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Analysis of the environmental behavior of farmers for non-point source pollution control and management in a water source protection area in China

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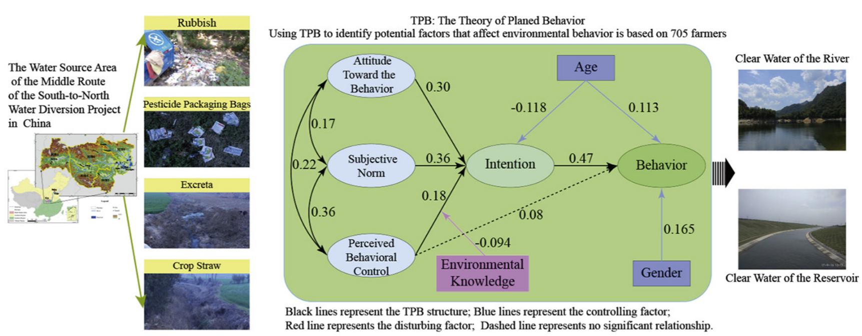
HIGHLIGHTS

- Using social psychological method studied management of non-point source pollution
- Subjective norm had the greatest impact on environmental behavior.
- The mediation effect of environmental intent was tested.
- Tested moderated mediation model of environmental knowledge.

GRAPHICAL ABSTRACT



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ABSTRACT

The environmental behavior of farmers plays an important role in exploring the causes of non-point source pollution and taking scientific control and management measures. Based on the theory of planned behavior (TPB), the present study investigated the environmental behavior of farmers in the Water Source Area of the Middle Route of the South-to-North Water Diversion Project in China. Results showed that TPB could explain farmers' environmental behavior (SMC = 0.26) and intention (SMC = 0.36) well. Furthermore, the farmers' attitude towards behavior (AB), subjective norm (SN), and perceived behavioral control (PBC) positively and significantly influenced their environmental intention; their environmental intention further impacted their behavior. SN was proved to be the main key factor indirectly influencing the farmers' environmental behavior, while PBC had no significant and direct effect. Moreover, environmental knowledge following as a moderator, gender and age was used as control variables to conduct the environmental knowledge on TPB construct moderated mediation analysis. It demonstrated that gender had a significant controlling effect on environmental behavior; that is, males engage in more environmentally friendly behaviors. However, age showed a significant negative controlling effect on pro-environmental intention and an opposite effect on pro-environmental behavior. In addition,

Abbreviations: NSP, non-point source pollution; PS, point source pollution; TPB, the theory of planned behavior; B, behavior; IN, intention; AB, attitude towards the behavior; SN, subjective norm; PBC, perceived behavioral control; EK, environmental knowledge; WSA-MR-SNWDP, the Water Source Area of the Middle Route of the South-to-North Water Diversion Project; SUB1, the Source Area; SUB2, the Southern Slope of Qinling; SUB3, the Danjiang Basin; SUB4, the Northern Slope of Daba Mountain; SUB5, the Duhe Basin; SUB6, the Reservoir Area.

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environmental knowledge could negatively moderate the relationship between PBC and environmental intention. PBC had a greater impact on the environmental intention of farmers with poor environmental knowledge, compared to those with plenty environmental knowledge. Altogether, the present study could provide a theoretical basis for non-point source pollution control and management.

1. Introduction

With the explosive growth in human populations, red tide and algae bloom in lakes and coastal waters frequently occur as a characteristic feature of the eutrophication of water bodies worldwide (Benham, 2017; Leip et al., 2015; Yan et al., 2016). Water pollution sources include point source pollution (PS) and non-point source pollution (NSP). Controlled PS has been significantly attributed to the implementation of systematic laws, standards, and comparatively high-quality engineering measures in recent years. Meanwhile, NSP has become a leading source of water pollution that is difficult to control (Shen et al., 2015). This pollution is mainly caused by agricultural runoff, atmospheric deposition, and urban storm water (Zhang et al., 2016). A previous study demonstrated that agriculture and rural areas were prime contributors to NSP (Zhang et al., 2011). Mekonnen et al. (2016) indicated that the total global N and P emissions to freshwater from agricultural production were 31 and 2.9 million tonnes per year, respectively. In Southeastern China and Northeastern India, N loads can reach above 100 kg N/ha. In China, 57% of the nitrogen entering watercourses were from agriculture (Min and Shi, 2018). China is a vast agricultural country; however, the subject of agricultural production focuses on some scattered ultra-small-scale farmers. They use their own methods to implement means of production and dispose of domestic waste ignoring the environmental pollution. It is only in a state of disorganization. On the other hand, the government provides grassroots public goods, but environmental management tends to focus on urban and industrial environments, neglecting the environmental management of rural areas. Further, government-led environmental management is inefficient, costly, and with poor results, often resulting in the "tragedy of the commons." Therefore, clarifying the relationship between the farmers' environmental behavior and potential influencing factors while implementing specific policies to restrict and optimize the behavior of farmers is essential to reduce the intensity and harm of NSP.

Environmental issues are mostly caused by human behavior (Oskamp, 2000). However, it is an effective way to change people's behavior to reduce environmental pollution (Gifford and Nilsson, 2014). Human behavior results from the combined effect of external contextual influences and internal psychological attributes, it can be self-centered or altruistic (Martin et al., 2017). Many behavioral studies focus on the intrinsic factors affecting the behavior of individuals, such as a study by Deng et al. (2017) which showed that attitudes have a significant impact on farmers' pro-ecological intentions. However, the factors external to the individual (such as signage or fines) can also affect people's decisions (Martin et al., 2017).

