Renewable Agriculture and Food Systems

cambridge.org/raf

Structural equation model of young farmers' intention to adopt sustainable agriculture: a case study in Bangladesh

Apurbo Sarkar[1], Hongyu Wang[1], Airin Rahman[2,3], Jony Abdul Azim[4], Waqar Hussain Memon[5] and Lu Qian[1]

[1]College of Economics and Management, Northwest A&F University, No.3 Taicheng Road, Yangling, Shaanxi 712100, China; [2]School of Finance and Economics, Jiangsu University, Zhenjiang 212013, China; [3]Department of Agribusiness and Marketing, Sher-E-Bangla Agricultural University, Dhaka 1207, Bangladesh; [4]School of International Education, Xidian University, Xian, Shaanxi 710071, China and [5]School of Mechanical Engineering, Nanjing University of Science and Technology, Xiaoling Wei, Nanjing 210014, China

Research Paper

Cite this article: Sarkar A, Wang H, Rahman A, Abdul Azim J, Hussain Memon W, Qian L (2022). Structural equation model of young farmers' intention to adopt sustainable agriculture: a case study in Bangladesh. *Renewable Agriculture and Food Systems* **37**, 142–154. https://doi.org/10.1017/S1742170521000429

Received: 23 February 2021
Revised: 9 August 2021
Accepted: 24 September 2021
First published online: 15 November 2021

Key words:
Behavior; intentions; structural equation modeling; sustainability; sustainable agriculture

Author for correspondence:
Lu Qian, E-mail: luqian@nwafu.edu.cn

Abstract

This paper aims to assess young farmers' willingness to adopt sustainable agriculture (SA) by implementing the expanded theory of planned behavior (TPB) within the northern region of Bangladesh. The outcomes attained specified that attitudes toward SA, perceived behavior control and perceived self-identity have progressive and fundamental impacts on adoption behavior and affect farmers' intentions to adopt SA's particular production mechanism. On the other hand, the social interface view toward SA is not significantly associated with the Bangladeshi farmer's adoption intention. The results also show that interconnections between social and familial pressure are not significant for sustainable farming practice adoption intentions. However, the interconnections among the psychosocial factors have a crucial role in formulating the TPB to forecast the intentional behavior for adopting SA practices. Thus, the government should highlight the advantages of several sustainable agricultural practices and circulate more detailed information regarding SA tactics to improve the knowledge gap of smallholder farmers. Furthermore, training facilities should be extended to improve the attitude and perceived self-identity of young farmers. Moreover, the formulation of structural information sharing platforms and agricultural value chain facilities should also help shape young farmers' interpersonal behavior in adopting SA practices.

Introduction

The ever-increasing population and reduction of cultivable land are frequently posing a serious burden to the maintenance of desirable food security, better working conditions and sound biodiversity for any country's agricultural sector, especially for developing countries (Krupnik *et al.*, 2017; Shew *et al.*, 2019). Most developing countries are trying to mitigate their progressive food and fiber demands by adopting intensifying agricultural production (Ali, 2007; Roy and Chan, 2012). The intensification of agricultural production and massive global food demand have threatened the most crucial factors of production and led to landfill issues, increase in the use of synthetic chemicals in the forms of fertilizers and pesticides, and most importantly, detritions of the environment and global biodiversity (Butchart *et al.*, 2010; Garcia *et al.*, 2014; Asrat and Simane, 2018). Global warming and climate change seriously hinder production, thus creating substantial pressure for agricultural sectors to curb food insecurity and malnutrition (Siegel, 2016; Shah *et al.*, 2019). Agricultural production has undergone a dramatic transformation over time. Particularly, after the Second World War, food and fiber production efficiency increased markedly due to modern innovation and technological advancement (Harwood, 1990). Synthetic fertilizer and pesticide use, as well as production intensifications, has indeed improved significantly. This further poses a significant threat to natural soil fertility, damaging environmental ecology and creating hazardous health conditions (Savci, 2012). Paradoxically, there is a rise in agricultural production and a rise in poverty and hunger. Growing global production processes are disrupted because we are damaging the very basis of agriculture through unsustainable activities. Conventional agriculture might have contributed to the situation, especially with climate change and ecological balance degradation (Warner *et al.*, 2010; Israel *et al.*, 2020). In the meantime, developing countries would suffer immensely from global warming and climate change; in particular, smallholder farmers would suffer greatly. Although Bangladesh is a mostly agro-based economy, most of the farmers in this country are still in a trap of poverty and hunger, which makes them more vulnerable in terms of climate change and global warming (Agrawala *et al.*, 2003; Agwu *et al.*, 2018; Tessema and Simane, 2019). Urgent transformation should be needed to assess the sustainable

environment, as current research indicates that climate change, especially global temperature, is dramatically rising, leading to unpredictable weather and exacerbating the circumstances that contribute to soil degradation, water contamination, threats of floods and famine. The main priority of sustainable food production is to meet people's present, fundamental food and fiber requirements, thus not narrowing the opportunity of future populations to meet their particular requirements (Adnan *et al*., 2017; Amare and Simane, 2018; Ruttan, 2019; Heylen *et al*., 2020). Sustainable agriculture (SA) practitioners incorporate the following three key goals into their research: climate safety, social supportability and economic sustainability (Koohafkan *et al*., 2012; Reytar *et al*., 2014; Whitehead *et al*., 2020).

Rapid urbanization, natural disasters, inadequate soil management and coercive farming methods are all threatening agricultural output in Bangladesh, the world's most heavily populated nation (Rahman and Mikuni, 1999). Seemingly, the Bangladeshi agricultural sector still lags in improved technological interactions, maintaining effective usage of land and water resources (Islam and Shirazul, 2009; Raihan *et al*., 2020). It is also experiencing decreasing productivity due to inappropriate agrochemical utilization, threatening its traditional agricultural systems (Faroque *et al*., 2011). Furthermore, the high percentage of illiteracy among farmers (approximately 80%) and weak awareness level worsen the situation (Rasul and Thapa, 2004). As a result of this vicious loop, farmers with large households typically ignore the possible advantages of agricultural expansion under sustainability themes (Rasul and Thapa, 2003). Finally, the government of Bangladesh is working to foster SA, with a focus on ensuring effective usage of on-farm resources and reducing reliance on off-farm inputs (Sultana *et al*., 2020). Interestingly, farmers' interpersonal behavior regarding sustainable agricultural practices in Bangladesh is still not fully understood by previous studies.

In the study's scope, we utilized the generalized theory of planned behavior (TPB) to analyze behavioral factors' influence on farmers' intentions to adopt SA. TPB is among the most common frameworks for forecasting and interpreting behavioral intentions (Feng *et al*., 2010; Borges *et al*., 2015; Borges and Lansink, 2016; Senger *et al*., 2017; Rezaei *et al*., 2018; Mohammadinezhad and Ahmadvand, 2020). TPB implies that the action of a person is dictated by his or her insistence to indulge in a particular outcome (Rhodes and Courneya, 2003; Rezaei *et al*., 2019), which includes motivations comprising behavioral perceptions, social expectations and assumed cultural influence (Chen, 2016). Similar studies concluded that although the main aim of TPB is to provide self-identification to perform any specific behavior, it could be suitable for predicting psychological motivations to perform or not to perform that behavior (Smith *et al*., 2007). In addition, recent empirical studies tend to demonstrate that behavioral motivation is not a feature of a discrete collection of behavioral factors but comprises a dynamic interdependency system (Adnan *et al*., 2019, 2020). Thus, the study extends the psychological motivation framework by evaluating the interrelationship among the associated factors to explore the complexity of the paradigm that has not been formally studied. SA is not a new idea, but this innovative farming mechanism has not been explored sufficiently within the behavioral dimensions of farmers. Particularly, farmers' opinions on adopting SA have not previously been explored within the context of a developing country. The important innovation in our study is to explore the adoption tendencies of SA among Bangladeshi farmers. Moreover, to quantify a structural representation of the evaluations, we employed the TPB, which is also relatively rare within these dimensions. To the best of our knowledge, this study will be one of the first attempts to explore the interpersonal behavioral component of young farmers within the Bangladeshi agriculture sector.

The rest of the paper is portrayed as follows: in the next section, we introduced and explored all the literature to develop the associated hypothesis. Section 'Materials and methods' presents the materials and methods, and section 'Results and discussions' portrays the results and discussion. Section 'Conclusion' denotes the conclusions of the study.

Literature review and hypothesis developments

As stated earlier, ever-increasing environmental pollution and global warming have had enormous negative impacts on agricultural productivity (Ruane *et al*., 2013), especially concerning irrigational water deficiency as a significant decisive factor for agricultural production (Misra, 2014). A sufficient set of literature could be traced that explored sustainable agricultural practices within various directions. Many of those studies are comprised of SA with a large variety of ecological, natural, socio-economic and socio-emotional advantages, involving enhancing productivity, enhanced economic freedom, nutritious eating, better health and balanced agricultural practices, the fewer burden of labor, relatively demanding and mentally pleasurable daily tasks, and healthier family ties (Hobbs *et al*., 2008; Scherr and McNeely, 2008; Hayati *et al*., 2010). For instance, Garnett *et al*. (2013) and Tilman *et al*. (2011) evaluated the themes of SA to mitigate the adverse effects of intensifications in agricultural production, and Rockstrom *et al*. (2017) utilized the concepts of SA. To quantify societal and global development, Busby *et al*. (2017) portrayed the effects of SA practices toward plant microbiomes and conservation and agricultural sustainability. Seemingly, SA adoption could be analyzed in terms of two major approaches. The first creative aspect emphasizes the generation, extension, transformation and exchange of SA information as a complete framework (Hassanein and Kloppenburg Jr, 1995, p. 1; Berg *et al*., 2013; Dwyer, 2013). The second aspect of SA is the interactive phase concerned with the following two questions: 'What leads farmers to adopt sustainable agriculture?' and 'Why adopt this sustainable form of agriculture?' The theoretical design of perceived value for prime agricultural users (farmers) (Bagheri, 2010; Bernués *et al*., 2016) and behavioral dimensions (Bopp *et al*., 2019; Adnan *et al*., 2020) has also been traced within the past few decades (for more details, see Zeweld *et al*. (2017), Menozzi *et al*. (2014), Karami and Mansoorabadi (2008) and Savari and Gharechaee (2020)).

