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Review

SUSTAINABLE AGRICULTURAL PRACTICES ADOPTION

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As it has been practiced for many decades, agriculture has had a significant negative impact on the environment. More land, fertiliser, and pesticides had been used to increase the yield to meet the demands of an expanding population. Consequences included deforestation and soil degradation as well as the extinction of biodiversity, irrigation issues, and pollution, among other things. This has resulted in developing a new type of agriculture known as sustainable agriculture to remedy the situation. Specifically, the goal is to "meet the food and textile needs of society in the present without risking the ability of future generations to meet their own needs." Using appropriate agricultural practices to implement sustainable agriculture is the most effective method of accomplishing this goal. According to research, farmers' decisions to effectively adopt sustainable agricultural practices are influenced by a variety of factors. In this paper, we firstly give an overview of sustainable agriculture practices. Then, we review the various factors affecting the adoption of these practices, and finally, we highlight the gap found in the literature.

Key words: farmer's decision, sustainable agriculture, sustainable practices adoption, behaviour, environment

Agriculture has a significant impact on the entire humanity, both positively and negatively. Between 1950 and 1980, more and more land was turned into agricultural land to feed the growing population (Gupta 2019). But this agricultural intensification has led to serious environmental problems as depicted in Figure 1 below.

Between 1990 and 2015, the total forest area has declined by three per cent from 4,128 million hectares to 3,999 million hectares, making agriculture the most significant driver of global deforestation (FAO 2016). A paper published by Negassa *et al.* (2020) showed that between 1980 and 2000, more than 55% of the newly cultivated areas in the tropical zone were at the expense of primary forests and that 28% of this expansion was at the cost of secondary forests. This deforestation is linked to biodiversity loss, with an estimated 1 million species (animals, plants, and insects) facing extinction in the coming decades to centuries (Almond *et al.* 2020). Biodiversity is typically described as the diversity of life on Earth with all its manifestations. It contains the variety of species, their genetic diversity, and how various forms of life engage in a complex natural environment. Because of the reduction in the diversity of species, the ecosystem in which this decrease has occurred may experience a break-

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down in its ability to operate effectively. It has an impact on economic systems as well as human civilization. The availability of diverse plants, animals, and other creatures as food, construction materials, and medicines is critical to the survival of humans in many civilizations and their availability as commodities (Rafferty 2019).

Another threat that agriculture is facing, it is climate change. Agriculture both causes and is impacted by climate change. Agriculture is responsible for about 17% of the greenhouse gas emissions contributing to climate change worldwide (Lynch *et al.* 2021). Methane (CH_4) from biochemical reactions, nitrous oxide (N_2O) from soil management, carbon dioxide (CO_2) from fossil fuel combustion, and changes in land use are the most significant contributors to his greenhouse gas emissions (Cloy & Smith 2018). Agriculture is also particularly vulnerable to climate change. Higher temperatures, for example, reduce the yields of beneficial crops when modifications in precipitation patterns increase the probability of crop failures in the short term and a reduction in long-term productivity (Lynch *et al.* 2021). It is one of the factors that contribute to the spread of pests and plant illnesses. Increased temperature and precipitation levels encourage the establishment and spread of most pest species by offering a warm, humid habitat and the required hydration for their development. Pesticides, fertilisers, and other toxic farm chemicals used to fight those pests and diseases can poison freshwater, marine ecosystems, air, and soil (Sen *et al*. 2021).

While agricultural production has increased significantly, this has not been without consequences for the soil. Indeed, the transition from natural vegetation to agriculture has decreased the capacity of soils to maintain themselves, which has led to adverse effects such as soil erosion, compaction, loss of soil structure, nutrient degradation, and soil salinity. As a result of soil deterioration, hydrological conditions are also altered (Srinivasarao *et al.* 2021). Vegetative cover is removed, and the soil surface is exposed to the impact of raindrops, causing a layer of soil to form a barrier that prevents water from infiltrating the soil. As a result, less rain infiltrates into the ground than it falls as rain (Chalise *et al.* 2019). Flooding is more frequent and widespread, and streams and springs are ephemeral due to runoff. This tends to promote erosion, resulting in increased sediment load in rivers, sediment build-up in dams, damage to hydroelectricity, obstruction of navigable streams, and reduced water quality (Nda *et al.* 2017).

