by the Chinese government to minimize the negative impact of agricultural activities, such as the zero-growth plan of chemical fertilizer[2] (Jin and Zhou 2018). As one of the responses to reduce chemical fertilizer, the government issued policies to encourage farmers to use organic fertilizer (Chu et al. 2012), which can effectively alleviate agricultural non-point source pollution (Duan et al. 2016). Compared with chemical fertilizer, the use of organic fertilizer needs more labor and monetary input (Wang et al. 2018). As a result, farmers prefer to use chemical fertilizer in agricultural production, and there is no widespread use of organic fertilizer throughout developing countries (Chadwick et al. 2015). Hence, how to encourage farmers' organic fertilizer adoption remains a problem that needs to be targeted.

[1] The data is from National Bureau of Statistics of China, 2020. More details, please refer to: https://data.stats.gov.cn/easyquery.htm?cn=C01.

[0] It is a plan issued by the Ministry of Agriculture of China in 2015 for increasing fertilizer use rate and promoting sustainable agricultural development. More details, please refer to: http://jiuban.moa.gov.cn/zwllm/tzgg/tz/201503/t20150318_4444765.htm.

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Existing studies have focused on revealing the determinants of farmers' organic fertilizer adoption and have found that farmers' characteristics, such as age, education (Hu et al. 2019), and cooperatives membership (Chu et al. 2012), positively affect farmers' use of organic fertilizer. Liu et al. (2019b) also found that technical training has a positive impact on farmers' adoption of organic fertilizers. Furthermore, families' characteristics have also been taken into consideration, such as the scale of land management (Li et al. 2019) and social internet (He et al. 2020). For example, based on 976 farmers of the Hubei and Shandong Provinces, China, Li et al. (2019) found that the larger the scale of land, the more likely farmers are to adopt organic fertilizer. Besides those external factors, it is also vital to consider how farmers' internal feedback mechanisms motivates them to adopt organic fertilizer by values, cognition, and perceptions (Chan et al. 2016; Raymond et al. 2013; von Heland and Folke 2014). Based on this, several studies have identified that psychological factors such as environmental concerns (Adnan et al. 2019) and risk perceptions (Lewicka 2011; Ratcliffe and Korpela 2016) are also associated with organic fertilizer adoption. However, they neglected the impacts of external environment changes, which also affect farmers' psychological mechanisms on the adoption of organic fertilizer.

According to attachment theory, as a result of past and current experiences, individuals formulate an attachment to a particular place (Morgan 2010). More specifically, to attain security and protection, individuals have an intrinsic psychological system that motivates them to act (Tsai 2012). Nevertheless, this does not necessarily predict what type of action is supported (Huber and Arnberger 2016). Evidence has indicated that individuals who are highly attached to their places with positive emotions often express their attachment through proximity-maintaining behaviors (Scannell and Gifford 2017). For instance, individuals have shown to be related to pro-environmental behaviors (Takahashi and Selfa 2015; Xu and Han 2019). Current studies have mainly explored the relationship between place attachment and pro-environmental behaviors in tourism. By using data from 452 visitors to the Dandenong Ranges National Park, Australia, Ramkissoon et al. (2013) found that place attachment has links to visitors' pro-environmental behavioral intentions. Zhang et al. (2014) found that tourism area residents' place attachment positively impacts their pro-environmental behavior.

Environmental cognition has also been linked to pro-environmental behaviors (Chen et al. 2018). Sanchez et al. (2016) have claimed that environmental cognition is another factor that has a positive impact on pro-environmental behaviors, while Heimlich and Ardoin (2008) found that this link is unreliable. When it comes to agriculture, adoption of organic fertilizer is beneficial for the environment, which is also viewed as one type of pro-environmental behavior (Wang et al. 2018). It is noted that little evidence has been found for how place attachment and environmental cognition affect farmers' organic fertilizer adoption together. Due to the development of urbanization, the fluidity of farmers has increased, and farmers' values are also changing. More and more farmers have left their hometown to find a good job, indicating that farmers' place attachment is gradually weakening (Wang et al. 2020b). In the meantime, because the government has been emphasizing the importance of protecting the environment, farmers have been concentrating more on environmental issues (Huang et al. 2017), which leads to a higher their environmental cognition than before. Therefore, based on societal developments, it is necessary to predict organic fertilizer adoption of farmers by putting place attachment and environmental cognition together.

It is essential to promote that farmers adopt organic fertilizer as an effective way to reduce the chemical inputs in China. Based on current studies, although the influence of place attachment and environment cognition on pro-environmental behavior has been well-studied, there has been little research that formulates farmers' psychological mechanisms for how place attachment and environmental cognition lead to particular motivations toward organic fertilizer adoption, and it is doubtful whether place attachment or environmental cognition will increase farmers' pro-environmental behavior and how they work in promoting farmers' organic fertilizer adoption. To address those questions, with a unique survey data of 944 farmers in Hubei province, China, this study aims to: (1) figure out farmers' place attachment, environmental cognition, and the adoption status of organic fertilizer and (2) identify the roles of place attachment and environmental cognition in farmers' organic fertilizer adoption in China. The rest of this paper is structured as follows: First, Section 2 gives the conceptual framework and proposes hypotheses. Section 3 and Section 4 present the data and methods and the results, respectively. Section 5 illustrates the discussion, and the Section 6 gives the conclusion and implications.