However, as the prime objectives of the study are to evaluate young farmers' motives or intentions to adopt SA practices, we employed the TPB and the expansion of social identity theory (SIT) to quantify the motives or intentions suggested by Savari and Gharechaee (2020) and Tan (2013). The TPB and SIT have been found to offer an excellent foundation and evaluate the willingness to adopt new approaches by using several distinct determinants (Fekadu and Kraft, 2002; Fielding *et al*., 2008). In predicting SA adoption preferences, it is necessary to evaluate farmers' perceptions about SA practices. The essential elements of TPB are attitude, subjective norms and perceived behavioral control (PBC), which shape an individual's behavioral intentions (Ajzen, 1991, 2005). When people assume that a particular action's conduct can create a favorable result, they can establish

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

a favorable outlook about actions (Ajzen and Fishbein, 1980). Throughout the SA framework, perceptions regarding environmentally friendly farming strategies affect adoption intentions (Fairweather and Campbell, 2003; Tilahun *et al.*, 2017). Intentions are moral decisions of how people would act in the long term, which provides a bridge through a person's attitude, perceptions, references and collective actions (Daxini *et al.*, 2018; Buyinza *et al.*, 2020), which can address any person's behavior profoundly (Daxini *et al.*, 2019; Grzelak *et al.*, 2019; Adnan *et al.*, 2020; Buyinza *et al.*, 2020). An attitude comprises several emotional reactions, ideologies and comportments toward any specific person, circumstance, mechanism, framework or action. Attitudes seem to comprise profound accumulations of knowledge, experience, expectations and obligations, which can shape strong impacts for measuring any set of behavioral actions (Palacios, 2005; Wauters *et al.*, 2010). Especially toward any new mechanism or situation, attitude provides specific information crucial to formulating a measurement framework (Orduño Torres *et al.*, 2020). Former research within the context of similar approaches indicated that the potential attitude toward any particular mechanism works as a predictive indicator for predicting any prospective actions (Daxini *et al.*, 2018; Rezaei *et al.*, 2019; Buyinza *et al.*, 2020). Positive attitudes concerning SA may possess a significant impact on social references. Based on this discussion, we propose hypothesis 1 as follows:

H1: Attitudes regarding sustainable agriculture (ATS) positively impact behavioral intentions to adopt sustainable agriculture practices (AI).

Social referencing enriches and controls any individual's interconnectivity with the social setting that can shape any specific behavior by predicting how social partners will appraise that behavior (Bandura, 1992; Walle *et al.*, 2017). Previous research traced the degree to which a farmer believes that reference groups and information channels impact a farmer's behavior in adopting any novel tactics (Roling and Wagemakers, 2000; Lee, 2005; Zeweld *et al.*, 2017). Social pressure is another form of social referencing that usually forces farmers to adopt particular strategies set by the government to safeguard societal benefits (Maertens and Barrett, 2013; Adenle *et al.*, 2019; Nguyen and Drakou, 2021). Simultaneously, a person is far more willing to behave in compliance with specified perceptions if these perceptions are compatible with everyone else's views in society (Zeweld *et al.*, 2020). Moreover, farmers' comprehensive, positive and command perceptions of SA practices may lead them to refer practices to other farmers (Adnan *et al.*, 2019; Zhang *et al.*, 2019; Li *et al.*, 2020). Therefore, we propose hypothesis 2.

H2: Social references (SR) positively impact behavioral intentions to adopt sustainable agriculture practices (AI).

PBC denotes any individual's ability to accomplish a specific behavior (Ajzen and Madden, 1986; Barlett, 2019; Eanes and Zhou, 2020). Ajzen (1991) defines PBC as the personal attributes and attitude regarding any specific situation, which can trigger the personal decision-making process. For example, it is apparent that if farmers possess favorable confidence regarding SA, there will be enough possibilities to adopt sustainable practices within their core farming methods (Adnan *et al.*, 2017; Waseem *et al.*, 2020). Therefore, PBC has profound moderating roles in shaping a person's decisions and mostly quantifies the particular attitude regarding the circumstances (Martinez and Lewis, 2016). Therefore, we propose hypothesis three.

H3: Perceived behavioral control (PBC) positively impacts the behavioral intentions to adopt sustainable agriculture practices (AI).

Self-identity is a generous approach to a person's persuasive behavior that can trigger and be triggered by the attitude of an individual possessed (Sparks and Shepherd, 1992; Sparks, 2000; Li *et al.*, 2020). Possible opportunities to flourish farmers' self-identity and influence created by other farmers' self-identities greatly impact changing their attitudes toward new situations (Cullen *et al.*, 2020). In contrast, those impacts have been traced mostly within visionary farmers (Sulemana and James, 2014). Moreover, past studies have demonstrated that the psychological impact of family and community can affect how important it is to undertake actions of significance (Kauppinen *et al.*, 2012; Van Thanh and Yapwattanaphun, 2015). Therefore, it is logical to assume that persons' trust throughout the decision to adopt SA practice might be affected by the views of friends, family members and society itself. It may also be concluded that farmers who have a positive perspective about SA intend to adopt sustainable farming practices (Ansari and Tabassum, 2018; Cullen *et al.*, 2020; Silva *et al.*, 2020). In addition, farmers' moral concern for the environment can be attributed to a presumed societal obligation to fulfil their actions. For example, when others share clear viewpoints that SA is socially acceptable and economically advantageous to the community, it is likely fair to assume those socially beneficial actions that quantify the farmer's self-obligations to participate in SA (Adnan *et al.*, 2017). Farmers may promote environmentally friendly behavior if they have enough information and resources to do so. In other words, the more opportunities and resources farmers have, the higher their expression of self-identity and behavioral control will be with respect to SA (Sadati *et al.*, 2010). In the simulation of such interactions, we propose hypothesis four.

H4: Perceived self-identity (PSI) positively impacts behavioral intentions to adopt sustainable agriculture practices (AI).

Individuals can influence the way they perceive and respond to the situation that has been known to them as socially appraisable (Bretherton, 1992), which creates a positive attitude toward performing the actions. Therefore, it is expected that if SA will be socially acceptable and if the peer farmer also appraises SA practices, the farmers will possess a positive attitude and *vice versa* (Sherif *et al.*, 1965; Saliba *et al.*, 2018; Ramborun *et al.*, 2020). Similarly, it could be expected that there might be some connections between attitude reformation and PBC for measuring any person's decisions. For example, if a farmer possessed a positive attitude toward any particular action, they were likely to construct a positive esteem of self-identity. Seemingly, they feel high self-esteem when they think they are good enough to perform those actions and *vice versa* (Stangor, 2014*a*, *b*). Therefore, it is fair to expect that behavioral components such as attitude or perceptions, social referents influence, PBC and perceived self-identity may positively impact farmers' adoption behavior toward SA and be interconnected. In the context of the above discussion, we evaluated the following additional hypotheses:

H5: Factors regarding the influences of attitudes (ATS) and social reference influence (SR) are positively interconnected to quantify behavioral intentions to adopt sustainable agriculture practices (AI).

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

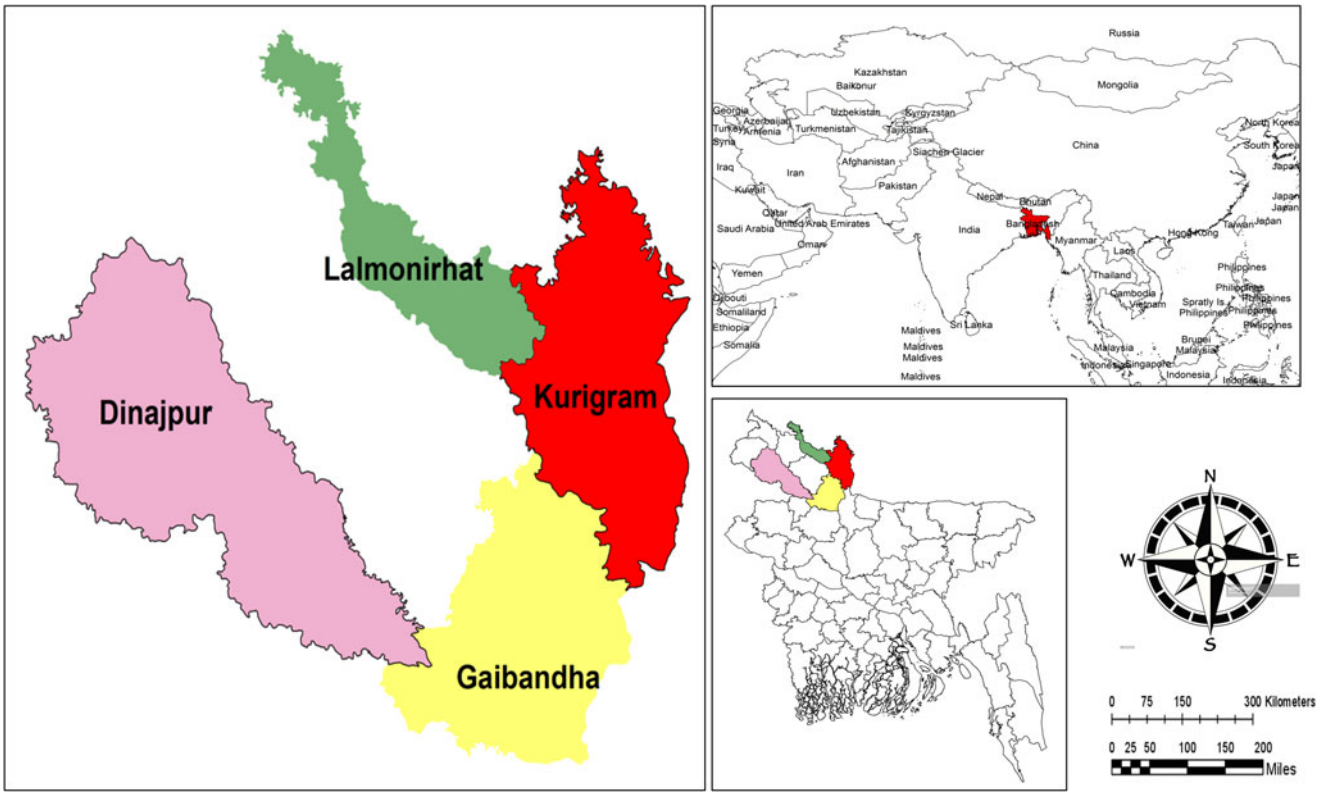

Fig. 1 Study area.

