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Measurement model to assess sustainable agriculture potential of Sri Lankan rice farmers derived using rural livelihood assessment framework: Studied in Mahaweli-Block (H)

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Abstract

This paper describes a systematic method that identified constructs and indicators of a measurement model to assess rice farmers' Sustainable Agriculture Potential (SAP). The method used the Rural Livelihood Assessment Framework (RLAF) definition to define SAP's primary constructs. The capital assets defined in RLAF (human, social, financial, physical, and natural) were then explained using previous Sustainable Agriculture (SA) research findings. An initial 130 indicators were framed into five-point Likert scale questions to form a research questionnaire. The questionnaire was initially administered among 64 selected farmers in a dominant rice cultivation region (Mahaweli Block H) in Sri Lanka. The responses were analyzed using the measurement model analysis technique using the Partial Least Square Structural Equation Modelling (PLS-SEM). Based on this analysis, 87 questions were identified as effective measures of the farmers' SAP. The refined questionnaire was surveyed among 386 rice farmers randomly selected in the same region. The responses were analyzed using the PLS-SEM techniques for each capital asset in the form of measurement models. The analysis proved those 87 questions (indicators) are productive and can explain farmers' SAP compositely. The researcher believes the model will be helpful for future researchers in assessing the strengths of SAP and the nexus between SAP and other variables, such as their ability to adopt more organic-centric farming and resilience to other varying factors impacting their farming. Furthermore, the method used to maximize the variance explained in developing indicators and ruling out the less productive indicators could be insightful for researchers in future studies.

Keywords: Capital assets, Formative indicators, PLS-SEM, Rural Livelihood, Sri Lankan rice farmers, Sustainable agriculture

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Introduction

Sustainable agriculture and farmers' potential to implement sustainable agricultural practices are widely discussed in global forums today. The United Nations General Assembly (2012) recognizes sustainability aspects of agriculture with more focus on ecological and social factors, including food security needs. Further, the United Nations Department of Economic and Social Affairs for Sustainable Development (2021) reemphasizes this unprecedented need for food and agriculture sustainability in the 21st century.

Today, the world faces an immense challenge in securing food needs for the increasing population without compromising the ability of future generations to meet their own needs (Lichtfouse et al., 2009). Some scholars define sustainable agriculture as a dynamic and complex ecosystem that can fulfil food needs within acceptable social, economic, and environmental costs and be resilient to environmental and economic changes (Conway & Barbier, 1990; Ackerman et al., 2014; Scherer et al., 2018).

FAO (Zoveda et al., 2014) more precisely defines 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, protesting, and enhancing natural ecosystems; 3) protecting and improving rural livelihoods and social wellbeing; 4) enhancing the resilience of people, communities, and ecosystems; and 5) promoting good governance of both natural and human systems. These five principles provide insightful direction for this research to delineate the study's boundaries.

The Sri Lankan government further realizes the timely need to implement measures to transition agriculture to a more sustainable aspect, including rice cultivation. The government attempted to switch cultivation to 100% organic in the middle of 2021. This move is a well-known failure that created political and economic turmoil in the country. The failure and the follow-on revisions to correct it have caused massive perturbation in the rice cultivation sector and created uncertainties in farmers' minds about the future of cultivation. The aftermath of the economic crisis in the country worsened the situation.

Nevertheless, realignment of the country's rice farming into a more sustainable and organic-centric system is still needed and high on the government's agenda. However, policymakers and other concerned parties do not know the Sri Lankan farmers' potential for sustainable agriculture (SA) and their preparedness to implement more organic-centric farming. This study investigated the nexus between SAPs of the farmers and their readiness for more organic-centric agriculture. The first hurdle was to find the correct dimensions to explain the SAP of the farmers. After an exhaustive literature review, it was found that defining and assessing SAP of the farmers is not straightforward. No comprehensively developed constructs and variables exist for such assessments in the current literature, particularly in the Sri Lankan rice farming sector. This paper discusses the method used by the researcher to address this gap by formulating a measurement model to assess the SAP of the farmers, to define its constructs, and produce indicators to explain them. Innovative application of Measurement model analysis technique available in the modern Partial Least Square Structural Equation Model (PLS-SEM) was used to assess and finalize the variables of SAPs of the farmers. The paper presents how the constructs of SAP were defined. Indicators were identified to explain those constructs following an exhaustive literature review. The model calculates the regression weights of the constructs, which describe SAP of the farmers compositely.

Rural Livelihood Assessment Framework

Farmers are a subset of rural livelihoods. According to Department for International Development (DFID), "a livelihood comprises the capabilities, assets (including both material and social resources), and activities required for living." A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future while not undermining the natural resource base. Ashley & Carney (1999) adapted this definition from Chambers & Conway (1992), who introduced sustainable rural livelihood assets in sustainable livelihood assessment framework of DFID. The framework describes rural livelihood assets in five main categories: human capital, social capital, financial capital, physical capital, and natural capital. Carney (1998), Scoones (1998), and Batterbury & Forsyth (1999) supplemented this explanation of five-dimensional capital assets. This study adopts the above description of capital assets to represent SAP of the farmers. However, these capital assets had to be defined to reflect their potential for implementing SA practices. Exhibit 1 below shows the constructs identified to determine the dimensions of SAP of the farmers. Observable indicators representing SAP of the farmers are required to explain each construct. These indicators were derived through an exhaustive literature review.

Measurement Model to Assess Sustainable Agriculture Potential of the Farmers

The constructs shown in Exhibit 1 and Figure 1 define the model for the assessment. The researcher found indicators to explain five capital assets through an exhaustive literature review of similar SA studies focused on various socioeconomic, socio-ecological, and socio-cultural factors.