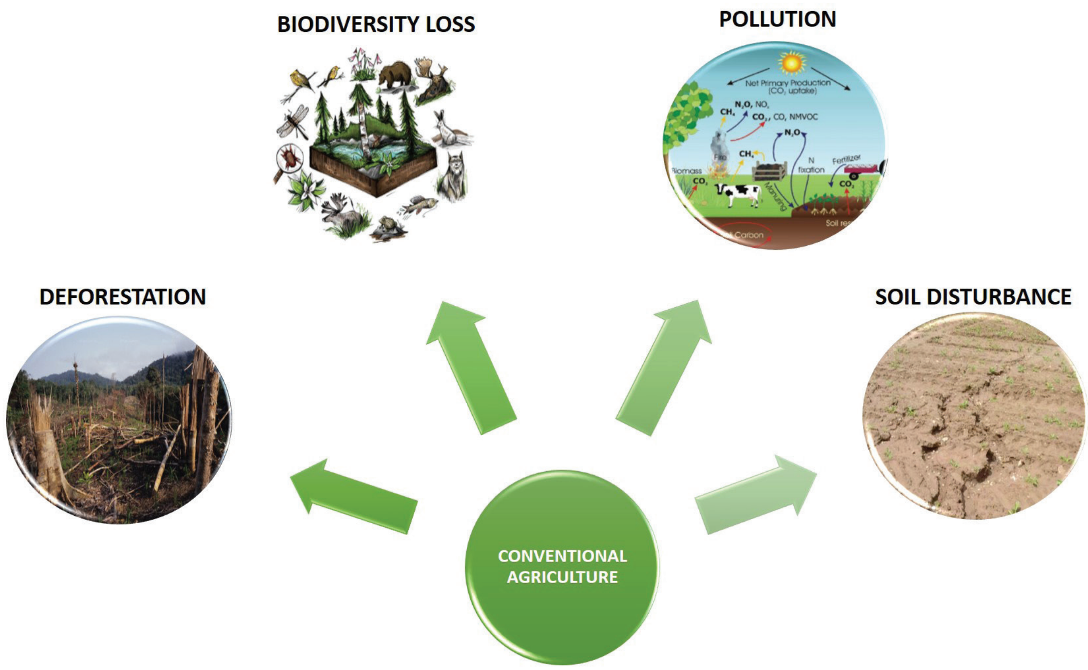

Figure 1. Some environmental problems of conventional agriculture.

In the face of worsening environmental problems and the fear of a global food shortage, some changes must occur in the way agriculture is practised. There is more than one way to farm, and taking into account all the above points, the implementation of actions to reduce the negative effects of agriculture on the environment has seen the advent of sustainable agriculture in the early 1980s. There is a variety of definitions of Sustainable Agriculture according to the issues motivating concern (Siebrecht 2020). It is view as an ideology with MacRae *et al.* (1990) who defined it as "A philosophy and a system of farming which has its roots in a set of values that reflect a state of empowerment, of Awareness of ecological and social realities, and of one's ability to take effective action". Trigo *et al.* (2021), on the other hand have defined sustainable agriculture as a set of strategies: "a management strategy which helps the producers to choose hybrids and varieties, a soil fertility package, a pest management approach, a tillage system, and a crop rotation to reduce costs of purchased inputs, minimize the impact of the system on the immediate and the off-farm environment, and provide a sustained level of production and profit from farming". As an ability to fulfil a set of goals we had de definition of Harwood (2020) where sustainable the agriculture was an "agriculture that can evolve indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment that is favourable both to humans and to most other species". The Food Agricultural Organization (FAO) definition of sustainable agriculture, is "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations" (FAO 2006). Among all this range of definitions, the only consensus, or nearly so, is that sustainable agriculture emphasizes the environmental, social, and economic issues in agriculture for the needs of present and future generations.