A suitable combination of internal and external factors can be successfully applied in the field of public administration to, for instance, reduce food waste (Russell et al., 2017), increase public health, and reduce energy waste (Park and Kwon, 2017). Martin et al. (2017) suggested that behavior change interventions were divided into four steps: first to define behavior, second, to identify the drivers of and barriers to the behavior, third, by intervention or obstruction of behavior driven by the factors uncovered in the second stage, and finally to evaluate the effect of behavioral intervention. However, the factors that cause NSP, such as the amount of fertilizer and pesticide inputs, random littering of domestic waste and others are complicated. Even so, the human behavior model could simplify the relationship between the influencing factors and specific behaviors, and it has been shown to be effective for understanding, interpreting, and handling behavioral interventions under certain circumstances (Heimlich and Ardoin, 2008).

Among the many sociopsychological research methods, Davis and Challenger (2009) contended that the theory of planned behavior (TPB) as a theoretical foundation could explain human environmental behavior. Furthermore, through a meta-analysis, Steinmetz et al. (2016) found that TPB had been successfully applied in various behavioral intervention studies. Greaves et al. (2013) conducted a study on the environmental behavior in three public places, finding that TPB could explain the variance of 46%–61% in intent, highlighting its strong explanatory power. However, Gifford and Nilsson (2014) argued that, although TPB has been widely used, it is still incomplete since, for instance, background factors (e.g., gender, age, etc.) can significantly influence intent and behavior. Moreover, in the context of public participation in environmental protection, there is widespread concern and attention to environmental knowledge (EK) as an important variable in the study of environmental behavior (Aregay et al., 2017). EK is also an important indicator for evaluating the effectiveness of environmental education, and it can significantly affect public concern about environmental issues and support for environmental protection (Michaela, 2012).

The South-to-North Water Diversion Project (SNWDP) is the world's largest cross-basin diversion project. The Middle Route (MR-SNWDP) was completed in 2014, and water has been transferred to North China by 9.5 km^3/year (Wilson et al., 2017). The Water Source Area (WSA-MR-SNWDP) is located in the dividing line between the north and south of China, including 39 counties (cities) in Shaanxi, Hubei, and Henan provinces (Hao et al., 2012). It has the characteristics of the prevailing climate and culture in the north and south of China, and the farmers here have somewhat strong representation of the status quo of the entire Chinese farmers. However, the water source area is located in the hinterland with a poor ability for self-cleaning. To ensure that the "clear water of the river runs into the reservoir and that the clear water of the reservoir is sent to the north", the environmental protection of the WSA-MR-SNWDP is the precondition for the smooth operation of MR-SNWDP (Rogers et al., 2016). With the implementation of the project, PS in the WSA-MR-SNWTP was well-controlled; the NSP from agricultural production and rural living as the main contributor to water pollution in the water source area was difficult to control.

Currently, most of the studies on NSP are focused on engineering (Duchemin and Hogue, 2009; Sliva and Williams, 2001) and modeling (Shen et al., 2014; Shen et al., 2015). But, a vast number of farmers are a critical stakeholder since they bear the burden of past and current negligence towards the environment. Unfortunately, few studies on human behavior have been conducted to reduce and control NSP. Therefore, based on TPB, we investigated 705 farmers in the WSA-MR-SNWDP. The primary purposes of this study are to (1) verify the suitability of TPB for studying the environmental behavior of farmers, and (2) analyze the influencing factors that affect the environmental behavior of farmers. This article seeks to expand TPB and provide theoretical guidance for the control and management of NSP.

2. Theoretical background and hypotheses

The TPB was developed by Ajzen (1991) as an extension of the theory of the reasoned action model. According to the theory, Ajzen (2006) proposed that "intention" (IN) is the most direct precondition for people to generate behavior (B), which is determined by the attitude towards the behavior (AB), subjective norm (SN), and perceived behavioral control (PBC). Behavioral beliefs (a good or bad evaluation of the outcome) produce AB, normative beliefs (social pressure from others or social groups) produce SN, and control beliefs (the factors that facilitate or impede behavior) produce PBC. If one's attitude towards the result of the behavior is more positive, the perceived social pressure is heavier, and there are more promotion factors, then a stronger intention to implement the behavior will emerge. Ultimately, actual behavior will be more likely to occur. However, actual behavior is not only affected by IN, but also it is directly influenced by PBC (de Leeuw et al., 2015). Therefore, PBC impacts behavioral intention and has a direct predictive effect on B.

TPB has been widely used in traffic, health, and psychological research activities (Steinmetz et al., 2016). TPB can predict environmental behavior and intentions when applied correctly (Ajzen, 2011). In a study on pro-environmental behaviors based on the TPB, de Leeuw et al. (2015) found that IN accounted for 27.3% of the variance for B. Furthermore, AB, SN, and PBC had significant positive effects on IN, and PBC had a significant positive effect on pro-environmental behaviors. Greaves et al. (2013) separately studied the three environmental behaviors finding that TPB also had good explanatory power; although, the effects of the behaviors (AB, SN, and PBC) on IN differed. Therefore, consistent with the TPB (Ajzen, 1991) and based on the studies mentioned above, we propose the following hypotheses:

H1. TPB is suitable for explaining the farmers' environmental behavior in the WSA-MR-SNWDP.

H2. PBC and IN have significant positive predictive effects on B. AB, SN, and PBC have a significant positive predictive power for IN.

H3. AB, SN, and PBC have significant positive effects on B via IN.

Some studies suggest that age has a significant impact on environmental behavior, suggesting that older people are more environmentally friendly than younger people (Gilg et al., 2005; Pinto et al., 2011). However, for young people in a new era, their level of education is overall higher than that available to the elderly. Gifford and Nilsson (2014) considered the impact of age on environmental behavior and found that, as age increases, people might pay less attention to the environment. Therefore, there are also studies that suggested younger individuals are more prone to environmental enhancement (Burton, 2014). Furthermore, numerous studies on environmental behavior have confirmed significant differences between males and females, and that females demonstrate greater environmental intention and environmental behavior (Cincera and Krajhanzl, 2013; Fielding and Head, 2012). Therefore, we assume that gender and age have a controlling effect on environmental intention and behavior.