Table 1: The constructs of SA potential of the Farmers

Constructs of SA potential of the farmers	***Type***	***Category***
SA Potentials of the Farmers (FSAP)	Composite	Latent
*Human Capital (**HC**)*	Independent	Latent
*Social Capital (**SC**)*	Independent	Latent
*Financial Capital (**FC**)*	Independent	Latent
*Physical Capital (**PC**)*	Independent	Latent
*Natural Capital (**NC**)*	Independent	Latent

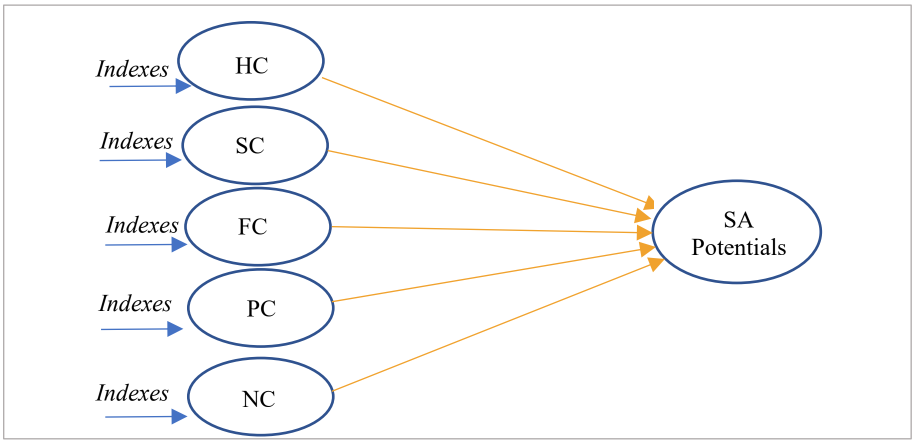

Figure 1. Measurement model for SA potential of the farmers

Material and Method

Deriving indicators of SAP of the farmers

The proposed constructs of the models are latent variables, and the researchers have explained such variables using observable indicators. The quantitative research method is popular in studying such combinations of latent constructs and observable indicators in literature. As explained by Leedy & Ormrod, 2001/2005; Cohen et al., 2007, the quantitative-descriptive approach effectively explores the underpinning variables of latent constructs associated with socioeconomic and natural factor explorations. Survey methods are standard in data collection in such quantitative-descriptive studies (Blanche et al., 2006), and structured questionnaires (indicators) are required for the surveys. According to quantitative measurement theories explained in the literature (Hair et al., 2017), researchers can derive measurement indicators in two ways, either in a "formative" or "reflective" manner, which depends on the nature of the construct of the study and the depth of the explanation anticipated by the researcher.

Formation of indicators

Maximizing variances explained in each construct is envisaged during this study. The indicators can be in the form of a formative or reflective manner to explain such constructs. The following diagram (Figure 2) demonstrates the differences between coverages of formative and reflective measurements. The formative approach covers the construct broadly and explains the construct compositely. In contrast, the reflective approach explains the construct in a covarying manner, explaining the construct with limited variables. For the objective of this study, the indicators are not necessarily covariant in explaining the constructs of capital assets, and the formative approach was found to be more promising to maximize the variances explained on each construct. Diamantopoulos & Winklhofer (2001) suggested forming formative indicators to ensure that causal priority between indicators and constructs is from indicators to the construct and reflective if the relationships are explained in a reversed manner. Furthermore, Fornell (1982) suggested formulating formative indicators when multiple indicators explain the construct. Similarly, Rossiter (2002) argued for forming formative ones if indicators represent the cause. These literature suggestions supplemented and supported the researcher's suggestion of using the formative approach to form indicators of capital assets in a composite manner.

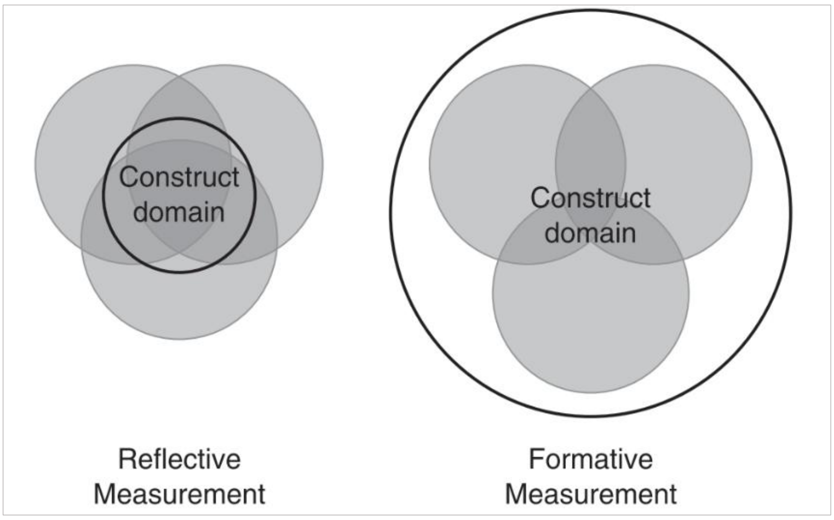

Figure 2. Formative vs Reflective Indicators
Source: Hair et al., 2017

The data analysis technique used in this study is PLS-SEM, which is discussed in detail below in this paper. PLS-SEM techniques provide parameters, algorithms, and rules for formative indicator analysis. When analyzing formative indicators in PLS-SEM, the method requires a duplicate set of reflective indicators apart from the construct's formative indicators (Hair et al., 2017). The method and this requirement are discussed in detail under the data analysis section discussed below in this paper. This requirement is also considered in forming the indicators to define SAP. The indicators of five capital assets were derived formatively, along with some reflective indicators for each.

Coding and scale of measurement of indicators

The determination of the appropriate coding and measurement of the indicators is essential for capturing the proper response to the indicators during a survey. Hair et al. (2016) suggested using ordinal scales, such as the Likert scale, which has become standard in deriving similar indicators for maintaining equidistance between responses. In this study too, the indicators are framed on a 5-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 is the same as between categories 3 and 4.

Literature Review for Deriving Indicators

Human Capital

According to Coleman (1988), human capital is a set of new skills and capabilities that enable one to act in a new way to prove productivity. Acquiring knowledge, building awareness and skills, developing positive attitudes, and blending values and beliefs with modern farming practices could be the most significant motivating factors for adapting SA practices. Improved literacy level, experiences, skills, household health, and living standards would be strong determinants of human capital, which researchers have investigated in similar studies (Memon, 1989; Petway et al., 2019; Porritt Jonathon, 2011; Radcliffe, 2017).

