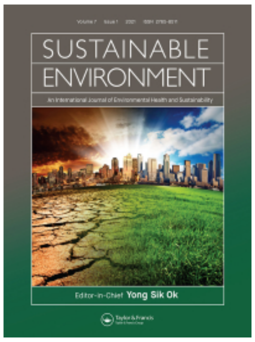

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The Nexus of farmers' Sustainable agriculture potential and readiness for more organic use in rice farming: Insights from resilience theory

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ABSTRACT

Sustainable Agriculture (SA) and the readiness of farmers to implement SA practices are broader discussions in global forums today. However, to date, there has been relatively little focus on holistically developed frameworks to assess farmers' SA potential or their linkage to farmers' readiness for SA practices such as adopting more organics in farming, particularly in Sri Lanka. To address this gap, we developed a conceptual model to determine farmers' resilience in implementing more organic use in farming. The model developed was a philosophical combination of ecosystem resilience theory, the rural livelihood assessment framework, and the dimensions of personal readiness to commit to or experience an action. We derived composite indicators to explain the variances of these constructs through a detailed literature review, followed by pre-testing indicators. Data were collected from 386 participants using a structured questionnaire consisting of 119 items. Partial least squares structural equation modelling techniques were used to analyze the variables and path coefficients of the model. Farmers' sustainable agricultural potential (SAP) was found to be moderately strong in this rice cultivation region. This potential positively influences their readiness for adapting more organics in farming. Some farmers perceived government support as effective. However, this support has not yet been transformed into organic adaptation. Natural capital was identified as the most influential factor in organic farming. Farmers' education, gender, the extent of sowing, farming methods, and agro-input type were moderating factors between SAP and their readiness for organic matter. Farmers did not deny organic adaptation and understood the need to reduce the use of chemicals.

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KEYWORDS
Adaptive resilience; capital assets; chemical fertilizer; institutional support; organic fertilizer; sustainable agriculture

Introduction

The principles of sustainable agriculture (SA) and their importance have been increasingly discussed in the economic, political, and academic domains over the last few decades. Today, the world faces an immense challenge in securing food needs for an increasing population without compromising the ability of future generations to meet their needs (Lichtfouse et al., 2009). Some researchers have defined sustainable agriculture as a dynamic and complex ecosystem that can fulfil food needs within acceptable social, economic, and environmental costs, as well as being resilient to environmental and economic changes (Ackerman et al., 2014; Conway & Barbier, 1990; Scherer et al., 2018).

The UN General Assembly (2012) has recognized the diversity of agricultural systems and processes in the emergence of a growing demand for food for the world's rising population. To address these emerging concerns, the United Nations passed a resolution to promote global SA production and productivity, mainly focusing on developing countries. This was reasserted in the Rio + 20 conference under the sustainable development goal to end hunger to achieve food security, improve nutrition, and promote SA. Sustainable Development Goal 2 (SDG2) provides more precise guidance on the interlinks between supporting SA. The goals include empowering small farmers, promoting gender equality, ending rural poverty, ensuring healthy lifestyles, tackling climate change, and other issues addressed within the development goals introduced in the SDG development agenda (UNODC, 2015). The FAO (2014) has defined five fundamental principles of sustainable food and agriculture that balance the social, economic, and environmental dimensions of sustainability: 1) improving efficiency in the use of resources; 2) conserving, protecting, and enhancing natural ecosystems; 3) protecting and improving rural livelihoods and social well-being; 4) enhancing the resilience of people, communities, and

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ecosystems; and 5) promoting effective governance of natural and human systems.The FAO (2014) and United Nations (2013) recommend: Judicious use of organic and inorganic fertilizers, improved soil moisture management, better practices for soil and land rehabilitation, appropriate cropping system, conservation of plant genetic resources, improved water productivity and precision irrigation, integrated pest management and setting policies, laws, incentives, and enforcement to promote the above. The World Bank (2007) points out that the following factors are critical in SA adaptation, increase and protect farmers' access to resources, widen the market access, capacity-building on appropriate technologies, improve credit facilities and infrastructure, increase rural job opportunities, and improve rural nutrition.

Also, FAO (2014) assert that enhanced resilience of people, communities, and ecosystems is critical to sustainable agriculture. Resilience is defined as the ability of a system and its parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner by ensuring the preservation, restoration, or improvement of its essential basic structures and functions. FAO (2014) further states that sustainable food and agriculture require responsible and effective governance mechanisms. Good governance is needed to ensure social justice, equity, and the long-term perspective on protecting natural resources. Increase effective participation, encourage the formation of associations, increase frequency and content of consultations among stakeholders, and develop decentralized capacity are proposed to improve are suggestions for good governance.

Governments, the private sector, and civil societies have been increasingly conserving economic, biological, cultural, and aesthetic capital for future generations while searching for strategies to mitigate the ill effects of heavy production-oriented modern agricultural practices (Bisht, 2013; Bowers, 1995). Governments have started determining new ways to address these issues, such as subsidizing organic farming (Opoku et al., 2020), providing agriculture subsidization to environmental land management schemes (Cusworth & Dodsworth, 2021), developing strategies for sustainable agrotourism (Knowd, 2006), integrating agricultural developments in rural development plans, and leveraging community-supported agriculture schemes (Marsden et al., 2002; Mert-Cakal, 2020).

The Sri Lankan government also implemented a sudden policy change in chemical fertilizer import and use options from 6 May 2021, under Imports and Exports (Control) Regulation No. 07 of 2021. The regulation banned the import of chemical fertilizer (CF)., pesticides, and herbicides to make agricultural systems financially and environmentally sustainable (Finance Ministry of Sri Lanka, 2019 and 2020). Furthermore, the government has enacted plans to incentivize research and inventions for eco-friendly organic fertilizer (OF) production that suit local environmental conditions.

However, farmers were shocked and shaken by this decision and have demonstrated their frustration with widespread protest action. At short notice, the government's effort to switch Sri Lankan agriculture to 100% organic farming has created massive perturbations in the rice cultivation ecosystem. This ecosystem has evolved over the last six decades and is centered on the intense use of chemical substances. National Science Foundation of Sri Lanka (2021) predicted a 30–35% yield loss in annual paddy production due to this attempted shift. This signals that the future of the country's cultivation and food security are heading toward a crisis. However, given the constant pressure from farmers because they claimed their crop production was declining, the government issued a gazette notice lifting the ban in November 2021. This then allowed the private sector to import chemical fertilizers, weedicides, and pesticides. However, the deteriorating economic situation from the lack of foreign reserves in the country has prevented the importation of adequate CF requirements. Therefore, the cost of available stocks has become unaffordable for many farmers. Farmers will no longer have the luxury of using excessive CF according to their fancies and whims, which have been practiced for decades.

Over the last six decades, farmers have been encouraged to use CF through a chain of subsidiaries that deliver them to their doorsteps (Central Bank, 2020a, 2020b). The tradition has continued by applying quantities determined by farmers in agricultural fields, likely without knowing the actual cost and other environmental consequences (Aravinna et al., 2005; Jayasinghe, 2017; Jayasinghe & Munaweera, 2017; Kendaragama et al., 2008; Nagenthirarajah & Thiruchelvam, 2008; Nishantha et al., 2015; Watawala et al., 2010). Irrespective of the outcome, farmers have been committed to the use of CF in modern rice farming. However, organic subsistence and biomass have fallen into disuse for decades. Their ties with OF are relatively weak (Department of Agriculture, 2019; Department of Census and Statistics, 2021). In this context, farmers face the extreme dual challenges of disconnecting from CF and reestablishing and strengthening their relationship with OF. It is unlikely that farmers are ready to end their relations with CF immediately and rebuild their ties with OF in such rapid succession.

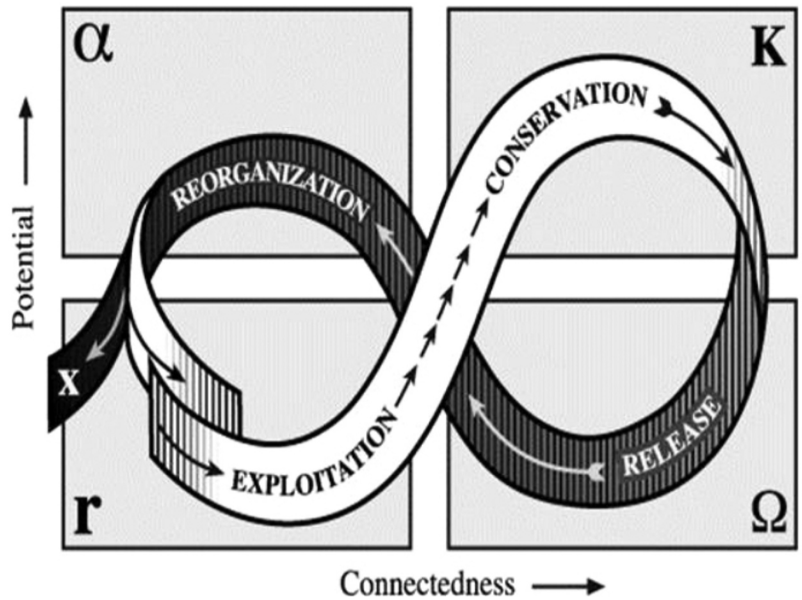

Figure 1. Adaptive resilience cycle. Source: https://www. resalliance. org/adaptive cycle.

To date, there have been no signs of adequate dialogue between the institutions and farmers in assessing their potential or listening to their opinions on their readiness to undertake this substantial task. It is also unknown to what extent the farmers have started believing and connecting with the institutional support organized by the government for this transition. Therefore, there is a need to investigate rice farmers' readiness to implement more organic use in farming to contribute to Sustainable Agriculture SA.

To date, farmers' readiness to implement SA activities has been investigated by considering sustainable agriculture potentials (SAP), economic, social, cultural, and environmental factors (Curr et al., 2014; Dharmawan et al., 2021; Gebska et al., 2020; Lichtfouse et al., 2009; Petway et al., 2019; Waseem et al., 2020). Government incentives are important for promoting SA (Cusworth & Dodsworth, 2021). Therefore, for this study there is a need for a holistic assessment of farmers' SAPs, their connectedness with CF and OF, and the effectiveness of government incentivization in supporting more organic farming. However, this examination is not straightforward and novel research designs are required. Such a research design requires a solid philosophical background that can provide a conceptual and research model to operationalize the research. However, no recent research outcomes explain the SA aspects and a conceptual model in this context to draw insights and understand the farmer's readiness for such a transition happening today in Sri Lankan context. Also, previous assessments do not provide a conceptual framework to measure farmers' readiness (resilience) to cope with sudden changes as the perturbation erupted in the Sri Lankan rice farming ecosystem. The theories, research models, factors so far used in such studies are summarized in the Table 1 of Annex A.

Among the various dominant theories used in SA adaptation studies, such as the theory of plan behavior (Waseem et al., 2020), diffusion of innovation theory (Rust et al., 2021), and Bourdieu's social theory (Cusworth & Dodsworth, 2021) resilience theory (RT) was selected as the guiding theoretical foundation for this study. Based on RT, the study has addressed these gaps of explaining farmers resilience to a sudden change.

Research question

The research question examined in this study is how to assess the relationships between farmers' sustainable agricultural potential (SAP), their readiness to move away from chemical fertilizer use, and implement the use organic fertilizers instead. Their perceived effectiveness of institutional incentives during this ongoing transition in Sri Lankan rice cultivation to adapt more organic in farming were also examined.

Literature review

A robust theoretical foundation was required to assess and understand farmers' readiness to replace CF with

Table 1. General definitions of livelihood capital assets

Capital assets	Definition
Human Capital	Health, Knowledge, Skills, Motivation, Joy, Passion, Empathy, Spirituality
Social Capital	Human relationships, partnerships, and cooperation. Networks, Communication channels, Families, Communities, Businesses, Trade unions, Schools and voluntary organizations, social norms, values, and trust
Financial Capital	The currency that can be owned or traded (Notes and coins, savings, Bonds)
Physical Capital	Goods and infrastructure owned, leased, or controlled by an organization or individual that contribute to production or service provision. The main components include lands, buildings, infrastructure (transport networks, communications, waste disposal systems), and technologies (from simple tools and machines to IT and engineering)
Natural (Environment) Capital	Natural capital (energy and matter) and processes are needed by systems to produce their products and deliver their services. Sinks that absorb, neutralize, or recycle wastes (e.g. forests, oceans); resources, some of which are renewable (timber, grain, fish, and water), whilst others are not (fossil fuels); and processes, such as climate regulation and the carbon cycle, that enable life to continue in a balanced way.