Hypotheses and conceptual framework

Place attachment

Place attachment is a multidimensional concept that focuses on an individual's perceptions, emotions, and behaviors as well as the link between the individuals and environment (Ratcliffe and Korpela 2016; Scannell and Gifford 2010b; Tonge et al. 2015). It exhibits both local material and symbolic contexts that give specific meaning and value to peoples' lives (Adger et al. 2011), and therefore, both the social and physical aspects of place attachment have been incorporated into the current study. In this study, we classify place attachment into two dimensions: natural attachment and civic attachment. Researchers have argued that the influence of each dimension of place attachment on environmental behavior varies (Scannell and Gifford 2010a). Hence, we input all dimensions of place attachment's influence on farmers' organic fertilizer adoption into a systemic theoretical model and propose the following hypothesis concerning the effects of the dimensions of place attachment on organic fertilizer adoption of farmers.

Natural attachment

Natural attachment can obviously rest on the physical features of a place. For example, the climate of a place that is similar to the place of an individual's hometown always forms a kind of attachment (Knez 2005). It includes a broad range of physical settings, from built environments (i.e., streets, houses, and non-residential indoor settings) to natural environments (i.e., climate, lakes, parks, forests, and mountains) (Manzo 2005). Similarly, environmental identity refers to the inclusion of nature into one's self-concept (Hernández et al. 2010). Clayton and Opotow (2003) found that individuals who strongly identified with the natural environment had more ecological behaviors than those with low environmental identity. Again, this study emphasizes that place attachment may be directed toward the physical aspects of a place, which in this case is natural attachment. Garcia et al. (2013) found that natural attachment can promote rural residents' environmentally friendly behavior in water conservation behavior. The aim of the pro-environmental behavior is to minimize the impacts of an individual's action on the natural environment (Kim 2012). Arable land is what farmers depend on for their survival, which is also part of the environment. Adopting organic fertilizer rather than chemical fertilizer is beneficial for reducing non-point pollution. Therefore, farmers will adopt organic fertilizer for sustainable production. Thus, we propose the hypothesis that

H1: Natural attachment positively affects farmers' adoption of organic fertilizer.

Civic attachment

Places not only contain the physical aspects of settings, but they also include social connections. The majority of the researches on place attachment (and related concepts) have focused on its social aspects (Twigger-Ross and Uzzell 1996), such as the positive interpersonal relations that occur within it (Pei 2019). Carroll et al. (2009) proposed that the factors influencing the evaluation and feelings of an individual toward the environment included social context and emotional bonding. Therefore, a strong sense of attachment drives individuals to transform their personal emotions into practical actions to support environmental strategies, which is also viewed as "civic attachment." Civic attachment refers to the relationship between individuals and the social aspects of their residence place, such as the community and other habitats (Scannell and Gifford 2010b), which is a group-symbolic place attachment (Hidalgo and Hernández 2001). Niemiec et al. (2017) found that civic attachment predicts the removal of an invasive species. When it comes to organic fertilizer adoption, there are certainly some farmers using organic fertilizers for sustainable production. To maintain a sense of connection and interaction with those farmers and to keep a sense of community, other farmers will tend to adopt organic fertilizers. Hence, due to farmers' deep interpersonal relationships in their villages, they will likely adopt organic fertilizer to make their hometown less polluted. Thus, we propose the hypothesis that

H2: Civic attachment positively affects farmers' adoption of organic fertilizer.

Environmental cognition

All human behaviors are relative to cognition (Locke 2000). According to experiments conducted by researchers, cognition influences behavior decision mechanisms at not only a conscious level but also an unconscious level (Courbalay et al. 2015). The improvement of cognition will inevitably lead to reasonable desired behaviors (Wossink and van Wenum 2003). In the field of environmental research, environmental cognition is referred as an awareness to the environmental issues and active involvement in environmental organizations (Henry and Dietz 2012), which indicates citizens' cognition of how to protect the environment. Recently, increasing studies have revealed that citizens' environmental cognition is higher than in the past (Paul et al. 2016; Shi et al. 2017; Wang et al. 2017). Understanding the role of individuals' environmental cognition regarding current environmental issues could improve the effectiveness of protected area management, which also includes activities that aim at promoting pro-environmental behaviors (Andrade and Rhodes 2012; Nastran 2015). Some studies have examined the correlation between environmental cognition and pro-environmental behaviors (Barbaro et al. 2015; Wang et al. 2020a). For example, Liu et al. (2020) found that a higher level of environmental cognition by citizens has a comprehensively beneficial effect on regional environmental quality. Mei et al. (2016) also found that citizens' cognition of environmental policies and regulations can result in the pro-environmental behaviors. For farmers in China, because the government has declared the benefits of organic fertilizer, they more or less created an environmental cognition of organic fertilizer adoption. Based on these premises, this paper aims to discover the link between environmental cognition and farmers' organic fertilizer adoption, where we use farmers' cognition of rural environmental regulations to measure their environmental cognition and propose the following hypothesis:

H3: Environmental cognition positively affects farmers' adoption of organic fertilizer.