Social Capital

Social capital is an asset produced when people interact, creating relationships and networks of trust and shared understanding (Gotschi et al., 2008). According to Sobel (2002), social capital describes circumstances in which individuals can use membership in groups and networks to secure benefits Putnam et al., 1993, and Coleman ,1994 defined social capital in detail as the networks, norms, trust, and links of reciprocity that facilitate cooperation and coordination. The accrued Social Capital of farmers was instrumental in adopting new agricultural practices; a study of young Greek farmers found that those with higher social capital were more likely to be innovative (Koutsou et al., 2014).

Financial Capital

Cash flow generation is essential for farmers to afford to take risks and develop a longer-term vision than daily subsistence. A synthesis carried out by Vorley (2002) on projects of 'policies that work for sustainable agriculture and regenerating rural livelihood' demonstrates that the selffinancing capacity of Brazilian farmers is vital to allow them to adopt more environmentally friendly practices. In the same study, limited access to credit is a significant impediment to small-scale agricultural production. Credit programs seldom reach smaller farmers due to power disparities and rent-seeking by larger farmers. The Bolivian case study under the same project explains that in contrast to large-scale mechanized agriculture, smallholders had no or little access to credit since they had no collateral, resulting in little commercial value for banks. The case studies also demonstrate the importance of off-farm income, such as retirement funds and city jobs. Many low-income households use migrant relatives' remittances for consumption or to pay expenditures such as education and health, so little usually remains for investment and farm-based accumulations (Tacoli, 1998). In general terms, financial capital explains an individual's or institution's savings, credit, and remittances, in this case, which would be direct determinants of the ability of farmers to adapt SA practices.

Physical Capital

Many researchers have investigated the ownership of farm plots, machinery, buildings, equipment, cultivation wells, granary, tools and equipment, transport networks, and access to technologies, including ICT, in assessing the physical capital of the farmers, which might influence their readiness for adapting SA (Myeni et al., 2019; Arellanes et al., 2003; Petway et al., 2019). The farm size and ownership of the farming plot are significant factors in SA studies. Gachango et al. (2015) and Rodríguez-Entrena & Arriaza (2013) found that the size of the farm positively relates to conservation agriculture adaptation. Whereas Läpple & van Rensburg (2011) Kallas et al. (2010) found that farm size inversely relates to the adaptation capabilities of organic farming. However, in their literature synthesis, Knowler & Bradshaw (2007) found that several researchers have tested this variable in 18 SA studies. Six studies had seen a positive correlation with SA, two were inversely related to SA, and ten studies were found to be insignificant. Given the mixed findings of previous researchers, farm size could contribute to farmers' readiness for SA in either way.

Natural Capital

Rezvanfar et al. (2009) concluded that accelerated soil erosion and declining fertility are significant constraints to agricultural production and SA. Soil fertility is the ability of soil to sustain plant growth and optimize crop yield. The organic and/or inorganic fertilizers fill the deficiencies. According to Spaling and Vander (2019), farmers claimed that retaining crop residue or regularly adding mulch to the field improves soil fertility (organic matter nutrients). Zahra (2018) found that soil fertility declines because of the growing use of chemical fertilizers and pesticides. The SA studies often investigated increasing soil organic matter and concerns about nutrient availability. Some researchers pointed out that soil organic matter is contingent on the availability of organic inputs (crop residue, manure, and compost) (Marongwe et al., 2011; Mupangwa et al., 2012; Palm et al., 2014; Dordas, 2015). The proximity of organic inputs further affects availability. Fields nearer to the homestead usually have higher organic matter because sources of manure and compost are nearby (Zingore et al., 2007; Guto et al., 2012).

Methodology

Research Questionnaire

The exhaustive literature review summarized above produced 108 formative questions and 22 reflective questions in the form of statements. The frame of the questions is, in a way, the respondents can answer on a scale of "strongly disagree" to "strongly agree." (5 points Likert scale). Table 1 shows the number of indicators derived against each construct in both categories.

Table 2: Number of Formative and reflective indicators of Constructs

Capital Asset	*Number of formative indicators*	*Number of Reflective indicators*
Human Capital	38	5
Social Capital	22	4
Financial Capital	15	3
Physical Capital	15	5
Natural Capital	18	5

Study Population

Anuradhapura district is the dominant rice-producing district in Sri Lanka, and Block H of Mahaweli belongs to this district and accounts for 20% of paddy cultivation extents (Department of Census and Statistics Sri Lanka, 2021). Division H comprises approximately 14,170 hectares of developed land under Mahaweli colonization schemes. The researcher selected this region because of its diverse nature of irrigation patterns (major, minor, and rain-fed). Figures 3 and Table 2 below show the geographical layout of block H and sown extents of rice and their percentages in the regions belonging to it. Most rice cultivation plots (more than 80%) are less than 2.5 acre plots which denotes that the sown extent is a fair representation of the farmer population in this region.

Table 3: Sown Extent (acres) in Mahaweli zones H in Anuradhapura district

Rice cultivation region in block H	*Acres*	*% to District Total*
Galnewa	9082	3%
Meegalewa	5220	2%
Galkiriyagama	5367	2%
Madatugama	7307	2%
Eppawela	8122	3%
Tabuttegama	7129	2%
Nochchiyagama	8257	3%
Thalawa	7437	3%

Source: Department of Census and Statistics Sri Lanka. (2020)

Sample size

Selecting a proper sample size is a fundamental requirement to prove the statistical significance of the findings of quantitative research studies. The sample size required for the study was determined by referring to the literature. According to Han et al. (2018), 225 farmer organizations and 25,623 registered members are in Block H of Mahaweli. Aheeyar (2007) found that 94% of the farmers in block H engage in rice cultivation. Krejcie & Morgan (1970) developed a table to determine a population's sample size for easy reference. This reference table shows that 377 samples would be sufficient for a population of 20,000 people and 379 for a population of 30,000. Therefore, 380 samples per unit was adopted for this study. Table 3 shows the samples collected from each region.

