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Factors affecting farmers' behavior in using nitrogen fertilizers: society vs. farmers' valuation in southwest Iran

Fatemeh Hamid[a], Masoud Yazdanpanah*[a], Masoud Baradaran[a], Bijan Khalilimoghadam[b] and Hossein Azadi[c,d,e]

[a]*Department of Agricultural Extension and Education, Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran;* [b]*Department of Soil Science, Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran;* [c]*Department of Geography, Ghent University, Ghent, Belgium;* [d]*Research Group Climate Change and Security, Institute of Geography, University of Hamburg, Hamburg, Germany;* [e]*Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic*

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Overapplication of nitrogen (N) has direct and indirect environmental and social impacts, both now and in the future. Therefore, applying N more efficiently is an important goal in many developing countries. The purpose of this study is to understand the factors affecting the intention of nitrogen consumption behavior by farmers in Ramshir county in Khuzestan province (located in southwestern Iran). To this end, we used the extensive normative activation model enriched with the planned behavior model to understand farmers' behavior. The statistical population for the study included 200 farmers in Ramshir county in Khuzestan province in southwestern Iran. Structural equation modeling revealed that the proposed model predicted 32% and 45% of the variance in intention and behavior, respectively. Personal norms were stronger predictors of intention, whereas attitude and subjective norms had no impact on intention. As fertilizer use continues to increase, imbalanced and unsustainable use of fertilizers and their environmental effects will become a major concern according to the findings. Factors that affect farmers' decision-making on fertilizer usage need to be studied and better understood in order to establish correct policies on costs, incentives, and future program goals. It is therefore important for policymakers to communicate information to producers through demonstration projects, technical assistance, and educational programs, in order to formulate successful emission control policies. Under a changed political environment, some integration of education and economic benefits could be lower cost and more effective tools to achieve desired conservative environmental goals.

Keywords: reduced nitrogen application; norm activation model; emotion; Iranian farmers

1. Introduction

Nitrogen (N) plays a major role in increasing agricultural production worldwide (Bontems and Thomas 2006; Elrys *et al*. 2019) to meet the increasing demand for food and to combat hunger due to population growth (Stuart, Schewe, and McDermott 2014). The use of N fertilizer has increased tenfold in the past six decades (Robertson and Vitousek 2009). However, applying N is risky in many circumstances (Monjardino *et al*. 2013), and overapplication of N is directly and indirectly associated with several environmental and social impacts, both now and in the future. These impacts include a

*Corresponding author. E-mail: yazdanm@asnrukh.ac.ir

loss of biodiversity, climate change, soil acidification, threats to human health, degradation of water quality, and eutrophication (Berre *et al*. 2013; Weber and McCann 2015; Elrys *et al*. 2019). Because it is highly mobile in water, N has a significant impact on groundwater pollution (Bontems and Thomas 2006; Barnes *et al*. 2011). This type of pollution has been reported in many parts of the world, such as the United States (Altieri and Nicholls 2001), Spain (Picazo-Tadeo and Reig-Martinez 2007), Egypt (Elrys *et al*. 2019), and Iran (Jalali 2011).

Furthermore, because N can enter into surface water through runoff from agriculture, many coastal rivers and bays have been polluted (Stuart, Schewe, and McDermott 2014) such as Mexico Gulf (Stuart, Schewe, and McDermott 2014). Moreover, N transforms into nitrous oxide (N_2O), a greenhouse gas (which is 298 times more active than carbon dioxide) that contributes significantly to climate change and global warming (IPCC 2006). The agricultural sector and food supply are the main suppliers of N_2O emissions – 60%–80% of total anthropogenic N_2O emissions (Steinfeld *et al*. 2006; IPCC 2006; Stuart, Schewe, and McDermott 2014), and increasing the level of nitrates in the soil causes metahemoglobinemia (low blood oxygen levels) in children and gastric, bladder, and oesophageal cancer in adults (Altieri and Nicholls 2001). Iran's agriculture and environment are facing almost all of the problems posed by the use of N. Worsening water quality due to the leaching of N from agriculture is a serious problem (Jalali 2005, 2011). Some studies (Qasemi *et al*. 2018; Rahmati *et al*. 2015) have revealed that concentrations of nitrates exceed the World Health Organization's acceptable thresholds. Moreover, Iran is at the top of the list of greenhouse gas emitters (Zobeidi *et al*. 2016).

Improper and excessive use of nitrogen fertilizers, in addition to wasting fertilizer and its negative impact on the environment – through the entry of fertilizer waste into water and soil resources – lead to wasting the farmers' financial resources.

Jayne, Zulu, and Nijhoff (2006) proposed the low use of outside inputs as a contributor to declining crop productivity. As Duflo, Kremer, and Robinson (2011) have noted, farmers frequently want to use more inorganic fertilizers, but face cost constraints when purchasing them, and they do not receive government subsidies to buy nitrogen fertilizers. While poverty and declining soil fertility as a constraint on crop production are a concern, farmers are forced to spend more of their income to provide nitrogen fertilizers. Although increasing the price of fertilizer will have environmental benefits, it will reduce crop production productivity. The results of many studies (Ricker-Gilbert, Jumbe, and Chamberlin 2014; Holden and Lunduka 2012) have shown that an increase in the price of nitrogen fertilizers will reduce demand for it, and the elimination of its price or the allocation of subsidies may increase consumption (Ricker-Gilbert, Jumbe, and Chamberlin 2014; Holden and Lunduka 2012).

The negative effects of nitrogen fertilizers on the environment, water, and soil on the one hand, and the reduction of crop yields on the other hand, have caused farmers to be concerned about using nitrogen fertilizers. Therefore, the use of these fertilizer resources in order to protect personal interests and monitor social environmental issues together requires the acquisition of behavioral skills, training, and consultation of experts, which has become an important goal in many developing countries (Robertson and Vitousek 2009; Sheriff 2005; Barnes *et al*. 2011; Kanter, Zhang, and Mauzerall 2015). In other words, using the opinions of experts in health protection, environmental protection, improving fertilizer management, sustainable production, reducing costs, and helping the mitigation of climate change are very important (Stuart, Schewe, and McDermott 2014; IPCC 2006).

Although farmers are aware of the risk N poses, they overapply this fertilizer and do not widely accept management practices and technologies developed for its optimal application (Stuart, Schewe, and McDermott 2014), so understanding their motivations is essential to reduce this behavior (Huang *et al*. 2012).

The first step to designing effective policy to encourage efficient N fertilizer application on farms is to understand the current behavior of farmers regarding N application. Since little is known about which factors influence farmers' decisions to use fertilizers (Stuart, Schewe, and McDermott 2014), it is necessary to investigate the perceptions and behavior of farmers regarding N fertilizer (Ribaudo *et al*. 2011). We argue that the future success of N management largely depends on farmers' intentions and behavior regarding adequate use of N. We ask the following questions: What encourages farmers' adequate use of N? What factor(s) determine(s) farmers' willingness to use, and actual use of, adequate N? The answers to these questions have important policy implications for the effective use of N on farms. These insights can help policymakers facilitate changes in farmers' intentions to use adequate N.

Although relatively comprehensive studies regarding farmers' attitudes and behavior regarding the application of chemical pesticides have been performed in Iran (Abadi 2018; Monfared, Yazdanpanah, and Tavakoli 2015; Rezaei, Seidi, and Karbasioun 2019), there are no studies on the overapplication of N in Iran, and this topic has received less attention by stakeholders (including researchers, practitioners, and even the public) than chemical pesticides. Therefore, this study provides much needed empirical data on farmers' perceptions and behavior toward reduced and efficient use of N on their farms. We hope that the results of this study draw more attention from scholars and policymakers to this neglected area. Furthermore, we believe that our results provide policymakers with meaningful information for improving the design of environmental policies aimed at reducing the consumption of N in Iran's agriculture and food supply.

Today, there is a growing interest in using cognitive approaches to better understand environmental decision making (Yazdanpanah *et al*. 2015; Delfiyan *et al*. 2020; Pakmehr, Yazdanpanah, and Baradaran 2020a; Rahimi-Feyzabad *et al*. 2020). In addition, researchers in the behavioral sciences consistently advocate the application of theories to better understand the determinants of individual decision making (Monfared, Yazdanpanah, and Tavakoli 2015; Pakmehr, Yazdanpanah, and Baradaran 2020b). A range of theoretical models from social psychology has been used extensively to investigate individual intention and pro-environmental behavior (Wittenberg, Blöbaum, and Matthies 2018; Tajeri Moghadam *et al*. 2020). Thus, given their potential for predicting individual environmental behavior (Zeweld *et al*. 2018; Boazar, Abdeshahi, and Yazdanpanah 2020), this study relied on social-psychological models to investigate farmers' behavior.

Today, the purpose of using nitrogen fertilizers is not only to increase production but also to reduce environmental pollution and move toward sustainable agriculture. Therefore, it is necessary to identify the factors influencing the tendency of farmers to reduce the consumption of nitrogen fertilizers. The first step in designing an effective policy to encourage the effectiveness of nitrogen fertilizers is to understand farmers' current behavior toward the use of nitrogen. Illiteracy and lack of awareness among farmers about the risks of long-term use of chemical inputs, such as nitrogen fertilizers, are among the issues that need to be addressed. The results of previous studies (e.g. Zhou *et al*. 2010; Williamson 2011; Han and Zhao 2009; Freeman and Omiti 2003) show that none of these studies examined the actual behavior of farmers in the use of nitrogen fertilizers to reduce environmental hazards. Since success in achieving sustainability and reducing environmental pollution largely depends on farmers' intentions and behavior toward the appropriate use of nitrogen, the current study seeks to use a broad-based activation model to understand farmers' behavior and intentions. The results of this study can be used to educate farmers to use nitrogen fertilizers and move toward sustainable agriculture to increase productivity and reduce environmental degradation.