Conceptual framework

Based on the analysis above, both place attachment and environmental cognition are inferred to play positive roles on the improvement of farmers' adoption rate of organic fertilizer. We attempt to incorporate these two factors (place attachment and environmental cognition) into this study and identify the effects of these concepts on farmers' organic fertilizer adoption. The conceptual framework is shown as Fig. 1.

Data and methodology

Methodology

As the explained variable y, "whether farmers adopt organic fertilizer," is a binary variable, this paper adopts the binary Logit model to investigate the impacts of place attachment and environmental cognition on farmers' organic fertilizer adoption. The binary Logit model is given by

$$p = F(y) = \frac{1}{1 + e^{-y}} \tag{1}$$

where p is the probability of adoption, a y value of "1" indicates that farmers are willing to adopt organic fertilizer, and a y value of "0" indicates that farmers are not willing to adopt organic fertilizer. $F(y)$ refers to the probability function that is estimated by the maximum likelihood method.

Next, we built Eq. (2) to explore the determinants of farmers' organic fertilizer adoption:

$$y = \alpha_0 + \alpha_1 PA + \alpha_2 EC + \Sigma_i \alpha i\, Xi + \varepsilon \tag{2}$$

where a y value of "1" indicates that a farmer adopts organic fertilizer and "0" indicates that a farmer does not adopt organic fertilizer. PA is the place attachment, and EC is the environmental cognition. X_i (i = 3,..., n) are the factors affecting the application of organic fertilizer by farmers and are listed in Table 1 (except place attachment and environmental cognition); α_i (i = 1, 2, 3,..., n) are the parameters to be estimated, where $\alpha_i > 0$ means explanatory variables have a positive effect on the probability of adopting organic fertilizer by farmers, and $\alpha_i < 0$ for negative effect. ε is the random error.

We used different estimators to estimate Eq. (2). In Table 3, Reg (1) refers to the Logit model for natural attachment with controls. Reg (2) indicates a Logit model for civic attachment with controls. In Reg (3), we re-estimate the same model, but it includes both natural attachment and civic attachment. In Reg (4), with the same sample as in Reg (3), we include all variables mentioned in Table 1. In Table 4, we again estimated Eq. (2) for different samples. For Reg (5) and Reg (6), we control for both individual and family characteristics and estimate the Logit model with a sub-sample divided into a low cognition group and a high cognition group, respectively. Similarly, in Reg (7) and Reg (8), we estimate the young group and the old group separately.

Selected variables

Besides the core explained variables (place attachment and environmental cognition), there are other variables like individual characteristics (Defrancesco et al. 2008) and family characteristics that also affect farmers' organic fertilizer adoption (Steg and Vlek 2009). As a result, we add individual characteristics (i.e., gender, age, educational attainment, farming seniority, and technology training) and family characteristics (i.e., household labor force, per capital total household