Table 4: Number of samples by each division

Cultivation divisions in Block H	***Sown Extent***	***Number of samples***
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

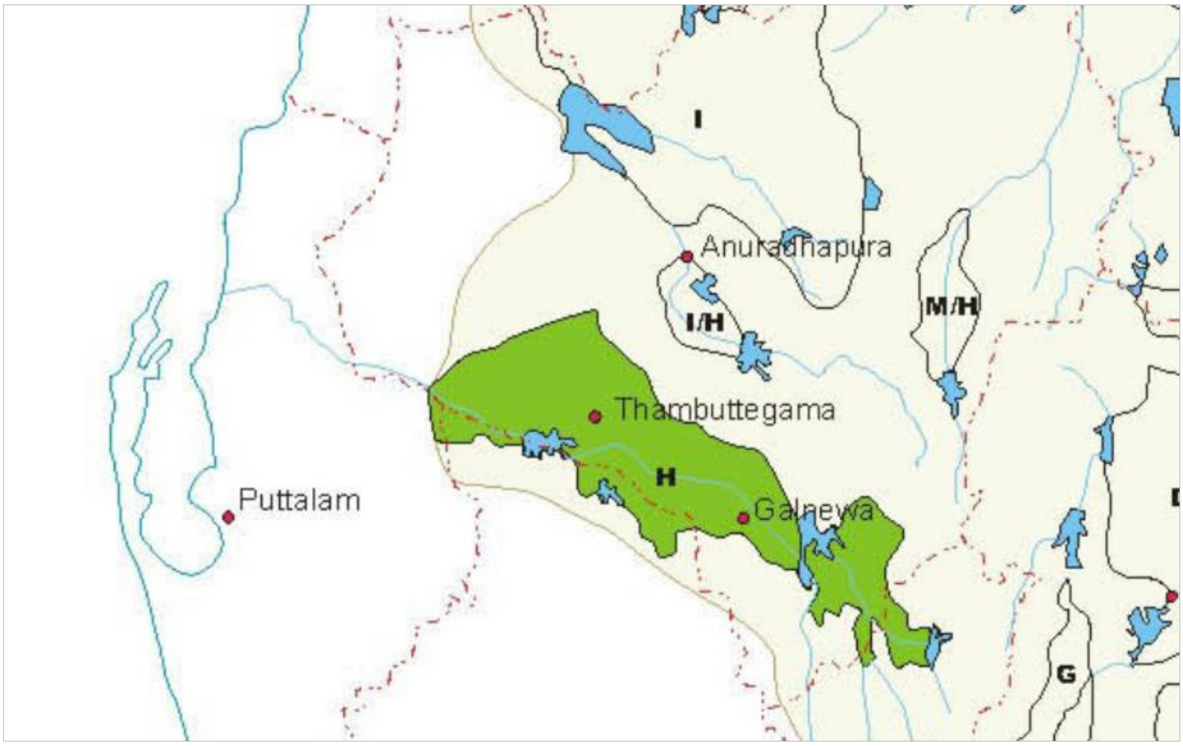

Figure 3. Geography of Mahaweli Block H
Source: Aheeyar, (2007)

Pilot Survey

Pretesting a questionnaire using a small number of respondents (pilot survey) is a widely used research practice to extract the most productive and appropriate questions from a broader questionnaire (Mugenda & Mugenda, 2003). This step is vital for ensuring that respondents have clarity and understanding of the questions with no ambiguity. It also helps to test the length and sequencing of questions, rectify inadequacies, reduce biases, protect against redundancy of questions, and reveal vague questions (Sekaran, 2003; Neuman, 2006; Easterby-Smith et al., 2021; Babbie, 2004; McBurney & White, 2007; Cooper & Schindler, 2003). The study undertook a pilot survey, considering the views mentioned above by various researchers.

Data Collection and Analysis of the Pilot Survey

From May 23 to June 4, 2022, 64 participants responded to the questionnaire, referring to the government fertilizer distribution lists available to agriculture officers in these divisions. The responses were analyzed following guidance and suggestions explained in the PLS-SEM literature (Hair et al., 2017). The measurements for five capital asset constructs comprised 108 formative indicators and 22 reflective indicators. The guidance provided in PLS-SEM on measurement model analysis, similar to popular Principle Component Analysis (PCA), was followed to assess the indicators.

Measurement model Analysis (PCA)

The measurement model analysis for formative indicators differs from the usual covariance-based regression analysis. PLS regression is an analysis technique that explores the linear relationships between multiple independent variables and a single or multiple dependent variable(s). Composite regression models with dependent constructs and their multiple independent variables can be assessed in PLS-SEM methods (Hair et al., 2017).

Steps in Measurement Model Analysis

The literature suggests applying the following steps in sequence to assessing measurement models.

Step 1: Assess the convergent validity of formative measurement constructs.
Step 2: Assess the formative measurement constructs for collinearity issues.
Step 3: Assess the significance and relevance of the formative indicators.
(Hair et al., (2017)

Assessing Convergent Validity (CV)

The PLS-SEM analyses the CV of formative constructs by calculating the correlation of formative measurement with alternative reflective measures of the same construct, as shown in Figure 4. The formative indicators, in a linear way, form the formative latent construct, and the explained variance (R2 value) of the compositely created latent construct which should be equal to 1 in an ideal situation (Bollen, 2011; Bollen & Bauldry, 2011)

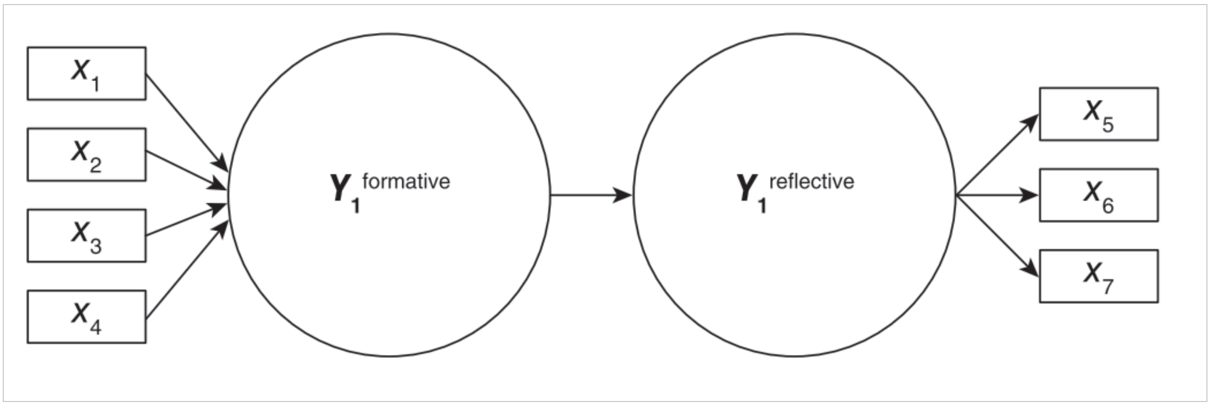

Figure 4. Model to measure convergent validity of formative indicators
Source: Hair et al. (2017)

The strength of the path coefficient linking the two constructs (formative and reflective) should be of magnitude 0.80 or a minimum of .070 for satisfactory convergent validity. In other means, this reflects the indicative R^2 value of the construct to be 0.64 or at least 0.50 to prove the convergent validity. The five formative latent constructs of the model were analyzed by applying the above criteria and rules. Exhibit 5 below depicts the summary of the CV analysis of the formative constructs of the model.

