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A Systematic Literature Review to Develop a Conceptual Model to Assess Farmers' Sustainable Agriculture Potential for Organic Use in Rice Cultivation in Sri Lanka

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ABSTRACT

The researcher found a timely need to assess Sri Lankan Rice Farmers' Sustainable Agriculture (SA) potential, their readiness to adopt more organic-centric farming, and the institutional help they receive for such adoption. Since no straightforward assessment method has been found in the literature, this paper describes how the researcher developed a conceptual framework and suggests indicators to explain the constructs for such an assessment. The conceptual model and indicators are drawn through a systematic literature review. The systematic literature review helped to find a set of credible and relevant articles for the study and provided a structured way of extracting usable findings for this study. Resilience theory (RT) properties are the foundation selected to develop the conceptual framework combined with the Rural Livelihood Assessment Framework (RLAF). The previous research findings of SA studies show that capital assets described in RLAF, Human, Social, Financial, Physical, and Natural, would adequately explain farmers' SA potentials. The suggestions from RT on ecosystem resilience can describe the farmer's predictive behaviours in this transitioning ecosystem. The researcher believes this conceptual combination is adequate to explore the unknowns mentioned in the study's objective. Also, the literature provides insights to develop an indicator framework which will guide the development of a research instrument explaining the latent constructs of the model in future research.

Keywords: Chemical fertilizer, Farmer resilience, Organic fertilizer, Rural livelihood, Sustainable Agriculture Potentials.

INTRODUCTION

The sustainability of agriculture has become a much-discussed topic in academia in this open era, particularly from the perspectives of its economic, social, environmental, and scientific dimensions. Sustainable Agriculture (SA) is more relevant today than before to meet rising food requirements for the ever-growing world population while adhering

to sustainability principles. Among various definitions of sustainable agriculture, Lichtfouse et al. (2019) define SA as meeting present needs without compromising future generations' ability to meet their own needs. Farmers are vital custodians of SA, and their ultimate decisions are critical determinants of the successful application of sustainable principles.

The FAO (Zoveda et al., 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 ecosystems; and 5) promoting effective governance of natural and human systems. FAO (2014) and United Nations (2013) recommend the 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: increasing and protecting farmers' access to resources and widening the market.

Governments, the private sector, and civil societies seek to conserve economic, biological, cultural, and aesthetic capital for future generations while searching for strategies to mitigate the ill effects caused by heavy production-oriented modern agriculture practices (Bisht, 2013; Bowers,1995). Governments have started thinking of new ways of addressing these issues, such as providing agricultural subsidization to environmental land management schemes (Cusworth & Dodsworth,2021), developing strategies for sustainable agro-tourism (Knowd, 2006), subsidizing organic farming (Dapaah et al.,2020), integrating agricultural developments into rural development plans (Marsden et al.,2002) and leveraging community-supported agricultural schemes (Mert & Miele, 2020).

The Sri Lankan government also realized this need, stopped importing chemical fertilizers and promoted biomass in mid of the year 2021. The government's sudden decision to shift agriculture to 100% organic was a misinformed and entire failure (Department of Census and Statistics, 2021). The government reversed the decision within less than a year. However, the decision caused a massive perturbation in the rice cultivation sector. Rice is the decade-long staple food crop in the country, and rice cultivation has been a predominant part of the economy and social values of the country for centuries (Mahawansa,1912). Today, chemical fertilizer scarcity prevails on the ground. Though there is no import restriction on chemical fertilizers, the farmers would not have as many chemical fertilizers around them as they used to (Department of Agriculture, 2021). Due to the country's worsening economy, the government is searching for a balanced approach for the mixed-use chemicals and organic in the future agriculture of this country.

The rice farmers have been heavily chemical-centric for decades. No farmer uses organic only in their rice farming today; according to recent statistics, 70% of farmers use chemical fertilizers only, and the rest adopt a hybrid approach (Department of Agriculture, 2021). In such a situation, the researcher doubts the resilience of farmers moving into more organic-centric rice farming. Adopting more organic-centric farming is widely accepted as a massive step to globally

transition agriculture into SA aspects. Applying such SA practices comes from farmers' potential, capabilities, knowledge, and external support. However, farmers' potential, qualifications, expertise, and other supportive interventions for sustainable practices are less assessed in the literature (Gebska et al., 2020; Lichtfouse et al.,2009; Curry et al.,2012). Cleveland (2001) further asserts that the ability to develop more SA would depend to a significant degree on a clearer understanding of the joint contribution of biophysical and social reality to scientific knowledge and epistemological processes of its production and transformation. The effectiveness of the other supportive interventions from the government and third parties is also becoming more critical in SA adaptations. Indeed, meeting food security needs and ensuring sustainable practices are competing priorities that might be too stressful for farmers to withstand alone.

The farmers' potential to transit agriculture to SA in Sri Lankan rice farming is unknown. Also, the researcher did not find a straightforward method to assess farmers' potential for more sustainable and organic use in rice farming. In hindsight, this paper discusses how the researcher conducted a systematic literature review in formulating a conceptual framework to measure farmers' potential, their adaptive capacity (readiness) for more organic-centric farming and the effectiveness of institutional support they receive. Developing such a conceptual framework requires insights from the existing literature through a comprehensive literature review (LR). The selection of suitable references relevant to the study is crucial for the success of such a review. Researchers have adopted two broader literature review methods in such studies: traditional narrative review and systematic reviews. A systematic literature review is a structured approach to systematically identifying articles for references. In this approach, the initial step is to select prospective articles and analyze them for their validity and relevance to the study's objectives. Then, an in-depth analysis will draw insights into conceptualizing the study's objectives.

The Objective of Literature Review

The objective discussed in this paper is to develop a conceptual framework to assess farmers' SA Potential, to adopt more organic fertilizers in farming and the effectiveness of the support they receive from the government by drawing insights from similar previous studies in this research domain. Also, to provide a guiding indicator framework to develop a research instrument referring to the existing literature.