Individuals cannot engage in cumbersome and dirty environmental behavior without knowing anything about the environment (Gifford and Nilsson, 2014). Therefore, EK plays an important role in environmental behavior research. EK is gained through familiarity and a basic understanding of the facts, principles, and issues concerning the environment, and it is accumulated through experience and education (Aregay et al., 2017). Hong (1998) considered EK as a dimension of environmental awareness. Environmental awareness includes EK, environmental values, environmental protection attitudes, and environmental protection behaviors. All of these are interlocking and incremental steps. Lyons and Breakwell (1994) surveyed environmental behavior and found that the best indicator of environmental concern and indifference was the perception of EK. Robelia and Murphy (2012) found that EK was necessary and inadequate for environmental decision-making. Based on the studies outlined above, the present study considers the influence of EK on environmental behavior. We employ EK as a moderator in the relationship with the internal TPB in this study. See Fig. 1 for a basic framework of the extended TPB model, which is a moderated mediation model (the mediating effect was moderated). Thus, it is expected that:

H4. With age and gender as control variables, EK will moderate the relationship between both B with AB, SN, and PBC via IN.

3. Material and methods

3.1. Procedure and sample

3.1.1. Measure

Environmental behavior is, in a narrow sense, a behavior which has a significant impact on the environment (Krajhanzl, 2010). In this study, the farmers' environmental behavior refers to those behaviors that can increase the NSP load in the process of agricultural production and living. Pro-environmental behavior means behaviors "that consciously seek to minimize the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002). In this study, pro-environmental behavior refers to actions taken to reduce the pollution of rivers and the reservoir. We first obtained the environmental behavior of farmers through the literature and interviews with experts on NSP research. Then, we classified and merged these behaviors. Finally, the principal farmers' behaviors (e.g., hazardous waste and human and animal excrement) that affect the water quality of the Danjiangkou Reservoir were determined.

This study used the following four items to measure IN: "Willingness to rationally dispose of waste generated in the process of living," "Willingness to do something to reduce water pollution in the production process," "Willingness to sacrifice certain interests to reduce water pollution," and "Willingness to stop others from worsening water quality." To ensure the internal consistency of each latent variable and ensure high reliability and validity of the questionnaire in this study, the items for AB and SN were taken from Deng et al. (2016) and the items for PBC from Renger and Reese (2017) (see Table S1).

For the measurement of EK, Hong and Fan (2016) designed a set of EK scales, but the scale is too complicated for farmers. Therefore, we using four current local environmental issues (i.e., whether waste, human and animal excrement, pesticide and fertilizer, and crop straw will cause water pollution in rivers or reservoirs) to measure the level of farmers' environmental knowledge (see Table S1). Because EK is obtained through the farmers' opinions on this knowledge, people have different understandings of each problem and display a lack of internal consistency. Therefore, the calculation of EK in this study is the average of the four local environmental issues.

3.1.2. Pilot

This study conducted random one-on-one interviews based on the items designed and the open-ended questions in Xichuan County, Nanyang City, in December 2016. The items were evaluated using seven-point Likert scale. The open-ended questions were as follow: (1) What are good or bad behaviors in terms of the water quality for rivers or the reservoir? (2) What do you consider the advantages and disadvantages of these behaviors? (3) Please list the individuals or groups who would approve of or think you should engage in these behaviors. (4) Please list any factors or circumstances that would make it easy or difficult for you to engage in these behaviors. A total of 55 questionnaires were obtained in the pilot survey. We conducted a content analysis of the pilot questionnaires. This procedure included examined the farmers' answers to the open-ended questions, modified unreasonable wording and removed invalid and unreliable items.

3.1.3. Questionnaire

The questionnaire comprised two parts. The first part included gender, age, education and environmental protection facilities, and other background information. The second part included the related questions items of constructs of the TPB and EK. We found that the seven-point Likert scale was more difficult for farmers to understand, so the

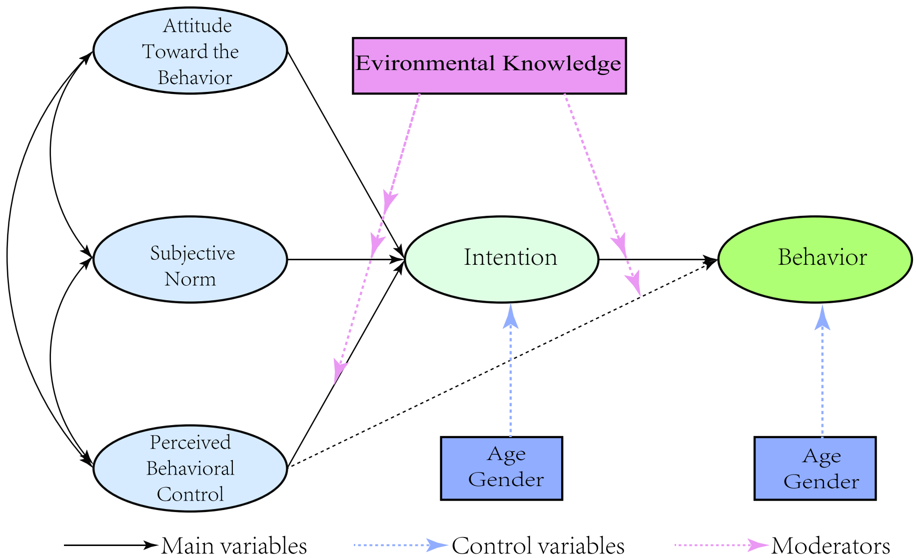

Fig. 1. Basic framework of Extended TPB model.

questionnaire eventually adopted a five-point Likert scale to evaluate each of the items. Table S1 shows the final version of the questionnaire items employed in the primary survey.