Source: Porritt (2011).

OF within SA principles. A thorough literature review helps researchers find a suitable theoretical foundation for conceptualizing research. In producing such a literature review, Petticrew (2001) and Healey and Healey (2010) have suggested that the 'systematic literature review' technique produces greater insights than the traditional 'narrative' approach. The study followed this suggestion, and 179 articles were selected from the Google Scholar and Web of Science databases. Of the 179 articles selected, 80 were directly relevant to this study.

Furthermore, 14 complete articles were selected that had been developed from solid theoretical backgrounds and were operationalized based on a precise research methodology. A detailed analysis of the selected references is presented in Table 1 of Annex A of this article. This qualitative analysis was performed by synthesizing the findings and recommendations. The results were consolidated and organized according to the main themes of the clusters identified. The remaining articles were also read, and literature saturation was observed with repetitive empirical findings, conceptual suggestions, and recommendations that were like the results of the selected 14 articles.

Theories used in sustainable agriculture studies

In this research discipline, several theories have been used to develop conceptual frameworks for assessing similar constructs such as farmers' readiness for organic adaptation. These conceptualizations have been associated with farmer or farm characteristics under the principles of sustainable or conservation agriculture. Waseem et al. (2020) deployed the Theory of Planned Behavior (TPB) in an investigation of the 'Adoption of SA practices in banana farm production'. In contrast, Dharmawan et al. (2021) deployed the gap analysis method using the Importance Performance Analysis (IPA) framework in their study of assessing 'Smallholders' readiness for sustainability standards in Palm Oil cultivation". Mulimbi et al. (2019) applied Theoretical Drivers of Innovation Adoption (TDIA) to investigate the 'Factors influencing the adoption of conservation agriculture'.

The concept of 'Satoyama', that is, a Japanese concept that encompasses rural livelihoods dependent on ecosystem management as ecosystem services, is the theoretical base used by Petway et al. (2019) in investigating 'knowledge, values, and opinions of farmers on organic farming'. Meanwhile, Wang (2018) studied the 'effects of integrating indigenous with scientific knowledge for the development of SA' using the Sustainable Agriculture Knowledge Development Framework with a bottom-up approach. A combination of Human Capital Theory (HCT), the Framework of Gender Equity (FGE), and Adult Learning Theory (ALT) was the theoretical base used by Zahra (2018) in a study assessing the 'impact of non-formal education in an integrated agricultural productivity project'. Šūmane et al. (2018) used the 'constructivist conceptualization of knowledge concept' to study the relevance of informal farmer knowledge and learning practices in strengthening agricultural resilience.

Cusworth and Dodsworth (2021) used Bourdieu's Social Theory (ST) to explain economic, social, and cultural symbolic capital. They deployed ST in conjunction with the good farmer concept in their study of assessing 'agricultural attitudes to the provision of the public good of an environment and land management policy (ELM)'. Mert-Cakal and Perera (2020) applied Social Innovation Theory and the concept of Alternative Food Networks (AFN) in a study on 'assessing social change through community-supported agriculture'.. Rust et al. (2021) deployed the Diffusion of Innovation Theory (DOI) in combination with Framing Theory (FT) to assess the Framing of SA by the farming press and its effect on SA implementation. Demont and Rutsaert (2017) used a SWOT[1] analysis based on a framework of the Sustainable Rice Platform (SRP) in a study of opportunities for sustainable value chain

(VC) upgrading. Von Loeper et al. (2016) studied the challenges faced by smallholder farmers and conservation agriculture using systems dynamics modelling (SDM) by applying the concept to the agricultural value chain. Sevinç et al. (2019) used demographic and socioeconomic factors to assess the effectiveness of attitudes toward the public support policy for SA.

Ecosystem resilience and resilience theory

The above discussed theoretical applications are insightful for understanding that researchers generally investigate farmers' socioeconomic potential, knowledge formation, and adaptation to SA. The discussions included attitudes and willingness toward environmental preservation and the perception of the effectiveness of institutional support. These concepts helped explain the constructs investigated in the proposed research project. However, the farmers' readiness to be abreast of changes in their resilience capacity, particularly during a transition, was not explained in detail in those theoretical applications. In addition to qualitative analysis of the 14 articles selected, other studies have proposed the socio-ecological ecosystem resilience concept to investigate the resilience capacity of the actors and institutions of such ecosystems. Socioecological ecosystem resilience explains an ecosystem's dynamic characteristics upon internal or external disturbances. This theory helped us understand the predictable behaviors of ecosystem inhabitants during transitions from one phase to another. Such changes in an ecosystem can stabilize or destabilize because of sudden forces or a series of forces. These suggestions can explain the current changes in rice cultivation ecosystems. There has been emerging research interest in the ecosystem resilience theory (RT) in sustainable rural development studies and agricultural systems.

Articles published by Darnhofer et al. (2010) and Oelofse and Cabell (2012) articulated the applicability of ecosystem resilience concepts in assessing livelihood resilience capacity in adapting to change. However, this literature review did not find fully operationalized research based on RT. Nevertheless, RT was the most appropriate conceptual platform for measuring the objectives of this study.

Characteristics of ecosystem resilience

Berkes et al. (2003) conducted a literature review of the characteristics of ecosystem resilience. Their synthesis asserts that resilience is essential for how societies adapt to externally imposed changes, such as global environmental changes. A society's adaptive resilience capacity is constrained by its actors' and institutions' resilience and the natural systems on which they depend at all levels. Adger (2000) proposed that the greater their resilience, the greater their ability to absorb shocks and perturbations and adapt to change. Conversely, the less resilient the system, the greater the vulnerability of institutions and societies to cope with and adapt to change.

Holling (1973) originally introduced the concept of resilience into the ecological literature. Gunderson (2000) expanded on this idea by explaining the nonlinear dynamics of the processes by which ecosystems maintain themselves in the face of perturbations. A heuristic model of the four system stages and the flow of events among them are shown in Figure 1. The adaptive cycle reflects the changes in two properties, that is, (1) the y-axis, the potential inherent in the accumulated resources and structures; and (2) the x-axis, the degree of connectedness among the controlling variables that might change because of an event. The exit marked with an X from the cycle indicated on the left side of the figure suggests the stage where the potential can leak away stylized and where a transition is most likely to fall into a less productive and unorganized system. The shaded part of the cycle is termed the '**back loop**' and explains the backward transition's release and reorganization phases (Holling, 1996; Holling & Gunderson, 2002).

Properties of resilience theory

The x-axis potential

According to Van der Leeuw (2009), the property of **potentials** explained in the RT of a socio-ecological ecosystem is overall capital or 'richness' that transitions into the next stage. Based on this suggestion, the property of potential explained in the RT is analogous to farmers' accrued livelihood capital over time. These capital assets align with the sustainable rural livelihood assessment frameworks described by Ashley & Carney (1999)), Scoones (1998), Batterbury and Forsyth (1999). They explain capital assets as economic, social, physical, human, and environmental. Porritt Porritt (2011) supplements these explanations by classifying them in the exact five dimensions in the more descriptive framework of the 'Five Capitals Model for livelihood Sustainability'. Combining these theoretical and conceptual suggestions, this study proposes farmers' SA potential as a composite measure of their economic, social, physical, human, and environmental capital.

The y-axis ecosystems actor's connectedness to controlling variables

Connectedness is the tightness of the bonds that ecosystem actors maintain with various controlling variables that might be subject to change at any time. Such controlling variables could be either stabilizing or destabilizing forces that could lead to eventual changes in the ecosystem. Stabilizing forces are essential to maintain productivity, fixed capital, and social memory, whereas destabilizing forces support diversity, flexibility, and new opportunities (Carpenter et al., 2001; Gunderson, 2000). These suggestions likely explain the transition efforts in the Sri Lankan rice cultivation ecosystem towards SA. There are three key predicted controlling variables that could influence farmers in this transition effort as: 'farmer's connectedness to chemical fertilizer', 'farmer's connectedness to organic fertilizer', and 'farmer's perceived effectiveness on governmental incentivization' provided in support of this transition. These three variables are likely to influence the actors in this ecosystem in the form of the stabilization or destabilization of the existing ecosystem.

Demographic factors

Various demographic factors have been identified related to farmers and farmyards that may influence this transition (Table 1). Demographic factors (DF) such as age, education, gender, type of farming method, variety of agro-inputs, and farm plot size are some of these, but are not exhaustive. There is no conclusion in the literature regarding distinct DFs that may have moderating effects on the relationships that apply to this study. The types of demographic factors and their moderating impact on the relationships between variables are contextual and may not suit one survey to another. Therefore, unknown DFs were identified, and their moderating effects were assessed in the conceptual model of this study.

Conceptualizing a framework for the study

The following conceptual framework conceptualizes this study based on the theory of the constructs that may determine farmers' readiness to reorganize their paddy tracks using organic fertilizers. Table 2 describes the latent constructs identified in this study, and the schematic diagram in Figure 2 indicates the relationships predicted between them and their directions. The following section presents the hypotheses and suggestions for assessing farmers based on the objectives of this study. The dependent variable identified for the investigation was farmers' readiness to adapt to OF, whereas the primary independent variable was farmers' SA potential, that is, capital assets. Farmers' readiness to release CF and their perceived effectiveness of Government incentives on SA supports are potential mediating variables that may influence the relationships between the dependent and independent variables. These relationships represent the predictive behaviors of different farmer fractions. Some DFs may moderate the relationship between the independent and dependent variables.

Conceptual framework

Author's own creation

Hypotheses

(1) H1: A positive relationship exists between the farmers' **SA Potential** and their **Readiness to Adapt** to OFOFs.
(2) H2: A positive relationship exists between the farmers' **SA Potential** and their **Readiness to Release** CF.
(3) H3: A positive relationship exists between farmers' **SA Potential** and the **Perceived Effectiveness** of Government incentives.
(4) H4: There is a positive relationship between farmers' **Readiness to Release** CF and their **Readiness to Adapt** OF.
(5) H5: There is a positive relationship between farmers' **Perceived Effectiveness** of Government incentives and their **Readiness to Adapt to** OF
(6) H6: Farmers' **Readiness to Release** CF ***positively influences*** the relationship between farmers' **SA Potential** and their **Readiness to Adapt to** OF OFs.
(7) H7: Farmers' **Perceived Effectiveness** on Government incentives ***positively influences*** the relationship between their **SA Potential** and their **Readiness to Adapt to** OFOFs.
(8) H8: Some demographic factors moderate the relationship between **SA Potential** and **Readiness to Adapt** to OF OFs.

Research method and materials

The proposed measurement model consisted of eight latent variables (FC, HC, SC, PC, NC, FPEGI, FRRCF, and FRAOF). DF is a group variable that represents observable demographic factors. This study aimed to explore the ground reality of farmers' SAP using these variables. Quantitative research approaches using structured questionnaires are often used to investigate socioeconomic and natural phenomena such as those being examined in this study (Cohen et al., 2007; Leedy & Ormrod, 2015). Blanche et al. (2006) suggested a quantitative—descriptive approach to investigate epistemologies related to constructs of this nature. They also used a quantitative descriptive approach for this study. According to quantitative measurement theories (Hair et al., 2017), researchers can derive measurement indicators in two ways, that is, either in a 'formative' or 'reflective' manner. This depends on the nature of the construct of the study, which will be discussed in detail later in this study. Developing indicators, in other words measuring variables, to measure these constructs and selecting an appropriate data analysis method for such a multi-item model were crucial for the success of the study.

Measuring variables

As required by the quantitative research methodology, this research needed an objective approach for collecting and recording data. The survey method captured real-time data on the variables described. Using research instruments with both open- and close-ended questions through survey research for gathering socioeconomic and natural data required for such an analysis are common. The variables in the proposed conceptual framework are latent constructs that could be measured by using observable variables. Observable variables were derived using formative and reflective indicators on appropriate scales. The variables were identified through an exhaustive literature review, pre-testing, and a pilot survey.

Scales and measurement

Determining the scale of the measurement is essential for deriving and framing the questions. Hair et al. (2016) suggested using ordinal scales such as Likert scale coding as a standard to derive similar measures to ensure the equidistance of scale points. They had a strong focus on coding to fulfil the requirement of equidistance when using such scales. Therefore the questions have been framed using the five-point Likert scale with the categories (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree, with the inference that the 'distance' between Categories 1 and 2 were the same as those between Categories 3 and 4. Previous studies have used similar coding (Hosseini et al., 2011; Krishnankutty et al., 2021; Memon Putnam et al., 1993; Purnomo & Lee, 2010). In this context, a 1–5 scale (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree) was considered suitable for this study. The questions were pretested through four scholarly reviews and assessed through a pilot survey to test the validity of the scale and question productivity.