2. Theoretical approach

2.1. Factors determining the behavior of farmers toward fertilizer utilization

Low recovery rates and large losses of fertilizer have increased the costs of food production and the environmental cost. To solve agricultural pollution issues, people who contribute to environmental pollution have to change their actions (Hopkins, Schnitkey, and Tweeten 1996). More specifically, voluntary conservative farmers' actions do not take place by themselves; not all farmers are willing to reduce their use of fertilizer because of the relevant risks of slowing yields and lowered chemical input production. Farmers will voluntarily reduce fertilizer use by lowering their production. Exogenous variables are key factors that influence the use of fertilizers, including land title, family farm, accessible working days, family debt, current assets, overall farm profits, public services (Zbinden and Lee 2005), farming, and the use of knowledge. In summary, a farmer's conservation pattern is jointly determined by human factors, physical conditions, financial conditions, and policy variables (Daberkow and McBride 2003).

2.2. Ethical responsibility

Reducing N fertilizer application may represent a conflict between farmers' personal interests and the collective interest because the increase in the use of fertilizer results in an increase in the yield crop and therefore in the farmer's income (Ju *et al*. 2016; Himmelstein *et al*. 2017). The question is, what motivates individuals to pursue environmentally friendly actions while having a detrimental impact on their income or convenience? Researchers believe that moral consideration makes people prefer the collective interest to their own self-interest. In other words, environmental protection measures, such as reducing the use of nitrogen fertilizers, are considered a kind of altruistic theory. This means that farmers who minimize their use of nitrogen fertilizers to improve the environment will not achieve the anticipated benefits, such as increasing income from the sale of more goods. Extension and awareness programs on the value of waste entry due to lack of adequate fertilizer use and environmental degradation tend to play a key role in improving the agricultural sector. Therefore, governments must increase the number of representatives of their additional services in order to raise awareness of the proper use of agricultural inputs among farmers. The Norm Activation Model (NAM) developed by Schwartz has a strong emphasis on moral considerations. Thus, we used an extended NAM to look at farmers' decisions on the application of N.

2.3. Norm activation model

The norm activation model (NAM), first suggested by Schwartz in 1977 (Schwartz 1977), is considered one of the most widely used models for predicting pro-

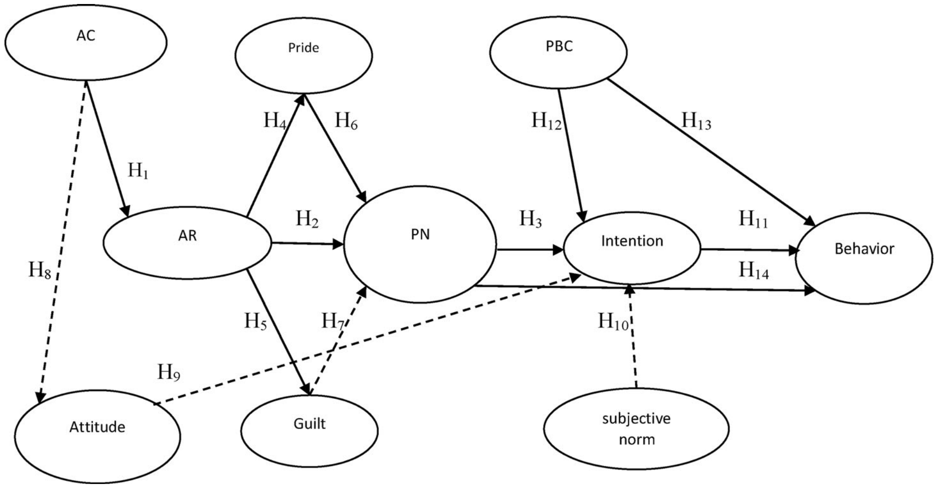

Figure 1. Theoretical framework.

environmental behaviors. Several studies (Clark, Kotchen, and Moore 2003; Harland, Staats, and Wilke 2007) have used the NAM as the basic principle to examine pro-environmental practices in different contexts, such as public transport (Bamberg and Möser 2007), electricity usage (van der Werff and Steg 2015), carbon footprint (Vaske, Jacobs, and Espinosa 2015), and responsible adoption of technology. The NAM mainly notes that an individual sacrifices his/her own benefit for others' mutual advantage and is rooted in altruistic behavior (Schwartz 1977; Clark, Kotchen, and Moore 2003). There are three key variables in the NAM used to predict pro-environmental behaviors, namely personal norms (PNs), ascription of responsibility (AR), and awareness of consequences (AC). Public norms contribute to a person's self-concept, which is correlated with a sense of moral obligation to performing a specific activity, such as environmentally friendly behavior (Thøgersen 2006). It has been found in previous studies that personal standards were an important factor that influenced various environmental behaviors, such as energy and water savings (Zhang, Wang, and Zhou 2013; Seyranian, Sinatra, and Polikoff 2015), public transport usage (Lind *et al.* 2015), and recycling (Thomas and Sharp 2013).

NAM has been frequently used to explain a broad range of pro-environmental behavior, such as pro-environmental decision making among convention goers (Han 2014), sustainable tourism (Han *et al.* 2019), carbon footprint mitigation (Vaske, Jacobs, and Espinosa 2015), energy use (van der Werff and Steg 2015), and the prevention of road traffic noise (Lauper *et al.* 2016), but the adequacy of NAM's predictive power has repeatedly been called into question (Han *et al.* 2019; Han 2014). Therefore, we added some components of the theory of planned behavior (attitude, subjective norms, and perceived behavioral control (PBC) as self-interested factors of NAM. In line with this argument, studies recommend that when NAM is applied to prosocial/pro-environmental behavior, other variables, such as attitude, subjective norms, and PBC, should be included in the model because of their clear contribution to explaining individual decisions (Han 2014; Han *et al.* 2019; Onwezen, Antonides, and Bartels 2013; Bamberg, Hunecke, and Blöbaum 2007; Wittenberg, Blöbaum, and Matthies 2018). However, the relationships between these variables and the main model variables have rarely been investigated and are not fully understood. The present study extends NAM by adding these four components to other basic components of NAM (Figure 1). Attitude, subjective norms, and PBC have repeatedly been used to examine environmental behavior (Rahimi-Feyzabad *et al*. 2020).

According to Ajzen (1991, 188), attitude refers to "the extent of an individual's satisfactory or unsatisfactory assessment or judgment of the action in question." Subjective norms refer to "the supposed social force to accomplish or not to accomplish the action" (Ajzen 1991, 188). Earlier studies (Bamberg and Möser 2007; Onwezen, Antonides, and Bartels 2013; Park and Ha 2014) used a combination of NAM and the theory of planned behavior (Onwezen, Antonides, and Bartels 2013; Han 2014; Han *et al*. 2019) and have argued that anticipated emotion can direct individual decision making and, therefore, be a stimulus for behavior. Humans are inherently inclined to embrace positive emotions and avoid negative emotions (Frijda 2007). Onwezen, Antonides, and Bartels (2013) argued that emotion acts as a self-regulatory function. In other words, anticipated emotion encourages people not only to act in harmony with their values to avoid undesirable feelings such as guilt but also to struggle for encouraging feelings such as pride. Therefore, the specific feelings of pride and guilt are applicable to considerate environmental actions within NAM. Although this model has been developed to understand altruistic actions, such as pro-environmental activity, self-conscious emotion is helpful in understanding environmentally sustainable conduct within NAM.

2.4. Research model and hypotheses

Figure 1 shows the proposed conceptual model in this study. The system includes 14 hypotheses. In addition, as indicated in the figure, the original NAM model consists of bold constructs (i.e. knowledge of consequences, assignment of obligation, personal norm, and purpose for behavior) and directions. Expected emotions of pride and shame, behavioral behaviors, and the social norm are integrated to extend and deepen the theory.

H1: Awareness of the consequences has a significant and positive effect on assigning responsibility.

H2: Assigning responsibility impacts the personal norm significantly and positively.

H3: Individual rule influences intention dramatically and positively.

H4: Responsibility assignment dramatically and positively affects anticipated feelings of pride.

H5: Ascription of responsibility dramatically and positively affects anticipated feelings of guilt.

H6: The anticipated feeling of pride affects the personal norm in a significant and positive way.

H7: The expected feeling of guilt affects the personal norm dramatically and positively.

H8: Awareness of the effects dramatically and positively impacts behavioral attitude.

H9: Attitude toward the behavior significantly and positively affects the behavior.

H10: Social norm significantly and positively affects behavior.

H11: Intention toward the behavior significantly and positively affects the behavior.

H12: Perceived behavioral control significantly and positively affects intention.

H13: Perceived behavioral control significantly and positively affects behavior.

H14: Personal norm significantly and positively affects behavior.

3. Methods

3.1. Fertilizer use and policy

In Iran, fertilization-related policies and promotional programs in the past few decades have focused on a fundamental principle, that is, ensuring availability and affordability of fertilizers, to maintain the nation's food security and environmental sustainability (Tehrani *et al*. 2010).