3.1.4. Survey

The WSA-MR-SNWDP is located in the inner hinterland of China. It is a mountainous region covering a total area of approximately 95.2 $\times 10^3$ km^2. This region is characterized by a northern sub-tropical monsoonal climate with an average annual rainfall of 700–1800 mm. Agricultural and urban areas account for 15% and 0.5% of the area, respectively (Li et al., 2011). To ensure that the research samples included as much information as possible on the environmental behavior of farmers throughout the WSA-MR-SNWDP, this study first applied DEM data to delineate the region into the Source Area (SUB1), Southern Slope of Qinling (SUB2), Danjiang Basin (SUB3), Northern Slope of Daba Mountain (SUB4), Duhe Basin (SUB5), and Reservoir Area (SUB6). For the Source Area, SUB1-SUB5 are farther away from the reservoir, and the distance to the digesters is longer. Therefore, two catchments for SUB1 and SUB2 each were selected. A catchment for SUB3, SUB4, and SUB5 each was selected. Since SUB6 greatly impacts water quality, we selected seven catchments through random sampling. To ensure the accuracy of the data, the investigation team consisted of seven graduate students who passed the training. In March 2017, one-on-one surveys were conducted for farmers in the SUB6, after which 330 questionnaires were collected. Excluding incorrectly completed and inconsistent questionnaires, 309 valid questionnaires were retained for a rate of 93%. From July to September 2017, 420 questionnaires were obtained from the SUB1-SUB5. Of these, 396 questionnaires were valid for an effective rate of 94%. Through the two surveys, 705 valid questionnaires were obtained for the WSA-MR-SNWDP (Fig. 2).

3.2. Statistical analysis

Accurate measurement of the latent variables is a prerequisite for the analysis of causal relations among these variables (Anderson and Gerbing, 1982). Therefore, we conducted an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) to develop measurements for the latent variables for AB, SN, PBC, IN, and B. The EFA was conducted by employing SPSS 20, and AMOS 20 was used for the CFA. Through the EFA, we removed items with factor loadings below 0.6 and cross-loadings above 0.4 (Hair et al., 1998). Through the CFA, we eliminated items with an SMC below 0.2 (Hooper et al., 2008). Next, we removed items B4–B7, I4 and A4 for B, IN, and AB, respectively.

A structural equation model (SEM) was employed using AMOS 20 to study the relationship between AB, SN, PBC, IN, and B. AMOS contains many fit indices. In this study, we used the fit indices of previous studies to evaluate the model (de Leeuw et al., 2015; Deng et al., 2016; Park and Kwon, 2017), which included the chi-squared fit statistic ($\chi 2$/df), the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), the normed fit index (NFI), and the comparative fit index (CFI). When the fit indices met or exceed the recommended values, the TPB model can be considered feasible for the current analysis of farmers' environmental behavior (Deng et al., 2016).

There are several ways to test the mediation effect. Among them, the causal steps approach (Baron and Kenny, 1986) and the Sobel Test (Sobel, 1982) are commonly used methods. However, those methods have been criticized for various reasons (Hayes, 2009; MacKinnon et al., 2002). Fortunately, MacKinnon et al. (2004) contended that bootstrapping interprets the mediation effect more strongly. Therefore, we calculated 5000 bootstrap samples in AMOS 20. If zero was not between the lower and upper bound of the Bias-corrected Percentile and Percentile, there was a significant effect at a confidence interval of 95% (Hayes, 2009).

Path analysis has demonstrated good statistical performance for testing moderated mediated models (Ozer, 2011). The process is divided into two steps of hierarchical moderator regression analysis. First, to reduce the multicollinearity, each variable was created as a summated index and was standardized (Hult et al., 2007). The first step was to do a hierarchical regression on the IN by adding control variables (age and gender) in the first layer and then adding the main effects (AB, SN, PBC, and EK), in the second layer. Finally, we added interactive items (AB $\times$ EK, SN $\times$ EK, and PBC $\times$ EK) in the third layer. The second step involved performing a hierarchical regression on B by including control variables (age and gender) in the first layer, the main effects (AB, SN, PBC, IN and EK) in the second layer, and the interactive items (IN $\times$ EK) in the third layer.

To further explore the moderating role of EK by adopting the upper and lower 27% rule of Cureton (1957), we categorized the samples into the high-level EK group (EK $>$ 4, n $=$ 225) and low-level EK group (EK $<$ 2.75, n $=$ 195). We calculated the significance of the direct and indirect effects by bootstrapping 5000 samples. Heterogeneity testing was performed to test the difference between the effects of high and low-level EK (Altman and Bland, 2003).