Table 5: Exhibit 5 Results of convergent validity analysis

Latent construct	Path coefficient	R^2 Value
HC^F→HC^R	0.924	0.853
SC^F→SC^R	0.784	0.615
FC^F→FC^R	0.895	0.801
PC^F→PC^R	0.828	0.686
NC^F→NC^R	0.700	0.491

Assessing Collinearity of Indicators

In PLS-SEM literature, collinearities of formative indicators are measured using the variance inflation factor (VIF), which is defined as the reciprocal of tolerance value. The tolerance value represents the variance of one formative indicator, which the other indicators in the same construct do not explain. In this concept of PLS-SEM, a tolerance value of 0.20 or lower and a VIF value of 5 or higher indicate a potential collinearity problem (Hair et al., 2011). Collinearity analysis of all formative indicators (VIF values) shows that some indicators have exceeded the above thresholds. These questions were ruled out from the questionnaire and not considered as productive to retain as measurements.

Assessing significance and relevance

The relevance of the contribution of the indicators in forming the construct is examined by analyzing the outer weight (relative importance) and outer loading (absolute importance) of the indicator. The significance of such a contribution is measured using the bootstrapping technique provisioned in PLS-SEM techniques. The following rules are proposed in the literature to determine their relevance and significance.

- When the weight of an indicator is significant, empirical support exists to retain the indicator.
- When the weight of an indicator is not significant, while the corresponding item loading is relatively high (i.e., ≥0.50) or statistically significant, the indicator should generally be retained.
- If the outer weight is not significant and the outer loading is relatively low (i.e., <0.5), it should be strongly considered to remove the formative indicator from the model.

After applying these rules to this measurement model, the results show some indicators did not comply with the above rules and conditions and those questions were dropped from the questionnaire.

Summary of the Outcomes of the Pilot Survey

After applying the above rules of data analysis, less relevant and insignificant measuring variables were eliminated from the measurement model. Out of 108 formative questions of five constructs that were surveyed through the questionnaire, only 69 indicators were qualified to be retained. Of the 22 reflective indicators, 18 were found to be productive measurements. The indicators were carried forward for a comprehensive survey with a larger sample size.

Main Study

Three survey teams used the refined questionnaire to collect data in the prescribed locations mentioned above during October and November 2022. The survey teams randomly met rice farmers at their doorsteps or farm fields and marked the responses to each question of the survey questionnaire in real time. The data collection concluded after they collected 400 samples covering each region.

Data Analysis and Findings

The PLS-SEM techniques applied during the pilot survey on measurement model (PCA) analysis were redeployed on each construct using 386 samples. The following section describes the analysis of the Formative-Reflective models for each construct. The constructs were analyzed using their grouped variables. The calculations resulted in a path coefficient value between formative and reflective constructs (> 0.7), R2 (> 0.5), and VIF (0.2-5.0) were observed. The significance and relevance of outer weights of each indicator to the predecessor constructs were assessed and found satisfactory for all constructs. The following figures show the outcomes of the analysis.

Human Capital

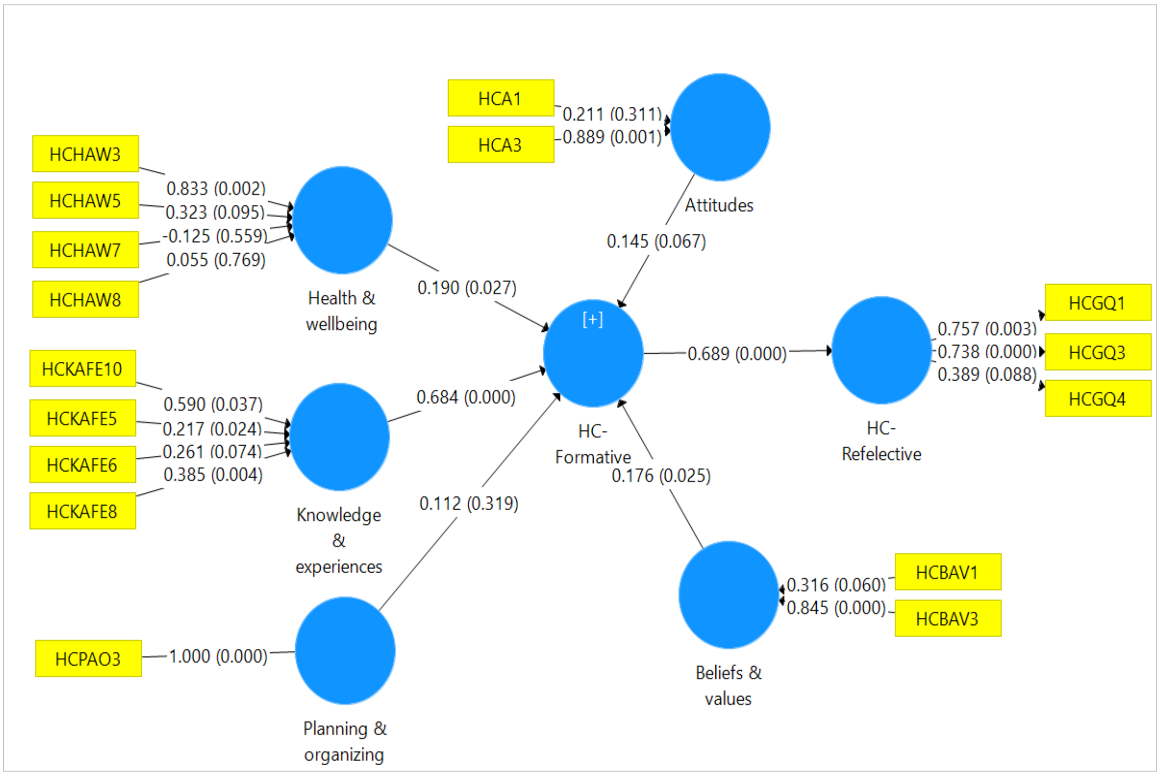

Figure 5. Path coefficient, significance, and relevance of human capital variables