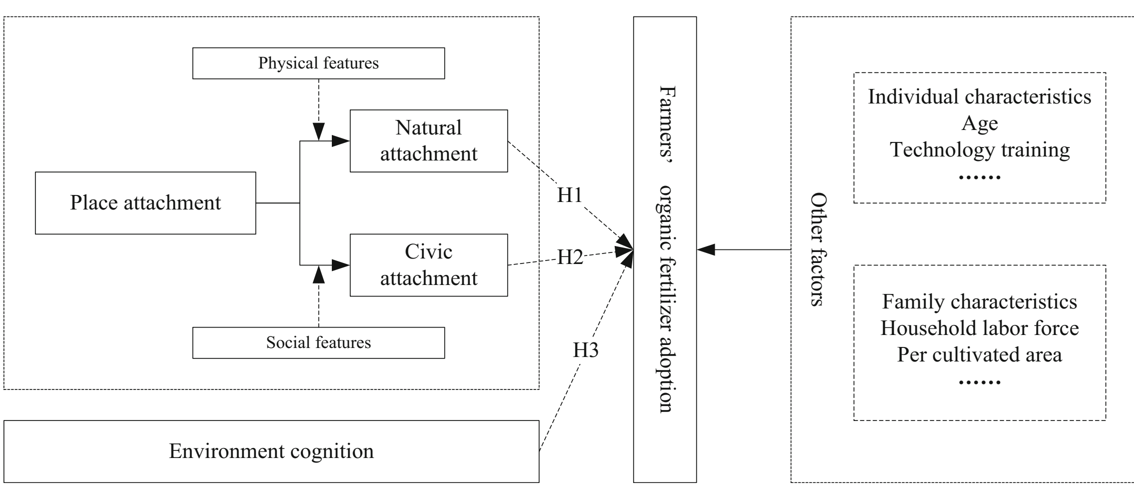

Fig. 1 Conceptual framework

Table 1 Description of the model variables

Variables	Description	Mean	Standard deviation
Explained variable			
Organic fertilizer adoption	Dummy = 1 if the farmer has adopted organic fertilizer, 0 = otherwise	0.252	0.434
Place attachment			
Natural attachment	I like the natural environmental of my living village (1–5 points)	4.335	0.744
Civic attachment	I get along well with the villagers in the village (1–5 points)	3.645	1.044
Environmental cognition	I know very well about rural environmental regulations (1–5 points)	3.322	1.196
Individual characteristics			
Gender	1 = male; 0 = female	0.545	0.498
Age	The age of the respondent (in year)	58.100	9.809
Educational attainment	The year of schooling (in year)	6.209	3.721
Farming seniority	The years of farming (in year)	37.349	13.711
Technology training	Dummy = 1 if the farmer participated in green agricultural technology training, 0 = otherwise	0.217	0.413
Family characteristics			
Household labor force	Number of household's labor force	3.140	1.446
Per capita total household income	The per capita total household income in 2017	1.449	2.366
Per cultivated area	Per cultivated area in 2017 (in hectares)	3.237	7.575
Agricultural waste disposal facilities	Dummy = 1 if the household has waste disposal facilities, 0 = otherwise	0.417	0.514

Notes: Authors' summary of the survey sample

income, per cultivated area, and agricultural waste disposal facilities) into the prediction (Zeng et al. 2019). Table 1 illustrates the meaning and basic statistics of the variables included in the model.

Survey design and data collection

Survey design

A questionnaire was used to collect data and was firstly designed to include the following aspects: demographical information, farmers' place attachment, environmental cognition, and adoption status of organic fertilizer. The draft questionnaire was then reviewed by four experts who mainly focus on agricultural resources and environmental economy. A second version was formed based on the comments received, and then a pilot survey was conducted with 20 farmers in Hubei Province. A further revision was made according to the feedback received from the pilot study. The final questionnaire contains four parts. The first part includes farmers' basic information of living conditions, like the distance between their home and the nearest market (measured in kilometers). The second part reflects the information of farmers' families and production management, including personal characteristics (e.g., gender, age, and educational attainment), families characteristics (e.g., number of family members and household annual total income), production conditions (e.g., areas of cultivated land and irrigation facilities), and adoption of organic fertilizer. The third part provides farmers' perceptions of social activities, and the final part measures farmers' environmental attitudes and the degree of place attachment.

Data collection

Hubei Province is one of the major agricultural provinces in China, with an agricultural output accounting for over 5% of China's total in 2018. According to *China Rural Statistical Yearbook* (2019),[3] the amount of chemical fertilizer applied per unit of Hubei Province is 188.05 kg/h, accounting for 83.58% of the international ceiling standard (225 kg/h). Hence, to achieve the zero-growth plan, the government encouraged farmers to adopt organic fertilizer. In this study, we implemented the data collection in Hubei Province. The formal survey was carried out from July to August 2018 by trained postgraduates in rural areas of Hubei Province through face-to-face interviews. First, we selected four cities to survey: Huanggang City, Jingmen City, Ezhou City, and Wuhan City, whose total agricultural production yield occupies nearly one-

[3] China Rural Statistical Yearbook (2019) is the collection of some statistical indicators in rural China in 2018.