In recent years, government policies based on the proper use of fertilizers are conducting research on soil testing and estimating the real needs of the land and plants for fertilizer use. Despite this, there is still no specific public policy for managing the use of fertilizers, especially nitrogen fertilizers, in their agricultural and horticultural lands, and gross over application of fertilizers is still common in Iran. This problem lies in the fact that end-users lack knowledge because the majority of the many millions of farmers received inadequate education about the importance and use of plant nutrients (Baybordi *et al*. 2000). For the sake of improving nutrient quality and reducing nutrient application, timely submission of scientifically validated fertilizer recommendations is also necessary. In addition to many other agricultural technologies, the soil testing and fertilizer recommendations project was important to improve efficacy in the use of N fertilizers. While these communication activities for fixed-term projects can be very effective, the country's long-term need is an ongoing network of qualified and dedicated extension experts to provide basic knowledge in the field and government in terms of financial investment, infrastructure support, and capacity building, where necessary (Baybordi *et al*. 2000).

In recent years, there have been many concerns around the world about the effects and consequences of some agricultural activities on the environment and society. Human warfare with nature after the Industrial Revolution, including the advent of artificial chemicals and the introduction of toxins and chemical fertilizers, have dealt a fatal blow to nature. Sustainable agriculture not only considers future needs to increase production but also maintains the quality of the environment as well as water and soil (Eshaghi 2010; Baybordi *et al*. 2000). Due to the importance of this issue, the system of agricultural promotion and education, as a result of direct and close communication with the executive sector, users, and farmers, who can exchange useful and up-to-date information, is one of the serious approaches to improving the pattern of consumption of chemical and hazardous fertilizers to protect the environment. Therefore, the agricultural extension and education system uses various methods and approaches to train the villagers on the optimal use of chemical fertilizers and to inform them about the destructive effects of over-consumption. These methods and services include holding collaborative projects, FFS projects, model sites for the production of healthy products, individual and group training, implementation of research-extension projects, publications and educational-promotional announcements, consulting services through the presence of promoters in the agricultural field, training of facilitators, and combining indigenous knowledge with information and new technologies (Eshaghi 2010).

3.2. Research and sampling method

The method used in this study followed two main aspects: (a) It is a type of experimental theory and research, (b) It is a causal-relational analysis, as it explores the causal relationship between variables. The sampling process was stratified at random with proportional allocation. The statistical population of the study includes all farmers in the Ramshir county in Khuzestan province in Southwestern Iran (Figure 2). A total

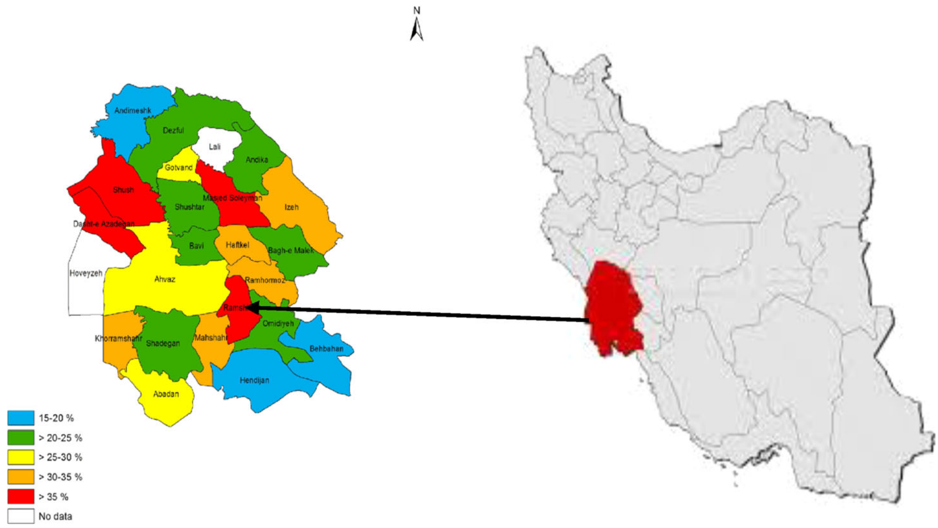

Figure 2. Location of the study area.

of 200 farmers who were responsible for household agriculture were selected through random sampling from a list provided by the local agricultural office during the summer of 2018.

The descriptive results of this study reveal that among our respondents, 14 were female and 186 were male. This reflects the fact that agriculture in the region is a business largely conducted by men, and men are usually the household head. The average age of respondents was 43.14 years. With regard to education, among participants, 50 (25%) had graduated from high school, 43 (21.5%) had no college degree, 41 (20.5%) had finished primary school, and 63 (31.5%) had finished middle school. The average family size was two people. The average agricultural experience was 48.19 years, and the average size of their farm was 11.26 hectares. The average nitrogen fertilizer they used was 434.42 kg. Of those studied, only 48 undertook soil tests.

3.3. Survey instrument

The data from this analysis were obtained using a questionnaire. The views and suggestions of the study advisor and supervisor, accompanied by researchers and experts from the Khuzestan Province Agricultural Organization, were used to determine the validity of the questionnaire. After the necessary corrections were made, it was assured that the questions presented could be used for calculation regarding the quality and characteristics of this study. A pilot test was carried out to determine the reliability and validity of the questionnaire, in which 30 copies of the questionnaire were distributed and completed by the farmers. The general Cronbach's alpha coefficient was estimated at 0.854 (AC = 0.85; AR = 0.88; PN = 0.86; Attitude = 0.82; SN = 0.90; PBC = 0.80; Pride = 0.89; Guilt = 0.95; Intention = 0.73; Behavior = 0.86). Selection of methods often entails certain variations, and our system, which is based on surveys, is no exception. While survey-based methods have limited usefulness in exploring some of the more complex nuances of certain conceptual categories, such as identity, they are of great use in testing well-established theories and also in identifying broad patterns of relationships among populations (Davidson *et al.* 2019). We used confirmatory factor analysis (CFA) to evaluate the reliability and validity of the measurement model. To perform CFA, the total number of samples was randomly divided into two subgroups of equal size (100 people in each group) for calibration and validation using SPSS software. The calibration group was used to modify the model and the validation group was used to confirm the stability of the model created from the calibration sample. Using calibration samples, the suitability of the data for factor analysis was evaluated. To modify the model with calibration data, first items with a factor loading below 0.5 were removed, and then items with a high modification index, or in other words, items that had a very high correlation with other items were also removed. Thus, the initial model was approved. The results indicated that the measurement model demonstrated an acceptable and adequate fit to the data (see Tables 1 and 2).

The univariate normality assumption was checked with the one-sample Kolmogorov-Smirnov Test (SPSS) and multivariate normality was assessed with the Shapiro-Wilk goodness-of-fit test on the distribution of the Mahalanobis distances. There were significant departures from normality on both tests. With regard to outliers, multivariate outliers have more influence on the factor solution than do univariate outliers, so that is what we checked. Using the Mahalanobis distance values, multivariate outliers can be identified using the χ^2 distribution. None were identified.

We assessed multicollinearity in two ways; first, we checked multicollinearity through the correlation matrix of all variables (Table 2). Neither bivariate correlation, however, exceeds the critical 0.70 threshold (Bryman and Cramer 1994), which is a strong indication that multicollinearity problems are absent. Furthermore, to check the multicollinearity, the variance inflation factor (VIF) should be less than 10. The results showed that the values were reasonably low and therefore multicollinearity was not a concern.

Furthermore, as presented in Table 2, the internal consistency between the variables was investigated. Composite reliability exceeded the recommended threshold of 0.60, ranging from 0.774 to 0.949. That is, all multiple-item measures for the variables had good internal consistency and reliability (Bagozzi and Yi 1988). Next, we tested the average variance extracted (see Table 2). The lowest value was 0.512, which exceeded the suggested cutoff value of 0.5 (Fornell and Larcker 1981). The average variance extracted, which ranged from 0.512 to 0.758, indicated good convergent validity.

There are a broad variety of variables that have been found to affect the decisions of farmers. Taking into account the complexity of these variables, the following five categories have been identified: demographic and socio-economic variables; capital, infrastructure, and technologies; structural and political factors; social and cultural factors; and cognitive and psychological factors (Dang *et al.* 2019). Collecting two or more factors or putting the range of factors into groups could be relatively difficult. Incorporating all the classes into one specific study is also very complex. In addition, each author has his/her own goal of investigating one or more specific groups of factors to explain the behavior of the farmers. Therefore, this research focuses primarily on cognitive and psychological factors.

4. Results

To analyze the data, SPSS20 and AMOS20 have been used in this study. First, confirmatory factor analysis (CFA) has been used to examine the measurement model and

Table 1. Items in the questionnaire.

	Alpha	Item
AC (*M* = 2.79, S*D* = 0.73)	0.85	Overuse of nitrogen fertilizer causes acid rain
		Overuse of nitrogen fertilizer can damage the environment
		Overuse of nitrogen fertilizer can adversely affect people's health
		Overuse of nitrogen fertilizer has negative effects on children's health
AR (*M* = 2.55, S*D* = 0.92)	0.88	I feel partly responsible for the ecological problems due to the use of N fertilizer in agriculture
		I feel jointly responsible for the ecological problems due to the use of N fertilizer in agriculture
		I believe that every farmer is partly responsible for the ecological problems caused by N fertilizer
PN (*M* = 2.92, S*D* = 1)	0.86	I feel an obligation to reduce and efficiently use N fertilizer
		I feel that I have a moral commitment to reduce and efficiently use N
		Regardless of what other farmers do, because of my own values I feel that I should reduce and efficiently use N
		If I reduce and efficiently use N, I will feel that I am making a personal contribution to something better
Attitude (*M* = 2.29, S*D* = 0.58)	0.82	For me, attending to reducing and efficiently using N is pleasant
		For me, attending to reducing and efficiently using N is attractive
		For me, attending to reducing and efficiently using N is wise
		For me, attending to reducing and efficiently using N is good
SN (*M* = 2.20, S*D* = 0.92)	0.90	Most people who are important to me think I should reduce and efficiently use N
		Most people who are important to me would want me to reduce and efficiently use N
		People whose opinions I value would prefer that I reduce and efficiently use N
PBC (*M* = 2.48, S*D* = 0.75)	0.80	It is mostly up to me whether or not to reduce and efficiently use N
		I have enough skill and knowledge to reduce and efficiently use N
		If I wanted to, I could easily reduce and efficiently use N
Pride (*M* = 2.56, S*D* = 0.83)	0.89	Imagine that your reduction and efficient use of N minimizes its negative impact on humans and the environment. How would you feel?
		Proud
		Accomplished
		Confident
		Worthwhile

(*Continued*)

Table 1. (*Continued*).