Social Capital

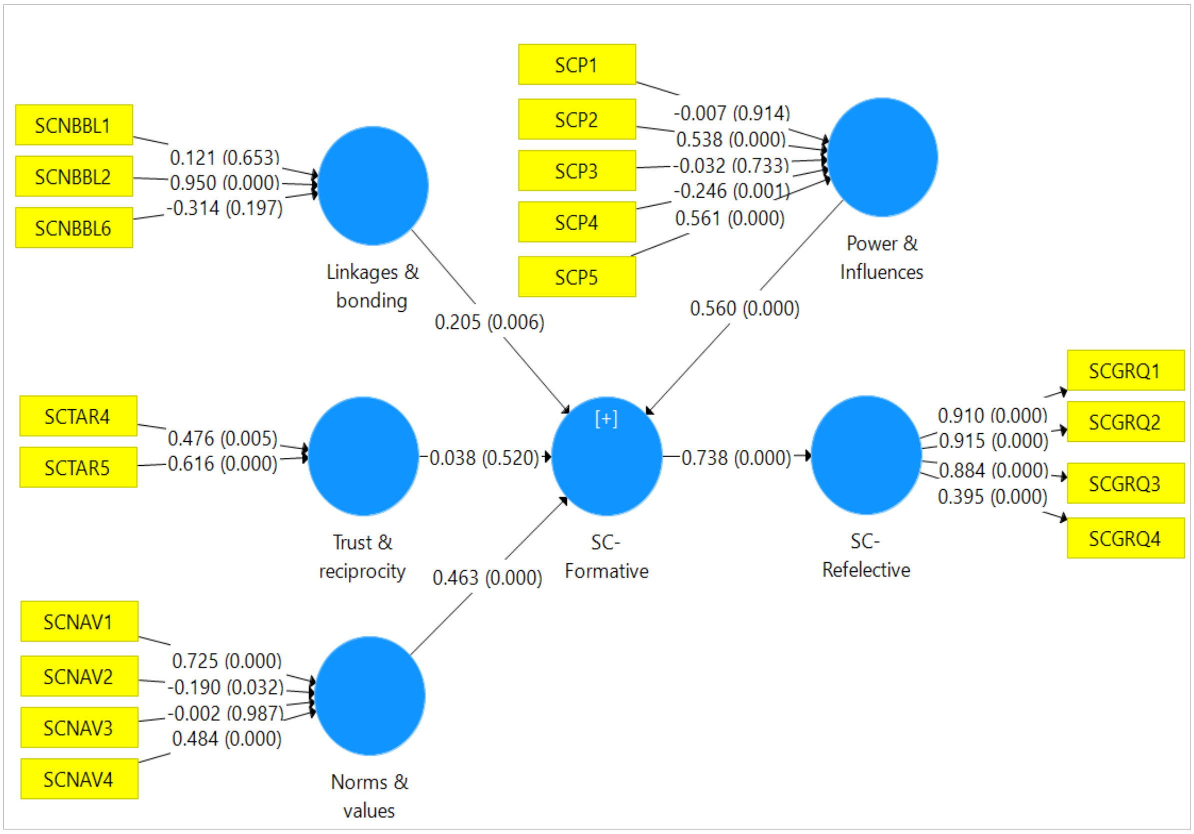

Figure 6. Path coefficient, significance, and relevance of social capital variables