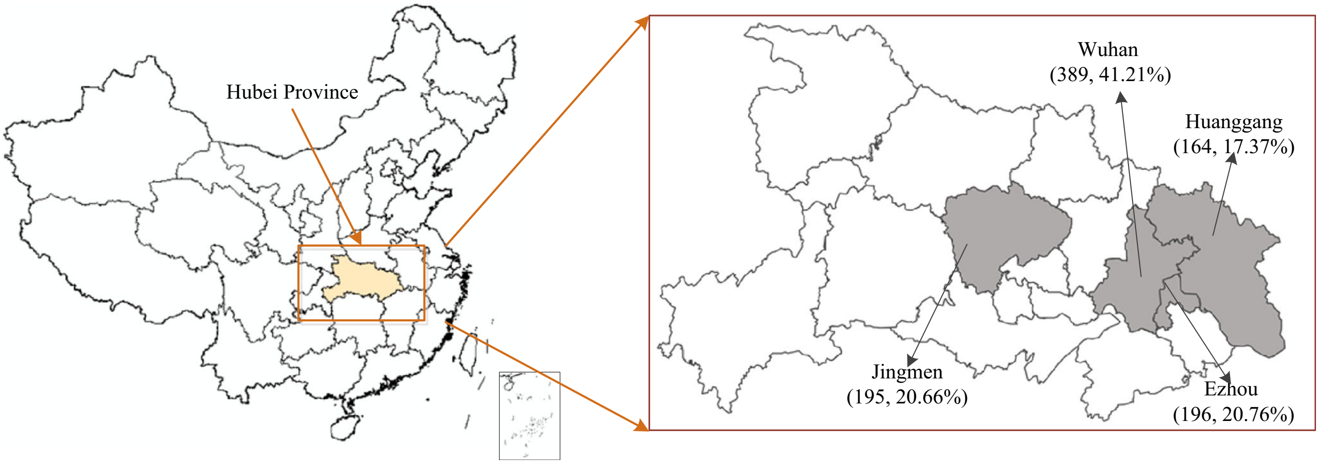

Fig. 2 Distribution of areas surveyed

third of Hubei's agricultural output. Furthermore, in each city, we selected 1 to 2 counties, and in each county, we selected 2 to 4 towns; in each town, we selected 1 to 3 villages, and then in each village, we chose 30 to 40 respondents randomly. A total sample of 1084 questionnaires were collected, with 140 removed due to missing values and logical errors. In total, we obtained 944 valid surveys for our empirical analysis, with an effective rate of 87.08%. Figure 2 shows the distribution of areas surveyed.

Basic characteristics of samples

From the basic characteristics of the sample families (Fig. 3), the proportions of men (54.45%) and women (45.55%) in the sample are almost equal. The respondents' educational attainment is mainly 6 years and below, accounting for 55.09% of the total sample, followed by 7 to 9 years (34.22%). According to the *China Rural Statistical Yearbook* (2019), the educational attainment distribution is almost consistent with that of Hubei Province. The number of household labor force is dominated by households with 1 to 3 persons (59.22%), followed by 4 to 6 persons (39.19%). In addition, the per capita net income of the sample households is 14490.95 yuan, which is close to the per capital net income of rural households in Hubei Province in 2018 (14,977.82 yuan). Therefore, the data we collected in this survey are representative. In addition, farmers have an average 6.209 years of education, which indicates they do not finish compulsory education on average.

Results

Place attachment and environmental cognition

Figure 4 shows the distributions of natural attachment, civic attachment, and environmental cognition of farmers. As Table 1 shows, the means of natural attachment and civic attachment are 4.335 and 3.645, respectively, which indicate that the respondents tended to agree with those questions about attachment. Interestingly, in Fig. 4, over 80% of farmers agreed about their natural attachment with their villages, while only about 60% farmers think that they had a civic attachment with their hometowns. The mean of environmental cognition is 3.322 (Table 1), which also indicates that farmers tended to know a lot about environmental regulations. However, Fig. 4 indicates that there are still about 21% of farmers who neither agree nor disagree that they knew a lot about environmental regulations.

Farmers' adoption status of organic fertilizer

Based on farmers' organic fertilizer adoption status distribution, we found that only 25.21% of total samples applied organic fertilizer, while those who did not adopt organic fertilizer accounted for 74.79%. There is still much room for improvement in the farmers' organic fertilizer adoption rate. Table 2 shows the percentages of adoption samples in different groups. Farmers with low cognition[4] accounted for 22.69%, while the high cognition group was over three times the low cognition group. Farmers in young group[5] accounted for 73.95%, but the old group was much lower (26.05%).

[4] We used a 5-point Likert-type scale to measure the degree of environmental cognition, so the low cognition group are farmers whose points are lower than 3 points, and the high cognition group are farmers whose points are not lower than 3 points.

[5] According to internationally accepted standards and the reality of China, we chose 65 years old as a sign, that is, farmers more than the young group are farmers who are not more than 65 years old, and the old group are farmers older than 65 years old.

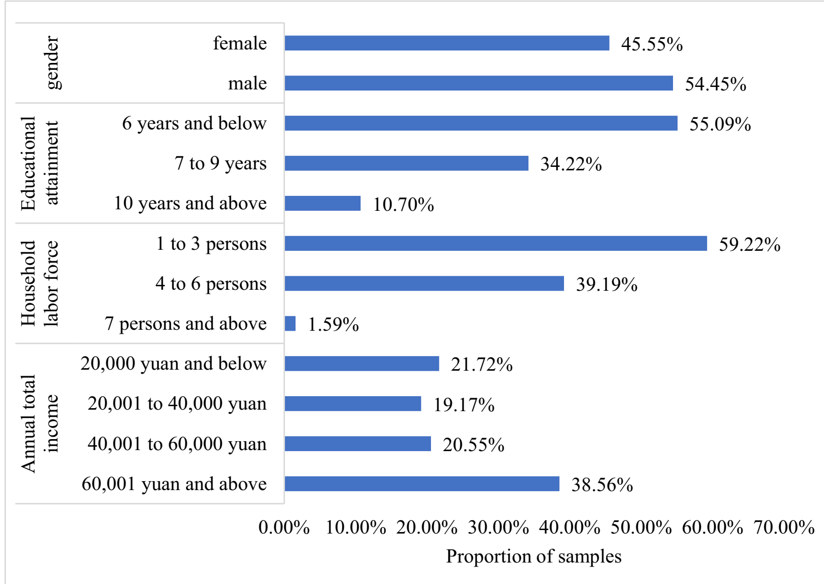

Fig. 3 Basic characteristics of samples

Place attachment and environmental cognition on farmers' organic fertilizer adoption

The main results for the whole sample ($N = 944$) are summarized in Table 3. We only report the results for the coefficients of interest (Pamuk et al. 2014). As shown in Table 3, the Chi-squared test statistics of four regressions are significant at the 1% level, which implies the joint significance of the organic fertilizer model. It also can be seen that regression (4) has the lowest value of AIC, which reflects the actual situation of farmers' organic fertilizer adoption more than the other three regressions. The significance of each variable in the regressions is almost the same, which indicates that the results of regression (4) are robust.[6] Therefore, we chose the estimation results of regression (4) for analysis.