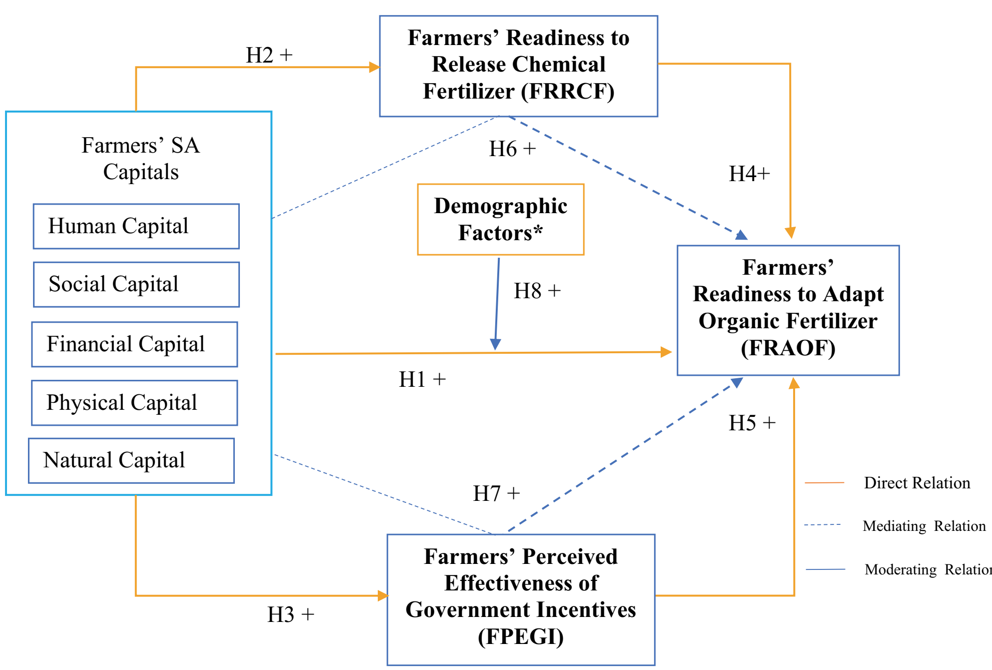

Figure 2. Conceptual framework for the study.

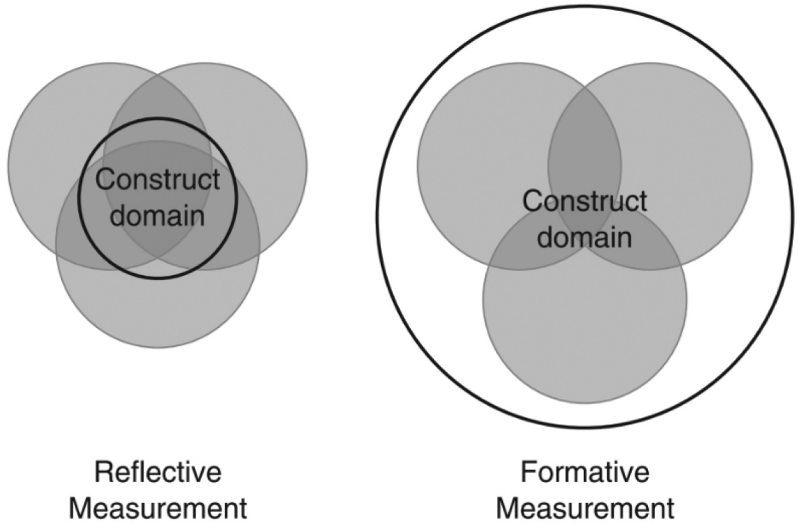

Figure 3. Formative vs reflective indicators. Source: Hair et al. (2017)

Formative and reflective indicators

Diamantopoulos and Winklhofer (2001) suggested the formation of formative indicators if the causal priority between indicators and constructs is from the indicators to the construct. In contrast, if the causal focus is from construct to indicator, reflective indicators are formed. Fornell and Bookstein (1982) suggested formulating formative indicators if a combination of indicators explained the construct, or developing reflective indicators if a trait presents the indicators. Similarly, Rossiter (2002) highlighted the importance of selecting reflective indicators if the indicators represented consequences and formative ones if the indicators represented the cause. Figure 3 demonstrates the coverage differences between these two measurements in these research domains. The formative approach maximized the variance explained by the construct. Maximizing explained variance was a fundamental requirement of this study. That is, we exhaustively identified the underlying variables of each latent construct that would optimally contribute to the formation of constructs. They were required to distinguish indicators to explain each capital asset that did not necessarily correlate with each other but would have contributed to explaining (forming) the construct providing substantial comprehension.

Composition of farmers' sustainable agriculture potential

Insights from the literature have helped to explain the constructs of SAP through a series of indicators derived by referring to the literature, ensuring maximum variance explained on five capital assets.

Farmers' accrued potential

Since farmers are obvious subset of rural livelihood, the researcher maps the 'Accrued Potentials' explained in RT to the capital assets explained in sustainable rural livelihood assessment framework described by (Carney, 1998; Batterbury & Forsyth, 1999; Scoones, 1998). They explain capital assets such as Economic, Social, Physical, Human, and Environmental. Porritt (2011) supplements these explanations by classifying them in the exact five dimensions in a more descriptive framework of the 'Five Capitals Model for livelihood Sustainability'. Combining these two theoretical and conceptual suggestions, the researcher proposes Farmer's SA potential as a composite measure of their Economic, Social, Physical, Human, and Environmental capital. The general definitions of rural livelihood assets (Table 1) helped to formulate farmers' Sustainable agriculture-related livelihood assets, which could contribute to the farmers' SA potential.

Farmers' perceived effectiveness of government intervention

Indicators for the latent construct FPEGI were derived in the formative form to ensure maximum coverage of institutional support in the categories of financial subsidies, materialistic aid, training and capacity building, and supportive policy decisions.

Readiness to release chemical fertilizer and adopt organic fertilizer

According to Webster's New Collegiate Dictionary (online), the definition of readiness is to be 'prepared mentally or physically for some experience or action'. Researchers have used this definition to assess personal readiness in various disciplines (Borotis & Poulymenakou, 2004, So & Swatmanc, 2006; Purnomo & Lee, 2010). Purnomo and Lee (2010) further synthesizes personal readiness in four dimensions, that is, physical readiness, technological readiness, psychological readiness, and economic readiness, in their study of assessing agriculture officers' readiness to use mobile phones. Building on the insights from these suggestions from the literature, these four dimensions of readiness are applicable to measuring farmers' readiness to move away from CF and implement OF practices, with careful explanation through variables. Farmers who show strengths in the four readiness dimensions would effectively continue farming, adhering to more SA standards than others, and vice versa.

Definition of indicators to measure the constructs

Table 2 shows the indicator framework, a summary of the literature review which guided the development of research questionnaire.

Research questionnaire

The literature review produced 21 groupings (demographic) questions and 175 formative and reflective questions that explained the latent contracts in the model. Four scholarly reviewers commented on improvements to the initial questionnaire. Subsequently, a lengthy questionnaire was administered in a pilot survey of 64 samples. The pilot survey data were analyzed using PLS-SEM techniques following the laws and rules explained in the literature (Hair et al., 2017). The researcher conducted data analysis in two stages, that is, measurement and structural models (The same approach described below the section of data analysis). The pilot survey yielded 119 questions (DF = 9, HC = 17, SC = 20, FC = 17, PC = 18,NC = 15, FPEGI = 15, FRRCF = 4, FRAO = 4) 110 productive questions to assess latent constructs and nine influential demographic factors for further investigation in the main study, as shown in Annex B. The questionnaire produced through the literature review and tested through the pilot survey was found to be suitable for the study. It took 30–40 min for an average respondent to answer all the questions.

Data analysis techniques

In Structural Equation Modeling (SEM) methods, Covariance-based (CB-SEM) and variance-based Partial Least Squares (PLS-SEM) are two different SEM analysis techniques. CB-SEM has primarily been used to confirm the established theory, whereas PLS-SEM is a prediction-oriented approach to SEM that has primarily been used for exploratory research and is appropriate for confirmatory analysis (Byrne, 2003; Chin et al., 2003; Joreskog & Herman 1982; Sarstedt et al., 2014). Mutyasira et al. (2018) used PLS-SEM in SA assessment-related studies because it is a nonparametric method that makes no assumptions regarding data distribution (Sarstedt et al., 2014). The primary objective of this study was to explore the relationships between latent and observable constructs developed based on predictions suggested using Resilience Theory (RT). The PLS-SEM method was used for data analysis in this study.

Study population

Smallholder farmers who cultivated less than two acres of rice farm plots have contributed to 70% of paddy production in the country. Meanwhile, farmers who hold 2–5 acres have contributed a further 25%. These statistics have indicated that the extent of cultivation was a fair representation of the farmer population density. Anuradhapura district accounted for 16% of total paddy cultivation in the country in terms of gross sowing extent. It represented all three primary irrigation schemes, that is, major, minor, and rain-fed. This study selected a sample population from Anuradhapura district, considering the significance of the cultivation volume and ensuring a diverse representation of irrigation methods.

In 1984, the government launched a turnkey project, 'Mahawali', to improve the national irrigation system. The Mahaweli scheme comprises five main blocks, that is, B, C, G, H, and Udawalawe. The Mahaweli H zone belonged to the Anuradhapura District. Mahaweli Block H was suitable for this study because of its socioeconomic importance. This selection was considered as an opportunity for assessing the long-term impact of socioeconomic changes undertaken in these regions under the Mahaweli Program in the 1980s on farmers. Figure 4 shows the geographical layout of the blocks and the extent of rice sown.

Selection of sample size

According to Han et al. (2019), 225 farmer organizations and 25,623 registered members were located in Block H of Mahaweli. Aheeyar et al. (2007) found that 94% of the farmers in Block H were engaged in rice cultivation. Israel (1992, 2013, pp. 3) developed a reference table to determine the sample size based

Table 2. Variables in the model

Variable	Type	Category
Farmers' SA Potentials(FSAP)	*Composite*	*Latent*
Human Capital (HC.)	*Independent*	*Latent*
Social Capital (S.C.)	*Independent*	*Latent*
Financial Capital (FC)	*Independent*	*Latent*
Physical Capital (PC.)	*Independent*	*Latent*
Natural Capital (N.C.)	*Independent*	*Latent*
Farmer's Perceived Effectiveness of Government Incentives (FPEGI)	*Mediating*	*Latent*
Farmer's Readiness to Release Chemical Fertilizer (FRRCF)	*Mediating*	*Latent*
Farmer's Readiness to Adapt Organic Fertilizer (FRAOF)	*Dependent*	*Latent*
Demographic factors (DFs)	*Moderating*	*Observed*

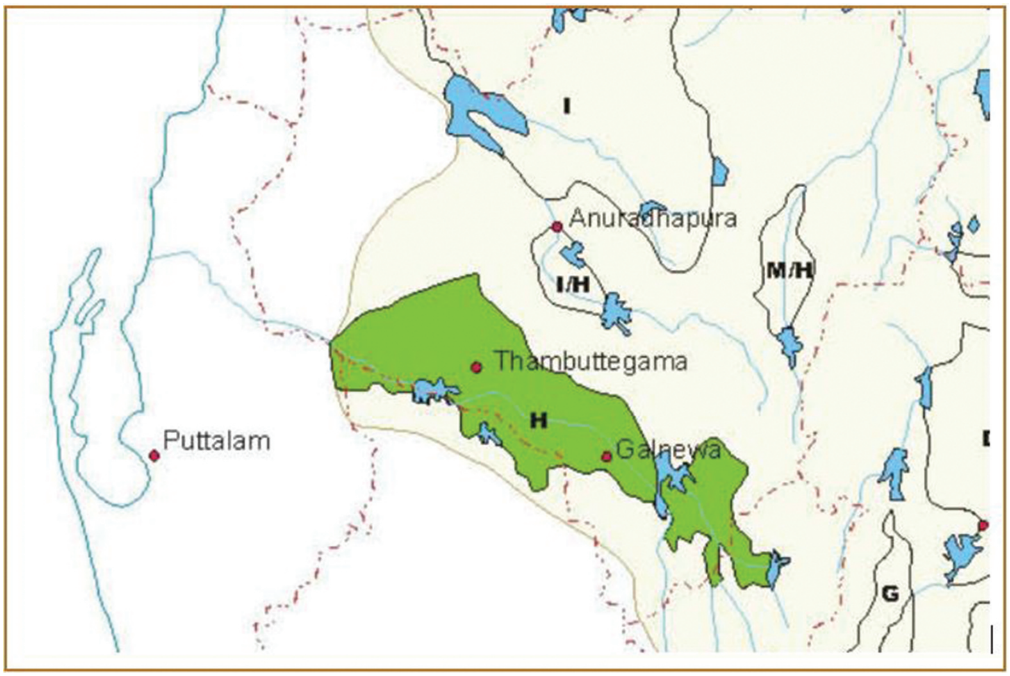

Figure 4. Geography of Mahaweli system H block. Source: Aheeyar et al. (2007).

on parameters related to the study population and probability. According to this reference table, the study population required a sample size of approximately 400[2]

This estimate complied with the calculations suggested by Krejcie and Morgan (1970), who used 379 samples for a study population of 25,000 individuals. According to Hair et al. (2011) and Marcoulides and Chin (2013), the minimum sample requirement for PLS-SEM application for this path model was at least 160, according to the 10th time rule explained in PLS-SEM (Hair et al., 2017). In line with these suggestions, the required sample size was determined to be 380 participants, as shown in Table 3.