Financial Capital

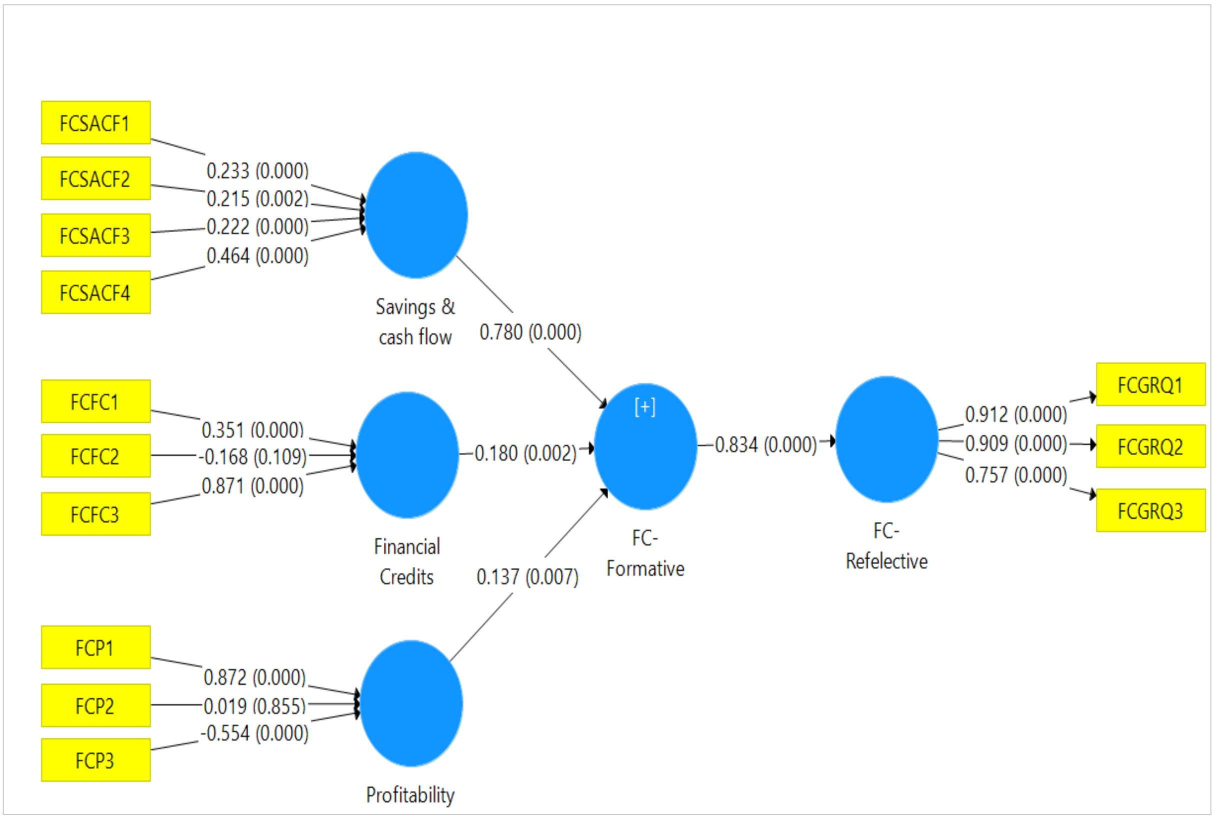

Figure 7. Path coefficient, significance, and relevance of financial capital variables

Physical Capital

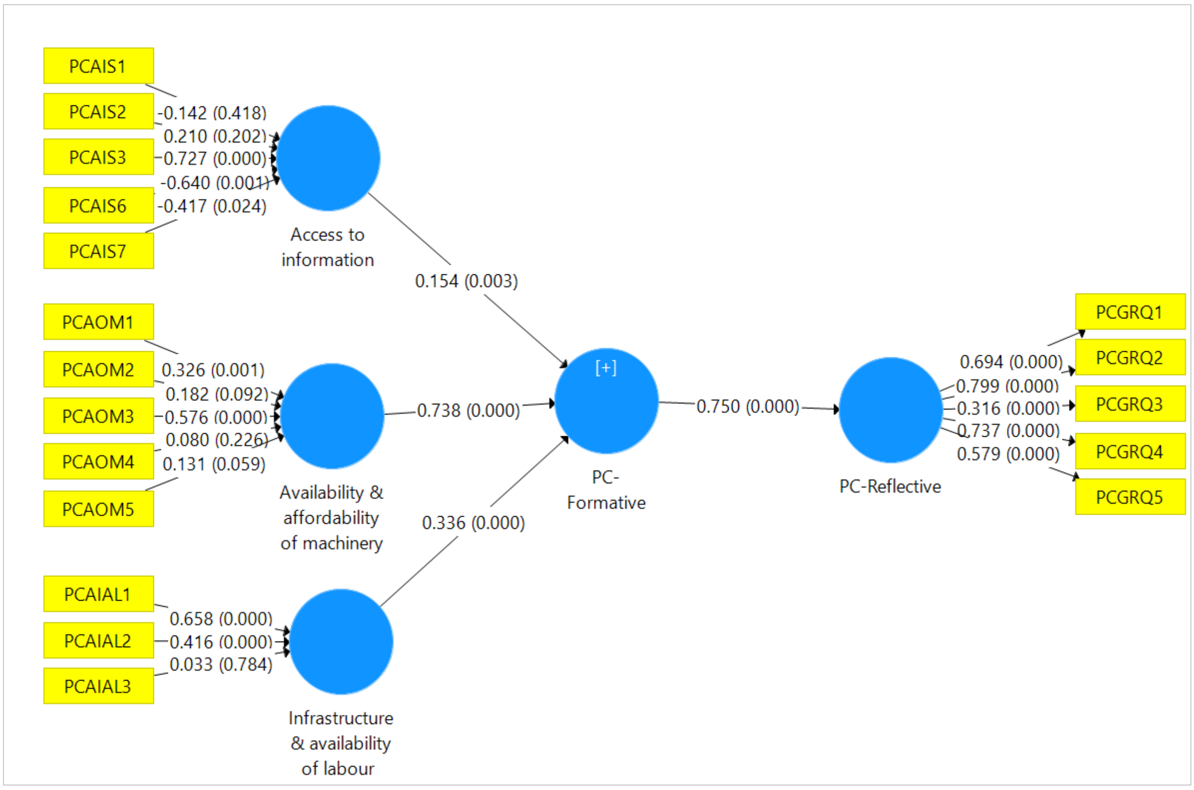

Figure 8. Path coefficient, significance, and relevance of physical capital variables