The results (in Table 3) indicate that natural attachment positively affects farmers' adoption of organic fertilizer, with a 10% significant level, where hypothesis 1 is verified. The estimated marginal effect of this variable indicates that the probability of adopting organic fertilizer increases by 3.80% for a 1-unit increase in natural attachment. Civic attachment also positively affects farmers' adoption of organic fertilizer, with a 1% significant level. This result is consistent with hypothesis 2, with a higher marginal effect (5.00%). Environmental cognition has a positive impact on farmers' adoption of organic fertilizer, with a 10% significant level. If farmers' environmental cognition increases 1 unit, then the possibility of adopting organic fertilizer will increase 2.00%. As expected, farmers who have higher environmental cognition have greater possibilities to adopt organic fertilizer than those with lower environmental cognition. Additionally, technology training is found to have a positive influence on the adoption of organic fertilizer, indicating that farmers who have received agricultural technology training tend to adopt organic fertilizer more than those who did not receive the training. But farming seniority negatively affects farmers' organic fertilizer adoption.

Heterogeneity of farmers' characteristics

Among the core explained variables, we found that both environmental cognition and age affect farmers' organic fertilizer adoption. Farmers who have higher environmental cognition are more likely to adopt organic fertilizer. Meanwhile, age also has a positive effect on farmers' adoption of organic fertilizer. Based on the results in Table 2, we found differences of organic fertilizer adoption rate between different environmental cognition groups and different age groups. To further explore the potential heterogeneity across farmers' environmental cognition measured by cognition degree of rural environmental regulations, we divided the total samples into two groups: low cognition and high cognition. To explore the potential heterogeneity across farmers' age, we divided the total samples into two groups: young and old.

The second component of the analysis focuses on the different subsamples of farmers. As shown in the Table 4, the Chi-squared test statistics of four regressions are all almost significant at the 1% level, which means that the four Logit models fit the data we used in the study well. The influences of place attachment are different between the low cognition group and high cognition group. In regression (5), only natural attachment positively associates with the low cognition

[6] We also estimated the results by the least squares estimation method and Probit model, respectively. The results of core variables are consistent with Reg (4) in Table 3, which indicates that the results are robust.

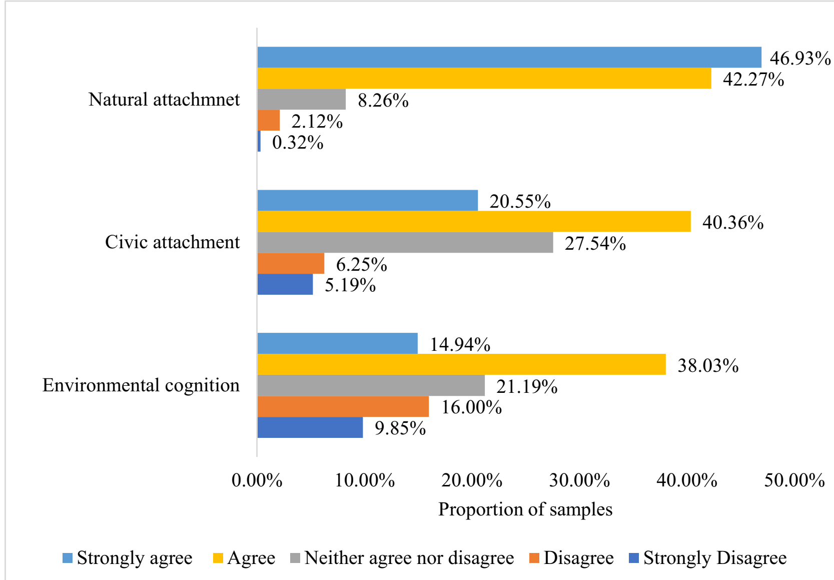

Fig. 4 Distributions of place attachment and environmental cognition in farmers ($N = 944$)

group's adoption of organic fertilizer with a 5% significant level, which shows that for farmers with low environmental cognition, only natural attachment significantly increases the probability of organic fertilizer adoption. In regression (6), only civic attachment has a positive effect on the high cognition group, which indicates that the civic attachment of the high environmental cognition group is higher, and they more easily adopt organic fertilizer. In regression (7), only civic attachment positively affects the young group's adoption of organic fertilizer with a 1% significant level. Hence, if young farmers have a deeper attachment with their hometown in a civic aspect, the possibility of adopting organic fertilizer is higher. But in regression (8), both natural attachment and civic attachment can encourage old farmers to adopt organic fertilizer, as in the regression (4). As a result, the two types of attachment have positive effects on old farmers' adoption of organic fertilizer. In addition, environmental cognition has a distinguishing association with organic fertilizer adoption in different age groups. The results of regression (7) and regression (8) show that environmental cognition only has a significant effect on farmers of the young group. The results show that if young farmers have higher environmental cognition, they are more likely to adopt organic fertilizer.

