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
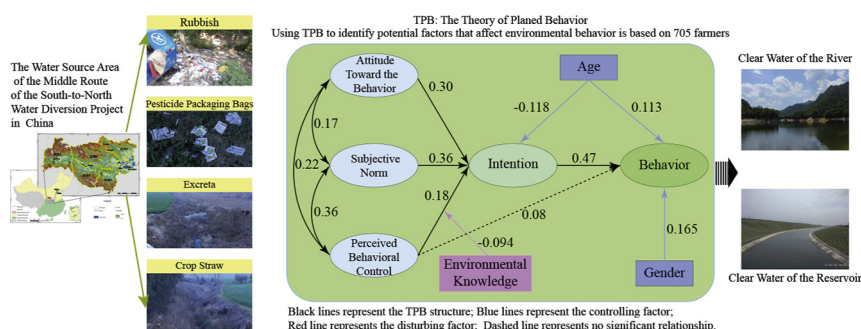
ABSTRACT

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,

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