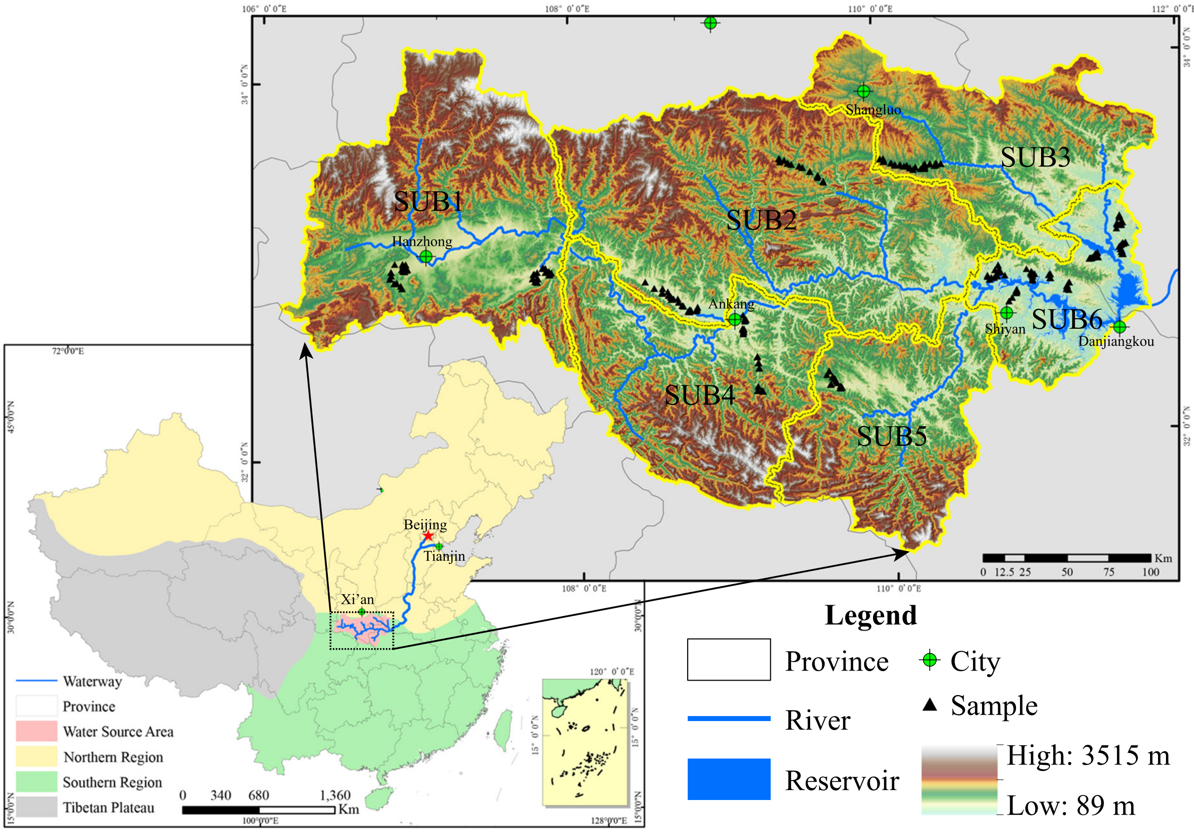

Fig. 2. Location survey samples Note: SUB1, the Source Area; SUB2, the Southern Slope of Qinling; SUB3, the Danjiang Basin; SUB4, the Northern Slope of Daba Mountain; SUB5, the Duhe Basin; SUB6: the Reservoir Area.

4. Results

4.1. Descriptive information of the sample

Table 1 provides the survey information of 705 households in the WSA-MR-SNWDP. The results indicate that the number of male and female respondents was 365 (51.8%) and 340 (48.2%), respectively. As for age and education, the results showed that the rural population tends to be aging with low levels of education. Most people were aged 40 to 60 years old and 60 to 80 years old, accounting for 44.3% and 45.3% of the total sample, respectively, almost 90% of the total population. Further, 26% of the respondents were illiterate; 34.9% had obtained a primary school education. In addition, there is a lack of environmental protection facilities; 74.9% of households do not have digesters, and half of the dwellings do not have trash collection systems. Table S3 shows that B, IN, AB, PBC, and EK are significantly variable differences in SUB1-SUB, but there is no significant difference in SN at the 0.05 significance level. Therefore, to ensure that the results cover the entire area, stratified sample surveys are required.

Table 1
Demographic information of respondents (N = 705).

Items	Category	Number	Percent
Gender	Male	365	51.77
	Female	340	48.23
Age	<20	3	0.43
	20–40	66	9.36
	40–60	312	44.26
	60–80	319	45.25
	>80	5	71
Education level	Illiteracy	183	25.92
	Primary school	246	34.89
	Junior high school	195	27.66
	High school	68	9.65
	University	13	1.84
Facility	Have biogas digester	177	25.11
	No biogas digester	528	74.89
	Have trash collection systems	344	48.79
	No trash collection systems	361	51.21

4.2. Measurement and structural models

For the EFA analysis, KMO was 0.794, the Bartlett test of sphericity was <0.001, the factor loading was >0.70, and the cross loading was <0.40. The results of the CFA analysis of the five latent variables B, IN, AB, SN, and PBC were provided in Table S2. Each latent variable was significant for the corresponding items. The standardization coefficients were all >0.60, Cronbach's alpha was >0.70, the composite reliability (CR) values were all within the range of 0.70 to 0.85, and the average of variance extracted (AVE) was >0.36. These results met the criteria recommended by Fornell and Larcker (1981). Therefore, in this study, all measurements of the latent variables demonstrated good reliability and validity.

4.3. Model analysis

The fitness index of the TPB model is shown in Table 2. The results were in accordance with $\chi2/df < 5.00$ (Wheaton et al., 1977). The GFI, AGFI, TLI, NFI, and CFI were >0.90 (de Leeuw et al., 2015; Hooper et al., 2008; Park and Kwon, 2017), and RMSEA was <0.07 (Hooper et al., 2008). The indices met the recommended levels. Therefore, TPB is applicable to the analysis of the environmental behavior of farmers in the WSA-MR-SNWDP and supports H1.

Fig. 3 summarized the structural results of the model. IN was positively related to B ($\beta = 0.470$, $p < 0.01$). IN contributed to 26% of the

Table 2
Fit indices of the model.

Fit indices	Estimate values	Recommended levels
χ2/df	3.884	<5.00
TLI	0.927	>0.90
GFI	0.938	>0.90
NFI	0.925	>0.90
AGFI	0.910	>0.90
CFI	0.943	>0.90
RMSEA	0.064	<0.07

variance in B. Therefore, IN can positively predict B. Meanwhile, AB ($\beta = 0.297$, $p < 0.01$), SN ($\beta = 0.360$, $p < 0.01$), and PBC ($\beta = 0.182$, $p < 0.01$) were significantly related to IN. AB, SN, and PBC explain 36% of the total variance of IN. That is, AB, SN, and PBC were predictors of IN. However, the correlation between PBC and B was not significant ($\beta = 0.080$, $p = 0.061$). Therefore, the results partially support H2.