Discussion

Understanding the links between farmer psychological characteristics and organic fertilizer adoption is an essential requirement for disseminating the adoption of organic fertilizer. The discussion below is based on the results presented above and could have practical implications to improve farmers' pro-environmental behaviors in the last part of this paper.

Two dimensions of place attachment have been proved to associate with farmers' adoption of organic fertilizer. If farmers are highly attached to their villages, it is more likely that they will protect their hometown from pollution. Compared with the use of chemical fertilizer, using organic fertilizer is more environmentally friendly. Organic fertilizer not only reduces greenhouse gas emissions (i.e., N_2O) but also water contamination (Duan et al. 2016), which makes the environment better. As a result, farmers with high natural attachment tend to use organic fertilizer to protect the environment of the villages in which they are living. Similarly, farmers who get along well with their neighbors also tend to create a more ecological collective environment to live in by adopting organic fertilizer.

Table 2 Adoption sample percentages of different groups ($N = 944$)

Categories	Options	Adoption samples	Total adoption samples	Account
Environmental cognition degree	Low cognition	54	238	22.69%
	High cognition	184	238	77.31%
Age	Young group	176	238	73.95%
	Old group	62	238	26.05%

Table 3 Estimation results of the Logit model

Variables	Reg (1)	Reg (2)	Reg (3)	Reg (4)	Marginal effects[1]
Place attachment					
Natural attachment	0.259**	-	0.227**	0.214*	0.038*
	(0.111)	-	(0.112)	(0.112)	(0.020)
Civic attachment	-	0.291***	0.275***	0.275***	0.050***
	-	(0.080)	(0.079)	(0.080)	(0.014)
Environmental cognition	-	-	-	0.113*	0.020*
	-	-	-	(0.066)	(0.012)
Individual characteristics					
Gender	-0.184	-0.158	-0.180	-0.163	-0.029
	(0.169)	(0.169)	(0.170)	(0.171)	(0.031)
Age	0.020	0.025**	0.023*	0.023*	0.004*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.002)
Educational attainment	0.034	0.035	0.037	0.036	0.007
	(0.024)	(0.024)	(0.024)	(0.024)	(0.004)
Farming seniority	-0.014	-0.016*	-0.015*	-0.016*	-0.003*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.002)
Technology training	0.557***	0.549***	0.535***	0.540***	0.097***
	(0.180)	(0.180)	(0.181)	(0.181)	(0.032)
Family characteristics	Have been controlled	Have been controlled	Have been controlled	Have been controlled	Have been controlled
Constant	-2.960***	-3.253***	-4.019***	-4.375**	-
	(0.745)	(0.706)	(0.811)	(0.838)	-
Log likelihood	-519.527***	-515.656***	-513.203***	-511.712***	-
AIC	1061.055	1053.312	1050.406	1049.423	-
Observations	944	944	944	944	944

Note: ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively, and the numbers in blankets are robust standard errors

[1] We calculated the marginal effects of variables in Reg (4)

Furthermore, different environmental cognition groups are affected by different place attachment dimensions. This shows their collective emotion for the environment. Natural attachment reflects a single link between farmers' personal emotions and their village surroundings. Farmers of the low cognition group probably pay more attention to their personal feelings; that is, natural attachment has a sufficient effect on the low cognition group's organic fertilizer adoption. Civic attachment reflects more complex links between farmers' contact with their fellow villagers. Consequently, farmers of the high cognition group probably pay more attention to the public's feelings, and civic attachment has a sufficient effect on the high cognition group's organic fertilizer adoption.

Additionally, it is interesting to see that farming seniority has a significantly negative effect on farmers' adoption of organic fertilizer. Qiu et al. (2014) thinks that the main reason is that some farmers have specific feelings for their villages, which illustrate that they have already lived in the villages for a long time and some farming habits are deeply embedded in their minds. In this context, for them, it is more familiar and reliable to use chemical fertilizer than organic fertilizer, which indicates that higher place attachment leads to less scientific farming habits.

The significant impact of environmental cognition in the results suggests that the degree of environmental cognition also encourages farmers to adopt organic fertilizer. This means that if farmers know more about the environmental regulations of the villages, they would prefer using organic fertilizer to produce agricultural food. Environmental regulations in China are substantially divided into two types: incentive environmental regulations and punitive environmental regulations (Liu et al. 2018). Among them, incentive environmental regulations aim at giving subsidies to farmers who take measures that are conducive to the environment, while punitive environmental regulations are the opposite; farmers who do not produce in accordance with those provisions will receive fines or other punitive measures. Based on the two kinds of environmental measures, farmers who know more about environmental regulations are more likely to form a production of pro-environmental cognition, which leads them to use organic fertilizer for production.