THE PRACTICES IN SUSTAINABLE AGRICULTURE

Numerous sustainable agricultural practices are being promoted globally, including sets of metrics for various sustainable farming approaches that incorporate Sustainable Agricultural Practices (SAP). Most of these methods may be classified into five farming categories (Pretty 2008). The first category of practices is associated with pest control. They are primarily concerned with avoiding the use of pesticide and herbicidal agents to maintain biodiversity, soil resilience, and the natural environment (Dara 2019). The second group is concerned with agriculture mechanization. It focuses on techniques that replace ploughing the soil and decreasing or eradicating tillage to preserve original soil quality (Sims & Kienzle 2017). When crops are grown and collected with little soil disturbance, the natural cover is being kept on the soil's surface, and crop rotations can be managed to maximize crop yields. The third set of techniques directly relates to integrated nutrient management and attempts to adjust the level of nitrogen in the soil, with no additional sources of nutrients (Gruhn *et al.* 2000). The fourth category concerns systems that mix plants and trees in the same plot like agroforestry to produce more natural and better nutrient flows, energy cycles, and carbon footprints than are currently available (Nair 1993). The last group of practices is concerned with soil and water. It is built on the use of a succession of processes that allow for the collection of water while also avoiding wind and water soil erosion (López-Vicente & Wu 2019). SAPs promotion has been adapted to meet the specific needs of nations or areas (Tey *et al.* 2017). This has led to different concepts of sustainable agriculture of which the most important of which are listed below:

1. *Conservation Agriculture* is a farming system that encourages the practices of agriculture with a "minimum soil disturbance, diversified crop rotations, and maintenance of organic soil cover" (Nyanga *et al.* 2020). It is one of the Best Management Practices (BMPs) tools that reinforces ecosystems with three crop management principles: direct planting of crops (that is, no-till), permanent soil cover crop residues or cover crops, and crop rotation

(Pittelkow *et al.* 2015). BMPs include soil and water conservation practices, other management techniques, and social actions that are developed for a particular region as effective and practical tools for environmental protection. Rarely does one single practice or action solve the concern, but often it is a combination of measures that are used. BMPs range from measures that involve a change in farming operations, like conservation tillage and crop rotation, crop nutrient management, pest management, conservation buffers, irrigation management, grazing management, animal feeding operations management, erosion, and sediment control to simple actions such as not applying manure before forecasted rainfall, etc.

2. *Good Agricultural Practices (GAP)* are defined by the FAO as a "*collection of principles to apply for on-farm production and postproduction processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability*" (Sareen 2016). One of his principal aspects is "preventing problems before they happen". Its three main objectives are: (1) ensuring safety and quality of produce in the food chain, (2) capturing new market advantages by modifying supply chain governance, and (3) improving natural resources use, workers' health, and working conditions. One of the key elements of GAP is "prevention of problems before they occur".
3. *Organic farming* is defined by the International Federation of Organic Agriculture Movements (IFOAM) as "*a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved*" (Miśniakiewicz *et al.* 2021) innovation, and science to provide high-quality food, benefit the shared environment, and promote fair relationships and a good quality of life for all involved. It is a subject of the certification (i.e., issuing a declaration by a third party. This is accomplished by using, where possible, agronomic, biological, and mechanical methods instead of synthetic materials.
4. *Sustainable Intensification* (SI) was established to address the issue of extensive agriculture. It is concerned with increasing the efficiency with which agricultural resources are used to produce more food on the same area of land while reducing negative environmental and social consequences (Petersen & Snapp 2015). Implementing techniques such as stone bunds along contours, shallow bowls filled with organic materials, and reforestation are all examples of activities that are being encouraged to achieve the SI objectives (Manzano Lepe 2016).
5. *Permaculture* is "the conscious design and maintenance of agriculturally productive ecosystems that exhibit the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people that provide food, energy, shelter, and other material and non-material needs sustainably" (Holmgren 2020). For example, you may repair the soil and preserve water while reclaiming space for permaculture waste streams. Essentially, the concept is to design a plant production system that considers each plant's function and how the plants relate to each other so that the elements within each plant help each other. Daily connections observed in nature serve as inspiration for this technique.

FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES

Researchers claim that the adoption of SAPs might strengthen people's resilience to climate change, help with soil degradation, and support agricultural output in a cost-effective, productive, and lucrative way (Wollni & Andersson 2014; Ngwenya *et al.* 2017; Aryal *et al.* 2020). The acceptance of novel agricultural techniques among farmers has been a subject of scientific inquiry since the 1950s (Manzano Lepe 2016). The decision to adopt SAP is based on several criteria as it is interdependent and multifactorial (Kassie *et al.* 2015). Several scientific kinds of research have attempted to explain the factors that affected the adoption of SAPs among farmers at a considerable level. A large number of publications is repeated, sometimes showing consistencies and sometimes showing conflicting the results. These variables are often categorized as follows in 4 groups (Figure 2).