LITERATURE REVIEW

The systematic literature review method is an explicit, rigorous, and transparent method of article selection and drawing insights for studies (Greenhalgh et al.,2004). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model is becoming popular in such approaches during the article selection phase to minimize the risk of bias (Liberati et al., 2009). Using this model in literature reviews makes the work replicable and more systematic. When the researchers can find plenty of articles related to the topic and can form an articles database with sufficient numbers, the systematic approach is preferred over the traditional narrative method (Lourenço& Jones, 2006; Pittaway & Cope, 2007). The initial random searches reveal that SA practices and farmers' readiness are common topics in recent literature, and it was possible to form an article database. Therefore, the researcher finds that a systematic literature review (SLR) is the best method for this

study using the PRISMA model for article selection.

Systematic Literature Review

In searching for articles, Google Scholar was used as the primary source, and Web of Science was used as the secondary source. In both cases, the article searches were done without defining a specific publication or period. Google Scholar is an increasingly popular search engine in the research domain. Web of Science is the oldest database of citations, dating back to the year 1900, providing substantial coverage of international research while guaranteeing the highest quality. In addition to the above databases, some articles were included from the Hector Kobbekaduwa Agrarian Research and Training Institute of Sri Lanka (HARTI), which were found to be within the search criteria adopted in this study.

The article search was carried out applying the following Boolean search terms:

"*sustainable agriculture*," "*conservation agriculture*," "*farmer readiness,"* "*farmer adaptation*," "*farmer potentials*," "*farmer capabilities,"* "*farmer knowledge*," "*exogenous factors on sustainable agriculture," "institutional factors on sustainable agriculture," "institutional support on sustainable agriculture,"* and *"government interventions on sustainable agriculture.*

The process identified many publications containing one or more of the above terms in the title, author keywords, or abstract of the publications. After eliminating duplicate articles, 179 publications were identified for preliminary analysis covering the period between 1977 and 2021.

During the search process, due consideration was given to the journal articles scientifically written in English. Additionally, three retrospective doctoral theses and some book chapters of conference proceedings that demonstrate direct relevance to the topic are included

All 179 abstracts were read, including some brief reading of chapters containing materials and methods to ensure that the documents are within our construct and relevance.

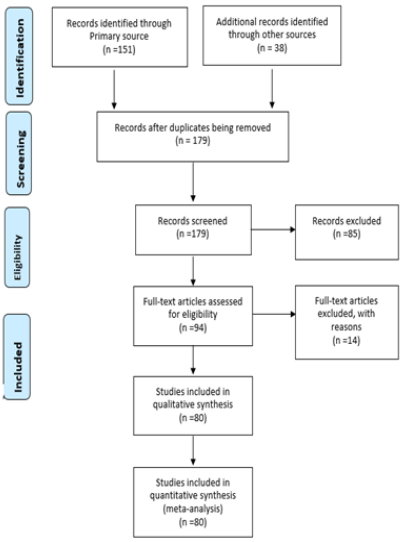

Figure 1: Results of Article processing using the PRISMA model

Publications with less relevance to constructs and publication years older than 1988 were excluded. Eventually, a total of 80 articles were analyzed in this study. The article includes full research papers, case studies, reviews, and literature reviews that directly relate to the topic discussed in the study. Fig. 1, shown above, depicts the steps of article selection with the numbers resulting in each step in the PRISMA model

Analysis of the article for validity and relevance for the study

The results of the first level of review are presented in this chapter, ordering them

into some key areas that would help assess the appropriateness of article selection for the objectives of this study. The literature references would help understand the investigated problem's cohesiveness, originality, validity, and research directions and methods. The quantitative synthesis discussed under the categories of growth of similar research interests over the years, global trend of the attractions in this discipline, the productivity of the selected journals, research strength of the authors of selected articles, global dispersion of the research interests, the pattern of research methods used in similar themes, co-occurrences of keywords and their linkage, and population of article citations according to the themes (clusters) investigated in the literature.

Growth of research interest over the years

Fig. 2 illustrates the growth of research interest in this area during the article publication period from 1988 to 2021. The increasing trend in publications in recent years may suggest a continuous evolution of the research interest in this discipline. Six articles published in 2021 during the first four months show a quick bounce of interest. They may be related to the global pandemic and growing concern over environmental preservation linked to agricultural practices

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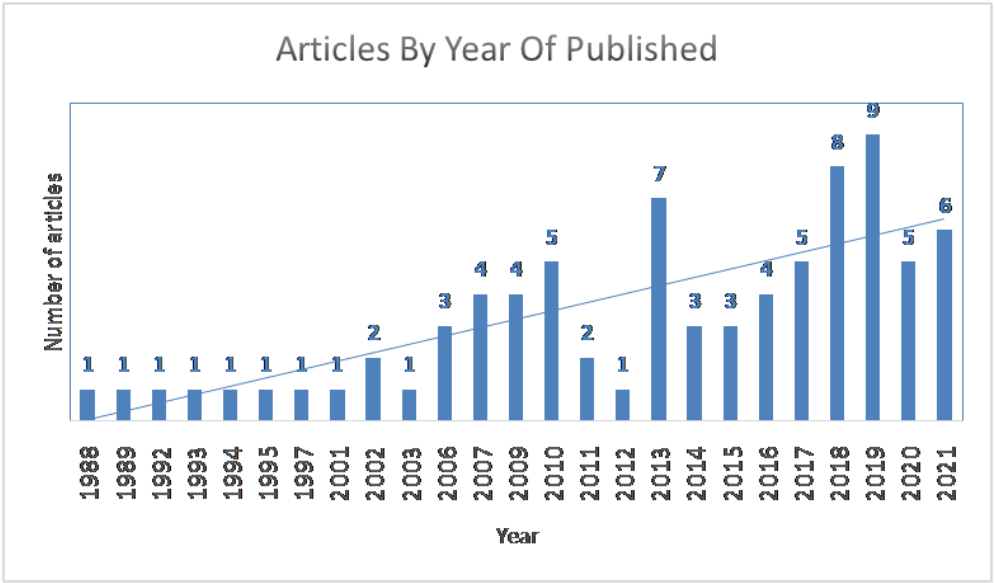

Figure 2: Growth of research interest over 1988-2021

Cluster analysis:

The preliminary findings of the article review show that the research interests can be considered in clusters according to the main themes of the studies. Therefore, the researcher classified articles into three main clusters, farmer adaptation to SA practices and influence of farm and farmer characteristics (FASA), Knowledge development and adaptation, associated factors related to SA (FKSA), and Impacts of Institutional/Governmental policy and regulations (support) on SA (ISSA) for the quantitative synthesis. Fig 03 below illustrates the research dispersion by those classified clusters. The analysis reveals the multidisciplinary nature of the

research area. The publications are spread according to the numbers (39, FASA), (26, FKSA), and (15 ISSA), as shown in the above diagram (Fig 03). This result shows that researchers perceive these three main themes in the SA discipline as important and consistent research trends in each cluster.