H6: Factors regarding the influences of attitudes (ATS) and perceived behavioral control (PBC) are positively interconnected to quantify the behavioral intentions to adopt sustainable agriculture practices (AI).
H7: Factors regarding the influences of attitudes (ATS) and perceived self-identity (PSI) are positively interconnected to quantify behavioral intentions to adopt sustainable agriculture practices (AI).
H8: Factors regarding the influences of social referencing (SR) and perceived behavioral control (PBC) are positively interconnected to quantify the behavioral intentions to adopt sustainable agriculture practices (AI).
H9: Factors regarding the influences of social referencing (SR) and self-identity (PSI) are positively interconnected to quantify the behavioral intentions to adopt sustainable agriculture practices (AI).
H10: Factors regarding the influences of perceived behavioral control (PBC) and self-identity (PSI) are positively interconnected to quantify the behavioral intentions to adopt sustainable agriculture practices (AI).

Materials and methods

Study area, respondents and survey instruments

The study's prime objectives are to measure the young farmer's intention to adopt SA practices within a developing nation's framework and measure the interconnection among the behavioral principles. We collected empirical pieces of information to evaluate the behavioral principles regarding adopting SA approaches. Within the context of the study, we randomly choose 400 farmers listed under the Teesta Barrage Irrigation Project (TBIP) located in four districts of the lower Teesta River Basin of Bangladesh, namely, Gainbandha, Lalmonirhat, Nilphamari and Kurigram (see Fig. 1 for a visual map of the study area). TBIP is one of the most significant irrigation projects in Southeast Asia and the largest irrigation marvel of Bangladesh. It is considered one of the most exceptional initiatives to foster sustainability in the Bangladeshi agriculture sector (Sarker *et al.*, 2011; Mukherjee and Saha, 2016). So the study area is most appropriate for the study. The survey instrument was developed according to Planned Behavior's theory proposed by Fishbein and Ajzen (1975). A well-structured questionnaire with a five-point Likert scale evaluation criterion was employed to collect empirical data that can foster the evaluation process. In this study, we define a young farmer as a person who engaged in farming activities ranging from 21 to 30 years. Measuring young farmers' engagements is aligned with the existing literature (Balezentis *et al.*, 2020; Munim and Noor, 2020). Therefore, the selected respondent's age range in the article could be recognized as young farmers. As the survey was conducted in Bangla, we modified some technical terms to keep the assumption to the point.

Moreover, we simplified some technical terms and several practices for a better understanding of the respondents. All the respondents were well informed about several basic sustainable agricultural practices before the responses were taken (e.g., crop rotation, permaculture, cover crops, soil enrichment, natural pest management, biointensive integrated pest management and better water management). Please check the supplementary material for more details. We evaluate only the farmers who possessed at least the basic idea about SA. We also conducted a pilot test to ensure the best fit of the survey methods, as suggested by Sezen and Çankaya (2013). After receiving feedback from the pilot test (with 30 farmers), we made the necessary adjustment and finalized the instrument. After a preliminary evaluation of the filled questionnaire, a complete set of 157 fully useable (with complete information and fit to our research objectives) feedback was found and used for further analysis. As a

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

Table 1. Variables used in the study

Items	Constructs	Cronbach's α	Reference
4	Intention to adopt sustainable agriculture (AI)	0.926	(Ajzen, 1985; Orbell *et al*., 1997; Montano and Kasprzyk, 2015; Terano *et al*., 2015; Rezaei *et al*., 2018; Buyinza *et al*., 2020)
3	Attitudes toward sustainable agriculture (ATS)	0.943	(Hrubes *et al*., 2001; De Groot and Steg, 2007; Armitage and Christian, 2017; Cristea *et al*., 2019; Ramborun *et al*., 2020)
3	Perceived behavior control (PBC)	0.832	(Terry and O'Leary, 1995; Trafimow *et al*., 2002; Sadati *et al*., 2010; Feola *et al*., 2015; Menozzi *et al*., 2015)
3	Social pressure from family and friends/ social references (SR)	0.923	(Stinner *et al*., 1989; Röling and Jiggins, 1994; Bowler, 2002)
3	Perceived self-identify (PSI)	0.913	(Madden *et al*., 1992; Fishbein *et al*., 2007; Dentoni and Peterson, 2011; Fishbein and Ajzen, 2011; Ansari and Tabassum, 2018)

multidimensional approach, SEM does not require strict sample size and data normalization criteria (Wong, 2013; Sarkar *et al*., 2020). Likewise, there is no universal criterion to predict a sufficient sample size for SEM. Thus, maintaining an appropriate sample size is a challenging task for the investigation. Hence, 100 responses could be the base point for running the path estimation.

Interestingly, Marcoulides and Saunders (2006) proposed observing the maximum number of arrows pointing toward the proposed model's latent variable to maintain a minimum sample size for satisfactory SEM estimation. They recommended that if two arrows pointed toward the latent variables, the lowest sample size should be 52. If it is 5, then the sample should be 70, and if the arrow count is 10, then the lowest number of the sample should be comprised of at least 91 respondents. Therefore, the final dataset of 157 young farmers passed by the above-discussed parameters of minimum sample size.

Analytical framework

We utilized various empirical approaches for evaluating farmers' intentional behavioral principles to adopt SA practices to feed the study's prime objectives. This study used AMOS tools to determine the assumption's consistency and efficiency, which also portrayed the model's structural representation and SEM estimation. SEM is a multidimensional approach for testing and evaluating multivariate structural linkages between theory and data that has driven modeling (Kelloway, 1995; Moreira *et al*., 2016). SEM differs from other modeling approaches, as they test the direct and indirect effects on pre-assumed causal relationships (Fan *et al*., 2016; Thirupathi and Vinodh, 2016; Sarkar *et al*., 2020). SEM is a combined analytical approach of confirmatory factor analysis (CFA) and path mapping. CFA (based on psychometrics) intends to evaluate latent psychological factors that cannot be assessed by single variables such as attitude and satisfaction.

In contrast, path mapping (based on biometrics) is derived from the prospects of evaluating the causal interrelationship among the associated indicators by generating a path illustration. On the other hand, critics often indicate pitfalls in statistical design, a weak ability to check the external validity of some limited models, and difficulty mastering within the aspects of SEM (Tarka, 2018). We implement CFA to assure the validity of the selected model and allocate the factor loading of the model by evaluating the reliability and validity of the elements involved. The study validated the proposed model and evaluated all the associated hypotheses (H1–H10) by structural equation modeling (SEM) tactics powered by AMOS. The study chose AMOS-based SEM, as it is more compatible with small observations, a shortage of available theory, and greater statistical compatibility than most other SEM tactics, for example, covariant base (CB-SEM), partial least squares based (PLS-SEM), EQS and LISREL (Byrne, 2001; Thakkar, 2020). We have adopted the maximum likelihood estimation tactics and covariance matrix as empirical inputs. To assess whether the model is fit or not, a set of fit models is constructed, such as the normed fit index (NFI), goodness of fit (GFI), root mean square error (RMSEA) and comparative fit index (CFI), as suggested by Tan (2013).

Variables selections

Table 1 denotes the excerpt questionnaire items we employed for the study. Table 1 also includes the context, range and associated sources of psychological variables in this analysis.

Results and discussion

Confirmatory factor analysis

We carried out a preliminary assessment using CFA to provide a comprehensive, precise and accurate representation of the selected framework. Moreover, two profound testing criteria of construct reliability (CR) and convergent validity (VE) should be implemented to ensure the reliability and validity of the proposed framework, as acclaimed by Fornell and Larcker (1981). Table 2 shows that the CR and VE values of every construct were >0.5, which confirmed that the chosen latent variables are reliable and valid, as recommended by Wong (2013) and Bagozzi and Yi (1988). However, the interpretation of discriminant validity has been completed by using VE outcomes to evaluate the convergent validity. In addition, the average variance extracted (AVE) of all essential constraints was carefully calculated.