Farmers factors

Age is one of the most studied farmers' characteristics, and its effects of adopting SAPs are not consensual. The expertise and resources that older farmers may have may provide them with greater opportunities to experiment with new technologies. On the other hand, younger farmers are more inclined to accept new technologies than older farmers since they have received more education than older group (Rajendran *et al.* 2016). According to some academics, older farmer is, the less likely he is to adopt new technology (Teklewold *et al.* 2013; Singh & Park 2018). The level of education of the farmer is another inconsistent factor. Haghjou *et al.* (2014) discovered that the connection between education and farmer adoption is negative. Other studies said that the better instructed the farmer is, the better readily they embrace new agricultural techniques (Teklewold *et al.* 2013; Ng'ombe *et al.* 2014) while a study by Tankari (2015) finds no evidence of an impact of educational levels on the adoption. Concerning Gender, according to the results, female farmers were more likely than male farmers to embrace sustainable farming practices (Mala & Malý 2013; Azam & Banumathi 2015; Kerdsriserm *et al.* 2016). In some studies, it is hypothesized that income is related to adopting new agricultural technologies. For example, Caviglia-Harris (2003) found a positive correlation between the adoption of SAPs by Brazilian farmers and their income, while Khaledi *et al.* (2010) and López & Requena (2005) found a negative effect of farmers income on Canadian and Spanish farmers. Adeola (2010) and Tosakana *et al.* (2010) found that farm experience had a significant and positive impact on the adoption of SAPs.

Farm factors

In terms of farm characteristics, previous research has discovered many important physical attribu-

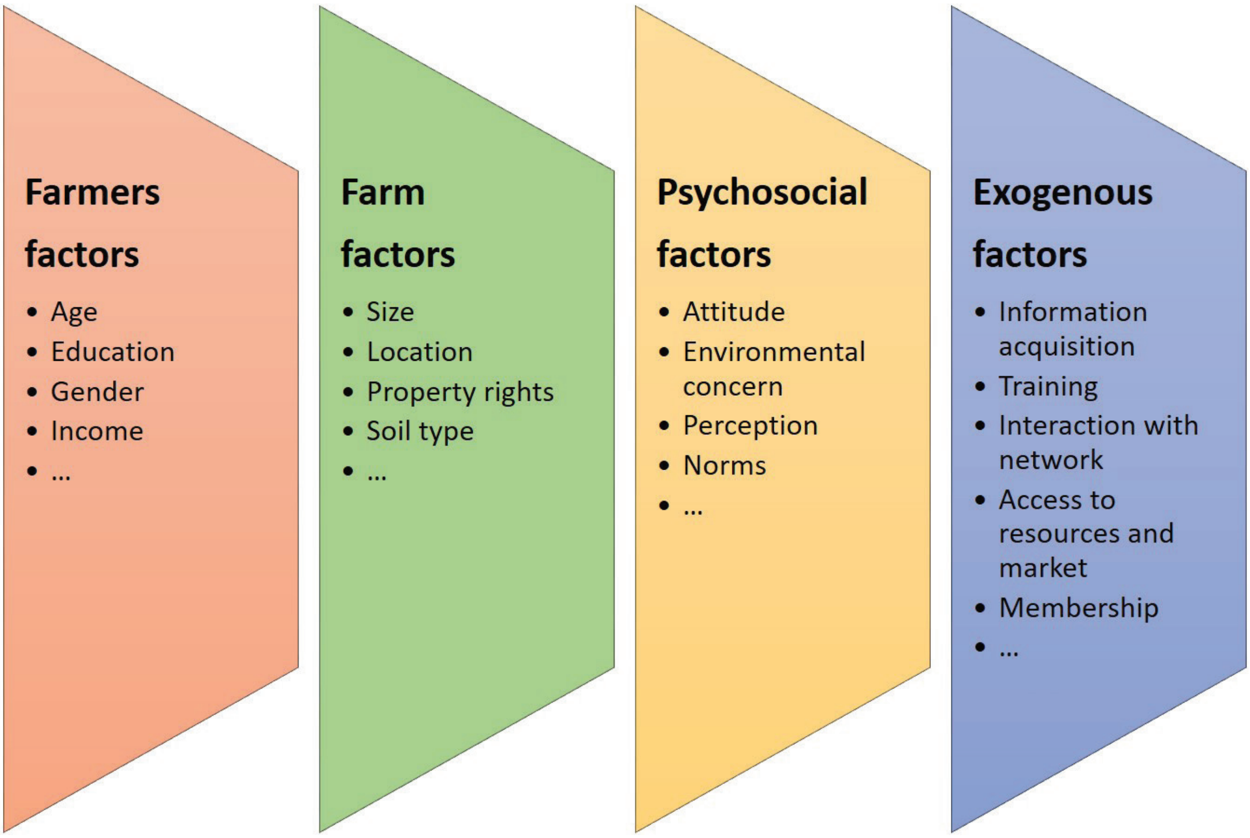

Figure 2. Overview of factors affecting the adoption of sustainable agricultural practices.