Data collection techniques

Three key informants selected directly associated with rice cultivation activities in these divisions

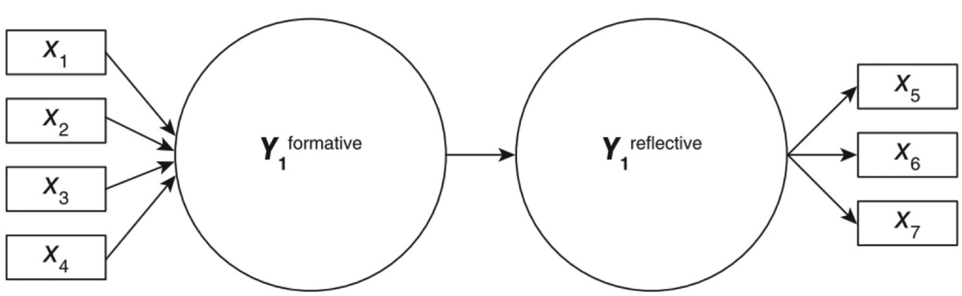

Figure 5. Model to measure convergent validity of formative indicators. Source: Hair et al. (2017).

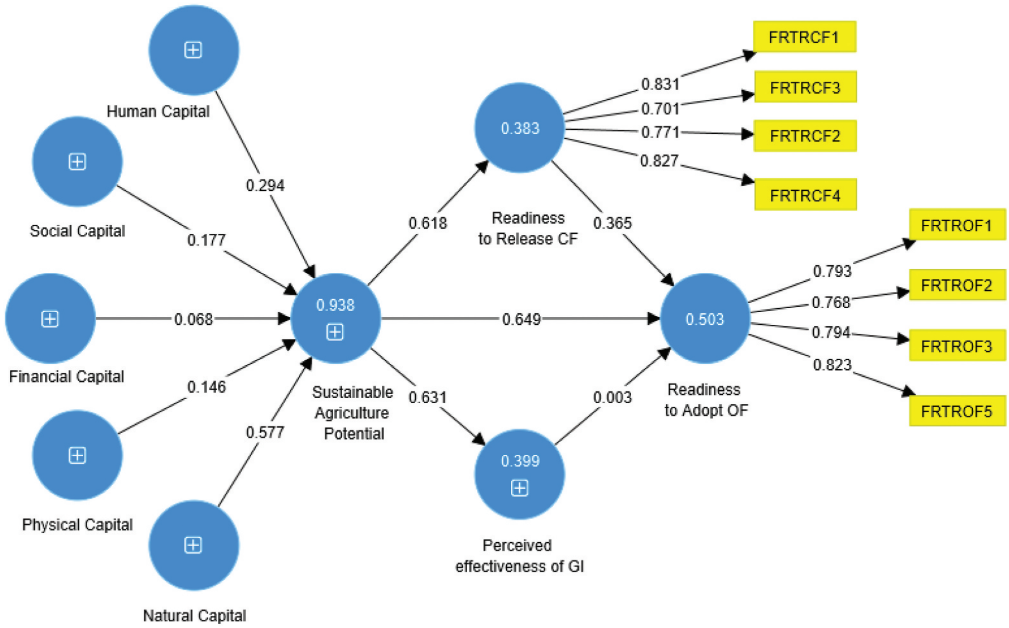

Figure 6. Model analysis stage 1 with total effects and R^2.

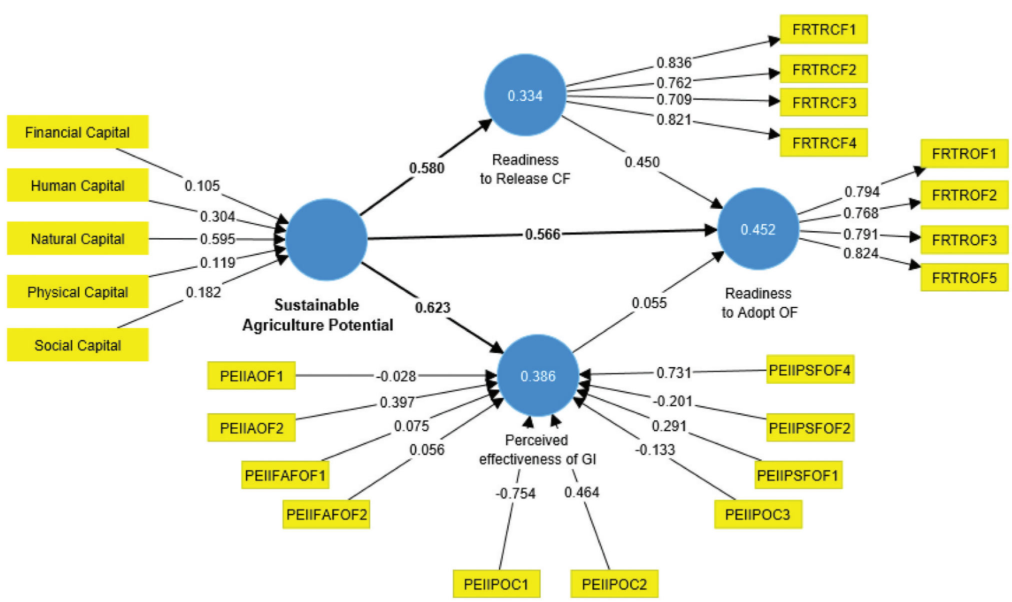

Figure 7. Model analysis stage 2 with total effects and R^2.

administered data collection with their teams. The key informants ensured the random selection of respondents from each division to minimize sample bias. Data were collected between October and November 2022.

Data analysis

The conceptual model of this study consisted of identical measurement and structural models, as explained in the structural equation modelling (SEM) theory. Therefore, data analysis was performed in two phases for each model, following suggestions from the literature. The outer variables (indicators) of the measurement model were initially analyzed to assess their validity and relevance. The variables qualified through the measurement model for the next stage were then used to analyze the structural model and inner variables (latent constructs). The structural model estimated the effects of the model path coefficients. Literature on SEM analysis were used for the measurements, structural model analysis, and conclusions (Hair et al., 2017). This approach was the same as that used in the pilot and main studies.

Measurement model analysis

The measurement model analysis included assessing the outer variables' quality, reliability, and validity before incorporating them into the structural model analysis. As explained in the previous chapter, the research model of this study contained six formative constructs measured compositely using a set of indicators. These two constructs were investigated using a set of reflective indicators. The remaining factors were demographic factors. The steps of analyzing formative and reflective indicators differed from one another. Therefore, formative and reflective measurements were assessed in sequence, following suggestions found in the literature for each type.

Analysis of formative variables

PLS-SEM suggested applying the following steps in sequence to assess the formative indicator models. The model was analyzed using 386 samples selected after the initial data cleaning of the 400 samples collected during the survey. The analysis was performed using the following steps:

Step 1: Assess the **convergent validity** of the formative measurement model

Table 3. Indicator framework -variables, indicators, and scales of measurements

Latent variables	Indicators	Scales of measurements
Farmers' Sustainable Agriculture Potentials		
Human capital *Memon Putnam et al. (1993) Petway et al. (2019); Porritt, Porritt (2011);* Radcliffe (2017)	*Literacy level, Experiences, Skills, Household health, Living standards*	*Level of education, knowledge of SA, Number of years in farming* *Other non-farm skills being practised are, Ability to use household labour, presence of good household health, level of motivation, norms, and beliefs on SA*
Social capital *Rust et al. (2021); Putnam et al. (1993),* Bourdieu (1986) Melles and Perera (2020)	*Trust, Norms, connectedness, Power, Reciprocity, Network structure*	*Increase in other assets due to membership or participation in Social networks, Labour support from group members, Income gained through membership in groups, Use of group tools, equipment, and infrastructure, Trust in communities and farmer organization, Strength of Communication channels, Food, labour, and other resource sharing practice*
Financial capital *Mulimbi et al. (2019); Kiptot et al. (2014);* Bowers (1995)	*Direct and indirect financial benefits, Savings, and Debts*	*Crop yields as a proxy—e.g. kilogram per hectare produced in last season, last drought or flood affected frequencies, Income/yields, Savings, Labour income, Expenditure/ Dependency ratio; off-farm income,*
Physical capital *(Myeni et al., 2019), (Arellanes & Lee, 2003,* Petway et al. (2019)	*Machinery, Buildings, Equipment, Cultivation well, Granary, Tools and equipment, Transport networks*	*Ownership and access to resources, Assessing levels and changes in conditions of and access to livelihood capitals, Asset ownership*
Natural capital *Scherer et al. (2018);* Bisht (2013); *Serebrennikov et al. (2020); D'souza (D'souza et al., 1993); Bowman and Zilberman (2013);* Bowers (1995)	*Soil, Water, Energy* *Biological resources*	*Soil fertility (nutrients), soil organic carbon, agroforestry, and tree carbon, soil moisture content, biomass, runoff/ erosion, pests, diseases observations and measurements, nature of neighbouring land, water availability recyclability of resources and waste minimization, the impact of weather events and climate change*
Farmers' Resilience Adaptiveness		
Release *Darnhofer et al. (2010),* Oelofse and Cabell *(2012),* Melles and Perera (2020)	*Ability to release and adjust*	*The disturbance requires some adjustment at the farm level. These can include new production methods, new crops, introduction or removal of animal husbandry, on-farm processing, direct marketing, etc*
Reorganize *Darnhofer et al. (2010),* Oelofse and Cabell (2012), Melles and Perera (2020)	*Ability to realignment*	*The perturbation requires a significant realignment of the resources and may involve introducing activities outside the traditional farming realm. These can include Agri-tourism, care farming, energy production (e.g. electricity from biogas, windmills, or photovoltaic panels), etc.*
Government interventions		
Institutions (Government interventions) Clune (2019), Demont and Rutsaert (2017), *Von Loeper et al. (2016)*	*financial and material subsidiaries, Professional support, Supportive policy on the environment, Timely education and training, Link supply chain and markets,*	*financial and material subsidies on public/private goods; influential role in knowledge development, transformation, and management, Support through policies, rules, and local norms; governing land and water use, enforcement of laws and regulations; managing land and water and environment preservation, government encouragements/promotions on collective action support to/partnerships development with the value chain actors (banks, insurance, research, private sector),*

Step 2: Assess the 'formative' measurement model for **collinearity issues**

Step 3: Assess the **significance and relevance** of the formative indicators
(Hair et al., 2017)

Assessing convergent validity

Assessing the convergent validity of the latent construct was the first step and required a unique analytical technique. The method suggested in the literature for convergent validity (CV) testing was used to measure and evaluate formative measurement indicators. The method analyzed the CV of formative constructs by calculating the correlation of formative measurement with alternative reflective measures of the same construct, that is each construct is considered as separate sub-models as 'construct-formative' and construct-reflective" as shown in Figure 5. The formative indicators formed the formative latent construct linearly, and the explained variance (R2 value) of the compositely created latent construct should equal 1 in an ideal situation (Bollen & Bauldry, 2011, 2011)

The SmartPLS4 software output of each latent construct sub-models and an assessment of the results are included in Annex 1.