Furthermore, AVE measures of all the indicators are higher than the minimum accepted value of 0.5, which secures the convergent validity suggested by Bagozzi and Yi (1988), Munim and Noor (2020) and Sarkar *et al*. (2020). After that, the discriminant validity of the model should be evaluated (Byrne, 2001). To do so, the square root of AVE measures should be utilized to confirm the discriminant validity, and it should be less than the AVE value, as referred to by Fornell and Larcker (1981). In terms of our current study, the square of all the correlational values was less than the AVE value. The conceptual structures thus had distinguishing

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

Table 2. Findings of confirmatory factor analysis

Construct		L	VE	CR
Attitudes toward sustainable agriculture (ATS)			0.8574	0.926
ATS_1	Sustainable agriculture is valuable because these practices are more environmentally friendly.	0.831		
ATS_2	Sustainable agriculture is desirable as these tactics could be useful to manage the adverse effects of environmental degradation.	0.847		
ATS_3	Sustainable agriculture somehow helps in enhancing a healthy lifestyle.	0.873		
ATS_4	The component of sustainable agriculture is very useful	0.897		
ATS_5	Sustainable agriculture is economically viable.	0.839		
Possible societal influences from friends, peers, family and others (SR)			0.854	0.924
SR_1	As SA practices exercise a healthy lifestyle, my family member encourages me to adopt sustainable agriculture practices.	0.799		
SR_2	I follow my friend's suggestions that I might have to adopt sustainable agriculture for not only safer work conditions but also the betterment of the environment and society.	0.901		
SR_3	I usually get a recommendation from my peer for adopting sustainable agriculture.	0.861		
Perceived behavior control (PBC)			0.810	0.901
PBC_1	I have better access to resources, financial assesses and training facilities, which triggers my ability to adopt sustainable agriculture practices.	0.768		
PBC_2	The adopting process is easy.	0.759		
PBC_3	I am confident about my abilities to adopt sustainable agriculture practices.	0.901		
Perceived self-identity (PSI)			0.843	0.918
PSI_1	I believe that I will adopt sustainable tactics as I possessed high morals that the SA practices trigger environmentally safe, better societal transitional, and human well begin.	0.819		
PSI_2	I want to identify myself as an environmentally friendly farmer and want to spread the betterment of SA for the sake of myself, my family and, moreover, for society.	0.890		
PSI_3	I believe that I am someone who wants to quantify healthier ecosystems.	0.819		
Adoption intention (AI)			0.840	0.916
AI_3	I am currently initiating the plan to adopt sustainable agricultural practices.	0.798		
AI_2	I am very resourceful and probably willing to see how I can follow sustainable agricultural methods.	0.861		
AI_4	I will make a plan in the future to adopt SA practices.	0.860		

L, factor loadings; VE, convergent validity; CR, construct reliability.

value, demonstrating that the frameworks seemed to be dynamic and interconnected. The endogenous correlations of the respective hypothesized frameworks have been evidently merged in their corresponding influences. The metrics are thus validated to demonstrate the strongest variable weights on a particular framework. Factors were then excluded from additional analyses if a particular element was largely or single factor leadenness occurred.

Structural model

In terms of adequate interpretation of the structural equation model, there is a lack of a well-established framework that can quantify standardization, and the comparing standards are also very diverse. Various researchers have used various tactics for various research dimensions, as SEM is a relatively complex and dynamic methodology. Prior research usually postulates a series of alternate models to explore the relationships among the experimental factors based on objectives, hypotheses and the collected dataset. According to Götz *et al.* (2010) and Barrett (2007), model selection, as well as assessment, should be centered on a selective synthesis of practical and theoretical concerns, numerical simulation, fitness value, partial fit index, representativeness test, and finally, the results should be compared with similar models (Table 3).

As per construct validity, the research framework of the study suitably matched the fit index. The model comprises a GFI of 0.921, which secures values higher than the acceptable value of 0.9, and the standardized root means that the square error value accounted for 0.052, which was significantly lower than the standard value of 0.08. The CFI evaluates the fitness of the framework with the help of measuring the difference between surveyed data and the conceptual framework, while the adjustments of the concerns for the integral of sampling size within the mechanism of χ^2 evaluation for securing the credibility of the framework (Gatignon, 2010) as well as by the evaluation of NFI (Bentler, 1990). The CFA is standard between 0 and 1, whereas the large values denote with more accuracy, and thus 0.95 or higher standard considered as most preferable suggested by Hu and Bentler (1999). The investigated framework produced NFI = 0.952, IFI = 0.981 and CFI = 0.981, which denote sufficient accuracy of the framework.

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

Table 3. Descriptive statistics of key variables

Constructs	Variables	Mean	Standard deviation
ATS	ATS_1		
	ATS_2		
	ATS_3		
	ATS_4		
	ATS_5		
SR	SR_1		
	SR_2		
	SR_3		
PBC	PBC_1		
	PBC_2		
	PBC_3		
PSI	PSI_1		
	PSI_2		
	PSI_3		
AI	AI_3		
	AI_2		
	AI_4		

The SEM model embraces a relatively concentrated and complex criterion, whereas the assessment mostly depends on the underlined theoretical views. Moreover, the sample size can greatly quantify the model setup. This creates some shortcomings regarding model viability, resulting in a paradoxical indication (La Du and Tanaka, 1989; Marsh *et al.*, 2005). To provide a better solution, Mulaik *et al.* (1989) provided well-structured evolutionary criteria popularly known as parsimony of fit indexes, the Parsimony Goodness-of-Fit Index (PGFI), and the Parsimonious Normed Fit Index (PNFI). The PNFI is a widely adopted tactic for assessing latent and existing variables (Sivo *et al.*, 2006). Parsimony is quantified throughout the design under which the evaluation criterion is set as per the combination of principles of independence, levels of freedoms and regression equations (Table 4). The value of PNFI is zero to one, whereas the higher the value is, the better the parsimonious capacity to derive the fit index (Hooper *et al.*, 2007). Within the study context, the study's output showed a PNFI value of 0.839, which portrayed a well-established correlational matrix and provided adequate measurement capacity among the exogenous and endogenous factors. We fail to reject H1 since attitudes concerning SA significantly positively impact interpersonal preferences (standardized coefficient = 0.251, $t = 3.309$), indicating that farmers with a more favorable attitude toward SA are more likely to pursue SA in the future. The more favorable the attitude about the benefit of SA farmers holds, the greater they tend to adopt SA practices, which denotes parallel findings of Bultena and Hoiberg (1992) and Tatlıdil *et al.* (2009). One of the surveyed farmers stated that 'Actually the attitude regarding sustainable agriculture in our regions is relatively new, while we the framers usually consider any novel tactics it fosters us economically'. His fellow farmer added that 'I usually like the approaches of better tillage management, cover crops, improved soil management and integrated pest management as those approaches may improve productivity'. According to one of the agricultural extension officers of the surveyed regions, the advantages that mostly trigger farmers to shape favorable practices largely depend on ecological, natural, socio-economic and socio-emotional advantages, including enhanced productivity, enhanced economic freedom, nutritious eating, better health and balanced agricultural practices, a lower burden of labor, relatively demanding and mentally pleasurable daily tasks and healthier family ties.

Hypothesis testing indicated that social referent does not influence the adoption behavior of SA practices (standardized coefficient = 0.079, $t = 0.954$). As a result, we reject hypothesis two (H2). Interestingly, in a study of Iowa farmers and agriculture professionals, Carolan (2006) also found the weakness of social referencing. However, Mishra *et al.* (2018), Kabii and Horwitz (2006), and Baumgart-Getz *et al.* (2012) found that social referencing could be influential in shaping adopting behavior. This could have happened because those studies represent farmers from technologically advanced countries. One of the farmers highlighted the lack of information-sharing platforms and access to agricultural values chain activities to utilize SA practices' potentialities effectively.

In line with the findings of Fairweather and Campbell (2003), Cristea *et al.* (2019), Heylen *et al.* (2020), Bernués *et al.* (2016), and Borges *et al.* (2015), the study also finds that PBC leads to willingness and regulates actions to shape behavior (standardized coefficient = 0.192, $t = 2.299$), which indicates that we fail to reject hypothesis three (H3). For Bangladeshi farmers, the shortage of resource supply and initial capital expenditure created huge barriers toward facilitating SA. In other words, the more wealth and incentives that farmers possess, the much more positive behaviors they will quantify, which is supported by the research of Floress *et al.* (2018). One farmer indicates that 'till now, there are no incentives or subsidies facilities has not taken by the government'. Moreover, 'easy access to the financial and risk-sharing network will be more helpful for us to adopt SA practices', his fellow farmer added. The research has indicated greater ambitions for the farmer who considered himself more ecologically responsible than the individual who has not aligned himself with such resources (standardized coefficient = 0.283, $t = 3.778$). The analysis showed that certain environmental impacts could shape farmers' behavior and ambitions to adopt SA practices. Recent studies have also found similar findings that farmers largely intended to adopt SA practices, as they are well concerned about environmental safety (Bopp *et al.*, 2019), and they are also found to exercise environmentally friendly farming practices regarding seedlings, land preparation, pesticide usage for harvesting and waste disposal (Daxini *et al.*, 2019). Table 4 denotes that we fail to reject hypotheses five (H5) to ten (H10) as per the analysis, as a positive interconnection was traced among the associated psychosocial factors. This outcome supported the previous results that a reciprocal association occurs between psychosocial factors (Brigance *et al.*, 2018; Caffaro *et al.*, 2019; Zeweld *et al.*, 2019; Foguesatto *et al.*, 2020). In terms of adopting SA, perceptions or attitudes toward SA practices have been closely interlinked to shape other farmers' views and the desire to engage in SA (PBC) to provide strong influence and potential options for recognition (perceived self-identity) with correlation coefficients of 0.529, 0.214 and 0.308, respectively.