tes that influence new agricultural practices adoption. Farm size was validated as a major determinant. It is sometimes assumed that owners of larger farms are more likely to invest in new technology (Kafle 2011; Nathanel *et al.* 2015), but its influence on adoption is inconsistent (Duncan & Claeys 2018). It was found to have a negative effect by Liu *et al.* (2019) and Pradhan *et al.* (2017). In an agricultural community, the size of a farm can indicate affluence and social honorability. Therefore, farmers with greater land may be able to use a portion of their land to adopt organic farming practices if they have the means to do so (Sapbamrer & Thammachai 2021). The farmer's property rights were also evaluated, as owning land rights improves the likelihood of adopting innovative farming methods (Hattam & Holloway 2005; Mohamed Haris *et al.* 2018). Simultaneously, throughout the adoption phase, certain criteria such as temperatures, soil type, geographic position, rainfall, and proximity to research institutions, markets, and specific districts were identified as critical (Manzano Lepe 2016).

Psychosocial factors

Psychosocial variables make up the third group, and they describe how people feel about certain actions (Nguyen *et al.* 2019). Cognition evaluation, in particular, is the procedure through which all farmers evaluate the pros and cons of SAPs packages in comparison to their current agricultural methods. Farmers' willingness to use SAPs rose when SAPs were seen to be preferable in terms of the environmental consequences, yield reaction, simplicity of use, and economic advantage, among other factors. SAPs are highly regarded for their favourable ecological benefits on the environment. This is due mainly to the fact of a healthy environment should result in increased yields and, consequently, better revenue. In addition, another aspect of cognitive thinking is concerned with the management of risks associated with the implementation of SAPs. According to the research, farmers were shown to favour adoption when a specific packaged SAP was seen to prevent or mitigate hazards connected with their conventional agricultural techniques (Rajendran *et al.* 2016).

For Serebrennikov *et al.* (2020), following theories, there is a range of attitudes that influence the likelihood of sustainable farming being adopted. One of them, Environmental attitude, is defined as "psychological tendency that is expressed by evaluating perceptions of or beliefs regarding the natural environment, including factors affecting its quality, with some degree of favour or disfavour" (Milfont 2007). Sapbamrer and Thammachai (2021) and Serebrennikov *et al.* (2020) showed that almost all the studies in their systematic reviews reported a positive correlation between the adoption of sustainable practices and environmental attitude. Perception is also a critical factor in determining whether or not sustainable practices will be adopted. From perceived behavioural control (Sharifuddin *et al.* 2018; Yanakittkul & Aungvaravong 2020) to risk perception (Radwan *et al.* 2011) and perceived benefit (Sriwichailamphan & Sucharidtham 2014), a positive link with the decision to adopt SAPs where found.

Exogenous factors

Exogenous factors deal with the extent or degree to which external mechanisms impact sustainable practices adoption by smallholders. It includes all the services to agricultural development, such as information acquisition, access to resources and markets, contact with extension agents, membership of an association, training, and others. Many studies have found that information is one of the critical factors that lead to the adoption of new farming practices. It helps farmers to learn about the presence of the technology as well as its practical usage, which increases the likelihood of the technology's adoption. Farmer adoption of new technology is only possible if the farmers have heard about it (Udimal *et al.* 2017). Numbers of Agricultural information sources (Savari *et al.* 2013; Pradhan *et al.* 2017) and the use of educational publications and mass media (Kaufmann *et al.* 2011) as well were found to be significant factors for the adoption of sustainable practices.

Adoption of SAPs was shown to be also more prevalent when extension agents were made available. Extension services play a key role in boosting agricultural growth in emerging economies, especially in those countries with fewer resources (Rajendran *et al.* 2016). They are essential sources of knowledge acquisition, and their advice enhances farmer competency in exploiting new technology and innovation. Studies report that contact with extension agents increased the probability of shifting to sustainable farming methods (Genius *et al.* 2006; Sodjinou *et al.* 2012; Anderson *et al.* 2019). Membership in a farmer group is another essential element that regularly shows a favourable impact on SAPs adoption (Manzano Lepe 2016). Hattam & Holloway (2005); Sriwichailamphan & Sucharidtham (2014); and Singh & Park (2018) for example, found a positive association with farmer's organization membership and adoption of SAPs, respectively, among farmers from Mexico, Nepal, and Thailand.