	Alpha	Item
Guilt ($M = 2.39$, $SD = 0,98$)	0.95	Imagine that your overuse of N fertilizer generates a negative impact on the environment and humans. How would you feel? Guilty Remorseful Sorry
Intention ($M = 2.40$, $SD = 0.89$)	0.73	I am willing to reduce and efficiently use N I intend to reduce and efficiently use N I plan to reduce and efficiently use N
Behavior ($M = 2.44$, $SD = 0.62$)	0.86	I use green manure instead of nitrogen fertilizers to boost crop yields and strengthen the soil To reduce the use of fertilizers, I use crop rotation on my farm

the reliability and validity of constructs. Then we performed structural equation modeling (SEM) to examine our hypotheses.

The use of SEM in many fields of science has a long tradition. However, discussions about the usefulness of this method are ongoing. Some SEM researchers believe that this is a method that allows testing causal relationships based on non-experimental data (Meehl and Waller 2002); others view structural equations as a worthless method and undermine the validity of its use (Freedman 1987, 1997). According to Cheng (2001), Structural Equation Modeling (SEM) has become one of the most common statistical techniques in the quantitative social sciences across various disciplines. This technique has become popular due to its sophisticated theory and its ability to solve important substantive issues. In many cases, changing the direction of the relationship between two constructs does not change the fit of the model and estimation of parameters. Further arguments are focusing on the possibility of using SEM to test the analysis of equivalent models, i.e. models with the same number of parameters, degrees of freedom, and different relationships between variables. They show similar alignment with the same empirical data.

This analytical methodology identifies whether models match, where there are redundancies, and can also help to determine what specific feature of the model is in conflict with the data. This is a kind of integration of various regression and factor analysis with some additional advantages over these approaches, including an effective way of dealing with multicollinearity and methods to take into account the unreliability of response data (Adnan, Hura Ahmad, and Adnan 2006; Payandeh Najafabadi, Omidi Najafabadi, and Farid-Rohani 2012). SEM can be implemented in both confirmative (testing) and exploratory (model construction) modes. It is, however, used in large part as a confirmatory technique. Here, a researcher is more likely to use SEM to determine the validity of a given model (Kaplan 2000). For this study, therefore, SEM was used to investigate the relationship between the research variables.

Using the measurement model obtained from the calibration samples, initial structural modeling used with maximum magnification estimate. The modification of the structural model was performed using the modification indices as a guide. This generated our hypothesized final model that would be subject to cross-validation.

Table 2. Pearson correlations between variables.

Variable	AC	AR	Pride	Guilt	PN	Attitude	SN	SE	Intention	Behavior
AC	1									
AR	0.531**	1								
Pride	0.187**	0.357**	1							
Guilt	0.488**	0.540**	0.540**	1						
PN	0.563**	0.686**	0.477**	0.552**	1					
Attitude	−0.049	−0.122	−0.104	0.008	−0.119	1				
SN	0.199**	0.276**	0.344**	0.432**	0.360**	−0.152*	1			
SE	0.434**	0.455**	0.262**	0.396**	0.469**	−0.136	0.410**	1		
Intention	0.252**	0.374**	0.386**	0.416**	0.427**	−0.121	0.258**	0.487**	1	
Behavior	0.361**	0.495**	0.290**	0.445**	0.431**	−0.210**	0.475**	0.577**	0.498**	1
CR	0.844	0.887	0.892	0.949	0.868	0.825	0.901	0.803	0.774	0.871
AVE	0.527	0.662	0.675	0.758	0.624	0.544	0.695	0.512	0.549	0.634
Goodness-of-Fit Statistics: $\chi^2 = 1164.686$ ($df = 772$, $p < 0.0001$), Relative $\chi^2 = 1.509$, RMSE$A = 0.051$, CF$I = 0.929$, IF$I = 0.930$, NFI = 0.818										

Note: **Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The indices obtained in the calibration model were as follows [relative x^2=1.567, $p < 0.0001$, GFI=(0.860), CFI=(0.890), RMSEA=(0.054)]. These indicators confirm the validity of the structural model. The structural model obtained was validated through validation data. In fact, cross-validation was performed in two stages for the measurement model and the structural model separately to confirm that there was no change in factor loads, indirect paths and direct paths. Finally, the validated model of cross validation was fitted using the dataset as a whole to evaluate the model fit and its suitability. The results of SEM with all samples showed a reasonable fit for our research model: $\chi^2 = 1325.722$ (df = 800, $p < 0.0001$), relative $\chi^2 = 1.657$, root mean square error of approximation = 0.057, comparative fit index = 0.906, incremental fit index = 0.908, normed fit index = 0.796. The appropriateness of the fit indices supports the validity of the approved model in the cross-validation stage.

4.1. SEM and hypothesis testing

SEM revealed the direct and indirect effects between the proposed model variables (Table 3 and Figure 3). According to the results, AC had a significant direct effect on AR (0.634, $p < 0.0001$) and predicted 40% of the variance in AR; thus, this research hypothesis is confirmed with a 99% confidence level and at the significance level of 0.001.

According to the results, AC had no effect on attitude (−0.093, $p < 0.263$). Therefore, the research hypothesis based on the positive and significant effect of AC on attitude is rejected.

AR had direct effects on pride (0.429, $p < 0.0001$), PN (0.653, $p < 0.0001$), and guilt (0.618, $p < 0.0001$). Therefore, the hypotheses are accepted and confirmed with a 99% confidence level and at the significance level of 0.00.

Based on the results, AC had indirect effects on guilt ($\beta = 0.391$) and pride ($\beta = 0.272$) and predicted 18% and 38% of the variance in pride and guilt, respectively. However, pride had a direct effect on PN (0.240, $p < 0.0001$). Guilt had no significant effect on PN (0.074, $p < 0.317$). Thus, the research hypothesis based on the positive and significant effect of guilt on PN is rejected. AC ($\beta = 0.508$) and AR ($\beta = 0.149$) had indirect effects on PN and they jointly predicted 69% of the variance in PN. PN (0.268, $p < 0.002$) and PBC (0.506, $p < 0.0001$) had direct effects on intention; therefore, the research hypotheses are confirmed with a 99% confidence level, whereas AC ($\beta = 0.137$), AR ($\beta = 0.215$), and pride ($\beta = 0.064$) had indirect effects on intention and together predicted 32% of the variance in intention. The effects of attitude (−0.011, $p < 0.886$) and subjective norms (−0.058, $p < 0.495$) on intention were not significant. Therefore, the hypotheses are not accepted and confirmed. Intention (0.175, $p < 0.035$), PN (0.151, $p < 0.05$), and PBC (0.468, $p < 0.0001$) had significant direct effects on farmers' behavior. Thus, this research hypothesis is confirmed with a 99% confidence level and at the significance level of 0.001. According to the results, AC ($\beta = 0.101$), AR ($\beta = 0.159$), PN ($\beta = 0.047$), and PBC ($\beta = 0.082$) had indirect effects on behavior. These constructs together predicted 45% of the variance in farmers' behavior.

5. Discussion

5.1. Pre-defined conceptual framework

To the best of our knowledge, no studies to date have investigated farmers' intentions and behavior toward reduced and efficient use of N fertilizer in Iran. Therefore, the findings of

Table 3. Direct and indirect standardized effects of the variables.

Variable	Social norms	AC	Self-efficacy	AR	Guilt	Pride	Attitude	PN	Intention	Behavior
Direct standardized effects										
AR		0.634								
Guilt				0.618						
Pride				0.429						
Attitude										
PN				0.653		0.240				
Intention			0.468					0.268		
Behavior			0.506					0.151	0.175	
Indirect standardized effects										
AR										
Guilt		0.391								
Pride		0.272								
Attitude										
PN		0.508		0.149						
Intention		0.137		0.215		0.064				
Behavior		0.101	0.082	0.159		0.047		0.047		
Total standardized effects										
AR		0.634								
Guilt		0.391		0.618						
Pride		0.272		0.429						
Attitude										
PN		0.508		0.802		0.240				
Intention		0.137	0.468	0.215		0.064		0.268		
Behavior		0.101	0.588	0.159		0.047		0.198	0.175	

this study contribute to a growing body of literature applying a psychological model in behavioral decision making to reduce and efficiently use N fertilizer. We explored psychological factors influencing the reduction and efficient use of N fertilizer application among farmers in Southwestern Iran as a health, environmental, and climate change mitigation strategy. We proposed a socio-psychological model that combines Schwartz's ethical model (NAM) and Ajzen's self-interest model (the theory of planned behavior). As Bamberg and Möser (2007) and Park and Ha (2014) have argued, environmental behavior is the best possible outcome of self-interest and prosocial motivations. Our proposed model predicted 32% and 45% of the variance in intention and behavior, respectively.