The mediation effect of IN was analyzed in Table 3. The results show that AB, SN, and PBC have indirect effects on B via IN. The leading indirect decisive factor of B was SN, with an indirect effect of 0.169 (SE = 0.029, Z = 5.828), followed by AB with an indirect effect of 0.140 (SE = 0.028, Z = 5.000). PBC had the least impact on IN as its indirect effect was 0.085 (SE = 0.085, Z = 3.542). And the 95% confidence interval for the Bias-corrected Percentile and Percentile all did not contain 0. But, the direct effect of PBC on B was 0.080 (SE = 0.050, Z = 1.600). The Bias-corrected Percentile and Percentile contain 0 at the 95% confidence interval, which is further supported by PBC having no significant direct impact on B. Summarizing the above results, they show that IN fully mediates the effects of AB, SN, and PBC on B. Therefore, these results support H3.

4.4. The moderating effect of EK

The results of the moderated regressions of EK on IN and B are presented in Table 4. The results show that age had a significant negative control effect on IN (−0.118, $p < 0.01$) but a significant positive control effect on B (0.113, $p < 0.01$). However, gender (female = 0, male = 1) had a significant positive control effect on B (0.165, $p < 0.05$) and no significant effect on IN (0.121, ns). The interaction term of EK and PBC had a significant negative impact on IN (−0.094, $p < 0.01$). Therefore, the PBC-IN pathway is moderated by EK. Table 5 summarized the moderated mediation results across the low and high-level of EK. Thus, for low-level EK, EK < 2.75, the simple effect and indirect effect of PBC are 0.422 ($p < 0.01$) and 0.236 ($p < 0.01$), respectively. For high-level EK, EK > 4, the simple effect and indirect effect of PBC are 0.161 ($p < 0.05$) and 0.063 ($p < 0.05$), respectively. Differences in the effects of PBC for low and high-level EK indicate that both the simple effect (0.261, $p < 0.05$) and indirect effect (0.173, $p < 0.1$) were stronger for low-level EK. Taken together, firstly, IN completely mediates the effect of PBC on B. Secondly, the interaction between PBC and EK has a significant impact on IN. Finally, under the high and low-level EK, the indirect effect of PBC on B is significantly different. According to Ng et al. (Ng et al., 2008), the extended TPB model is a mediated moderation model (IN fully mediates the moderating effect of EK on the PBC-IN-B pathway). These results partially support H4.

5. Discussion

In recent years, the impact of water quality has changed from PS to NSP (Shen et al., 2015), so NSP has become the main factor affecting the water quality of the Danjiangkou Reservoir (Hao et al., 2012; Li and Zhang, 2011). This article, based on the theoretical framework of TPB, presents a study of the farmers' environmental behavior for NSP control and management. We first used the SEM method to analyze the explanatory power of TPB to farmers' environmental behavior and the relationship among components of the TPB. Then, using path analysis, we analyzed the moderated mediation model of EK.

The CFA analysis results and the model fitness index showed that using the TPB model is suitable for analyzing the environmental behavior of farmers. IN was able to significantly predict the variance of B by 26%, while AB, SN, and PBC were significant predictors of IN indicating a 36% variance of intent. Chin (1998) noted that the explanatory power of >0.19 reaches acceptable explanatory power, a power of >0.33 indicates moderate explanatory power. Therefore, the ability of environmental intention to interpret environmental behavior is relatively small but acceptable. However, AB, SN, and PBC reached a moderate level of explanatory power for the farmers' environmental intention. Previous studies applying TPB to environmental intention demonstrated that intention accounted for 27.3% of the variance in environmental behavior (de Leeuw et al., 2015). The antecedents of IN (AB,

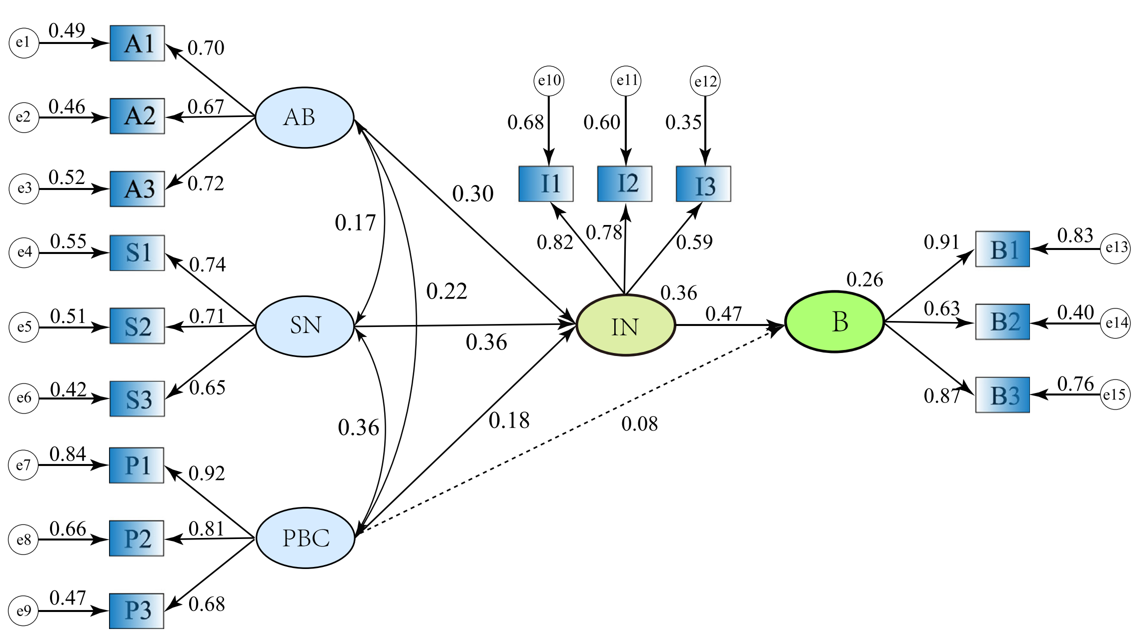

Fig. 3. The normalization coefficient and fit indices of the TPB model Note: B, Behavior; IN, Intention; AB, Attitude towards the behavior; SN, Subjective norm; PBC, Perceived behavioral control; Solid arrows represent a significant impact, while dashed arrows represent no significant effect.