Analysis of reflective variables

The measurement model consisted of eight reflective variables (indicators) explaining two latent constructs of farmers' readiness to implement OF and move away from CF The criteria for analyzing reflective data in PLS-SEM differed from those in the formative analysis. In PLS-SEM, researchers applied the following rules and statistical parameters for reflective measurement analysis:

- Internal consistency (Cronbach's alpha, composite reliability)
- Convergent validity (indicator reliability, average variance extracted)
- Indicator reliability
- Discriminant validity

Hair et al. (2017)

The results of the reflective indicator assessment are included in Annex 1.

Summary of measurement model analysis

The completion of formative and reflective variable analyses led to measurement model analysis. The indicators shown in Annex 1 are suitable for the structural model analysis section of this chapter which explains the steps and results of the structural model evaluation.

Structural model evaluation

The conceptual model designed for this study involved testing higher-order structures containing two construct layers. Such models are known as hierarchical component models (HCMs) in PLS-SEM (Lohmöller, 1989). The model's second-order construct, SAP, consists of five formative constructs (five capital assets) that capture the different SAP attributes separately. Hierarchical approaches have been used previously when analyzing complex models, such as this one (Jarvis et al., 2003; Sarstedt et al., 2014; Wetzels et al., 2009),

The HCM model in this study characterized a formative—formative nature, where higher-order constructs (HOC) and lower-order constructs (LOCs) were measured using formative indicators. In analyzing such models, researchers usually assigned all indicators from the LOCs to the HOC. This is known in the literature as the repeated indicator approach (Hair et al., 2016). When implementing this approach, all formative indicators describing the five capital assets are repeatedly used to measure SAP in the model. However, the literature explains potential issues when modeling formative—formative and reflective—formative HCMs using a repeated indicator approach. In such settings, variance in the HOC is explained by its LOCs, yielding an R^2 value close to one. Consequently, any additional path coefficients other than those of the LOCs can become relatively small and insignificant (Ringle et al., 2015).

To address this issue, a combination of the repeated indicator approach and latent variable scores should be applied in a two-stage HCM analysis. In the first stage, a repeated indicator approach was used to obtain the latent variable scores for the LOCs. In the second stage, the LOC scores were used as the manifest variables in the HOC measurement model. The two-stage approach was found to be appropriate for this model analysis and was implemented. Therefore, the model was initially analyzed using a repeated indicator approach. Figures 6 and 7 show the results of these two stages.

Testing of hypotheses

The model in Stage 2 was used to test the following hypotheses. Five hypotheses represented the model's path coefficients, and the other two reflected the indirect mediating effect of the FRRCF and PEoGI variables. The eighth hypothesis investigated the potential moderating effects of demographic factors. Figures 8 and 9 depict the path coefficients and total effects of the model after applying the PLS-SEM algorithm using the SmartPLS4 software. The path coefficients of the model represent the first five hypotheses. The difference between the value of the path coefficient and the total effect of the relationship between SAP and RAOF represented the sixth and seventh hypotheses showing the predicted mediating effects of the RRCF and PEoGI constructs on the relationship between SAP and RAOF.

Tables 4 and 5 show the four predicted hypotheses out of the first five, with a statistical significance of 0.05. The fifth hypothesis, that is, farmers' perception of the effectiveness of government interventions was weak and not statistically significant (0.454).

Table 6 presents the indirect effects representing the model's sixth and seventh hypotheses. The sixth hypothesis exists, and the seventh hypothesis was weak and not statistically significant. The seventh hypothesis of the model was linked to the fifth hypothesis, which was relatively weak, and led to these results.

The eighth hypothesis investigated the moderating effects of demographic factors and found that five demographic factors, as shown in Table 7–8, moderated the relationship between farmers' SAP and RAOF. The findings were statistically significant with a probability value of 95% or closer.

Importance and performance analysis

The importance—performance map analysis (IPMA) available in the PLS-SEM techniques was used to assess the strength of the individual contributions of the latent constructs to their predecessor variables (Figure 10). IPMA adds a two-dimensional view to the analysis that compares the average values of the latent variable scores and variables' effects (Fornell et al., 1996; Höck et al., 2010; Kristensen et al., 2000; Slack, 1994).

In summary, the analysis was concluded with the acceptance of six of the eight hypotheses defined in the study. The predicted positive relationship between the farmers' perceived effectiveness of government incentives and their readiness to implement OF of the fifth hypothesis did not exist. This nonexistence also causes the rejection of the seventh hypothesis, which was interlinked with the seventh hypothesis. Five demographic factors showed moderating effects on the relationship between farmers' SAP and their readiness to implement organic farming. The results have highlighted the present characteristics of on the ground reality, and the results could differ in the assessment of another cross section. However, the objective of this study was not theory testing but rather the use of theory to explore the unknowns of the subject matter. Therefore, no alternative model was proposed based on these results.

Discussion and conclusion

Farmers' connectedness to organic fertilizers

The conceptual model predicted that farmers who possess substantial accrued capital assets and maintain ties with organic fertilizers are likely to implement more organic use in farming. The results have shown a transition rate of approximately 30% for farmers with strong SAP to organic, with no mediating effects. Another 26% were ready to move to organic farming given that they are prepared to disconnect from CF. There were no farmers that would switch to organic because of various incentives provided by the government. The frequency analysis has shown that farmers' knowledge of organic agriculture and attitudes toward implementing more organic use practices were moderate (60%). However, only 19% of farmers were fully ready to embrace organic farming. This has demonstrated the inadequate maturity of the natural capital of this farming livelihood and the farmers' lack of resilience in risk-taking on the perceived decline in economic gain. Natural capital is the most influential capital asset in organic adaptation, followed by Human capital. Social capital is the strongest but less effective than financial capital. Physical capital is weak and less influential in forming SAP. Waseem et al. (2020), Dharmawan et al. (2021), and (Krishnankutty et al., 2021) concluded that social, economic, and structural factors influence farmers' readiness for more SA. This study has found that natural capital was the most influential farming asset which has highlighted the need for improvement.

Importance of improving natural capital

Of the five capital assets, the farmers' natural capital was the most prominent contributor to their preparedness for organic farming. In-depth IPMA analysis of each indicator of natural capital showed that improving the farm plot soil fertility and the soil structure were the dominant factors affecting farmers' motives for moving to more organic use agriculture. Supplementing this finding, Nederlof E. S. and Dangbégnon (2007) emphasized the need for an integrated soil fertility management approach for sustainable agriculture. Improvement through

Table 4. Number of samples by each division

Cultivation divisions in Block H	Sown Extent	Number of samples Estimated
Galnewa	9082	60
Meegalewa	5220	34
Galkiriyagama	5367	35
Madatugama	7307	48
Eppawela	8122	53
Tabuttegama	7129	47
Nochchiyagama	8257	54
Thalawa	7437	49
Total Mahawali (H) Block	57921	380

Table 5. Hypothesis testing—path coefficients

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Perceived _effectiveness of GI -> Readiness_ to Adopt OF	0.055	0.066	0.074	0.749	0.454
Readiness to Release CF -> Readiness_ to Adopt OF	0.450	0.446	0.065	6.890	0.000
Sustainable _Agriculture Potential -> Perceived _effectiveness of GI	0.623	0.613	0.163	3.815	0.000
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	0.271	0.269	0.083	3.257	0.001
Sustainable _Agriculture Potential -> Readiness to Release CF	0.580	0.584	0.037	15.605	0.000

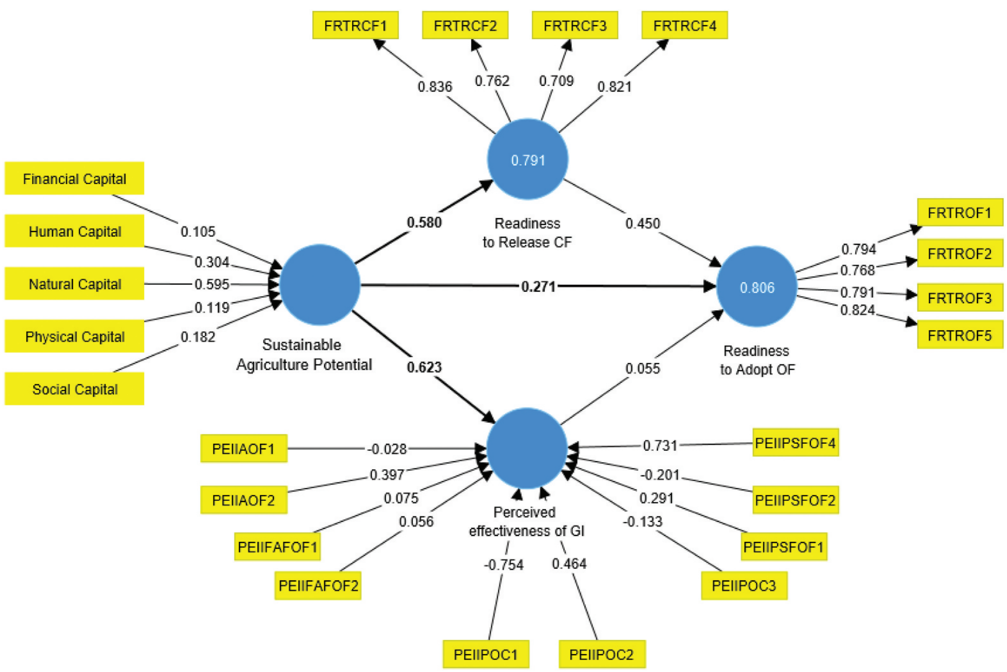

Figure 8. Model with path coefficients.

organic manure, fertilizers, and cover crops was suggested. Kankwatsa et al. (2019) found that laboratory analyses of composite soil samples showed that the soil's physical and chemical properties depended on previous cropping patterns, soil management practices, and soil characteristics. However, there was no evidence from laboratory tests conducted on the soil samples in this region. Testing for soil is of prime importance, which is in line with Wijesinghe's (2021) suggestion of location-based soil testing and the provision of fertilizer at a subsidized price, more scientifically based on soil conditions.

Traditional soil fertility management practices

Indigenous rice farmers previously practiced a systematic approach and used scientific techniques for land preparation and soil fertility management (Irangani & Shiratake, 2013). However, these farming practices have become extinct in the region. Before planting, they determined

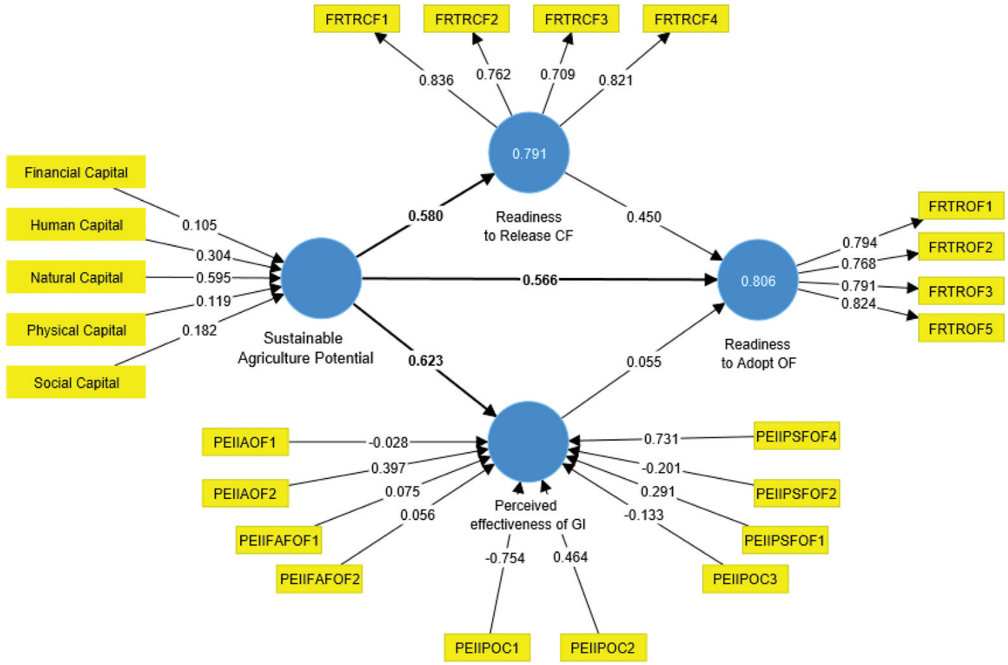

Figure 9. Model with path total effects.