Regarding the predictive power of our proposed model, results revealed that the model is an effective tool for investigating farmers' intentions and behavior regarding reduced and efficient N fertilizer application. Compared to the theory of planned behavior as a common model of pro-environmental behavior, our model has appropriate explanatory power. For example, in their meta-analysis, Armitage and Conner (2001) found that, on average, the power of the theory of planned behavior for predicting intention and behavior is about 39% and 27%, respectively, while our proposed model explained 32% and 45% of the variance in intention and behavior, respectively, to reduce and efficiently use N fertilizer. Therefore, our proposed model is comparable to the theory of planned behavior.

5.2. Main findings

The predictive power of our proposed model revealed that the model is an effective tool for investigating farmers' intentions and behavior toward reduced and efficient N

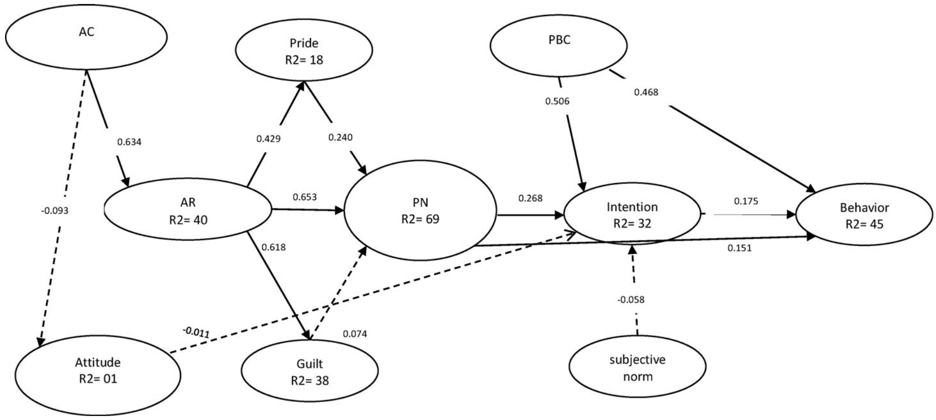

Figure 3. Structural model of farmers' behavior in using nitrogen fertilizers.

fertilizer application. Compared to the theory of planned behavior as a common model of pro-environmental behavior, our model has appropriate explanatory power.

Regarding factors that influence the decision to use N fertilizer, SEM revealed that as AC increased, AR also increased. However, AC had no effect on attitude. Barnes *et al.* (2011) pointed out that being aware of the relationship between performing a certain agricultural activity and its potential for damage can change farmers' behavior and attitude. Huang *et al.* (2008) pointed out that farmers' lack of knowledge on the amount of N fertilizer required by the crop is the major cause of its misuse (Huang *et al.* 2008). Another important finding of this study is that PN emerged as a main factor (motivator) in prosocial motivations. AR and Pride were the main determinants of PN, although the effect of AR was stronger than pride. Farmers who are well informed about the possible consequences of overusing N fertilizer and anticipate positive emotions regarding less and efficient use of N tend to have a strong sense of personal responsibility to reduce and efficiently use N fertilizer. Furthermore, PN and PBC predicted farmers' intentions, whereas attitude and subjective norms had no significant effects on intention. These results are consistent with past studies which found that PN and subjective norms together have no direct influence on intention (Bamberg, Hunecke, and Blöbaum 2007). Therefore, if a person's AC and AR levels increase in connection with overuse of nitrogen fertilizers, PN increases. Thus, it is very important that farmers first be aware of the hazardous effects of overusing N fertilizers on humans, society, and the environment, as this will increase their sense of responsibility and might lead to increased PN regarding efficient use of N. Finally, PN and PBC were the main determinants of farmers' behavior toward reduced and efficient use of N fertilizer. These findings reveal that ethical aspects (prosocial motivations) take precedence over self-interest in predicting farmers' intentions and behavior regarding efficient use of N. In other words, as Figure 3 shows, PN and PBC predicted farmers' intentions to reduce fertilizer application, whereas attitude and subjective norms as the main drivers of self-interest had no effect on intention.

Our findings reveal that the self-interest variables (attitude and subjective norms) failed to make a significant and consistent contribution to predicting farmers' intentions. This is not surprising, because self-interest is associated with maximizing profit, which stands in direct opposition to reducing the application of chemical fertilizer. It may be that the farmers, when making decisions about fertilizer use, may have been thinking of potential reduced crop production due to reduced fertilizer application. For example, Davidson *et al*. (2014) reported that farmers believe that N fertilizer budgets are large enough for them to reduce and more efficiently use N, but they also pointed out that the economic risk of applying too little N is very high. In line with this finding, Kassam and Dhehibi (2016) found that Egyptian farmers believe that the more fertilizer they use, the greater the crop growth and thus their profitability will be; therefore, they use more fertilizer than crops require. We conclude from this finding that ethical factors can better predict decisions to use N fertilizer than self-interest.

PBC is another important factor that influences farmers' intentions and behavior regarding reduced and efficient use of N fertilizer. Farmers must be confident that they have the skills and knowledge to be able to reduce and efficiently use N fertilizer. The role of PBC in a range of pro-environmental behavior has been substantiated by a large number of researchers (Azadi *et al*. 2019; Azadi, Yazdanpanah, and Mahmoudi 2019; Bozorgparvar *et al*. 2018). According to Bandura (1977), PBC refers to individual skill, knowledge, and ability to perform a new behavior. In this study, PBC measured the degree to which farmers felt they had the self-confidence to reduce and efficiently use N fertilizer on their farms.

In other words, farmers' perception of how easy or difficult it is to reduce and efficiently use N fertilizer is expected to have an impact on their behavior. This perception is largely dependent on the knowledge, skill, and ability of the farmer. Therefore, PBC influences farmers' intentions and behavior. Farmers who are more confident that reducing and efficiently using N fertilizer is easy and/or those who believe that the reduced and efficient use of N fertilizer is under their management are more able to do that and utilize N fertilizers effectively. This finding highlights the importance of extension and education programs to empower farmers to feel confident in reducing and efficiently using N fertilizer. Huang *et al*. (2008), in a study in China, found that by training, education, expert guidance, and other extension activities, farmers can reduce N fertilizer from 20% to 30% without reducing their rice production. Improving farmers' knowledge about soil nutrients is a form of empowerment and self-efficacy. Self-efficacy is a cognitive variable that focuses on self-confidence to be able to change individual practices. This can help farmers overcome a sense of powerlessness. In other words, self-efficacy is related to positive feelings such as hope and self-confidence. Therefore, this condition can occur both among literate and illiterate people (Wuepper and Lybbert 2017; Wuepper, Zilberman, and Sauer 2020; van Valkengoed and Steg 2019). Kassam and Dhehibi (2016) argued that a lack of knowledge about soil nutrients leads to imbalanced fertilization. Furthermore, providing financial and educational assistance to farmers and providing precise recommendations for application rates and timing based on soil type, irrigation, and previous crops are very effective ways of increasing farmers' PBC.

Furthermore, the results show that most people have a low level of education. Therefore, it can be said that the level of education is effective in understanding behavior toward the use of nitrogen fertilizers. In other words, the more educated people are, the more willing they are to accept and engage in positive behaviors. Therefore, in order to better understand behavior toward nitrogen fertilizers, it is necessary to encourage farmers to continue their education.

In general, the environmental actions of farmers can be affected by several factors and solutions. Abundant studies in the fields of environmental psychology, human ecology, environmental sociology, and others led to the conclusion that a portion of the harm to the environment is the product of the harmful actions of humans. Consequently, the factors which affect (and shape) human behavior should be explained and recognized in order to improve the environment. It should be noted that several studies have looked at factors that form the attitudes of individuals toward the environment and natural resources, i.e. pro-environmental behaviors. For example, according to the planned behavior theory, Niaura (2013) analyzed the factors influencing young people's pro-environmental behaviors and revealed that pro-environmental attitudes affect pro-environmental behavior. The need for better management practices was most likely recognized by young farmers, new owners, and conservation-based farmers (Seitz and Swanson 1980; Burton 2014; Gifford and Nilsson 2014). Furthermore, in the decision-making process toward conservative practice, the age and years of education of the household head, confidence, and perception of net benefits play a role. In addition to the characteristics of farmers, exogenous variables are crucial factors influencing the actions of farmers applying fertilizers, such as land ownership, usable farm, family working days, family debt liabilities, overall farm profits, public services (Zbinden and Lee 2005), farming knowledge, and access to information (Yazdanpanah and Feyzabad 2017). In summary, the tendency of a farmer to preserve the environment can be calculated collectively by human attributes, environmental factors, financial conditions, and policy variables.