Simultaneously, social referencing impacts toward SA have a stronger correlational impression to shape belief, expectation and controlling power (PBC). It also possessed a strong and positive interconnection toward shaping farmers' self-identity, with

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

Table 4. Regression weights

Path	Unstandardized estimate	SE	Critical ratio	*P* value	Standardized estimate
ATS->AI	0.261	0.068	3.309	0.000***	0.251
SR->AI	0.079	0.079	0.954	0.423	0.079
PBC->AI	0.193	0.081	2.299	0.018***	0.192
PSI->AI	0.318	0.091	3.778	0.000***	0.283

***$P < 0.05$.

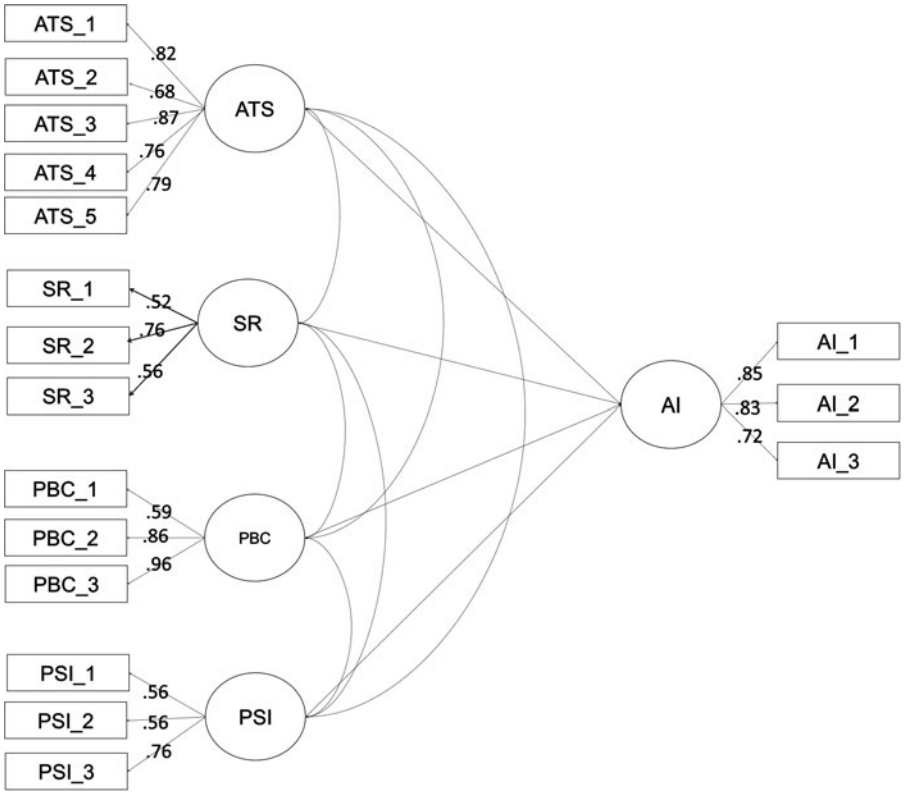

Fig. 2 Path diagram.

correlation coefficient values of 0.451 and 0.409. In particular, as per the correlation coefficient values of 0.379, it has been shown that there is a relatively positive association between high control of perceived behavior on SA and the opportunities to build self-identity as ecological perceptions. According to the graphical illustration portrayed within Figure 2, the interconnections among the psychosocial factors have been crucial for better understanding the prediction powered by the TPB. An increasing rate of approximately 33% has been traced within the accumulated variances of adopting the behavior (Table 5).

Conclusions

The principle of SA comprises a crucial alteration in young farmers' behavioral components. SA seeks to minimize the total effect on the economy, human health and the ecosystem by utilizing renewable resources and preventing environmental damage. As stated in the results section, attitudes toward SA significantly quantify adoption intentions. Perception is usually derived from mind storming tendencies, whereas decisions have usually been made as per the like or dislike of any particular thing. The more optimistic or auspicious farmers are regarding SA, the more likely they are to adopt SA practices. The findings also reflected that favorable resources, tactical knowledge and training facilities also led farmers to adopt SA practices. However, Bangladesh is still facing hurdles for facilitating SA practices because the farmer's literacy rate is low, and they possessed limited knowledge regarding SA. The governmental authority could initiate long-term training facilities, promote innovative technologies and provide support via subsidies to increase the approachability of SA within agricultural sectors. Easy financing and risk-sharing opportunities could be introduced to improve young farmers' self-identity and PBC. In addition, agricultural extension services could act more responsibly and sensibly to support technical know-how and other guidance to enrich farmers' knowledge, which eventually improves the attitude level of young farmers. In measuring SA's adoption criterion, perceived self-identity has also emerged as the crucial factor.

Moreover, there is small involvement of social referents traced to the formulation of the decisional framework to availing these dynamic criteria of modern farming systems. Governments need to emphasize and promote the dimensions of a farmer's self-

https://doi.org/10.1017/S1742170521000429 Published online by Cambridge University Press

Table 5. Correlation results

Relationship	Correlation's value	*P* value
ATS<->SR	0.529	0.000***
ATS<->PBC	0.214	0.005***
ATS<->PSI	0.308	0.000***
SR<->PBC	0.451	0.000***
SR<->PSI	0.409	0.000***
PBC<->PSI	0.356	0.000***

***$P < 0.05$.

identity. Such activities help farmers create their self-identity and usually assist in shaping positive perceptions toward SA. Agricultural departments and extension services need to work closely with farmers and increase awareness-building campaigns to promote SA practices within rural farmers, as most of the rural farmers in Bangladesh are relatively uneducated and mostly not aware of the goodness of SA. Agriculture extension departments need to increase and expand demonstration facilities to transmit the social, economic and environmental benefits of sustainable agricultural practices. Legislators and policymakers should impose strict rules and a certain level of environmentally friendly farming practices, which eventually increase the adoption rate. These tactics are crucial for most developing countries, such as Bangladesh.

Moreover, the farmer needs to be more aware of the new technology of farming and environmentalism. In the context of our study, we found that a social referencing factor does not have significant impacts on triggering the adoption behavior of framers regarding SA. However, it has a positive and viable relationship related to resource obtainability opportunities and self-identity formation. This could be because most of the farmers within the surveyed area lack knowledge regarding sustainability and do not possess sufficient expertise. Therefore, the government should increase training facilities and promote new environmentally friendly technologies to minimize the gap between the theory and practices of SA.

The study comprised its findings by evaluating a relatively small sample size from the prospects of a developing country's agricultural sector. Therefore, there is a chance of bias in the responses. If the data can be traced from a wide region covered with different geographic circumstances, it will be more interesting. However, the study used the notion of SA with broad aspects. It will be more influential if the adoption intention of some specific sustainable practices could have been examined. Future studies could use several distinctive SA practices in the form of a model and test the affectivity of those practices (check supplementary material for more details regarding several sustainable practices). Moreover, the study largely depended on statistical software; it would be more useful to give SEM in the form of equations to portray the findings more concisely.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1742170521000429.

Data. Data and material are available upon request.

Acknowledgements. We cordially thank Professor Su Zhong Feng, Professor, Management School, Xian Jiaotong University, for assistance with the SEM technique guidelines, and Dr. Saleh Shahriar for his comments that significantly help us to improve the manuscript. We would also like to show our gratitude to the Experts group for sharing their pearls of wisdom within the questionnaire parts, which was a great help during this research, and we thank two 'anonymous' reviewers for their so-called insights.

Conflict of interest. There are no conflicts of interest/competing interests associated with the study.

Code availability. Not applicable to the study.

Authors' statement. All the authors read and approve the submission into the current form. All authors declare there is no conflict of interest associated with this article.

References

Adenle AA, Wedig K and Azadi H (2019) Sustainable agriculture and food security in Africa: the role of innovative technologies and international organizations. *Technology in Society* **58**, 101143.

Adnan N, Nordin SM and Bin Abu Bakar Z (2017) Understanding and facilitating sustainable agricultural practice: a comprehensive analysis of adoption behaviour among Malaysian paddy farmers. *Land Use Policy* **68**, 372–382.

Adnan N, Nordin SM, Bahruddin MA and Tareq AH (2019) A state-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption: assessing farmers behavior. *Trends in Food Science & Technology* **86**, 439–452.

Adnan N, Nordin SM and Anwar A (2020) Transition pathways for Malaysian paddy farmers to sustainable agricultural practices: an integrated exhibiting tactics to adopt green fertilizer. *Land Use Policy* **90**, 104255.

Agrawala S, Ota T, Ahmed AU, Smith J and Van Aalst M (2003) Development and climate change in Bangladesh: focus on coastal flooding and the Sundarbans. Citeseer.

Agwu OP, Bakayoko A, Jimoh SO and Stefan P (2018) Farmers' perceptions on cultivation and the impacts of climate change on goods and services provided by Garcinia kola in Nigeria. *Ecological Processes* **7**, 36.

Ajzen I (1985) From intentions to actions: a theory of planned behavior. In Kuhl J and Beckmann J (eds), *Action Control*. Berlin, Heidelberg: Springer, pp. 11–39. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen I (1991) The theory of planned behavior. *Theories of Cognitive Self-Regulation* **50**, 179–211.

Ajzen I (2005) *Attitudes, Personality, and Behavior*. London, UK: McGraw-Hill Education (UK).

Ajzen H and Fishbein M (1980) *Understanding Attitudes and Predicting Social Behavior*. Hoboken, NJ: Prentice-Hall.

Ajzen I and Madden TJ (1986) Prediction of goal-directed behavior: attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology* **22**, 453–474.

Ali AMS (2007) Population pressure, agricultural intensification and changes in rural systems in Bangladesh. *Geoforum; Journal of Physical, Human, and Regional Geosciences* **38**, 720–738.

Amare A and Simane B (2018) Does adaptation to climate change and variability provide household food security? Evidence from Muger sub-basin of the upper Blue-Nile, Ethiopia. *Ecological Processes* **7**, 13.

Ansari SA and Tabassum S (2018) A new perspective on the adoption of sustainable agricultural practices: a review. *Current Agriculture Research Journal* **6**, 157–165.

Armitage CJ and Christian J (2017) From attitudes to behavior: basic and applied research on the theory of planned behavior. Planned Behavior Routledge. pp. 1–12.

Asrat P and Simane B (2018) Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes* **7**, 7.