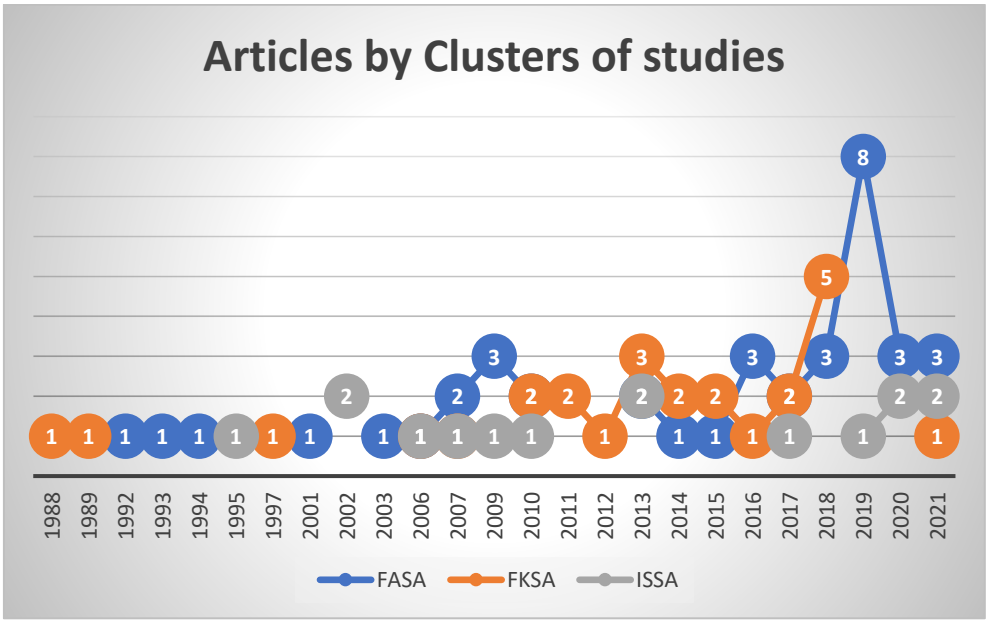

Figure 3 : Research interest by clusters of studies

Credibility of journals

Of the 80 articles selected for the study, 43 are from ranked journals or journals with an impact factor greater than 3, listed in Table 01. The rest of the articles are from credible journals published by reputed publishers such as Elsevier, Springer, Routledge, Taylor and Francis, Wiley-Blackwell, Cambridge Core, and MDPI AG

Authors' profiles of selected articles

Table 2 below shows some profiles of the authors of the articles with citations (>200). There were 269 authors involved in 80 selected publications, only four authors were involved in 2 articles concurrently, and the rest were engaged in a single article. These statistics show the high diversity of research interest among scholars.

Table 1: Journals and publishers of selected articles

Journal Name	*ABDC Ranking*	*Count of Articles*	*Impact Factor*	*Publisher*
Global Environmental Change	A*	2	10.427	Elsevier
Ecology	A	1	4.7	Wiley-Blackwell Publishing
Local Environment		1	4.55	Elsevier
Agriculture systems		1	4.49	Elsevier
Environmental Management			4.175	Springer International Publishing
Ecology and Society		2	4.14	Blackwell Publishing Asia Pvt Ltd
American Journal of Experimental Agriculture		1	4.12	Publons
International Journal of Social Economics	B	2	3.986	Emerald Group Publishing
Journal of Sustainable Tourism	A*	4	3.986	Taylor & Francis Online
Sustainability (Switzerland)		8	3.889	MDPI
Land Use Policy	A	1	3.85	Elsevier
Food Policy	B	1	3.788	Emerald Publishing
Land Degradation and Development		1	3.775	Wiley online library
Environment & Planning A	A*	2	3.033	Sage Publications
Economic and Social Review	B	1	2.661	Economic and Social Studies Ltd
Agriculture and Human Values	B	12	2.222	Springer International Publishing
Australian Journal of Agricultural and Resource Economics	A	1	1.49	Wiley-Blackwell Publishing
European Journal of Political Economy	A	1	1.248	Elsevier
Agricultural and Resource Economics Review	B	1	0.61	Cambridge Core

Table 2: Details of selected authors

Author	*Citations*	*Affiliation*	*Research Interest*
Duncan Knowler	1771	Simon Fraser University, Canada	Ecological, environmental natural resource economics
Darnhofer Ika	376	University of Natural Resources and Life Sciences, Vienna	Resilience, Organic Farming, Rural Sociology, Rural Development, Farmer Decision Making
Gerard D'Souza	318	College of Agriculture & Humans, Prairie View	Agricultural Economics
Johan Ahnström's	308	Swedish University of Agricultural Sciences	Farmers and nature conservation
Hoffmann, Volker	283	Computational Science, Remote Sensing, Machine Learning	Department of Management, Technology, and Economics of ETH Zurich
Marsden, Terry	260	Cardiff University	Environmental Policy and Planning
Bowman, Maria S.	232	USDA Economic Research Service	Natural resource economics
Šūmane, Sandra	230	Baltic Studies Centre	Geoinformatics (GIS), Social Theory, Qualitative Social Research, Urban/Rural Sociology

Countries of article publication:

The following diagram (Fig 4) displays the distribution of research studies by country. There is a clear geographic dispersion reflected in this collection of articles: the USA (9), Europe (6), India (6), England (5), Nigeria (4), Sri Lanka (4), Tanzania (3), and South Africa (3), leading this list. The list represents publications from 39 countries across the world.