6. Conclusions and policy implications

The findings of this research have practical implications for the public sector and advisory and extension services with respect to communication with farmers to encourage reduced and efficient use of N fertilizer. The results reveal the importance of farmers' training and education regarding the benefits of reducing and efficiently using N fertilizer in terms of income, consumer health, societal well-being, and the environment. Therefore, investing in extension training and education on efficient N use is a critical policy need for Iranian farmers. Therefore, farmers should be conscious of the economic, social, and environmental challenges raised by overuse of N (AC). Messages should describe the expected consequences of overuse of N, such as climate change, threats to consumer health, loss of water and soil quality and biodiversity, and greater incidence of cancer. Farmers should recognize that overuse of N leads to a range of problems. Then they should feel that they can help to reduce or resolve these hazards by changing their actions. That is, they should understand that ecological hazards will decrease if they reduce their N application. It is expected that these efforts will stimulate farmers' intentions and behavior to reduce and efficiently use N by enhancing moral obligation and PBC. It is essential that extension and education programs focus on linkages between N fertilizer application and consumer health, destruction and pollution of natural resources, loss of biodiversity, and climate change. Such efforts should be designed to make farmers conscious of the consequences of their N fertilizer application. For example, agricultural extension and education programs should use images and scenarios to increase awareness of the costs of fertilizer application and engender a strong obligation to act to reduce N application. Farmers with these features will be more prone to actually acting to reduce N application (see also Ebreo, Vining, and Cristancho 2003). Furthermore, farmers should be supported (technically, financially, and educationally) to minimize defensive reactions and increase participation in programs touting reduced and efficient use of N fertilizer. According to the findings of this study, the following recommendations are developed:

- Policymakers must convey information to producers through demonstration projects, technical assistance, and awareness programs, in order to formulate successful emission control policies. Through a changing political environment, some integration of education and economic incentives could be lower prices and more effective tools for achieving desired conservative environmental objectives.
- The results indicate that the lack of guidance in determining the appropriate levels of fertilizers for farmers' land may have led to high levels of nitrogen fertilizer use. Training greatly reduces the risk of nitrogen overuse. Therefore, further educational programs should be introduced to avoid the overuse of nitrogen fertilizers by farmers. It also significantly reduces the probability of overusing nitrogen.
- Since weather conditions are critical in determining whether to use fertilizer, timely local weather forecasts help farmers to evaluate the risks and decide the appropriate amount of fertilizer to use.
- It is essential to implement new models of extension services, such as the model under which those services are delivered by specialist extension agricultural agencies and funded by farmer organizations, such as commodity cooperatives.

Although this study focused on Iran, research methods and survey techniques are highly important in other regions where smallholders dominate and share many socio-economic attributes with Iranian farmers, in particular in South and Southeast Asia, as well as Sub Saharan Africa. When the use of fertilizers increases, unbalanced and unnecessary usage of fertilizers may become a significant concern for their environmental impact. The factors determining farmers' decision making on fertilizer use must be investigated and better understood to develop the relevant price policies, incentives, and future priority extension programs.

Future studies may involve a more in-depth analysis of the issue of overuse on a wider geographical scale. It is also necessary to consider the factors which caused farmers to continue overfertilizing and how environmental costs that are at present external to farmers may be internalized through policies, apart from lack of knowledge on the part of farmers and the strong will to secure returns. Extending the analysis to pesticide use will also be important, as it is undergoing similar growth and has the potential to have a detrimental effect on the environment. In addition, new methods for extension services need to be identified in order to provide farmers with tailor-made knowledge and advice on safe fertilizer usage for particular crops under different agro-climate conditions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Masoud Yazdanpanah http://orcid.org/0000-0001-8610-0173

References

Abadi, B. 2018. "The Determinants of Cucumber Farmers' Pesticide Use Behavior in Central Iran: Implications for the Pesticide Use Management." *Journal of Cleaner Production* 205: 1069–1081. doi:10.1016/j.jclepro.2018.09.147.

Adnan, N., M. Hura Ahmad, and R. Adnan. 2006. "A Comparative Study on Some Methods for Handling Multicollinearity Problems." *MATEMATIKA* 22 (2): 109–119.

Ajzen, I. 1991. "The Theory of Planned Behavior." *Organizational Behavior and Human Decision Processes* 50 (2): 179–211. doi:10.1016/0749-5978(91)90020-T.

Altieri, M., and C. I. Nicholls. 2001. "Ecological Impacts of Modern Agriculture in the United States and Latin America." In *Globalization and the Rural Environment*, edited by O. T. Solbrig, R. Paarlberg, and F. DiCastri, 121–135. Cambridge, MA: Harvard University Press.

Armitage, C. J., and M. Conner. 2001. "Efficacy of the Theory of Planned Behaviour: A Meta-analytic Review." *The British Journal of Social Psychology* 40 (Pt 4): 471–499. doi:10.1348/014466601164939.

Azadi, Y., M. Yazdanpanah, M. Forouzani, and H. Mahmoudi. 2019a. "Farmers' Adaptation Choices to Climate Change: A Case Study of Wheat Growers in Western Iran." *Journal of Water and Climate Change* 10 (1): 102–116. doi:10.2166/wcc.2018.242.

Azadi, Y., M. Yazdanpanah, and H. Mahmoudi. 2019b. "Understanding Smallholder Farmers' Adaptation Behaviors through Climate Change Beliefs, Risk Perception, Trust, and Psychological Distance: Evidence from Wheat Growers in Iran." *Journal of Environmental Management* 250: 109456. doi:10.1016/j.jenvman.2019.109456.

Bagozzi, R. P., and Y. Yi. 1988. "On the Evaluation of Structural Equation Models." *Journal of the Academy of Marketing Science* 16 (1): 74–94. doi:10.1007/BF02723327.

Bamberg, S., M. Hunecke, and A. Blöbaum. 2007. "Social Context, Personal Norms and the Use of Public Transportation: Two Field Studies." *Journal of Environmental Psychology* 27 (3): 190–203. doi:10.1016/j.jenvp.2007.04.001.

Bamberg, S., and G. Möser. 2007. "Twenty Years after Hines, Hungerford, and Tomera: A New Meta-Analysis of Psycho-Social Determinants of Pro-Environmental Behaviour." *Journal of Environmental Psychology* 27 (1): 14–25. doi:10.1016/j.jenvp.2006.12.002.

Bandura, A. 1977. "Self-Efficacy: Toward a Unifying Theory of Behavioral Change." *Psychological Review* 84 (2): 191–215. doi:10.1037/0033-295X.84.2.191.

Barnes, A. P., J. Willock, L. Toma, and C. Hall. 2011. "Utilising a Farmer Typology to Understand Farmer Behaviour towards Water Quality Management: Nitrate Vulnerable Zones in Scotland." *Journal of Environmental Planning and Management* 54 (4): 477–494. doi:10.1080/09640568.2010.515880.

Baybordi, M., M. J. Malakouti, H. Amirmokri, and N. Naficy. 2000. "Chemical Fertilizer Consumption Trend." In *Production and Optimized Consumption of Chemical Fertilizers in Iran: Towards Sustainable Agriculture*, 25–33. Karaj, Iran: Nashre Amozesh Keshavarzi Publications. (In Persian).

Berre, D., J. P. Boussemart, H. Leleu, and E. Tillard. 2013. "Economic Value of Greenhouse Gases and Nitrogen Surpluses: Society vs Farmers' Valuation." *European Journal of Operational Research* 226 (2): 325–331. doi:10.1016/j.ejor.2012.11.017.

Boazar, M., A. Abdeshahi, and M. Yazdanpanah. 2020. "Changing Rice Cropping Patterns among Farmers as a Preventive Policy to Protect Water Resources." *Journal of Environmental Planning and Management* 63 (14): 1–17.

Bontems, P., and A. Thomas. 2006. "Regulating Nitrogen Pollution with Risk Averse Farmers under Hidden Information and Moral Hazard." *American Journal of Agricultural Economics* 88 (1): 57–72. doi:10.1111/j.1467-8276.2006.00838.x.

Bozorgparvar, E., M. Yazdanpanah, M. Forouzani, and B. Khosravipour. 2018. "Cleaner and Greener Livestock Production: Appraising Producers' Perceptions Regarding Renewable Energy in Iran." *Journal of Cleaner Production* 203: 769–776. doi:10.1016/j.jclepro.2018.08.280.

Bryman, A., and D. Cramer. 1994. *Quantitative Data Analysis for Social Scientists*. London: Routledge.

Burton, R. J. F. 2014. "The Influence of Farmer Demographic Characteristics on Environmental Behaviour: A Review." *Journal of Environmental Management* 135: 19–26. doi:10.1016/j.jenvman.2013.12.005.