Bagheri A (2010) Potato farmers' perceptions of sustainable agriculture: the case of Ardabil province of Iran. *WCPCG* **5**, 1977–1981.

Bagozzi RP and Yi Y (1988) On the evaluation of structural equation models. *Journal of the Academy of Marketing Science* **16**, 74–94.

Balezentis T, Ribasauskiene E, Morkunas M, Volkov A, Streimikiene D and Toma P (2020) Young farmers' support under the Common Agricultural Policy and sustainability of rural regions: evidence from Lithuania. *Land Use Policy* **94**, 104542.

Bandura A (1992) Social cognitive theory of social referencing. In Feinman S (ed.), *Social Referencing and the Social Construction of Reality in Infancy*. Boston, MA: Springer US, pp. 175–208.

Barlett CP (2019) Chapter 5 – social psychology theory extensions. In Barlett CP (ed.), *Predicting Cyberbullying*. Cambridge, Massachusetts: Academic Press, pp. 37–47.

Barrett P (2007) Structural equation modelling: adjudging model fit. *Personality and Individual Differences* **42**, 815–824.

Baumgart-Getz A, Prokopy LS and Floress K (2012) Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature. *Journal of Environmental Management* **96**, 17–25.

Bentler PM (1990) Comparative fit indexes in structural models. *Psychological Bulletin* **107**, 238.

Berg G, Zachow C, Müller H, Philipps J and Tilcher R (2013) Next-generation bio-products sowing the seeds of success for sustainable agriculture. *Agronomy* **3**, 648–656.

Bernués A, Tello-García E, Rodríguez-Ortega T, Ripoll-Bosch R and Casasús I (2016) Agricultural practices, ecosystem services and sustainability in High Nature Value farmland: unraveling the perceptions of farmers and nonfarmers. *Land Use Policy* **59**, 130–142.

Bopp C, Engler A, Poortvliet PM and Jara-Rojas R (2019) The role of farmers' intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. *Journal of Environmental Management* **244**, 320–327.

Borges JAR and Lansink AGO (2016) Identifying psychological factors that determine cattle farmers' intention to use improved natural grassland. *Journal of Environmental Psychology* **45**, 89–96.

Borges JAR, Foletto L and Xavier VT (2015) An interdisciplinary framework to study farmers' decisions on adoption of innovation: insights from expected utility theory and theory of planned behavior. *African Journal of Agricultural Research* **10**, 2814–2825.

Bowler I (2002) Developing sustainable agriculture. *Geography (Sheffield, England)* **87**, 205–212.

Bretherton I (1992) Social referencing, intentional communication, and the interfacing of minds in infancy. In Feinman S (ed.), *Social Referencing and the Social Construction of Reality in Infancy*. Boston, MA: Springer US, pp. 57–77.

Brigance C, Soto Mas F, Sanchez V and Handal AJ (2018) The mental health of the organic farmer: psychosocial and contextual actors. *Workplace Health & Safety* **66**, 606–616.

Bultena GL and Hoiberg EO (1992) Farmers' perceptions of the personal benefits and costs of adopting sustainable agricultural practices. *Impact Assessment* **10**, 43–57.

Busby PE, Soman C, Wagner MR, Friesen ML, Kremer J, Bennett A, Morsy M, Eisen JA, Leach JE and Dangl JL (2017) Research priorities for harnessing plant microbiomes in sustainable agriculture. *PLoS Biology* **15**, e2001793.

Butchart SH, Walpole M, Collen B, Van Strien A, Scharlemann JP, Almond RE, Baillie JE, Bomhard B, Brown C and Bruno J (2010) Global biodiversity: indicators of recent declines. *Science (New York, N.Y.)* **328**, 1164–1168.

Buyinza J, Nuberg IK, Muthuri CW and Denton MD (2020) Psychological factors influencing farmers' intention to adopt agroforestry: a structural equation modeling approach. *Journal of Sustainable Forestry* **39**, 1–12. https://doi.org/10.1080/10549811.2020.1738948

Byrne BM (2001) Structural equation modeling with AMOS, EQS, and LISREL: comparative approaches to testing for the factorial validity of a measuring instrument. *International Journal of Testing* **1**, 55–86.

Caffaro F, Roccato M, Cremasco MM and Cavallo E (2019) An ergonomic approach to sustainable development: the role of information environment and social-psychological variables in the adoption of agri-environmental innovations. *Sustainable Development* **27**, 1049–1062.

Carolan MS (2006) Social change and the adoption and adaptation of knowledge claims: whose truth do you trust in regard to sustainable agriculture? *Agriculture and Human Values* **23**, 325–339.

Chen M-F (2016) Extending the theory of planned behavior model to explain people's energy savings and carbon reduction behavioral intentions to mitigate climate change in Taiwan–moral obligation matters. *Journal of Cleaner Production* **112**, 1746–1753.

Cristea A, Bozgă NA, Tița VD and Munteanu C-C (2019) Young Romanian farmers' perceptions regarding sustainable agriculture. *New Trends in Sustainable Business and Consumption* **466**, 466–479

Cullen P, Ryan M, O'Donoghue C, Hynes S, hUallacháin DÓ and Sheridan H (2020) Impact of farmer self-identity and attitudes on participation in agri-environment schemes. *Land Use Policy* **95**, 104660.

Daxini A, O'Donoghue C, Ryan M, Buckley C, Barnes AP and Daly K (2018) Which factors influence farmers' intentions to adopt nutrient management planning? *Journal of Environmental Management* **224**, 350–360.

Daxini A, Ryan M, O'Donoghue C and Barnes AP (2019) Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour. *Land Use Policy* **85**, 428–437.

De Groot J and Steg L (2007) General beliefs and the theory of planned behavior: the role of environmental concerns in the TPB. *Journal of Applied Social Psychology* **37**, 1817–1836.

Dentoni D and Peterson HC (2011) Multi-stakeholder sustainability alliances in agri-food chains: a theory of reasoned action approach. *International Food and Agribusiness Management Review* **14**, 83–108.

Dwyer J (2013) Transformation for sustainable agriculture: what role for the second pillar of CAP? *Bio-based and Applied Economics* **2**, 29–47.

Eanes FR and Zhou X (2020) The role of attitudes, social norms, and perceived behavioral control as factors influencing urban and suburban residential adoption of stormwater best management practices. *Environmental Management* **65**, 737–747.

Fairweather JR and Campbell HR (2003) Environmental beliefs and farm practices of New Zealand farmers contrasting pathways to sustainability. *Agriculture and Human Values* **20**, 287–300.

Fan Y, Chen J, Shirkey G, John R, Wu SR, Park H and Shao C (2016) Applications of structural equation modeling (SEM) in ecological studies: an updated review. *Ecological Processes* **5**, 19.

Faroque MAA, Kashem MA and Bilkis SE (2011) Sustainable agriculture: a challenge in Bangladesh. *International Journal of Agricultural Research, Innovation and Technology* **1**, 1–8.

Fekadu Z and Kraft P (2002) Expanding the theory of planned behaviour: the role of social norms and group identification. *Journal of Health Psychology* **7**, 33–43.

Feng J, Fu Z, Zheng X and Mu W (2010) Farmers' purchase intention of agricultural machinery, an application of the theory of planned behavior in China. *Journal of Food, Agriculture & Environment* **8**, 751–753.

Feola G, Lerner AM, Jain M, Montefrio MJF and Nicholas KA (2015) Researching farmer behaviour in climate change adaptation and sustainable agriculture: lessons learned from five case studies. *Journal of Rural Studies* **39**, 74–84.

Fielding KS, McDonald R and Louis WR (2008) Theory of planned behaviour, identity and intentions to engage in environmental activism. *Journal of Environmental Psychology* **28**, 318–326.

Fishbein M and Ajzen I (1975) *Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research*. Pennsylvania: Philosophy and Rhetoric.

Fishbein M and Ajzen I (2011) *Predicting and Changing Behavior: The Reasoned Action Approach*, 1st Edition. New York: Taylor & Francis. https://doi.org/10.4324/9780203838020

Fishbein M, Ajzen I, Albarracin D and Hornik R (2007) A reasoned action approach: some issues, questions, and clarifications. *Prediction and Change of Health Behavior: Applying the Reasoned Action Approach* **13**, 281–295

Floress K, Reimer A, Thompson A, Burbach M, Knutson C, Prokopy L, Ribaudo M and Ulrich-Schad J (2018) Measuring farmer conservation behaviors: challenges and best practices. *Land Use Policy* **70**, 414–418.

Foguesatto CR, Borges JAR and Machado JAD (2020) A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide. *Science of The Total Environment* **729**, 138831.

Fornell C and Larcker DF (1981) Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research* **18**, 39–50.

Garcia RA, Cabeza M, Rahbek C and Araújo MB (2014) Multiple dimensions of climate change and their implications for biodiversity. *Science (New York, N.Y.)* **344**, 1247579.

Garnett T, Appleby MC, Balmford A, Bateman IJ, Benton TG, Bloomer P, Burlingame B, Dawkins M, Dolan L, Fraser D, Herrero M, Hoffmann I, Smith P, Thornton PK, Toulmin C, Vermeulen SJ and Godfray HCJ (2013) Sustainable intensification in agriculture: premises and policies. *Science (New York, N.Y.)* **341**, 33–34.

Gatignon H (2010) Confirmatory factor analysis. In Gatignon H (ed). *Statistical Analysis of Management Data*. New York, NY: Springer, pp. 59–122.

Götz O, Liehr-Gobbers K and Krafft M (2010) Evaluation of structural equation models using the partial least squares (PLS) approach. In Esposito Vinzi V, Chin WW, Henseler J and Wang H (eds), *Handbook of Partial Least Squares: Concepts, Methods and Applications*. Berlin, Heidelberg: Springer, pp. 691–711.