Table 3
Effects of intention, attitude towards the behavior, subjective norms, and perceived behavioral control on pro-environmental behavior.

Factor	Effect	Point estimate	Product of coefficients		Bootstrapping			
					Percentile 95% CI		BC 95% CI	
			S.E.	Z	Lower	Upper	Lower	Upper
IN	Direct effects	0.470	0.044	10.682	0.384	0.556	0.382	0.555
AB	Indirect effects	0.140	0.028	5.000	0.089	0.198	0.090	0.199
SN	Indirect effects	0.169	0.029	5.828	0.114	0.230	0.115	0.231
PBC	Total effects	0.165	0.045	3.667	0.077	0.254	0.077	0.255
	Indirect effects	0.085	0.024	3.542	0.042	0.135	0.044	0.136
	Direct effects	0.080	0.050	1.600	−0.020	0.177	−0.018	0.177

Note: IN, intention; AB, attitude towards the behavior; SN, subjective norms; PBC, perceived behavioral control; S.E., standardized error; BC, Bias corrected percentile; 5000 bootstrap samples.

SN, and PBC) explained 35%–66% of the variance in environmental intention (Greaves et al., 2013; Laudenslager et al., 2004; Mannetti et al., 2004). Therefore, using TPB to study the environmental intention and behavior of farmers in the WSA-MR-SNWDP is suitable and demonstrates good explanatory power.

Regarding the antecedents of IN, our results show that AB, SN, and PBC have an indirect effect on B via IN, but PBC has no direct effect on behavior (Section 4.3). This shows that farmers' environmental behavior is mainly affected by their perceived social pressure. Moreover, farmers will also weigh the advantages and disadvantages of the behaviors and the ability to carry out the behavior. Similarly, the work of Deng et al. (2016) showed that the farmer's decision-making behavior is jointly influenced by internal and external factors. At all times, the behavioral logic of public goods managers do not to weigh their own behavior with personal gains and losses but to compare it with others in rural China (He, 2004). Therefore, this kind of pressure from other individuals or groups becomes the farmers' code of conduct for public goods management. This view was confirmed in this study since SN had the greatest indirect impact on B. However, in recent years, as the market economy has infiltrated the rural areas, the normative effects that formed intuitively have weakened. The farmers' decision-making behaviors are also considering their own interests and abilities (He, 2000). Consequently, there are significant indirect effects of AB and PBC on B as well. The results of this study are consistent with Lam (2006) and Greaves et al. (2013). In addition, our results also show that PBC had no direct impact on B. A possible explanation is that the farmers' environmental behavior is rational.

Table 4
Regression results of testing the moderation effects for intention and behavior.

Variables	First stage (dependent variable = intention)			Second stage (dependent variable = behavior)		
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Genders (female = 0, male = 1)	0.121	0.003	0.002	0.165*	0.065	0.061
Age	−0.118**	−0.096**	−0.086**	0.113**	0.154**	0.154**
AB		0.221**	0.222**		0.172**	0.175**
SN		0.269**	0.265**		0.029	0.030
PBC		0.208**	0.211**		0.028	0.025
EK		0.123**	0.131**		−0.063	−0.062
EK × AB			0.000			
EK × SN			−0.036			
EK × PBC			−0.094**			
IN					0.378**	0.372**
EK × IN						−0.039
R^2	0.016	0.265	0.277	0.022	0.241	0.243
Adjusted R^2	0.013	0.259	0.268	0.019	0.233	0.234
R^2 change		0.249	0.012		0.219	0.002
F	5.676**	59.136**	3.830**	7.857**	40.228**	1.521

Note: IN = Intention; AB = Attitude towards the behavior; SN = Subjective norms; PBC = Perceived behavioral control; EK = Environmental knowledge; × represent interactive items; *p < 0.05, **p < 0.01.

Numerous studies have shown that gender and age significantly affect environmental behavior (Gilg et al., 2005; Pinto et al., 2011). Despite numerous studies showed that women are more likely to engage in pro-environmental behaviors (Burton, 2014), our results showed that men engage more in pro-environmental behaviors. The results of this study are similar to those of Xiao and Hong (2010), which showed that women demonstrate less pro-environmental behaviors than do men in China. Gifford and Nilsson (2014) reviewed previous research showing that, in China, women are more likely to demonstrate pro-environmental behaviors in domestic settings, and men are more likely to demonstrate pro-environmental behaviors in public settings. The NSP control and management related behavior is a public goods management behavior in open settings, so this study provides a reasonable result. Age has a significant negative control effect on IN. In contrast, age demonstrates a significant positive control effect on B. That is, older farmers are more likely to engage in pro-environmental behaviors, but younger ones have more pro-environmental intentions. Similarly, other studies have also shown that older people are more likely to engage in pro-environmental behaviors (Pinto et al., 2011; Swami et al., 2011). The reason behind this result is that the age of the farmers reflects the social cohort in which they were raised, particularly the historical and social context, with a particular education and ways to socialize (Burton, 2014). The younger generation grew up with access to additional environmental education. It makes them have more pro-environment intentions (Brodt et al., 2006). But they are more willing to spend their time on agriculture and other practices than on pro-environmental behaviors (Burton and Wilson, 2006). On the contrary, when the elderly do away with heavy labor, they have more time to engage in pro-environmental behaviors.