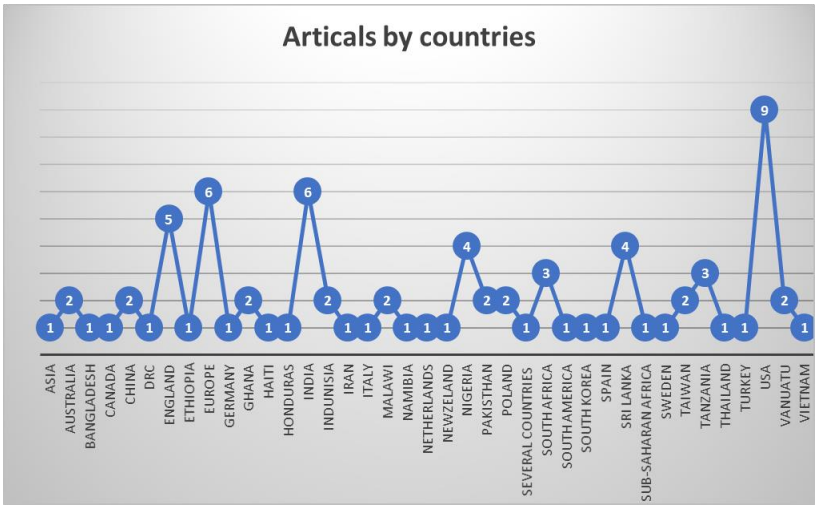

Figure 4: Article Publications by Country

Nature of research and methods used:

The distribution of the articles according to the research methods used in the articles is displayed in the following diagram (Fig 5). The results show that most (26) of the research has been conducted using the quantitative method. There are 23 types of research done on the qualitative paradigm, whereas there are 2 in the mixed method. Papers on reviews and case studies are widespread in the discipline and contribute to the literature of this study area.

Keyword core occurrence analysis:

The core occurrence analysis of keywords is carried out to examine the connectedness of the 310 keywords of 80 selected articles. The relevant keywords are shortlisted for 125 out of the total and depicted in the following image (Fig 6) in 16 clusters. The minimum number of occurrences is set to a single occurrence in this analysis to reflect the diverse research carried out under the discipline of SA. The analysis shows that previous studies have focused more on sustainable and conservation agriculture. The research intensity on indigenous knowledge is a highlight.

Article citations by clusters

Table 3 below demonstrates the most cited (> 100 citations) 14 articles, which are categorized according to the key themes of this discussion. The results indicate the importance of three areas under discussion on this topic. FASA is the most dominant cluster among scholars, and other influencing factors of FKSA and ISSA follow the trend. This analysis concludes the chapter on the quantitative synthesis of this article review, and the following chapter summarizes the outcomes of qualitative thematic analysis.

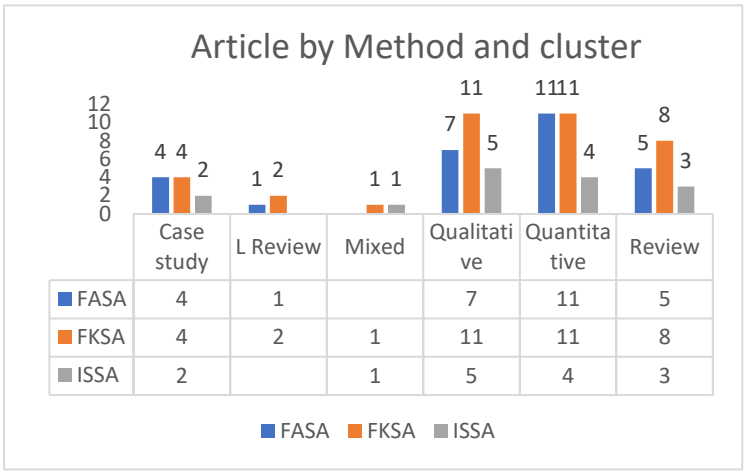

Figure 5: Research methods used in clusters by research

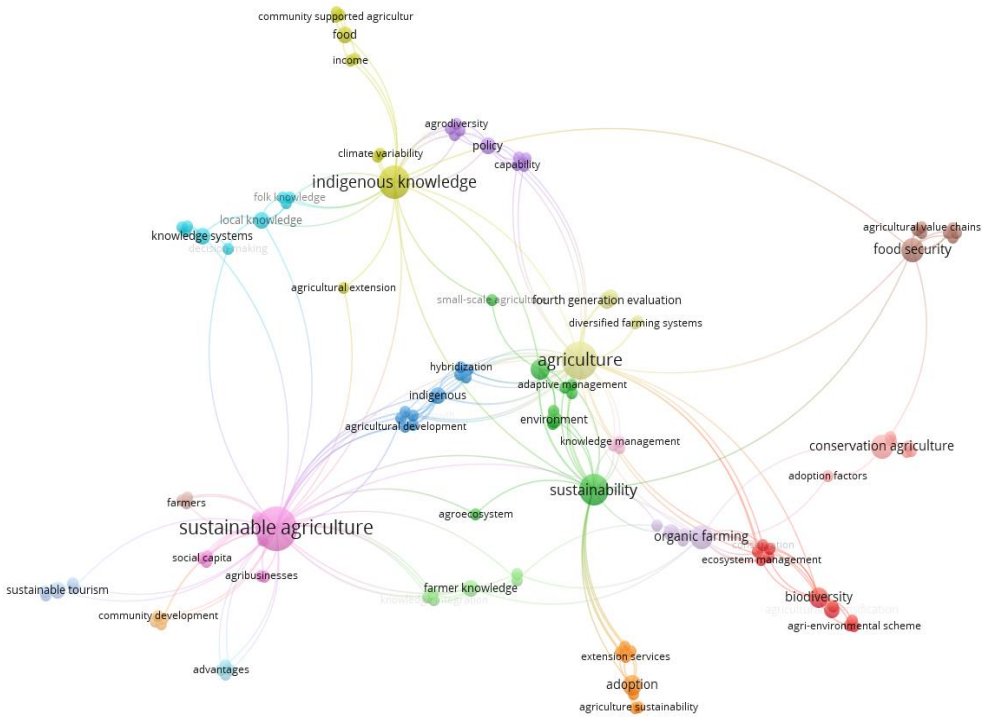

Figure 6: Core occurrence of keyword nexus and the density

Table 3: The most cited 14 articles out of 80 articles by cluster (>100 citations)