Table 4 Estimation results of the Logit model

Variables	Reg (5) Low cognition	Reg (6) High cognition	Reg (7) Young group	Reg (8) Old group
Place attachment				
Natural attachment	0.527**	0.199	0.152	0.488*
	(0.258)	(0.130)	(0.124)	(0.276)
Civic attachment	0.208	0.299***	0.225***	0.539***
	(0.158)	(0.093)	(0.088)	(0.189)
Environmental cognition	-	-	0.146*	0.024
	-	-	(0.079)	(0.121)
Individual characteristics				
Gender	0.148	-0.304	-0.148	-0.162
	(0.388)	(0.196)	(0.194)	(0.387)
Age	0.059**	0.009	-	-
	(0.025)	(0.016)	-	-
Educational attainment	-0.065	0.076***	0.038	0.023
	(0.055)	(0.028)	(0.028)	(0.053)
Farming seniority	-0.054***	0.001	-0.002	-0.028*
	(0.017)	(0.011)	(0.008)	(0.015)
Technology training	0.727*	0.459**	0.684***	-0.092
	(0.396)	(0.209)	(0.204)	(0.422)
Family characteristics	Have been controlled	Have been controlled	Have been controlled	Have been controlled
Constant	-6.212***	-2.108***	-3.490***	-3.417
	(1.886)	(0.554)	(0.771)	(1.578)
Log likelihood	-114.785***	-386.464***	-379.489***	-127.784**
AIC	253.570	796.928	782.979	279.567
Observations	245	699	704	240

Note: ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively, and the numbers in blankets are robust standard errors

Conclusion and policy implications

Farmers face decisions on how to optimize their agricultural activities, including adopting pro-environmental-friendly practices. However, despite the desirable impacts in reducing the overuse of chemical inputs, the adoption rate of organic fertilizer has been rather moderate. This study adopted the Logit model to investigate the roles of farmers' place attachment and environmental cognition in organic fertilizer adoption. We found that both farmers' natural attachment and civic attachment are determinants that can be used to encourage farmers' organic fertilizer adoption. If there is a 1-unit increase in natural attachment, the probability of adopting organic fertilizer increases by 3.80%, and civic attachment has a higher effect at 5.00%. Farmers with high environmental cognition also tend to adopt organic fertilizer. If environmental cognition of farmers increases by 1 unit, the possibility of adopting organic fertilizer will increase to 2.00%.

We reveal that farmers with various environmental cognition and age, natural attachment, and civic attachment play different roles in their adoption of organic fertilizer. Environmental cognition only works on younger farmers. Therefore, we propose that the village committees should take farmers' various characteristics into consideration when designing targeted measures in infrastructure construction and organize corresponding activities for farmers' knowledge exchange, to deepen their place attachment with villages. This will promote pro-environmental behaviors among farmers. We also put forward that environmental protection publicity and education should be implemented to encourage farmers' organic fertilizer adoption by improving farmers' environmental cognition, which is conducive to the protection of the environment.

First is to improve farmers' organic fertilizer adoption through increasing different dimensions of place attachment. According to the findings of Deng and Zhu (2015), due to rapid urbanization, farmers' place attachment is decreasing. Farmers in China have less attachment to their villages and have fewer communication with their neighbors. Hence, the government of China should appeal to farmers to return home to start businesses and realize rural revitalization, which can improve farmers' place attachment to their hometown; the village committees should pay more attention to fundamental constructions to increase farmers' natural attachment (especially low environmental cognition farmers) and hold group activities regularly to improve civic attachments (especially for high environmental cognition farmers), which in turn promotes their adoption of organic fertilizer. In addition, to offset this negative effect of farming seniority, the government should firstly conduct lectures on scientific fertilization for farmers and then send professional instructors to teach them how to fertilize scientifically, thereby appropriately and gradually changing farmers' wrong farming habits and promoting the adoption of organic fertilizer.

Second is to promote farmers' environmental cognition for encouraging organic fertilizer adoption. Though the government promotes sustainable development, farmers' environmental cognition is still lightly weak (Zhou et al. 2014), mainly as a result of farmers' stubborn and outdated values. We also found that environmental cognition positively affects younger farmers' organic fertilizer adoption behavior. This is consistent with the reality in China. With the government's promotion of the importance of protecting the environment in China (Jia et al. 2019), young farmers' acceptance degree of environmental regulations is generally higher than that of the old farmers (Yang and Wang 2015). Therefore, to efficiently increase farmers' environmental cognition, the government could adopt vivid forms like animation and comic strips to disseminate environmental knowledge and regulations. These methods make information more accessible for farmers, especially older farmers, to help them understand the pro-environmental information.

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Data availability Data sharing is not applicable to this article as no datasets were generated during the current study.

Declarations

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