Regarding EK as influencing personal behaviors (Heimlich and Ardoin, 2008), in this study, EK has no direct effect on B. However, EK moderated the PBC-IN path, and IN fully mediated the negative moderating effect of the farmers' EK on the PBC-IN-B pathway (see Section 4.4). Similarity, Aregay et al. (2017) results showed that EK did not have a direct effect on the farmers' behavior. And Park and Kwon (2017) showed that EK (negative and weak) serves to promote positive intention and actual behavior via PBC. Contrary to previous findings, the leading proximal antecedent of behavioral intention affecting the

Table 5
Moderated mediated results across the low and high levels of environmental knowledge.

Moderator	Level	AB		SN		PBC	
		Simple	Indirect	Simple	Indirect	Simple	Indirect
EK	Low	0.222**	0.124**	0.354*	0.198**	0.422**	0.236**
	High	0.380**	0.173**	0.341**	0.155**	0.161*	0.063*
	Difference	0.158	0.049	0.013	0.043	0.261*	0.173+

Note: IN = Intention; AB = Attitude towards the behavior; SN = Subjective norms; PBC = Perceived behavioral control. EK was below 2.75 and above 4 for low and high-levels. Indirect effects and significance were based on 5000 bootstrapping samples using AMOS. The difference in the significance between low and high was based on the heterogeneity test. +p < 0.10, *p < 0.05, **p < 0.01.

environmental behavior in the TPB model is PBC (de Leeuw et al., 2015; Fielding et al., 2008). In this study, among the farmers with poor EK, PBC was the main factor influencing the environmental intent. The key factors affecting farmers with rich EK were AB and SN (see Table 5). The main reason behind this result is that all the research subjects in the research by de Leeuw et al. (2015) and Fielding et al. (2008) were students who had relatively less time and ability to perform pro-environmental behaviors. Similarly, for farmers with poor EK, their environmental awareness was weak. They thought that their unfriendly environmental behaviors did not affect water quality. For them, the protection of water quality is a matter for the government, and they have no ability or money do it. The results of our study also showed that EK does not have a moderating effect on AB and SN. The possible explanation for this result is that the pro-environmental attitude and perceived social pressure are more influenced by the environment and culture in which they live, regardless of the EK they hold. These finding can help us better understand the role of EK and suggest that intervention efforts might be most effective if those efforts directly affected the PBC of farmers with relatively poor EK.

5.1. Implications

Based on the above findings, "pro-environmental behavior leaders" should be shaped and they will play important exemplary and leading role in the management and control of NSP. Meanwhile, especially in water source protection areas, government departments should establish a penalty schedule. Those who pollute the water quality would be fined accordingly. Moreover, middle-aged and older farmers tend to have low EK, and there is insufficient environmental protection infrastructure in rural areas. The media and government departments should disseminate more EK among farmers and provide more information about the consequences of further unfriendly environmental behaviors to change their mindset. At the same time, additional environmental protection infrastructure should be put in place, and more efficient and safer agricultural production technology seminars should be provided in rural areas. It is important for farmers to have the ability to devote themselves to environmental protection.

The control and management of NSP needs comprehensive utilization of multi-subject method. This study fills the gap of previous research on the human behavior in control and management of NSP. We used TPB, a typical sociopsychological structure, to analyze the farmers' environmental behavior regarding control and management of NSP. The results indicate that TPB is suitable for analyzing the environmental behavior of farmers in reducing non-point source pollution, expanding the application of TPB at the farmers level for NSP management and control. In the theory of planned behavior, EK is introduced into the TPB model as a moderator, and reasonable conclusions are obtained, which can provide a basis for better understanding of the role of EK in environmental behavior studies and theoretical guidance for behavior intervention.

5.2. Limitations of this study

Although we did a systematic analysis and discussion in the current study, limitations of this study should be noted. First, the data obtained were self-reported by farmers and therefore subject to the effect of social approval and common methodological variation. To mitigate the impact of social approval and common method variation on the authenticity of self-reported data, the survey was conducted in the form of one-on-one interviews. Farmers were provided with a detailed explanation of the meaning of each item to ensure that the investigation remained aligned to the research purposes. Farmers were also informed that there was no conflict of interest and that their anonymity would be guaranteed. Second, the ability to explain environmental behavior was relatively low because the environmental protection designed by this research only involved the disposal of rubbish and human and livestock excrement. In this study, behaviors pertaining to the environmental protection related to straw, kitchen waste, and domestic wastewater treatment were not included because they are not inherently consistent. This limitation also exists in other relevant studies (de Leeuw et al., 2015; Fielding et al., 2008). Third, the measurement of EK only measures the daily EK, it does not involve professional EK, so the measurement of EK is not comprehensive enough. Finally, the environmental behavior of farmers may also be affected by factors such as family income and cultural differences, which were not included in this study. Therefore, future research should consider the impact of these factors on environmental behavior.

6. Conclusions

The present study drew on a well-established sociopsychological model to examine the environmental behavior of farmers concerning NSP control and management. The results show that it is suitable to use TPB to analyze the environmental behavior of farmers regarding the control and management of NSP. IN fully mediated the relationship between its antecedents (AB, SN, and PBC) and B. Different from the results of previous studies on environmental behavior, SN was the main factor that affected the farmers' environmental behavior, but among the farmers with relatively low-level EK, PBC was the main factor affecting the farmers' environmental behavior. And gender (female = 0 and male = 1) and age had positive control over environmental behaviors (i.e., males and older people were more pro-environmental behavior). Only age had a negative control over environmental intentions (i.e., younger people were more pro-environmental IN). NSP is a major global challenge that will continue into the future. For managers and researchers of NSP, the current research provides valuable information for intervening with the farmers' environmental behavior to achieve NSP control and management.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version, at https://doi.org/10.1016/j.scitotenv.2018.03.273. These data include the Google map of the most important areas described in this article.

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