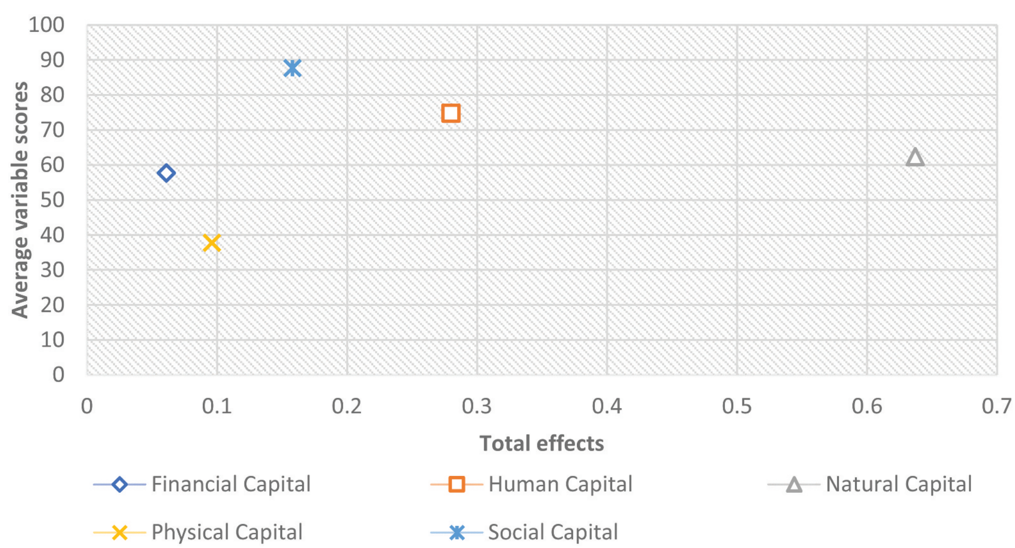

Figure 10. Importance and performance map of capital assets on FRAOF.

the appropriate land preparation time based on the rainfall pattern and lunar calendar, using auspicious times (Nekath, Karna, Hora, and Yoga). The farmers generally began their land preparation activities with monsoon rainfall, which usually started in September (Ak rain[3] 'wessa'), after the long dry season. The farmers cut the bushes and cleared the fields, retaining the debris in the paddy field, which gradually decomposed and provided soil nutrients. In addition, farmers knew the importance of intercropping, mid-season cropping system techniques, and releasing cattle into rice fields. The intercropping method was applied by cultivating crops on ridges or at selected sites. Mid-season cropping involved scattering the seeds of pulses, legumes, and large-seeded cereals a week before the rice harvest (Irangani & Shiratake, 2013; Authors' childhood memory and experiences). In recent years, farmers have neglected these soil fertility management practices. Farmers no longer practice these methods. Krishnankutty et al. (2021) concluded that traditional rice cultivation was profitable and recommended scaling production up in

Table 6. Hypothesis testing—total effects

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Perceived _effectiveness of GI -> Readiness_ to Adopt OF	0.055	0.066	0.074	0.749	0.454
Readiness to Release CF -> Readiness_ to Adopt OF	0.45	0.446	0.065	6.89	0
Sustainable _Agriculture Potential -> Perceived _effectiveness of GI	0.623	0.613	0.163	3.815	0
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	0.566	0.57	0.046	12.199	0
Sustainable _Agriculture Potential -> Readiness to Release CF	0.58	0.584	0.037	15.605	0

Table 7. Hypothesis testing—indirect effects

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Sustainable _Agriculture Potential -> Readiness to Release CF -> Readiness_ to Adopt OF	0.261	0.259	0.038	6.852	0.000
Sustainable _Agriculture Potential -> Perceived _effectiveness of GI -> Readiness_ to Adopt OF	0.034	0.042	0.046	0.743	0.458

Table 8. Hypothesis testing—moderating effects of demographic factors

Path coefficients	Difference	1-tailed	2-tailed
	(Gender = M—Group = F)	(Gender = M vs Group = F) p value	(Gender = M vs Group = F) p value
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	−0.166	0.966	0.068
	(<O/L—OL or >OL)	(<O/L vs OL or >OL) *p* value	(<O/L vs OL or >OL) *p* value
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	0.194	0.019	0.038
	(Inputs—Mixed (More chemicals)—Inputs -Other)	(Inputs—Mixed (More chemicals) vs Inputs -Other) p-value	(Inputs—Mixed (More chemicals) vs Inputs -Other) p-value
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	−0.185	0.974	0.053
	(Method-(Mixed -more modern)—Methods-other)	(Method-(Mixed -more modern) vs Methods-other) *p* value	(Method-(Mixed -more modern) vs Methods-other) *p* value
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	−0.163	0.966	0.068
	(Extent −2.5 Acre—Extent other Acres)	(Extent −2.5 Acre vs Extent additional Acres) p-value	(Extent −2.5 Acre vs Extent other Acres) p-value
Sustainable _Agriculture Potential -> Readiness_ to Adopt OF	0.149	0.041	0.081

developing countries. Wang (2018) asserted that integrating indigenous and scientific knowledge is a way to balance the economic and ecological dimensions of sustainable agricultural development. The conclusions of the previous studies supplement those of the present study.

Effective irrigation systems

Current water management practices do not improve the preparedness of farmers for organic matter. Approximately 40% of farmers are dissatisfied with the waterworks, and the scheduled water releases for farming have demonstrated the inefficiencies of these irrigation schemes. Some farmers were satisfied with the current water release scheme but did not contribute to organic adaptation. Farmers depend solely on chemicals to control weeds. This evidence has highlighted the impact of irrigation bureaucracy deciding the quantity and time of water delivery with no provision for coordination with the ability of farmers to use water (Herath, 1981). Continued flooding helps ensure sufficient water and weed control (IRRI, 2019), and irrigation systems should consider this need. The need for effective water management has been highlighted by the findings of Serebrennikov et al. (2020). The importance of water conditions in soil nutrient management is an essential part of SA, as Kiełbasa et al. (2018) highlighted. An immediate expert revision of field irrigation canals (waterworks), maintenance of surrounding bunds, cropping fields, and timing and volume of water release is strongly suggested. Modifications to these areas and scientific recommendations are essential before the next revision of the policy and regulatory framework for transitioning cultivation to a more sustainable path using organics (IRRI, 2019).

Integrated pest management control

According to a survey, farmers were unaware of integrated pest management systems. Indigenous knowledge should be incorporated into contemporary pest and weed control, while promoting integrated pest management plans (Legg & Viatte, 2001; Senanayake & Premaratne, 2016; Šūmane et al., 2018). This is in line with the findings of Wang (2018) regarding the need for more scientific research to examine the scientific underpinnings of indigenous knowledge, and particularly its ecological implications. Developing integrated pest management control knowledge and practices that blend modern and traditional approaches is one way of reducing chemical use and shift to more environmentally friendly rice farming. As Wang (2018) has highlighted, China's agricultural system can draw lessons from conventional farming practices, which apply to Sri Lanka, given that rice farming has historically evolved around high levels of natural resources in this tropical country.

Use of green manures

Knowledge of leguminous green manure as a reliable alternative for nitrogen is rare in farming communities in this rice-farming region. Nayak et al. (2012) studied the long-term effects of different integrated nutrient management methods on soil organics in the Indo—Gangetic plains in India. They found that farmers could fulfil 100% of their nitrogen needs from leguminous green manure. Farmers in this region also met half of their fertilizer needs from farmyard manure, crop residue, or green manure. Roger et al. (1991) suggested the use of biological nitrogen fixation as an alternative or supplementary nitrogen source in rice farming. According to them, nitrogen-fixing green manures (azoda and legumes) have been used for centuries in some rice-growing areas in the wetlands of the Philippines. Altieri (1995) proposed the production of high-volume green manure biomass, such as lupin, to improve soil nitrogen content.

Although the feasibility of using green manure widely in Sri Lankan rice farming is scientifically unknown, there is likely a missed opportunity for research and development of green manure use in this tropical country. *Mimosa pudica* (Nidi Kumba) belongs to the legume family and is widely grown in Sri Lanka. In the past, we learned about the potential for using such plants as nitrogen sources in our school's agricultural lessons. However, most of us may not have seen them being used practically as nitrogen sources in the country. The formation of appropriate knowledge on green manure and domestic organic substances for more sustainable agriculture by blending the best traditional knowledge with modern knowledge that suits the present conditions and demands is of prime importance.

Other capital assets

The strengths of human and social capital were comparatively less influential in preparing farmers for organic farming, as was financial capital, which was moderately strong in the average latent variable score. Weak physical capital is an area for broad improvement. Improving farmers' capital assets in SAP requires strategies for more value chain inclusion in the rice farming sector. The World Bank (2009a, 2009b) has emphasized the need to integrate many different sources of agricultural innovation and actors in the value chain, including researchers, farmers, CSOs,[4] and the private sector. Social recognition and approval are factors that motivate farmers to adopt organic materials.

Leveraging the risk management abilities of farmers can ensure that they are ready for the implementation of organic farming. This study has highlighted the high impact of insurance schemes on farmers' readiness for organics, despite only a few insurance schemes being operational. The need for crop insurance schemes and their effectiveness in leveraging farmers' resilience to change have also been discussed and suggested by Thorbecke and Svejnar (1987) and Weerahewa (2006). This research has shown the poor performance of private and public banks and the mass media in support of SA.

Farmers' connectedness with chemical fertilizers

The model predicted that farmers' composite SAP accrued annually would prepare them to move away from CF and navigate along the adaptive resilience cycle during this transition more than others would. The prediction exists, and a unit variation of the SAP influence (0.58) variation on farmer readiness to move away from using chemical fertilizer in the present context. This finding means that 42% of farmers would resist avoiding chemicals, although they are sound on SAP. Of these ready-to-release chemicals, 13% are not fully prepared to implement organic farming. This implies that some farmers realize the need to minimize the use of chemicals, but do not trust organic fertilizers as an alternative.

Farmers' strong connectedness to CF over the decades has been an obstacle to minimizing chemical use in farming. The Sri Lankan government accorded substantial amounts of chemical fertilizer imports and provided subsidies to farmers in the late 1950s under various schemes. Farmers rely heavily on subsidy-driven chemical used rice farming. The survey results have demonstrated that only approximately 20% are ready to move to organic farming. Farmer strengths in terms of physical and financial assets are less productive, making them more prepared to reduce their chemical use. Nevertheless, government subsidy schemes have progressively focused on providing chemical fertilizers free of charge or equivalent monetary subsidies to rice farmers (Department of Census and Statistics, 2021; 1962). This grant scheme will further connect farmers with chemicals.

The results of this study have shown that most farmers are aware of the detrimental environmental and social effects of the intense use of chemicals in rice farming. In this rice cultivation region, 73% understood that CF used farming was not the way forward and 63% realized the harmful effects of intense chemical use in farming. However, approximately 80% are still tightly connected with CFs, because no other viable alternative exists. There is no understanding of actual profitability because farmers receive CFs free of charge or at concessional rates. Rodrigo and Abeysekera (2015) found that higher fertilizer use increased paddy production. However, the fertilizer price did not necessarily increase or decrease production, and the fertilizer subsidy scheme firmly controlled it. Farmers' connectedness with CF is related to government subsidy schemes for chemical fertilizers. These findings support Weerahewa's et al. (2021) discussion and conclusions regarding nonscientific government policy actions on chemical fertilizer imports and subsidies.

Since the Green Revolution, governments have shifted their attention from environmentally friendly farming to the instant intensification of production volumes. The unstoppable fertilizer subsidies that we see today are the result of such initiatives. In addition, traditional organic-friendly rice varieties have been replaced by chemically sensitive, high-yielding varieties. However, these findings remain controversial. One-sided initiatives that disregard local potentialities have received broad criticism from experts (Kikuchi & Aluwihare, 1990; Weerahewa et al., 2010). We have observed these consequences.

Perceived effectiveness of government support

Farmers with a strong SAP perceived government support as moderately effective. These perceptions relate to the support they have received from chemical fertilizers over the past decades. The government has recently launched support schemes for organic agriculture, but promises have not motivated farmers to move to organic used agriculture. Evolving such a relationship towards more organic used farming cannot occur overnight. There was a critical shift in rice cultivation in the country in the late 1950s and the early 1960s. This era is widely known as the Green Revolution and the beginning of chemical introduction into cultivation (Herath, 1981). However, this shift did not occur overnight. Farmers gradually implemented the use of these chemicals after strong initial resistance to the move. Likewise, the ongoing transition from chemicals to organic compounds requires progressive change.

As Herath (1981) and Weerahewa et al. (2021) have highlighted, rice self-sufficiency has been the fundamental driving principle of Sri Lankan government policies, which is likely to continue. However, substantial adjustments to the scale and direction of assistance provided to the rice sector during this transition are critical for success. The productivity and competitive advantage of organic rice production within sustainable agricultural principles requires further research and development. Government support should exceed grants for R&D instant cash grants to rice farmers would compel them to stay in their comfort zones for chemical use. This situation provides an opportunity to assess the productivity and profitability of chemical-driven paddy production and determine the correct mix of chemicals and organics. The input costs are not adequately known and perceived by farmers because government grants heavily subside the inputs, which requires deep analysis.