Training programs assist farmers in learning best practices and correct procedures for sustainable production, as well as informing them of the advantages they will receive if they change their old practices (Sapbamrer & Thammachai 2021). Karki *et al.* (2011) found that better-trained Nepalese tea farmers are more likely to adopt organic farming practices. The positive effect of training in the adoption process of sustainability has also been proved by many other researchers (López & Requena 2005; Sriwichailamphan & Sucharidtham 2014; Murtaza & Thapa 2017; Aryal *et al.* 2018). Access to credit is one of the main variables when considering an individual's access to resources. Simtowe & Zeller (2006) have shown that it encourages technology adoption by alleviating financial constraints and increasing household risk-taking capacity for maize farmers in Malawi. Also, access to water sources in Thailand for rice farmers had a positive effect on their decision to adopt sustainable agricultural practices (Pornpratansombat *et al.* 2011).

DISCUSSION AND GAP IN THE LITERATURE

The literature review has shown that the implementation of new behaviour is impacted by both exogenous and endogenous variables. Those researches have been conducted through different theoretical frameworks. On the one hand, with theories that claim people decide based on self-interest and self-interest alone. Then, with approaches that focus on evaluating choices based on the intention, norms, or both (Schlüter *et al.* 2017). The most popular of them is the Theory of Planned Behaviour of Ajzen. This theory states that before adopting a behaviour, you must intend to do so, and this intention is determined by three essential factors; attitudes, subjective norm, and perceived behavioural control (Ajzen 1991). It means that people will consider potential outcomes, the social expectations of significant referents, and any roadblocks before performing a given behaviour. Despite its popularity, the TPB has been criticized (Ajzen 2011). The claim that attitudes, subjective norms, and perceptions of behavioural control are enough to anticipate intentions, then the behaviour is one sort of challenge that the theory may face. To solve this issue, the researchers propose to introduce other factors into the TPB to increase its predictive validity. The integrative approach was thus born with the integration of other theories such as the theory of reasoned action (Heong *et al.* 2002), Diffusion Of Innovation theory (Reimer *et al.* 2012), the Value belief Norms theory (Price & Leviston 2014), the Technology Acceptance theory (Zeweld *et al.* 2017), or more recently the Norms Activation Theory (Rezaei *et al.* 2019). But according to Nguyen & Drakou (2021), the majority of research on sustainable agricultural adoption applying an extending model of the TPB is on high and middle-income countries. Thus, further studies are still needed to understand the influence of farmers' attitudes and intentions on organic agriculture in developing countries.

Another critique levelled about the idea of planned behaviour is that it fails to account for the gap that exists between intentions and actual behaviour. Not only because the TPB is more effective at explaining intentions than it is at explaining behaviours themselves, but also because there is a significant level of variability in the strength within this connection (Norman & Conner 2005), it is, therefore, necessary to identify the elements that may influence the chances for intentions to be followed through to behavioural change. But only a few researchers have proposed some moderator and mediator factors that may affect the intention-behaviour connection in the context of sustainable agricultural practices adoption. For example, Li *et al.* (2021) introduced

Eco-compensation as a moderation when studying the mechanism that drives farmers to improve the agricultural system in China. In contrast, other researchers focused on farmers' intention by adding others factors like self-identity, moral norms, risk perception (Maleksaeidi & Keshavarz 2019; Savari & Gharechaee 2020; Ataei *et al.* 2021). To fill this gap, future research must focus on bridging the gap between farmers' intent and their behaviour.

CONCLUSIONS

From the discussion in the preceding section, we can see that a variety of factors have been found to play a role in the decision of farmers to move towards sustainable agriculture. These findings come from a broad range of disciplinary backgrounds, including psychology, economics, sociology, anthropology, agricultural extension, and others, resulting in a large and diverse literature (Anibaldi *et al.* 2021). Some academics think that this corpus of work has reached its limit in terms of contributing to more sophisticated knowledge of SAP adoption. But while farmers may intend to adopt sustainable agricultural practices, they may not take any actions, which is called the intention-behaviour gap (Nguyen *et al.* 2019). For that reason, there is an intense drive for more study to generate better insights and higher-level policy proposals.

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