Cheng, E. W. L. 2001. “SEM Being More Effective than Multiple Regression in Parsimonious Model Testing for Management Development Research.” *Journal of Management Development* 20 (7): 650–667. doi:10.1108/02621710110400564.
Clark, C. F., M. J. Kotchen, and M. R. Moore. 2003. “Internal and External Influences on Pro-Environmental Behavior: Participation in a Green Electricity Program.” *Journal of Environmental Psychology* 23 (3): 237–246.
Daberkow, S. G., and W. D. McBride. 2003. “Farm and Operator Characteristics Affecting the Awareness and Adoption of Precision Agriculture Technologies in the U.S.” *Precision Agriculture* 4 (2): 163–177. doi:10.1023/A:1024557205871.
Dang, H. L., E. Li, I. Nuberg, and J. Bruwer. 2019. “Factors Influencing the Adaptation of Farmers in Response to Climate Change: A Review.” *Climate and Development* 11 (9): 765–774. doi:10.1080/17565529.2018.1562866.
Davidson, D. J., C. Rollins, L. Lefsrud, S. Anders, and A. Hamann. 2019. “Just Don’t Call It Climate Change: Climate-Skeptic Farmer Adoption of Climate-Mitigative Practices.” *Environmental Research Letters* 14 (3): 034015. doi:10.1088/1748-9326/aafa30.
Davidson, E. A., J. N. Galloway, N. Millar, and A. M. Leach. 2014. “N-Related Greenhouse Gases in North America: Innovations for a Sustainable Future.” *Current Opinion in Environmental Sustainability* 9: 1–8.
Delfiyan, F., M. Yazdanpanah, M. Forouzani, and J. Yaghobi. 2020. “Farmers’ Adaptation to Drought Risk through Farm-Level Decisions: The Case of Farmers in Dehloran County, Southwest of Iran.” *Climate and Development*: 1–12.
Duflo, E., M. Kremer, and J. Robinson. 2011. “Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya.” American *Economic Review* 101 (6): 2350–2390. doi: 10.1257/aer.101.6.2350.
Ebreo, A., J. Vining, and S. Cristancho. 2003. “Responsibility for Environmental Problems and the Consequences of Waste Reduction: A Test of the Norm-Activation Model.” *Journal of Environmental Systems* 29 (3): 219–244. doi:10.2190/EQGD-2DAA-KAAJ-W1DC.
Elrys, A. S., S. Raza, A. I. Abdo, Z. Liu, Z. Chen, and J. Zhou. 2019. “Budgeting Nitrogen Flows and the Food Nitrogen Footprint of Egypt During the Past Half Century: Challenges and Opportunities.” *Environment International* 130: 104895. doi:10.1016/j.envint.2019.06.005.
Eshaghi, S. R. 2010. “Importance and Position of Agricultural Extension and Training in the Optimal Use of Chemical Fertilizers by Villagers for Sustainable Agriculture, First Congress of Fertilizer Challenges in Iran, Tehran, Research Institute.” https://www.civilica.com/Paper-FERTILIZER01-FERTILIZER01_017.html.
Fornell, C., and D. F. Larcker. 1981. “Evaluating Structural Equation Models with Unobservable Variables and Measurement Error.” *Journal of Marketing Research* 18 (1): 39–50.
Freedman, D. A. 1987. “As Others See Us: A Case Study in Path Analysis.” *Journal of Educational Statistics* 12 (2): 101–128.
Freedman, D. A. 1997. “Some Issues In the Foundation of Statistics.” In *Topics in the Foundation of Statistics*, edited by B. C. van Fraassen, 19–39. Dordrecht: Springer.
Freeman, H. A., and J. M. Omiti. 2003. “Fertilizer Use in Semi-Arid Areas of Kenya: Analysis of Smallholder Farmers’ Adoption Behavior under Liberalized Markets.” *Nutrient Cycling in Agroecosystems* 66: 23–31.
Frijda, N. H. 2007. *The Laws of Emotion*. Nawwah, NJ: Erlbaum.
Gifford, R., and A. Nilsson. 2014. “Personal and Social Factors That Influence Pro-Environmental Concern and Behaviour: A Review.” *International Journal of Psychology* 49 (3): 141–157. doi:10.1002/ijop.12034.
Han, H. 2014. “The Norm Activation Model and Theory-Broadening: Individuals’ Decision-Making on Environmentally-Responsible Convention Attendance.” *Journal of Environmental Psychology* 40: 462–471. doi:10.1016/j.jenvp.2014.10.006.
Han, H., J. Yu, B. Koo, and W. Kim. 2019. “Vacationers’ Norm-Based Behavior in Developing Environmentally Sustainable Cruise Tourism.” *Journal of Quality Assurance in Hospitality & Tourism* 20 (1): 89–106.
Han, H. Y., and L. Zhao. 2009. “Farmers’ Character and Behavior of Fertilizer Application: Evidence from a Survey of Xinxiang County, Henan Province, China.” *Agricultural Sciences in China* 8 (10), 1238–1245.
Harland, P., H. Staats, and H. A. Wilke. 2007. “Situational and Personality Factors as Direct or Personal Norm Mediated Predictors of Pro-Environmental Behavior: Questions Derived

from Norm-Activation Theory." *Basic and Applied Social Psychology* 29 (4): 323–334. doi: 10.1080/01973530701665058.
Himmelstein, J., A. Ares, D. Gallagher, and J. Myers. 2017. "A Meta-Analysis of Intercropping in Africa: Impacts on Crop Yield, Farmer Income, and Integrated Pest Management Effects." *International Journal of Agricultural Sustainability* 15 (1): 1–10. doi:10.1080/14735903.2016.1242332.
Holden, S., and R. Lunduka. 2012. "Do Fertilizer Subsidies Crowd out Organic Manures? The Case of Malawi." *Agricultural Economics* 43 (3): 303–314. doi:10.1111/j.1574-0862.2012.00584.x.
Hopkins, J., G. Schnitkey, and L. Tweeten. 1996. "Impacts of Nitrogen Control Policies on Crop and Livestock Farms at Two Ohio Farm Sites." *Review of Agricultural Economics* 18: 311–324.
Huang, J., R. Hu, J. Cao, and S. Rozelle. 2008. "Training Programs and In-the-Field Guidance to Reduce China's Overuse of Fertilizer without Hurting Profitability." *Journal of Soil and Water Conservation* 63 (5): 165A–167A. doi:10.2489/jswc.63.5.165A.
Huang, J., C. Xiang, X. Jia, and R. Hu. 2012. "Impacts of Training on Farmers' Nitrogen Use in Maize Production in Shandong, China." *Journal of Soil and Water Conservation* 67 (4): 321–327. doi:10.2489/jswc.67.4.321.
Intergovernmental Panel on Climate Change (IPCC). 2006. "IPCC Guidelines for National Greenhouse Gas Inventories." In *Agriculture, Forestry and Other Land Use*, edited by S. Eggleston *et al.*, Vol. 4. Hayama, Japan: IGES.
Jalali, M. 2005. "Nitrates Leaching from Agricultural Land in Hamadan, Western Iran." *Agriculture, Ecosystems & Environment* 110 (3–4): 210–218.
Jalali, M. 2011. "Nitrate Pollution of Groundwater in Toyserkan, Western Iran." *Environmental Earth Sciences* 62 (5): 907–913. doi:10.1016/j.agee.2005.04.011.
Jayne, T. S., B. Zulu, and J. J. Nijhoff. 2006. "Stabilizing Food Markets in Eastern and Southern Africa." *Food Policy.* 31 (4): 328–341. doi:10.1016/j.foodpol.2006.03.008.
Ju, X., B. Gu, Y. Wu, and J. N. Galloway. 2016. "Reducing China's Fertilizer Use by Increasing Farm Size." *Global Environmental Change* 41: 26–32. doi:10.1016/j.gloenvcha.2016.08.005.
Kanter, D. R., X. Zhang, and D. L. Mauzerall. 2015. "Reducing Nitrogen Pollution While Decreasing Farmers' Costs and Increasing Fertilizer Industry Profits." *Journal of Environmental Quality* 44 (2): 325–335. doi:10.2134/jeq2014.04.0173.
Kaplan, D. 2000. *Structural Equation Modeling: Foundations and Extensions*. Vol. 10. Newburry Park, CA: Sage.
Kassam, S. N., and B. Dhehibi. 2016. *Mechanization to Drive a Process for Fertilizer Subsidy Reform in Egypt ERF Policy Brief no. 22 December 2016*. Accessed May 19, 2019. www.repo.mel.cgiar.org/handle/20.500.11766/5755.
Lauper, E., S. Moser, M. Fischer, and E. Matthies. 2016. "Explaining Car Drivers' Intention to Prevent Road-Traffic Noise: An Application of the Norm Activation Model." *Environment and Behavior* 48 (6): 826–853. doi:10.1177/0013916515570476.
Lind, H. B., T. Nordfjaern, S. H. Jørgensen, and T. Rundmo. 2015. "The Value-Belief-Norm Theory, Personal Norms and Sustainable Travel Mode Choice in Urban Areas." *Journal of Environmental Psychology* 44: 119–125.
Meehl, P. E., and N. G. Waller. 2002. "The Path Analysis Controversy: A New Statistical Approach to Strong Appraisal of Verisimilitude." *Psychological Methods* 7 (3): 283. doi:10.1037/1082-989x.7.3.283.
Monfared, N., M. Yazdanpanah, and K. Tavakoli. 2015. "Why Do They Continue to Use Pesticides? The Case of Tomato Growers in Boushehr Province in Southern Iran." *Journal of Agricultural Science and Technology* 17 (3): 577–588.
Monjardino, M., T. M. McBeath, L. Brennan, and R. S. Llewellyn. 2013. "Are Farmers in Low-Rainfall Cropping Regions Under-Fertilising with Nitrogen? A Risk Analysis." *Agricultural Systems* 116: 37–51. doi:10.1016/j.agsy.2012.12.007.
Niaura, A. 2013. "Using the Theory of Planned Behavior to Investigate the Determinants of Environmental Behavior among Youth." *Environmental Research, Engineering and Management* 63 (1): 74–78. doi:10.5755/j01.erem.63.1.2901.

Onwezen, M. C., G. Antonides, and J. Bartels. 2013. “The Norm Activation Model: An Exploration of the Functions of Anticipated Pride and Guilt in Pro-Environmental Behaviour.” *Journal of Economic Psychology* 39: 141–153. doi:10.1016/j.joep.2013.07.005.

Pakmehr, S., M. Yazdanpanah, and M. Baradaran. 2020a. “How Collective Efficacy Makes a Difference in Responses to Water Shortage Due to Climate Change in Southwest Iran.” *Land Use Policy* 99: 104798. doi:10.1016/j.landusepol.2020.104798.

Pakmehr, S., M. Yazdanpanah, and M. Baradaran. 2020b. “Explaining Farmers’ Response to Climate Change- Induced Water Stress through Cognitive Theory of Stress: An Iranian Perspective.” *Environment, Development and Sustainability*. doi:10.1007/s10668-020-00846-3.