Impact of demographic factors

The future of rice cultivation depends on younger farmers and their readiness determines the direction of the transition. There was no explicit finding of an age-wise influence on the relationship between farmers' SAP and their readiness to adapt to OF. However, the study has shown that some young farmers, although willing to release chemicals, have shown resistance to moving into organic farming. This implies that some young farmers understand the need to minimize CF. However, organic adaptation has not been proven to be a solution.

Female farmers are more inclined toward more organic used cultivation than males in this region. This finding was statistically significant in the two-tailed test, which indicated that female farmers possessing a strong SAP showed more readiness than others, and vice versa. Until the late nineties, females contributed substantially to rice farming in Sri Lanka. Females were a driving force for rice cultivation when transplanting dominated in that era as the best sowing method. Gradually, direct broadcasting methods have become dominant and have slowly removed females from rice farming. Research institutes and authorities should rethink the seed varieties that have worked effectively in the past for transplanting methods and consider a balance between the sowing methods of transplanting and direct sowing. This approach could attract more females to farming and create domestic job opportunities with fewer sociocultural side effects. The influence of females on more organic used farming is rare in the literature, and Mishra (2017) found similar characteristics in females' higher readiness to implement organic farming than males.

Farmer education moderates farmers' readiness to implement organic practices reversely. Farmers who did not reach the ordinary standard level of the national education system were more enthusiastic about organic matter cultivation than those with higher education. The two-tailed finding was statistically significant, indicating that farmers who were less educated and affluent in the SAP showed a higher readiness for organic matter than others, and vice versa. Knowler and Bradshaw (2007) examined 31 studies related to farmers' readiness for conservation agriculture practices and found that education was positively significant in seven, negatively significant in three, and insignificant in the remainder.

As predicted, farmers implementing more modern methods have had less interest in moving to organic than others, as is the case with farmers who are biased toward more chemical agro-inputs. The farmers who consistently grow 2.5-acre rice plots, who are potentially the original 'Mahawali rice farmers', are more ready to move into organic than others. In addition, Knowler and Bradshaw (2007) found that farm size was positively influenced in six studies and negatively influenced in two, whereas the rest were not significant.

Conclusion

Various studies have examined farmer readiness to implement sustainable or conservative agricultural practices (Table 1). Farmer and farm-year characteristics as well as the socioeconomic and ecological factors influencing them to adopt more SA practices have been investigated. However, the framework developed to assess farmer SA potential and conceptualize a way of determining their resilience to a force imposed on the ecosystem is novel. This conceptual model can be replicated in future studies.

The approach of an exhaustive literature review to derive the indicators of the construct in a formative manner, pre-testing the long list of indicators in a pilot survey, and the use of PLS-SEM techniques for dimension reduction (PCA) proved to be a practical methodology to ensure the maximum variance explained in each construct. We believe that future researchers should consider this innovative approach in their future research.

The results have shown that farmer SAP influenced their readiness to adopt more organics in farming. The strength of SAP towards organic adaptation explained in this study is approximately 57%, if 100% is the optimal condition. It is clear from this research finding that economic readiness curtails the ability of farmers to release and implement CFs. It is not only the farmers' weak financial capital that causes this obstacle. Instead, the issue evolves around the productivity and profitability of the outturn. These results are in line with those of Wang et al. (2021), suggesting that using environmentally friendly technology may increase productivity, which is also viable for farm profitability. The research findings have shown that natural capital is the most influential asset in adapting more organics in farming. This study has identified that the most effective way to improve natural capital applicable to the local context is challenging. As Ashley and Carney (1999) has suggested, maintaining the long-term productivity of natural resources without undermining livelihoods or compromising livelihood options is suitable today.

Farmers have not denied the possibility of using more organic in farming. However, they need well-directed handholding support towards SA from the government, private sector, and society. Continued financial subsidies for CF will connect them to chemicals. This is in line with the findings of Weerahewa et al. (2021) and Chandrasiri et al. (2019) regarding the need for a more scientific way of balancing organics and chemicals to sustain rice farming in this country. A holistic plan for developing natural capital is a way forward for a more economical, social, and environmentally friendly rice framing.

Notes

1. (Strengths, weaknesses, opportunities, and threats).
2. Confidence level—Confidence level 95% ($P = .05$), Precision level (±) 5 %,Population size 25,623×.94 24,085, Required total samples – 394.
3. Ak rain (AK wessa) is a slight rain End of September to early October.

4. CSOs -Civil Society Organizations.

Disclosure statement

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

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Data availability statement

Apart from the authors own collection and formation of data, there are no other external data been used in this manuscript and there is no specific data availability requirement for the reviewers and readers.

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Annex A

Table A1. Finding of recent studies on farmer assessments for sustainable agriculture

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
Farmer Adaptation to Sustainable Agriculture				
(1) Waseem et al. (2020)	(Pakistan)-Assessment on Implementation of sustainable agriculture practices in banana farm production	Quantitative study: 300 samples, two-stage sampling, logistic regression, and SEM analysis	Theory of planned behavior	Socioeconomic and psychosocial factors are significantly correlated with adoption; studied extension methods are suggested as promotions
(2) Dharmawan et al. (2021)	(Indonesia) -Smallholders' readiness for sustainability standards (SS) in palm oil cultivation	Qualitative (Case) Study: mixed method data, 35 in-depth interviews, and quantitative data	Gap analysis method, using Importance Performance Analysis (IPA.)	Socio-structural, sociocultural, ethics of subsistence and pragmatism, production, and marketing are significant factors in SS adaptation; farmers are responsible for economic but less for social and environment criterions
(3) Krishnankutty et al. (2021)	(Kerala, India) Sustainability of traditional rice cultivation (socioeconomic analysis)	Quantitative study: 300 samples Descriptive, multivariate analysis, multinomial logit model, Odds ratio, Satiety index, Garrett's Ranking/ Percentages	Economic, socio-demographic, and institutional factors mapped in Indian Costs Concept for Farm Management	socioeconomic factors, farm size, education, yield and yield maximization, input stability, tolerance to environmental stress, and marketability are highlighted. Traditional rice cultivation is less costly, and scaling up is recommended for developing countries
(4) Cusworth and Dodsworth, (2021)	(England) Exploration of agricultural attitudes to the provision of public goods. Environment Land Management policy (ELM) scheme	Qualitative (case) study: 65 in-depth interviews with 40 different interviewees, including repeat interviews in a one-year interval (In Summer time of year 2007 and year 2008)	Bourdieu's social theory and the good farmer concept Symbolic capitals: (economic, social, cultural)	ELM mediates the farmer's autonomy in delivering the dual needs for sustainable and productive agriculture on their farms. The proclivity for farmers to seek maximization, efficiency, and optimization may help get the most out of policy in both produced and public goods provided.
(5) Mert-Cakal & Mara (2020)	(Wales) Investigation of bottom-up response to social change through inclusion and empowerment of community supported agriculture (CSA) schemes	Qualitative case studies spending 3–5 d in the field volunteering in daily work, observations, and semi-structured interviews in 4 CSAs	Application of Social innovation theory on CSA Detentions, Product Empowerment, Processes in Alternative food networks	Producer-led C.S.A. is more self-sufficient than the community-led model; CSA has demonstrated resilience in times of crisis (Covid-19), nurturing community ties and caring for vulnerable people. CSA supports economic sustainability and resilience
(6) Rust et al. (2021)	(England) Framing of sustainable agricultural practices by the farming press and its effect on the adoption of sustainable practices	Qualitative (case) study: Media content analysis combined with 60 qualitative interviews using snowball sampling using an online agriculture database	Diffusion of innovation theory (DOI) was deployed combined with framing theory (FT.)	Most farmers were not motivated to try more sustainable practices solely by reading the farming press alone. Instead, the farmers rely more heavily on other sources, such as trusted and empathetic farmers; raising more awareness of SA is recommended
(7) Mulimbi et al. (2019)	(Congo) Assessment of the effect of conservation agriculture (CA) promotion program	Quantitative study: 225 random stratified samples, use of logit model (CA adaptation) and ordered logit model (perceived benefits of CSA.)	Theoretical drivers of innovation adoption (IA) in conjunction with empirical studies of CA.	Reliability of income and food security are key perceived factors in adapting CA; focus on the differences in adoption between specific crops, land tenure (owned vs. collective/ tribal), and general soil fertility are highlighted as necessary, and empowering women is a highlight

(*Continued*)

Table A1. (Continued).

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
Farmer knowledge of Sustainable Agriculture				
(8) Petway et al. (2019)	(Taiwan) -Assessment of knowledge, values, and opinions of farmers on organic farming	Qualitative study: 113 samples obtained in a group setting, principal component analysis (PCA), in two-scale and four-phased levels	'Satoyama' Japanese concept that encompasses rural livelihoods dependent on ecosystem management as ecosystem services	Organic practices are more influenced by life experiences than by school-taught concepts. ownership of farmland, stable irrigation source, consumers' health and food safety, and social approval are key contributing variables to organic farming
(9) Wang, (2018)	(China) Integrating Indigenous with Scientific Knowledge for the Development of Sustainable Agriculture	Qualitative study using 165 samples, interviews through walking in the village assuring equal gender participation	Sustainable agriculture knowledge development framework bottom-up approach)	The integration of indigenous with scientific knowledge is concluded as the way forward to balance the economic and ecological dimensions of sustainable agricultural development
(10) Zahra (2018)	(Bangladesh) Evaluating the impact of non-formal education in an Integrated Agricultural Productivity Project (IAPP)	Quantitative study: 623 samples,15 treatment and six control groups, multilevel, multivariate analysis, and structural equation modelling	A combination of human capital theory (HCT) and framework of gender equity (FGE) has been deployed. (Supported by adult learning theory)	Farmer knowledge is significant in IAPP success, SA technology skills, productivity, access to literacy, agricultural resources, and information are found to be critical factors for determining farmer success in farmer schools, and the importance of learning for adult farmers is highlighted for (resource-poor communities)
(11) Šūmane et al. (2018)	(Europe) Exploration of the relevance of informal farmer knowledge and learning practices in strengthening agricultural resilience	Qualitative (case) study) based on 11 case studies carried out within the RETHINK research program	Constructivist Conceptualization of knowledge is being developed by actors in their specific contexts	Personal curiosity, willingness to learn, social networking, farmers' organizations, supportive formal knowledge, and governance structures are central elements for successful learning integration knowledge exchange to enhance sustainability and resilience.
Institutional factors in Sustainable Agriculture				
(12) Demont & Rutsaert (2017)	(Vietnam) Exploration of opportunities for sustainable value chain (VC) upgrading for quality rice production, a transition from a quantity-focused producer to a credible supplier of quality rice	Mixed method study: Stacked surveys and Purposive sampling, SWOT analysis for component listing, and Orientation Round method for scoring SWOT components	SWOT analysis on the framework of Sustainable Rice Platform (SRP) (developed based on economic, social, and environmental outcomes)	The SWOT analysis indicated that the sector's major weaknesses are the poor linkages in the value chain and the absence of a national brand and international reputation in international markets; the necessity of horizontal and vertical coordination for sustainable growth is highlighted.
(13) Von Loeper et al. (2016)	(South Africa) Analyzing challenges facing smallholder farmers and conservation agriculture in participating in the modern economy	Quantitative study: Data from existing ethnographic research and causal loop diagrams (CLD) for analysis using endogenous and exogenous variables	System dynamics modelling related to the agricultural value chain, banks, insurers, retailers, and traders as key VC actors	Banks may have the potential to trigger an impact on smallholder farmers' productivity that could then attract other value-chain industries to take part in supporting these farmers in conservation agriculture
(14) Sevinç et al. (2019)	(Turkey) Farmers' Attitudes toward Public Support Policy for Sustainable Agriculture	Quantitative study: 734 samples through face-to-face interviews, Categorical regression analysis on optimal scaling	Demographic and socioeconomic factors on the effectiveness of government policy on (SA.)	Public support is necessary but insufficient for the sustainability of agriculture. Age of the farmer, education level, property type, crop types, and income factors affecting farmers' attitudes, suitability, adequacy, and efficiency of subsidies were found problematic, particularly for non-irrigated farmers

Annex B. Research questioner used in the main study

Table B1. Categorical questions to observer Demographic Factors.