Cluster	Citation Tag	Country	Number of citations
Farmer Adaptation of Sustainable Agriculture (FASA)	**Ahnstroem2009**	Europe	308
	D'souza1993	USA	318
	Knowler2007	Canada	1771
	Ackerman2014	USA	199
	Bowman2013	USA	232
	Darnhofer2010	New Zeeland	376
	Ndamani2015	Ghana	100
Farmer knowledge on Sustainable Agriculture (FKSA)	**Changa2010**	Tanzania	112
	Senanayake2006	Sri Lanka	118
	Sumane2018	Europe	230
Institutional factors on Sustainable Agriculture (ISSA)	**Choo2009**	South Korea	153
	Hoffmann2007	Namibia	283
	Knowd2006	Australia	131
	Marsden2002	Europe	260

Findings of Previous Research Studies

The approach of the qualitative review was a detailed reading of all selected articles (80) and performing a summary of the analysis, further shortlisting the most relevant complete research studies, which were found to be the most helpful in identifying the factors to explain the constructs and characteristics mentioned in the objectives above. Additionally, due consideration was given to the articles, which would help derive indicators from measuring the factors during the assessment. Exhibit 1 depicts the summary of the qualitative analysis with highlights of the findings. Out of the abovementioned 80 selected articles, 14 were further shortlisted to summarize the results (Exhibit 1). These 14 articles are publications of complete research studies developed on solid theoretical backgrounds deploying methodical analysis. This qualitative analysis outlines the areas of study, techniques used in data analysis, conceptual backgrounds adopted, and the findings' highlights. Farm and farmer characteristics, capital assets, indigenous knowledge, competencies, and supportive extensions are the main dimensions investigated by the majority of the researchers so far in this research area of assessing farmers in the discipline of SA research domain.

These dimensions have been examined within the sustainable economic, social, and environmental frameworks. Farmer knowledge and awareness of sustainable agriculture are being investigated in academia in the form of knowledge adaptation, development, transformation, and sharing. Key emphasis is found on the requirement of external parties' support in integrating and externalizing tacit, indigenous, and modern knowledge, which is perceived as essential in ensuring SA. Institutional extensions such as governing policies, regulations, and value chain extension services supporting SA are investigated under socioeconomic and environmental considerations.

Exhibit 1: Findings of recent studies of farmer assessment 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 Adoption of Sustainable Agriculture Practices in Banana Farm Production	Quantitative Study: 300 samples, Two stage sampling, logistic regression, and SEM analysis	Theory of planned behaviour	Socioeconomic and psychosocial factors significantly correlate 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, socio-cultural, ethics of subsistence and pragmatism, production, and marketing are significant factors in SS adaptation; farmers are responsible for economic but less for social and environmental criteria

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
(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 & 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 (During the Summer 2007 and 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 & Miele, 2020)**	(Wales)- Investigation of bottom-up response	Qualitative case studies	Application of Social Innovation Theory on CSA Detentions, Product	Producer-led type of CSA is more self-sufficient than

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
	to social change through inclusion and empowerment of community-supported agriculture (CSA) schemes	spending 3–5 days in the field volunteering in daily work, observations, and semi-structured interviews in 4 CSAs	Empowerment, and Processes in Alternative food networks	the community-led model; CSA has demonstrated that it is resilient 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)	The majority of Farmers are 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 the Conservation agriculture	Quantitative study: 225 random stratified samples, use of logit model (CA	Theoretical drivers of Innovation adoption (IA) in conjunction with	Reliability of Income and food security are key perceived factors in

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
	(CA) promotion program	adaptation) and ordered logit model (perceived benefits of CSA)	empirical studies of CA	adapting to CA; focus on the differences in adoption between specific crops, land tenure (owned vs. collective/tribal), and general soil fertility are highlighted as important, and empowering women is a highlight.
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 were 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	Qualitative study using 165 samples,	Sustainable agriculture knowledge	The integration of indigenous with scientific

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
	with Scientific Knowledge for the Development of Sustainable Agriculture	interviews through walking in the village assuring equal gender participation	development framework bottom-up approach)	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 nonformal education in an Integrated Agricultural Productivity Project (IAPP)	Quantitative study: 623 samples,15 treatment and 6 control groups, multilevel, multivariate analysis, and structural equation modelling	A combination of human capital theory (HCT) and the 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	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

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
	practices in strengthening agricultural resilience			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, the 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 the 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	Quantitative study: Data from existing ethnographic research and	System dynamics modeling related to the agricultural value chain, banks, insurers, retailers,	Banks may have the potential to trigger an impact on

Author and year	Country and area of the study	Data Collection and Analysis Techniques	Theoretical/Conceptual/ Analytical framework	Key Findings and Recommendations
	smallholder farmers and conservation agriculture in participating in a modern economy	Causal-loop diagrams (CLD) for analysis using endogenous and exogenous variables	and traders as key VC actors	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 in (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.

Researchers have used different theories in developing conceptual frameworks to assess similar constructs associated with the farmer or farm characteristics under sustainable or conservation agriculture principles in this research discipline. Waseem et al. (2020) deployed the Theory of Planned Behaviour (TPB) in an investigation of the "Adoption of SA practices in Banana farm production."

Dharmawan et al. (2021) deployed a 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) in investigating the "Factors influencing the adoption of conservation agriculture."