Grzelak A, Guth M, Matuszczak A, Czyżewski B and Brelik A (2019) Approaching the environmental sustainable value in agriculture: how factor endowments foster the eco-efficiency. *Journal of Cleaner Production* **241**, 118304.

Harwood RR (1990) A history of sustainable agriculture. In *Sustainable Agricultural Systems*. CRC Press, pp. 3–19.

Hassanein N and Kloppenburg Jr JR (1995) Where the grass grows again: knowledge exchange in the sustainable agriculture movement 1. *Rural Sociology* **60**, 721–740.

Hayati D, Ranjbar Z and Karami E (2010) Measuring agricultural sustainability. In Lichtfouse E (ed.), *Biodiversity, Biofuels, Agroforestry and Conservation Agriculture*. Netherlands: Springer, pp. 73–100.

Heylen C, Meunier F, Peeters A, Ek S, Neang M, Hean S and Peanh S (2020) Multidimensional benefits of sustainable agriculture practices of Cambodian smallholder farmers. *Sustainable Agriculture Research* **9**, 10–25.

Hobbs PR, Sayre K and Gupta R (2008) The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society B-Biological Sciences* **363**, 543–555.

Hooper D, Coughlan J and Mullen M (2007) Structural equation modeling: guidelines for determining model fit. *The Electronic Journal of Business Research Methods* **6**, 195–200.

Hrubes D, Ajzen I and Daigle J (2001) Predicting hunting intentions and behavior: an application of the theory of planned behavior. *Leisure Sciences* **23**, 165–178.

Hu L and Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal* **6**, 1–55.

Islam MS and Shirazul D (2009) Farm mechanization for sustainable agriculture in Bangladesh: problems and prospects. 5th APCAEM Technical Committee Meeting and the Expert Group Meeting on Application of Agricultural Machinery for Sustainable Agriculture. United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery, Manila, Philippines p. 14–16.

Israel MA, Amikuzuno J and Danso-Abbeam G (2020) Assessing farmers' contribution to greenhouse gas emission and the impact of adopting climate-smart agriculture on mitigation. *Ecological Processes* **9**, 51.

Kabii T and Horwitz P (2006) A review of landholder motivations and determinants for participation in conservation covenanting programmes. *Environmental Conservation* **33**, 11–20.

Karami E and Mansoorabadi A (2008) Sustainable agricultural attitudes and behaviors: a gender analysis of Iranian farmers. *Environment, Development and Sustainability* **10**, 883–898.

Kauppinen T, Vesala KM and Valros A (2012) Farmer attitude toward improvement of animal welfare is correlated with piglet production parameters. *Livestock Science* **143**, 142–150.

Kelloway EK (1995) Structural equation modelling in perspective. *Journal of Organizational Behavior* **16**, 215–224.

Koohafkan P, Altieri MA and Gimenez EH (2012) Green agriculture: foundations for biodiverse, resilient and productive agricultural systems. *International Journal of Agricultural Sustainability* **10**, 61–75.

Krupnik TJ, Schulthess U, Ahmed ZU and McDonald AJ (2017) Sustainable crop intensification through surface water irrigation in Bangladesh? A geospatial assessment of landscape-scale production potential. *Land Use Policy* **60**, 206–222.

La Du TJ and Tanaka JS (1989) Influence of sample size, estimation method, and model specification on goodness-of-fit assessments in structural equation models. *Journal of Applied Psychology* **74**, 625–635.

Lee DR (2005) Agricultural sustainability and technology adoption: issues and policies for developing countries. *American Journal of Agricultural Economics* **87**, 1325–1334.

Li J, Feng S, Luo T and Guan Z (2020) What drives the adoption of sustainable production technology? Evidence from the large scale farming sector in East China. *Journal of Cleaner Production* **257**, 120611.

Madden TJ, Ellen PS and Ajzen I (1992) A comparison of the theory of planned behavior and the theory of reasoned action. *Personality and Social Psychology Bulletin* **18**, 3–9.

Maertens A and Barrett CB (2013) Measuring social networks' effects on agricultural technology adoption. *American Journal of Agricultural Economics* **95**, 353–359.

Marcoulides GA and Saunders C (2006) Editor's comments: PLS: a silver bullet? *MIS Quarterly* **30**, iii–ix.

Marsh HW, Hau K-T and Grayson D (2005) Goodness of fit in structural equation models. Contemporary psychometrics: a festschrift for Roderick P. McDonald Lawrence Erlbaum Associates Publishers, Mahwah, NJ, US. pp. 275–340.

Martinez LS and Lewis N (2016) The moderated influence of perceived behavioral control on intentions among the general U.S. population: implications for public communication campaigns. *Journal of Health Communication* **21**, 1006–1015.

Menozzi D, Fioravanzi M and Donati M (2014) Farmer's motivation to adopt sustainable agricultural practices. *Bio-based and Applied Economics* **4**, 125–147.

Menozzi D, Fioravanzi M and Donati M (2015) Farmer's motivation to adopt sustainable agricultural practices. *Bio-based and Applied Economics* **4**, 125–147.

Mishra B, Gyawali BR, Paudel KP, Poudyal NC, Simon MF, Dasgupta S and Antonious G (2018) Adoption of sustainable agriculture practices among farmers in Kentucky, USA. *Environmental Management* **62**, 1060–1072.

Misra AK (2014) Climate change and challenges of water and food security. *International Journal of Sustainable Built Environment* **3**, 153–165.

Mohammadinezhad S and Ahmadvand M (2020) Modeling the internal processes of farmers' water conflicts in arid and semi-arid regions: extending the theory of planned behavior. *Journal of Hydrology* **580**, 124241.

Montano DE and Kasprzyk D (2015) Theory of reasoned action, theory of planned behavior, and the integrated behavioral model. *Health Behavior: Theory, Research and Practice* **70**, 231.

Moreira PS, Sotiropoulos I, Silva J, Takashima A, Sousa N, Leite-Almeida H and Costa PS (2016) The advantages of structural equation modeling to address the complexity of spatial reference learning. *Frontiers in Behavioral Neuroscience* **10**, 10–18. doi: doi: 10.3389/fnbeh.2016.00018

Mukherjee B and Saha UD (2016) Teesta barrage project—a brief review of unattained goals and associated changes. *International Journal of Science and Research* **5**, 2027–2032.

Mulaik SA, James LR, Van Alstine J, Bennett N, Lind S and Stilwell CD (1989) Evaluation of goodness-of-fit indices for structural equation models. *Psychological Bulletin* **105**, 430.

Munim ZH and Noor T (2020) Young people's perceived service quality and environmental performance of hybrid electric bus service. *Travel Behaviour and Society* **20**, 133–143.

Nguyen N and Drakou EG (2021) Farmers intention to adopt sustainable agriculture hinges on climate awareness: the case of Vietnamese coffee. *Journal of Cleaner Production* **303**, 126828.

Orbell S, Hodgkins S and Sheeran P (1997) Implementation intentions and the theory of planned behavior. *Personality and Social Psychology Bulletin* **23**, 945–954.

Orduño Torres MA, Kallas Z and Ornelas Herrera SI (2020) Farmers' environmental perceptions and preferences regarding climate change adaptation and mitigation actions; towards a sustainable agricultural system in México. *Land Use Policy* **99**, 105031.

Palacios SPI (2005) Farmers' attitudes towards sustainable agriculture in Japan. *Japanese Studies* **25**, 187–202.

Rahman MZ and Mikuni H (1999) Farmers' attitudes towards sustainable agriculture issues and environmental quality in a selected area of Bangladesh. *American Journal of Alternative Agriculture* **14**, 22–29.

Raihan ML, Onitsuka K, Basu M, Shimizu N and Hoshino S (2020) Rapid emergence and increasing risks of hailstorms: a potential threat to sustainable agriculture in Northern Bangladesh. *Sustainability* **12**, 5011.

Ramborun V, Facknath S and Lalljee B (2020) Moving toward sustainable agriculture through a better understanding of farmer perceptions and attitudes to cope with climate change. *The Journal of Agricultural Education and Extension* **26**, 37–57.

Rasul G and Thapa GB (2003) Sustainability analysis of ecological and conventional agricultural systems in Bangladesh. *World Development* **31**, 1721–1741.

Rasul G and Thapa GB (2004) Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives. *Agricultural Systems* **79**, 327–351.

Reytar K, Hanson C and Henninger N (2014) *Indicators of Sustainable Agriculture: A Scoping Analysis*. Washington, DC, USA: World Resources Institute.

Rezaei R, Mianaji S and Ganjloo A (2018) Factors affecting farmers' intention to engage in on-farm food safety practices in Iran: extending the theory of planned behavior. *Journal of Rural Studies* **60**, 152–166.

Rezaei R, Safa L, Damalas CA and Ganjkhanloo MM (2019) Drivers of farmers' intention to use integrated pest management: integrating theory of planned behavior and norm activation model. *Journal of Environmental Management* **236**, 328–339.

Rhodes RE and Courneya KS (2003) Modelling the theory of planned behaviour and past behaviour. *Psychology, Health & Medicine* **8**, 57–69.

Rockstrom J, Williams J, Daily G, Noble A, Matthews N, Gordon L, Wetterstrand H, DeClerck F, Shah M, Steduto P, de Fraiture C, Hatibu N, Unver O, Bird J, Sibanda L and Smith J (2017) Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio* **46**, 4–17.

Röling NG and Jiggins JLS (1994) Policy paradigm for sustainable farming. *European Journal of Agricultural Education and Extension* **1**, 23–43.

Roling NG and Wagemakers MAE (2000) *Facilitating Sustainable Agriculture: Participatory Learning and Adaptive Management in Times of Environmental Uncertainty*. Cambridge, UK: Cambridge University Press.