Park, J., and S. Ha. 2014. “Understanding Consumer Recycling Behavior: Combining the Theory of Planned Behavior and the Norm Activation Model.” *Family and Consumer Sciences Research Journal* 42 (3): 278–291. doi:10.1111/fcsr.12061.

Payandeh Najafabadi, A. T., M. Omidi Najafabadi, and M. R. Farid-Rohani. 2012. “Factors Contributing to Academic Achievement: A Bayesian Structure Equation Modelling Study.” *International Journal of Mathematical Education in Science and Technology* 44 (4): 490–500.

Picazo-Tadeo, A. J., and E. Reig-Martinez. 2007. “Farmers’ Costs of Environmental Regulation: Reducing the Consumption of Nitrogen in Citrus Farming.” *Economic Modelling* 24 (2): 312–328. doi:10.1016/j.econmod.2006.08.002.

Qasemi, M., M. Farhang, H. Biglari, M. Afsharnia, A. Ojrati, F. Khani, M. Samiee, and A. Zarei. 2018. “Health Risk Assessments Due to Nitrate Levels in Drinking Water in Villages of Azadshahr.” *Environmental Earth Sciences* 77 (23): 782. doi:10.1007/s12665-018-7973-6.

Rahimi-Feyzabad, F., M. Yazdanpanah, R. J. Burton, M. Forouzani, and S. Mohammadzadeh. 2020. “The Use of a Bourdieusian ‘Capitals’ Model for Understanding Farmer’s Irrigation Behavior in Iran.” *Journal of Hydrology* 591: 125442. doi:10.1016/j.jhydrol.2020.125442.

Rahmati, O., A. N. Samani, N. Mahmoodi, and M. Mahdavi. 2015. “Assessment of the Contribution of N-Fertilizers to Nitrate Pollution of Groundwater in Western Iran (Case Study: Ghorveh–Dehgelan Aquifer).” *Water Quality, Exposure and Health* 7 (2): 143–151. doi:10.1007/s12403-014-0135-5.

Rezaei, R., M. Seidi, and M. Karbasioun. 2019. “Pesticide Exposure Reduction: Extending the Theory of Planned Behavior to Understand Iranian Farmers’ Intention to Apply Personal Protective Equipment.” *Safety Science* 120: 527–537. doi:10.1016/j.ssci.2019.07.044.

Ribaudo, M., J. Delgado, L. Hansen, M. Livingston, R. Mosheim, and J. Williamson. 2011. *Nitrogen in Agricultural Systems: Implications for Conservation Policy*. Economic Research Report No. (ERR-127), USDA. https://www.ers.usda.gov/publications/pub-details/?pubid=44919

Ricker-Gilbert, J., C. Jumbe, and J. Chamberlin. 2014. “How Does Population Density Influence Agricultural Intensification and Productivity? Evidence from Malawi.” *Food Policy* 48: 114–128. doi:10.1016/j.foodpol.2014.02.006.

Robertson, G. P., and P. M. Vitousek. 2009. “Nitrogen in Agriculture: Balancing the Cost of an Essential Resource.” *Annual Review of Environment and Resources* 34 (1): 97–125. doi:10.1146/annurev.environ.032108.105046.

Schwartz, S. H. 1977. “Normative influences on altruism.” *Advances in experimental social psychology*, 10 (1): 221–279.

Seitz, W. D., and E. R. Swanson. 1980. “Economics of Soil Conservation from the Farmer’s Perspective.” *American Journal of Agricultural Economics* 62 (5): 1084–1088. doi:10.2307/1240320.

Seyranian, V., G. M. Sinatra, and M. S. Polikoff. 2015. “Comparing Communication Strategies for Reducing Residential Water Consumption.” *Journal of Environmental Psychology* 41: 81–90.

Sheriff, G. 2005. “Efficient Waste? Why Farmers Over-Apply Nutrients and the Implications for Policy Design.” *Review of Agricultural Economics* 27 (4): 542–557. doi:10.1111/j.1467-9353.2005.00263.x.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. De Haan. 2006. *Livestock’s Long Shadow: Environmental Issues and Options*. Rome: Food and Agricultural Organization, United Nations.

Stuart, D., R. L. Schewe, and M. McDermott. 2014. “Reducing Nitrogen Fertilizer Application as a Climate Change Mitigation Strategy: Understanding Farmer Decision-Making and Potential Barriers to Change in the US.” *Land Use Policy* 36: 210–218. doi:10.1016/j.landusepol.2013.08.011.

Tajeri Moghadam, M., H. Raheli, S. Zarifian, and M. Yazdanpanah. 2020. “The Power of the Health Belief Model (HBM) to Predict Water Demand Management: A Case Study of Farmers’ Water Conservation in Iran.” *Journal of Environmental Management* 263: 110388. doi:10.1016/j.jenvman.2020.110388.

Tehrani, M. M., M. R. Balali, F. Moshiri, and A. A. Daryashenas. 2010. “Recommendation and Estimate of Fertilizer in Iran: Challenges and Opportunity.” In *Collection of Papers for Oral Presentation at the 1st Iranian Fertilizer Challenges Congress: Half a Century of the Fertilizer Consumption*, 2–25. Tehran, Iran: Sana Publications.

Thøgersen, J. 2006. “Norms for Environmentally Responsible Behaviour: An Extended Taxonomy.” *Journal of Environmental Psychology* 26 (4): 247–261. doi:10.1016/j.jenvp.2006.09.004.

Thomas, C., and V. Sharp. 2013. “Understanding the Normalisation of Recycling Behaviour and Its Implications for Other Pro-Environmental Behaviours: A Review of Social Norms and Recycling.” *Resources, Conservation and Recycling* 79: 11–20.

van der Werff, E., and L. Steg. 2015. “One Model to Predict Them All: Predicting Energy Behaviours with the Norm Activation Model.” *Energy Research & Social Science* 6: 8–14.

van Valkengoed, A. M., and L. Steg. 2019. “Meta-Analyses of Factors Motivating Climate Change Adaptation Behaviour.” *Nature Climate Change* 9 (2): 158–163. doi:10.1038/s41558-018-0371-y.

Vaske, J. J., M. H. Jacobs, and T. K. Espinosa. 2015. “Carbon Footprint Mitigation on Vacation: A Norm Activation Model.” *Journal of Outdoor Recreation and Tourism* 11: 80–86. doi:10.1016/j.jort.2015.05.002.

Weber, C., and L. McCann. 2015. “Adoption of Nitrogen-Efficient Technologies by US Corn Farmers.” *Journal of Environmental Quality* 44 (2): 391–401. doi:10.2134/jeq2014.02.0089.

Williamson, J. M. 2011. “The Role of Information and Prices in the Nitrogen Fertilizer Management Decision: New Evidence from the Agricultural Resource Management Survey.” *Journal of Agricultural and Resource Economics* 36 (3): 552–572.

Wittenberg, I., A. Blöbaum, and E. Matthies. 2018. “Environmental Motivations for Energy Use in PV Households: Proposal of a Modified Norm Activation Model for the Specific Context of PV Households.” *Journal of Environmental Psychology* 55: 110–120. doi:10.1016/j.jenvp.2018.01.002.

Wuepper, D., and T. J. Lybbert. 2017. “Perceived Self-Efficacy, Poverty, and Economic Development.” *Annual Review of Resource Economics* 9 (1): 383–404. doi:10.1146/annurev-resource-100516-053709.

Wuepper, D., D. Zilberman, and J. Sauer. 2020. “Non-Cognitive Skills and Climate Change Adaptation: Empirical Evidence from Ghana’s Pineapple Farmers.” *Climate and Development* 12 (2): 151–162. doi:10.1080/17565529.2019.1607240.

Yazdanpanah, M., and F. R. Feyzabad. 2017. “Investigating Iranian Farmers’ Satisfaction with Agricultural Extension Programs Using the American Customer Satisfaction Index.” *Journal of Agricultural & Food Information* 18 (2): 123–135.

Yazdanpanah, M., N. Komendantova, Z. N. Shirazi, and J. Linnerooth-Bayer. 2015. “Green or in Between? Examining Youth Perceptions of Renewable Energy in Iran.” *Energy Research & Social Science* 8: 78–85.

Zbinden, S., and D. R. Lee. 2005. “Paying for Environmental Services: An Analysis of Participation in Costa Rica’s PSA Program.” *World Development* 33 (2): 255–272. doi:10.1016/j.worlddev.2004.07.012.

Zeweld, W., G. Van Huylenbroeck, G. Tesfay, H. Azadi, and S. Speelman. 2018. “Impacts of Socio-Psychological Factors on Actual Adoption of Sustainable Land Management Practices in Dryland and Water Stressed Areas.” *Sustainability* 10 (9): 2963. doi:10.3390/su10092963.

Zhang, Y., Z. Wang, and G. Zhou. 2013. “Antecedents of Employee Electricity Saving Behavior in Organizations: An Empirical Study Based on Norm Activation Model.” *Energy Policy* 62: 1120–1127.

Zhou, Y., H. Yang, H. J. Mosler, and K. C. Abbaspour. 2010. “Factors Affecting Farmers’ Decisions on Fertilizer Use: A Case Study for the Chaobai Watershed in Northern China.” *Consilience* 4: 80–102.

Zobeidi, T., M. Yazdanpanah, M. Forouzani, and B. Khosravipour. 2016. “Climate Change Discourse among Iranian Farmers.” *Climatic Change* 138 (3–4): 521–535. doi:10.1007/s10584-016-1741-y.