The concept of "Satoyama" (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 the "knowledge, values, and opinions of farmers on organic farming." At the same time, 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 basis used by Zahra (2018) in a study assessing the "Impact of nonformal education in an integrated agricultural productivity project." Actors in their specific contexts are developing the concept of the "constructivist conceptualization of knowledge," which is adopted by Šūmane et al. (2018) in their study of the "Relevance of informal farmer knowledge and learning practices in strengthening agricultural resilience."

Cusworth & Dodsworth (2021) deployed Bourdieu's social theory (ST), which explains symbolic capitals (economic, social, cultural.) in conjunction with the good farmer concept in their study assessing "Agricultural attitudes to the goods and public provision of an environment and land management policy (ELM)." Mert & Miele (2020) applied social innovation theory and the concept of alternative food networks (AFN) in a study on "Assessing social change through community-supported agriculture." Diffusion of innovation theory (DOI) was deployed in combination with framing theory (FT) in an assessment of "Framing of SA by the farming press and its effect on adoption SA" by Rust et al. (2021). SWOT analysis based on a framework of the sustainable rice platform (SRP) was deployed by Demont & Rutsaert (2017) in analyzing the "Opportunities for sustainable value chain (VC) upgrading." Whereas Von et al. (2016) studied "Challenges faced by smallholder farmers and conservation agriculture" using systems dynamics modelling (SDM), applying the concept to the agricultural value chain. Demographic and socioeconomic factors on the effectiveness of government policy on SA were used to investigate "Attitudes toward Public Support Policy for SA by Sevinç et al. (2019)

In continuing analysis of articles, literature saturation was observed in further reading articles with repetitive findings similar to the above summarization. In addition to the above results, emerging research interests are noticed in applying resilience thinking to socio-ecological ecosystems, also known as resilience theory (RT), in the literature. The RT has been adopted as the theoretical framework in studies assessing the resilience of livelihoods of rural communities and agricultural ecosystems by some researchers (Darnhofer et al.,2010; Ifejika Speranza et al., 2014; Oelofse& Cabell, 2012). However, using resilience thinking for a quantitative assessment that would help better understand the ground realities of farmer resilience on sudden transitions is a less focused area in the literature so far. Nevertheless, resilience thinking (RT) is the most appropriate conceptual platform found to measure the objectives of this study, which would explain the constructs that need to be measured to assess farmers' readiness for the SA transition.

Resilience Thinking

Berkes et al. (2003) synthesized the characteristics of ecosystem resilience. They assert that resilience is an important element of how societies adapt to externally imposed change, such as global environmental change. The adaptive capacity of all levels of society is constrained by the resilience of their institutions and the natural systems on which they depend. Adger (2000) proposed that the greater their resilience is, the greater their ability to absorb shocks and perturbations and adapt to change. Conversely, the less resilient the system is, the greater the vulnerability of institutions and societies to cope and adapt to change.

Holling (1996) originally introduced the resilience concept into the ecological literature. Gunderson (2000) further expanded the idea by explaining the nonlinear dynamics of 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 Fig. 07 below. The **adaptive cycle** reflects the changes in two properties: (1) the y-axis: **the potential** inherent in the accumulated resources and structures; (2) the x-axis: the degree of **connectedness** among controlling variables of an event. The exit (marked with an X) from the cycle indicated at the left of the figure suggests, in a stylized way, the stage where the potential can leak away and where a shift is most likely into a less productive and organized system. The shaded part of the cycle is termed the 'back loop' (Holling,1996) and concerns the **Release** and **Reorganization** phases.

Development of a conceptual framework

Histories of adaptive cycles are influenced by their potential and their connectedness (Holling, 1996; Gunderson 2000). Van der Leeuw (2009) further describes the property of **potential** of a socio-ecological

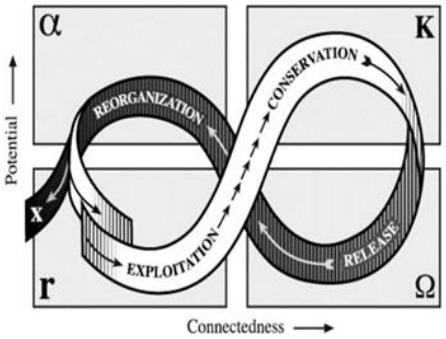

Figure 7 : Résilience Adaptive cycle

Source : https://www.resalliance.org/adaptive-cycle

The dependent variable in this framework is the resilience adaptive cycle (RAC), which is described in four constructs: Exploitation (Growth), Conservation, Release, and Reorganization. The cycle's growth or exploitation (r) phase sees rapid colonization or expansion. This is followed by the conservation (K) phase, in which the system becomes increasingly specialized and rigid. In the release (Ω) phase, the system undergoes a collapse that 'radically and rapidly reduces its structural complexity' (Chapin et al., 2009). This is followed by a reorganization or renewal phase (α) in which resources are reorganized into a new system, which may resemble its predecessor or may have significantly different properties. The above explanation of RT is likely the most promising theoretical framework to achieve the research objective of assessing farmer readiness for transitioning from one phase to another in the ecosystem.

system as its overall capital or 'richness' that is available to be transformed into the next transition stage. The property of **connectedness** refers to 'the control that the system has over itself, and the degree of **flexibility** or **rigidity** available to respond to system's dynamics. These

suggestions of RT help to describe the constructs to measure the degree of farmers' potential and other factors that might determine their resilience during a transition to an ecosystem they belong to and live in. Y-axis: Farmer potentials, X-axis: connectedness among controlling variables, and RAC: Farmer capacity on growth (exploitation), conservation, release, and reorganization are explained in RT.

Farmer Potentials sustainable agriculture adaptation

According to Van der Leeuw(2009), the property of **Potentials** explained in RT of a socio-ecological ecosystem is overall capital or 'richness' that can be transformed into the next transition stage. With this suggestion, the researcher argues that the property of potential explained in RT is analogous to the farmer's accrued SA capital over the years. The sustainable rural livelihood assessment framework (Ashley & Carney,1999; Scoones,1998; Batterbury & Forsyth, 1999) further explains capital assets such as economic, social, physical, human, and environmental capital. Porritt Jonathon (2011) supplemented these explanations by classifying them into the exact five dimensions more descriptively in a framework of the "Five Capitals Model for Sustainability." Combining these two theoretical and conceptual suggestions, the researcher proposes Farmer's Economic, Social, Physical, Human, and Environmental capitals as determining constructs in measuring their readiness to adapt to SA activities in a transition.