Roy R and Chan NW (2012) An assessment of agricultural sustainability indicators in Bangladesh: review and synthesis. *The Environmentalist* **32**, 99–110.

Ruane AC, Major DC, Winston HY, Alam M, Hussain SG, Khan AS, Hassan A, Al Hossain BMT, Goldberg R and Horton RM (2013) Multi-factor impact analysis of agricultural production in Bangladesh with climate change. *Global Environmental Change* **23**, 338–350.

Ruttan VW (2019) *Sustainable Agriculture and the Environment: Perspectives on Growth and Constraints*. New York: CRC Press. https://doi.org/10.1201/9780429308031

Sadati SA, Fami HS, Asadi A and Sadati SA (2010) Farmer's attitude on sustainable agriculture and its determinants: a case study in Behbahan County of Iran. *Research Journal of Applied Sciences, Engineering and Technology* **2**, 422–427.

Saliba R, Callieris R, D'Agostino D, Roma R and Scardigno A (2018) Stakeholders' attitude towards the reuse of treated wastewater for irrigation in Mediterranean agriculture. *Agricultural Water Management* **204**, 60–68.

Sarkar A, Qian L and Peau AK (2020) Structural equation modeling for three aspects of green business practices: a case study of Bangladeshi RMG's industry. *Environmental Science and Pollution Research* **27**, 35750–35768.

Sarker DC, Pramanik BK, Zerin AI and Ara I (2011) Climatic impact assessment: a case study of Teesta Barrage irrigation project in Bangladesh. *International Journal of Civil & Environmental Engineering* **11**, 99–110.

Savari M and Gharechaee H (2020) Application of the extended theory of planned behavior to predict Iranian farmers' intention for safe use of chemical fertilizers. *Journal of Cleaner Production* **263**, 121512.

Savci S (2012) Investigation of effect of chemical fertilizers on environment. *Apcbee Procedia* **1**, 287–292.

Scherr SJ and McNeely JA (2008) Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of the Royal Society B-Biological Sciences* **363**, 477–494.

Senger I, Borges JAR and Machado JAD (2017) Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. *Journal of Rural Studies* **49**, 32–40.

Sezen B and Çankaya SY (2013) Effects of green manufacturing and eco-innovation on sustainability performance. *The Proceedings of 9th International Strategic Management Conference* **99**, 154–163.

Shah KU, Dulal HB and Awojobi MT (2019) Food security and livelihood vulnerability to climate change. *Food Security in Small Island States* **1**, 219–237. https://doi.org/10.1007/978-981-13-8256-7_12

Sherif CW, Sherif M and Nebergall RE (1965) *Attitude and Attitude Change: The Social Judgment-Involvement Approach*. Philadelphia: Saunders.

Shew AM, Durand-Morat A, Putman B, Nalley LL and Ghosh A (2019) Rice intensification in Bangladesh improves economic and environmental welfare. *Environmental Science & Policy* **95**, 46–57.

Siegel FR (2016) Natural processes linked to climate changes that threaten food security. In *Mitigation of Dangers from Natural and Anthropogenic Hazards*. Springer Briefs in Environmental Science. Cham: Springer, pp. 63–65. https://doi.org/10.1007/978-3-319-38875-5_12

Silva JRD, Mauad JRC, Domingues CHDF, Marques SCC and Borges JAR (2020) Understanding the intention of smallholder farmers to adopt fish production. *Aquaculture Reports* **17**, 100308.

Sivo SA, Fan X, Witta EL and Willse JT (2006) The search for 'optimal' cutoff properties: fit index criteria in structural equation modeling. *The Journal of Experimental Education* **74**, 267–288.

Smith JR, Terry DJ, Manstead AS, Louis WR, Kotterman D and Wolfs J (2007) Interaction effects in the theory of planned behavior: the interplay of self-identity and past behavior. *Journal of Applied Social Psychology* **37**, 2726–2750.

Sparks P (2000) Subjective expected utility-based attitude–behavior models: The utility of self-identity. In Terry DJ and Hogg MA (eds), *Attitudes, Behavior, and Social Context: The Role of Norms and Group Membership*. Mahwah, NJ, US: Psychology Press, pp. 31–46.

Sparks P and Shepherd R (1992) Self-identity and the theory of planned behavior: assessing the role of identification 'green consumerism'. *Social Psychology Quarterly* **55**, 388–399.

Stangor DC (2014*a*) *The Feeling Self: Self-Esteem. Principles of Social Psychology*, 1st International Edn. British Columbia: BCcampus.

Stangor DC (2014*b*) *Exploring Attitudes. Principles of Social Psychology*, 1st International Edon. British Columbia: BCcampus.

Stinner DH, Paoletti MG and Stinner BR (1989) In search of traditional farm wisdom for a more sustainable agriculture: a study of Amish farming and society. *Agriculture, Ecosystems & Environment* **27**, 77–90.

Sulemana I and James HS (2014) Farmer identity, ethical attitudes and environmental practices. *Ecological Economics* **98**, 49–61.

Sultana M, Ahmed JU and Shiratake Y (2020) Sustainable conditions of agriculture cooperative with a case study of dairy cooperative of Sirajgonj District in Bangladesh. *Journal of Co-operative Organization and Management* **8**, 100105.

Tan TH (2013) Use of structural equation modeling to predict the intention to purchase green and sustainable homes in Malaysia. *Asian Social Science* **9**, 181.

Tarka P (2018) An overview of structural equation modeling: its beginnings, historical development, usefulness and controversies in the social sciences. *Quality & Quantity* **52**, 313–354.

Tatlıdil FF, Boz İ and Tatlidil H (2009) Farmers' perception of sustainable agriculture and its determinants: a case study in Kahramanmaras province of Turkey. *Environment, Development and Sustainability* **11**, 1091–1106.

Terano R, Mohamed Z, Shamsudin MN and Latif IA (2015) Factors influencing intention to adopt sustainable agriculture practices among paddy farmers in Kada, Malaysia. *Asian Journal of Agricultural Research* **9**, 268–275.

Terry DJ and O'Leary JE (1995) The theory of planned behaviour: the effects of perceived behavioural control and self-efficacy. *British Journal of Social Psychology* **34**, 199–220.

Tessema I and Simane B (2019) Vulnerability analysis of smallholder farmers to climate variability and change: an agro-ecological system-based approach

in the Fincha'a sub-basin of the upper Blue Nile Basin of Ethiopia. *Ecological Processes* **8**, 5.

Thakkar JJ (2020) Applications of structural equation modelling with AMOS 21, IBM SPSS. In Thakkar JJ (ed.), *Structural Equation Modelling: Application for Research and Practice (with AMOS and R)*. Singapore: Springer, pp. 35–89. https://doi.org/10.1007/978-981-15-3793-6_4

Thirupathi RM and Vinodh S (2016) Application of interpretive structural modelling and structural equation modelling for analysis of sustainable manufacturing factors in Indian automotive component sector. *International Journal of Production Research* **54**, 6661–6682.

Tilahun M, Angassa A and Abebe A (2017) Community-based knowledge towards rangeland condition, climate change, and adaptation strategies: the case of Afar pastoralists. *Ecological Processes* **6**, 29.

Tilman D, Balzer C, Hill J and Befort BL (2011) Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences of the USA* **108**, 20260–20264.

Trafimow D, Sheeran P, Conner M and Finlay KA (2002) Evidence that perceived behavioural control is a multidimensional construct: perceived control and perceived difficulty. *British Journal of Social Psychology* **41**, 101–121.

Van Thanh N and Yapwattanaphun C (2015) Banana farmers' adoption of sustainable agriculture practices in the Vietnam uplands: the case of Quang Tri Province. 1st International Conference on Asian Highland Natural Resources Management (AsiaHiLand) and 2nd IDRC-SEARCA Upland Fellowship and Conference Chiang Mai, Thailand January 7–9, 2015 5:67–74.

Walle EA, Reschke PJ and Knothe JM (2017) Social referencing: defining and delineating a basic process of emotion. *Emotion Review* **9**, 245–252.

Warner K, Hamza M, Oliver-Smith A, Renaud F and Julca A (2010) Climate change, environmental degradation and migration. *Natural Hazards* **55**, 689–715.

Waseem R, Mwalupaso GE, Waseem F, Khan H, Panhwar GM and Shi Y (2020) Adoption of sustainable agriculture practices in banana farm production: a study from the Sindh Region of Pakistan. *International Journal of Environmental Research and Public Health* **17**, 3714.

Wauters E, Bielders C, Poesen J, Govers G and Mathijs E (2010) Adoption of soil conservation practices in Belgium: an examination of the theory of planned behaviour in the agri-environmental domain. *Land Use Policy* **27**, 86–94.

Whitehead J, MacLeod CJ and Campbell H (2020) Improving the adoption of agricultural sustainability tools: a comparative analysis. *Ecological Indicators* **111**, 106034.

Wong KK-K (2013) Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Marketing Bulletin* **24**, 1–32.

Zeweld W, Van Huylenbroeck G, Tesfay G and Speelman S (2017) Smallholder farmers' behavioural intentions towards sustainable agricultural practices. *Journal of Environmental Management* **187**, 71–81.

Zeweld W, Huylenbroeck GV, Tesfay G and Speelman S (2019) Impacts of socio-psychological factors on smallholder farmers' risk attitudes: empirical evidence and implications. *Agrekon* **58**, 253–279.

Zeweld W, Van Huylenbroeck G, Tesfay G, Azadi H and Speelman S (2020) Sustainable agricultural practices, environmental risk mitigation and livelihood improvements: empirical evidence from Northern Ethiopia. *Land Use Policy* **95**, 103799.

Zhang T, Yang Y, Ni J and Xie D (2019) Adoption behavior of cleaner production techniques to control agricultural non-point source pollution: a case study in the Three Gorges Reservoir Area. *Journal of Cleaner Production* **223**, 897–906.