Question	Response
Name (Optional):	. . . .
Contact (Optional):	. . . .
Gender:	. . . .
Age:	. . . .
Religion:	. . . .
(1) What is your level of education	(a) Have not attended school (b) Grade 1 to Grade 5 (c) Grade 6 to Grade 11 (d) Passed OL (e) Passed AL (f) Bachelor's degree or above
(2) How do you fulfill labour requirements for your rice farming	(a) Myself only (b) And my households (c) Hired labour (d) All above
(3) Are you a member of any farmers' organization	Yes/No
(4) With whom do you mainly discuss issues related to rice farming or seek advice on improvements?	(a) Government field officers (b) Agricultural researchers (c) Paddy buyers (d) Input sellers (e) Fellow farmers (f) Specify other
(5) What are the agro-inputs you use in rice farming	(a) Organic substances only (b) Organic mainly and less chemical substances (c) Chemical substances mostly and less organic (d) Both organic and chemical substances (e) Specify other
(6) What are the farming practices you apply in rice cultivation?	(a) Modern methods using available machinery (b) Traditional methods (c) A mix of traditional and modern methods (d) Specify Other
(7) What is the size of your main rice farming plot in acres	. . . .
(8) Do you retain crop residues in the farm plot?	Yes/No
(9) Do you experience animal threats in your farming? Which threatens your rice farming?	Yes/No, If yes, please specify Please specify . . . .

Table B2. Scaler indicators to assess model relationships.

SN	Indicator	Measuring Indicators description
Human Capital		
	Human Capital—Generic reflective indicators	
(1)	HCGQ1	I am well motivated to continue with rice farming
(2)	HCGQ3	I am well aware of nature-friendly farming activities
(3)	HCGQ4	I regularly apply nature-friendly farming activities in rice farming
	Human Capital -Composite formative **indicators**	
		Health and wellbeing
(4)	HCHAW3	It is infrequent our health issues impact our rice farming activities
(5)	HCHAW5	I am well satisfied with my relationships with friends
(6)	HCHAW7	I am not worried at all about everything that is happening these days
(7)	HCHAW8	I am optimistic about the next 12 months
		Knowledge and Farming Experiences
(8)	HCKAFE10	I know the most effective method that can control weeds
(9)	HCKAFE5	I know the importance of utilizing organic compost
(10)	HCKAFE6	I know the irrecoverable consequences of neglecting irrigation on time
(11)	HCKAFE8	I know biological methods to control pests effectively
		Planning and organizing
(12)	HCPAO3	I do the farming at the proper time
		Attitudes
(13)	HCA1	We must protect natural resources for the next generation even if it incurs short-term losses to our outturn
(14)	HCA3	Intense use of chemicals in farming affects the health of people and animals
		Beliefs and values
(15)	HCBAV1	I believe that minimizing the use of chemicals is a timely need
(16)	HCBAV3	The yield produced through fewer chemicals is healthier
(17)	HCBAV6	My children/child will continue with our farming traditions
Social Capital		
	(SA practices Examples: Selecting better seeds for improved yield, minimizing chemical fertilizer use, improving soil fertility, minimum use of chemicals in pests and weed control, minimizing water waste and pollution, etc.)	
Social Capital—Generic reflective indicators		
(18)	SCGRQ1	I am living in a society where I am thoroughly encouraged to adopt SA practices
(19)	SCGRQ2	I am living in a society where I am fully supported in adopting SA practices
(20)	SCGRQ3	I am living in a society where SA is considered an important
(21)	SCGRQ4	I will gain more social recognition if I adopt SA practices
Social Capital -Composite formative indicators		
		Networks and connectedness, a) Bonding -similar individuals within a network, b) Bridging conservationists, c) Linkage -policymakers
(22)	SCNBBL1	Farmer organization provides me with significant help for my farming activities
(23)	SCNBBL2	I receive significant support from community associations in which I am a member of
(24)	SCNBBL6	I receive significant support from agriculture researchers for my farming activities
		Trust and reciprocity
(25)	SCTAR1	I trust the advice and support received from my fellow farmers on the above practices
(26)	SCTAR4	I trust the advice and support received from banks and other financial institutions on the above practices
(27)	SCTAR5	I trust the advice and support received from insurance companies on the above practices
(28)	SCTAR6	I trust the advice and support received from agro-chemical sellers on the above activities
		Norms and values
(29)	SCNAV1	Some fellow farmers compel me to more nature-friendly farming practices
(30)	SCNAV2	I am always happy to produce harvest with higher standards
(31)	SCNAV3	I will receive more social recognition if I adapt to more environmentally friendly farming methods
(32)	SCNAV4	I will receive better price/demand if I produce paddy using organic matter and with less chemical use
		Power
(33)	SCP1	It is a condition of my land load to adapt the above practices
(34)	SCP2	Paddy buyers give better rates to farmers who adopt those practices
(35)	SCP3	Agro-Input sellers give discounts and credit facilities to farmers who adopt the above practices
(36)	SCP4	I feel government officials are becoming more supportive of the farmers who adopt the above practices
(37)	SCP5	I find that wealthy farmers in our society support us in adapting the above practices
Financial Capital		
Financial Capital—Generic reflective indicators		

(*Continued*)

Table B2. (Continued).

SN	Indicator	Measuring Indicators description
(38)	FCGRQ1	I am economically strong to continue with rice farming
(39)	FCGRQ2	Getting financial aid for my farming needs is not challenging
(40)	FCGRQ3	My rice farming is generally profitable
Financial Capital—Composite formative indicators		
		Savings and cash flow
(41)	FCSACF1	Ensuring household food security is not a challenge for me
(42)	FCSACF2	Meeting of financial needs of my family is not a challenge for me
(43)	FCSACF3	I do make a good surplus in each season
(44)	FCSACF4	Re-investing in rice farming is not a challenge for me
		Financial Credits
(45)	FCFC3	I can borrow money from local providers easily for a reasonable interest rate
(46)	FCFC1	Obtaining a loan from a state bank is not a challenge for me
(47)	FCFC2	Obtaining a loan from a private bank is not a challenge for me
		Remittances
(48)	FCR1	I receive substantial income from my other businesses
(49)	FCR3	Though rice farming is my main job, I do part-time jobs with good earning
(50)	FCR4	In addition to rice farming, I do other agriculture, which gives me a considerable income
(51)	FCR5	I receive regular income from my savings in the bank
		Profitability
(52)	FCP1	I get a fair price for my harvest, and the income is generally profitable
(53)	FCP2	The selling price keeps increasing in parallel with the cost increase of agro-inputs
(54)	FCP3	The profit I generate keeps increasing with the price increase of other household commodities
Physical Capital		
Physical Capital—Generic reflective indicators		
(55)	PCGRQ1	I have the required types of machinery and equipment for rice farming
(56)	PCGRQ2	I can afford to hire the types of machinery when needed
(57)	PCGRQ3	I have access to SA agricultural knowledge
(58)	PCGRQ4	I get market information easily
(59)	PCGRQ5	I have easy access to agro inputs selling outlets
Physical Capital—Composite formative indicators		
		Availability of machinery
	(Machinery examples (Sprayer machine, water pump, two-wheeler tractor, four-wheeler tractor, planter, harvester, etc.)	
(60)	PCAOM1	I do possess the required agricultural types of machinery and equipment necessary for my farming
(61)	PCAOM2	Maintaining those types of machinery is not an issue for me
(62)	PCAOM3	I can afford to hire the above types of machinery whenever needed with no issues
(63)	PCAOM4	The charges I pay for the hiring of types of machinery are affordable
(64)	PCAOM5	The charges I pay for hiring types of machinery are reasonable
		Access to information and consultancy services and market information
(65)	PCAIS1	I listen to radio programs related to rice farming, and they are useful
(66)	PCAIS2	I watch television programs on rice farming, and they are useful
(67)	PCAIS6	I read newspaper articles related to rice farming, and they are useful
(68)	PCAIS7	I regularly read the leaflet and broachers distributed on rice farming, and they are useful
(69)	PCAIS3	I find helpful agriculture-related videos on the internet and social media, and they are useful
		Access infrastructure and availability of labour
(70)	PCAIAL1	It is easy to access the paddy buyers
(71)	PCAIAL2	It is easy to access agriculture suppliers and vendors
(72)	PCAIAL3	It is easy to find the labour required for rice farming activities
Natural Capital		
Natural Capital—Generic reflective indicators		
(73)	NCGRQ1	The soil condition of my farm plot can be improved for organic fertilizer use
(74)	NCGRQ2	I get an adequate water supply for my farming
(75)	NCGRQ3	The location of my farm plot is less vulnerable to natural disasters
Natural Capital—Composite formative indicators		
		The soil fertility of the land
(76)	NCSFL1	I think the soil fertility of my farm plot is in good condition

(*Continued*)

Table B2. (Continued).

SN	Indicator	Measuring Indicators description
(77)	NCSFL2	I think I can improve the soil in my farm plot for organic fertilizer use
		Availability of carbonic substances to improve soil fertility
(78)	NCACS3	I can prepare the compost required for my farm plot
(79)	NCACS4	I can find a good amount of green manure crop in the vicinity of my farm plot
(80)	NCACS2	I can find reasonable amounts of poultry manure or cow dung in the vicinity of my farm plot
		Effectiveness of waterworks and adequacy of water
(81)	NCEWAW1	The waterworks to my farm plot are well maintained
(82)	NCEWAW2	I am satisfied with the timing of the water-releasing intervals for farming
(83)	NCEWAW3	I can rely on rainwater, too, to a reasonable extent
(84)	NCEWAW4	I can pump water to my plot if required
		Frequencies of whether extremes and animal attacks
(85)	NCFWA1	I am not facing severe crop damage due to drought
(86)	NCFWA2	I am not facing severe crop damage due to floods
(87)	NCFWA3	I am not facing severe crop damage due to animal attacks
Farmers' Perceived Effectiveness on Government Interventions		
Farmers' Perceived Effectiveness on Government Interventions—Generic reflective indicators		
(88)	PEIIGRQ1	The government financial schemes started in support of organic fertilizer are useful
(89)	PEIIGRQ2	The training programs launched in support of organic fertilizer use are useful
(90)	PEIIGRQ3	The materialistic support we receive from the government during this transition is useful
(91)	PEIIGRQ4	The government is making a supportive policy decision in support of farmers adopting organic fertilizers
Farmers' Perceived Effectiveness on Government Interventions—Composite formative indicators		
		Availability of organic fertilizers for farming
(92)	PEIIAOF1	Organic fertilizers are available in the market
(93)	PEIIAOF2	I am confident in using the available organic fertilizer in the market in my rice farming
		Financial aid in purchasing organic fertilizer
(94)	PEIIFAFOF1	The government financial support program for promoting organic fertilizer is functioning well
(95)	PEIIFAFOF2	I think the government financial aid on organic fertilizer would continue for upcoming seasons too.
(96)	PEIIFAFOF3	We all receive that financial aid with fewer papers work, and procedures
		Provisioning of compensation in case farmers end up with a shortage of harvest due to the transition
(97)	PEIIPOC1	The government announcement of compensation schema for possible losses in harvest due to organic fertilizer use is encouraging me
(98)	PEIIPOC2	We can trust such promises from the government to a reasonable extent
(99)	PEIIPOC3	I have seen such compensatory aids given to us in the past in incidents of crop losses
		Provisioning of more suitable seeds for organic fertilizer
(100)	PEIIPSFOF1	There is a government program providing more suitable seeds for carbonic fertilizer use
(101)	PEIIPSFOF2	The prices of seeds suitable for carbonic fertilizer provided by the government are reasonable
(102)	PEIIPSFOF4	We can find those seeds in nearby outlets
	Farmers' Readiness to Release the Use of chemical fertilizers—Reflective Indicators	
(103)	FRTRCF1	Minimizing chemical fertilizer use is a timely need
(104)	FRTRCF2	Though it may impact my yield, I am willing to minimize chemical fertilizer use
(105)	FRTRCF3	The use of intensive chemical fertilizer is not the way forward for future rice farming
(106)	FRTRCF4	I am willing to try organic substances as an alternative to chemical fertilizers
	Farmers' Readiness to reorganize farm plots with organic fertilizers -Reflective Indicators	
(107)	FRTROF1	The use of the organic substance in rice farming is not new to me
(108)	FRTROF2	We can produce more profitable outturn using organic fertilizers
(109)	FRTROF3	I can produce organic fertilizers to meet my needs domestically
(110)	FRTROF5	The use of organic fertilizer is the sustainable future of rice farming