Connectedness

The **connectedness** is the tightness of bonds the actors of the ecosystem developed with various controlling variables that might be subject to change at any time. Such controlling variables could be in the form of either **stabilizing or destabilizing** forces of the ecosystem. Stabilizing forces are essential in maintaining productivity, fixed capital, and social memory, whereas destabilizing forces support diversity, flexibility, and new opportunities(Carpenter et al., 2001). These explanations can arguably be used to explain the present situation of the transition happening in the ecosystem of Sri Lankan rice cultivation towards the SA aspects. There are three key predicted controlling variables that could influence farmers in this transition: "**farmers' connectedness to chemical fertilizer**," "**farmers' connectedness to organic fertilizer,**" and "**farmers' trust in governmental incentivization."** These variables could reasonably influence the actors of this ecosystem in the form of stabilization or destabilization. Table 4 helps to understand the strength of those variables in the current ecosystem where the farmer's connectedness with chemical fertilizer is vital in current farming practices, and they are literally disconnected from the use of organic fertilizers.

Table 4 : Use of chemical and organic fertilizers in current rice farming

Applications	***2019/ 2020***	***2018/2 019***	***2017/2 018***	***2016/2 017***	***2015/2 016***	***2014/2 015***
Use of Chemical fertilizers	69.70%	66.80 %	62.50 %	57%	68%	64%

Use of Chemical and organic fertilizers	30%	32.90 %	35.80 %	42%	31%	35%
Use of Organic fertilizers	0.10%	0.20%	0.50%	-		

Source: Department of Census and Statistics (2021)

Capabilities of Adaptiveness Resilience

The actor movements in the framework, capacity for adaptive resilience, are described in four stages: growth, conservation, release, and reorganization. The cycle's growth or exploitation (r) phase sees rapid colonization or expansion. This is followed by the conservation (K) phase, in which the system becomes increasingly specialized and rigid. In the release (Ω) phase, the system undergoes a collapse that 'radically and rapidly reduces its structural complexity' (Chapin et al., 2009). This is followed by a reorganization or renewal phase (a) in which resources are reorganized into a new system, which may resemble its predecessor or have significantly different properties. Table 5 below reflects the present status of rice cultivation, which has reached a close saturation in terms of its productivity. This indicates that the ecosystem is in the conservation phase of its evolution, which is driven by the heavy use of chemical fertilizer use. However, in the present context, farmers would have to release the use of chemical fertilizers and adopt organic fertilizers. Farmers' behaviours and reactions to this perturbation created by the scarcity of chemical fertilizers can be predicted using RT. The farmers will have to enter the "backloop" of the cycle if they are willing to adopt organic fertilizer and move on to the reorganization phase of the adaptive cycle.

Table 5: Productivity performance of current rice farming

INDICATORS	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Production index (Base Period: (2007 - 2010 = 100)	115	104	103	124	90	129	118	64	105	123
Contribution to National Consumption	97.2%	99.3%	99.1%	99.5%	85.0%	94.4%	99.3%	76.1%	94.4%	99.5%

Source: Department of Census and Statistics (2021)

Institutional Incentivisation

Farmers' trust in institutional incentivization could be considered a stabilizing force during such a transition in this ecosystem. In this situation, the farmers' perceived effectiveness on institutional incentivization would be a determining factor to keep them in the reorganization phase of adaptive resilience. However, trust depends on the degree of supportive interventions operating effectively. Some researchers have found governmental interventions that would influence farmers' SA capabilities below. Cusworth & Dodsworth (2021) found that institutional intervention in environmental land management policy mediates farmer

autonomy in delivering the dual needs for sustainable and productive agriculture on their farms. Demonte and Rutsaert(2017) found that poor linkages in the value chain (VC), the absence of international reputation, and the necessity of horizontal and vertical VC coordination are opportunities for sustainable VC upgrading. Von et al.(2016) asserted the potential of banks to impact smallholder farmers' productivity, which could attract other value chain industries for SA initiatives. According to Sevinç et al.(2019), public support is necessary but insufficient for the sustainability of agriculture, and the suitability, adequacy, and efficiency of subsidies are found to be problematic, particularly for non-irrigated farmers. These findings indicate the necessity of institutional support, such as environmental management policies, effective annuities, and value chain upgrading, highlighting supportive interventions that could elevate the farmer's confidence in SA adaptation.

Conceptual Framework

Based on the above rationalization, the researcher predicts that the following relationships shown in Fig 8 would explain the farmers' behaviours in navigating the adaptive resilience cycle during this transition. The degree of their resilience would determine their stay in the adaptive cycle or exit from it. Based on the above explanation, the researcher predicts that the four main farmer fractions may behave or react to the situation differently in responding to the requested change.

- Those who have some connectedness to organic fertilizers and are strong in their accrued capital assets try to reutilize them to create new bonds with organic fertilizers by moving into the reorganization phase.
- Those comfortable in the conservation phase of the adaptive cycle would resist releasing chemical fertilizer use; however, their strong SA potentials would influence them to treat the release of chemical fertilizer as a crucial need of the time and show a willingness to move into the reorganization phase.
- Farmers who do not possess adequate capital assets to reorganize with organic fertilizer use in farming would decide to wean away from agriculture, exiting the adaptive cycle.
- The farmers with good capital assets would try to capitalize on government incentivization and move into the reorganization phase.

The researcher believes that understanding each fraction's size would be significant in assessing the farmers' readiness to adapt to organic fertilizers. The findings would provide decisive information for policymakers, academics, and other value creators in this ecosystem.

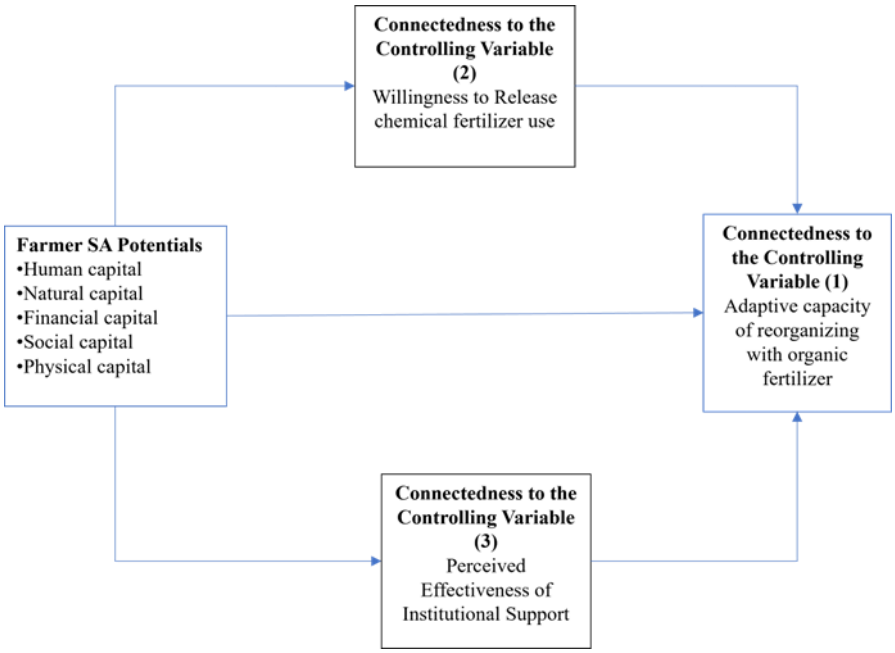

Figure 8: Conceptual framework to assess farmer readiness for sustainable agriculture activity (Adapting organic fertilizer) -Authors' creation

Indicator Framework

According to Creswell (2003), the quantitative research methodology maintains the assumption of an empiricist paradigm, and the research itself is independent of the researcher. As a result, data are used to measure reality objectively. Leedy and Ormrod(2001) mention that the "intent of the quantitative study is to establish, confirm, or validate relationships and to develop generalizations that contribute to the theory." Creswell (2003) states that quantitative research "employs strategies of inquiry such as experimental and surveys and collects data on predetermined instruments that yield statistical data." These literature explanations of the quantitative research paradigm can be predictive, explanatory, and confirming. The above characteristics of quantitative methodology align closely with this conceptual proposal, and therefore, the researcher views that quantitative research methodology is appropriate for such a study.

Previous researchers have measured the similar variables proposed in this conceptual framework in different contexts, as summarized in Exhibit 02 below. Adopting and refining those indicators to suit this context is the most productive and efficient way forward in developing the research instrument for this research work. Developing an indicator framework is necessary, which could be used as the primary source of questionnaire development. A structured questionnaire composed of closed and open-ended questions can be considered the appropriate research instrument, the approach of similar previous quantitative studies. The initial questionnaire developed based on the indicators found in the literature could be tested in a mini research (pilot survey) to assess the validity and further firm up the final questionnaire for data collection. The

stratified random sampling technique, which is the technique adopted in similar farmer interviews in the literature, would be a suitable sampling technique to measure the constructs. Face-to-face farmer interviews are the standard approach adopted by previous studies and deemed appropriate for this study. Descriptive statistics and formative and reflective factor analysis under PLS-based structural equation modelling are suitable data analyzing techniques in the literature in such assessments. The further literature synthesis provides the following indicators and scales of measurements, which are helpful in developing a structured questionnaire for the study (Exhibit 02)

Exhibit 02- Indicator Framework -Variables, Indicators, and Scales of Measurements

Latent variables	***Indicators***	***Scales of measurements***
Farmers' Sustainable Agriculture Potentials		
Human capital ***Memon 1989; Petway et al. 2019;Porritt, Jonathon,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 practiced 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 & 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.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*

Latent variables	*Indicators*	*Scales of measurements*
Natural capital ***(Scherer et al. 2018; Bisht,2013);Serebrennikov et al.2020 ;Gebska et al. 2020; Bowman & 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& Cabell, 2012; Melles & 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& Cabell, 2012;Melles & 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 &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),*

DISCUSSION AND IMPLICATIONS

Sri Lankan farmers' SA potentials for more organic use in farming are unknown, and the thorough literature review concludes that there is no straightforward method to assess those scientifically, as the researcher envisages. The researcher's attempt to utilize existing literature to formulate a conceptual model on the targeted objectives was found promising. Also, the researcher extended the review to develop a guiding indicator framework that will be usable to derive the indicators that can explain the constructs of the conceptual model. The literature shows that investigations such as farmers' adaptation of organic fertilizers, which contributes to SA, are assessed within economic, social, and environmental aspects within SA principles and standards. Previous studies have found that institutional support mediates preparing farmers to implement organic-friendly farming. The five capital assets explained in the rural livelihood assessment framework (RLAF) adequately demonstrate farmers' SA potential when considering the factors studied in similar studies. The previous literature proves that Human, Social, Financial, Physical and Natural capital assets would sufficiently describe factors associated with farmers' SA potential. The adaptive resilience cycle (RT) is a solid theoretical platform to explain the farmers' predictive behaviour in this transition. The RT concept and mapping its properties to RLAF within the SA aspect can adequately describe the current context of the research objective.

An indicator framework which can explain the variance of the model's constructs is the suggested way forward for developing measurable indicators for this study. The determinantal factors on farmers' readiness for SA mentioned in Exhibit 02 above will help formulate indicators (questions) for the research questionnaire through a follow-up specific literature review on each construct. A structured research questionnaire guided by this indicator framework would suffice for a researcher to operationalize the research in a selected sample population. The literature review under this defined objective helps meet the intended results by unfolding solid theoretical insights and empirical findings to build a research framework and for a scientific assessment of farmers' SA potentials and capabilities of adopting more organics in farming.

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