Natural Capital

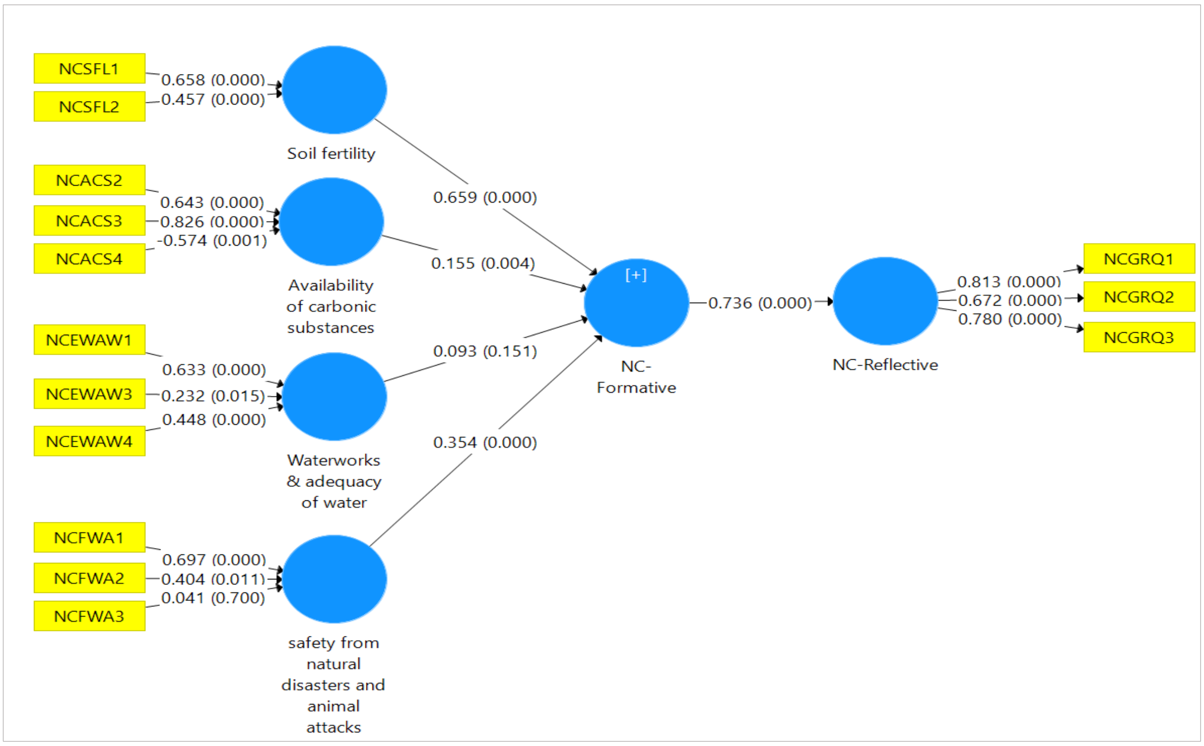

Figure 9. Path coefficient, significance, and relevance of natural capital variables

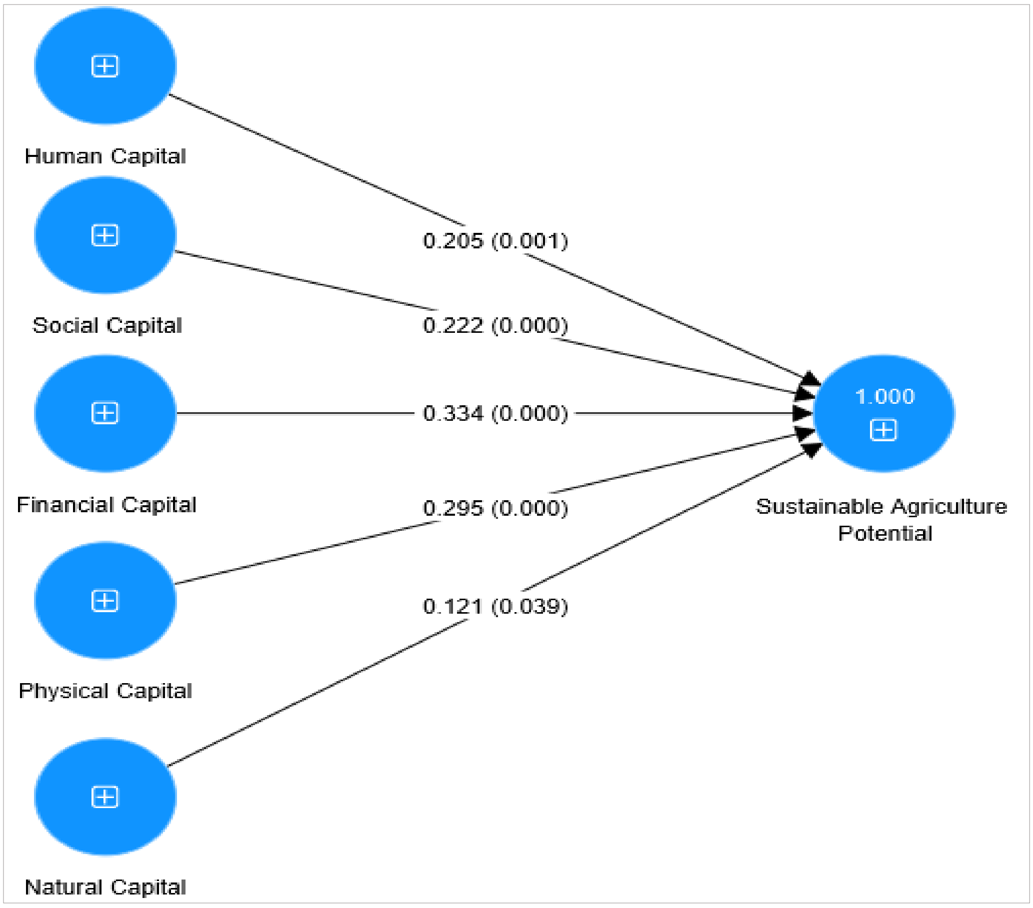

Figure 10. Path coefficient, the significance of the construct of SAP

Measurement Model to Assess Sustainable Agriculture Potential of the Farmers

The formative indicators found productive in the previous steps were used to analyze the SAP of the farmers. Figures 10 and Tables 4 and 5 show the effectiveness (regression weights), strength (latent variable scores) and statistical significance of capital assets on SAP. The regression weight indicates the comparison of the strength of each capital asset compositely contributing to form SAP. These path coefficient values reflect the current situation.

Table 6: Path coefficients and p-values of SAP constructs

Constructs	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Financial capital -> Sustainable _agriculture potential	0.334	0.325	0.064	5.227	0.000
Human capital -> Sustainable agriculture potential	0.205	0.202	0.061	3.355	0.001
Natural capital -> Sustainable _agriculture _potential	0.121	0.12	0.059	2.068	0.039
Physical capital -> Sustainable _agriculture _potential	0.295	0.293	0.062	4.754	0.000
Social capital -> Sustainable _agriculture _potential	0.222	0.224	0.063	3.517	0.000

Table 7: Performances of capital assets

Latent Variable (LV)	LV performance
Financial capital	94.337
Human capital	85.758
Natural capital	70.826
Physical capital	96.280
Social capital	-4.385

Conclusion

This paper described how a measurement model was formulated with its constructs and indicators to assess SAP of the farmers. The five capital assets of RLAF were found suitable to explain the dimensions of SAP exhaustively. Previous sustainable agriculture studies helped to collect as many indicators as possible that can compositely explain the respective constructs. The measurement model techniques in PLS-SEM technologies are practical in filtering out the most productive indicators to construct research questionnaires with an optimal number of questions. Formulating the indicators in a formative composite manner met the objective of maximizing the variance explained on predecessor constructs. The model calculates the effectiveness (regression weights) of each capital asset on the SAP of farmers, reflecting the strength of the livelihood of the farmer. Furthermore, the model can predict the strength (variable score) of each capital asset. For example, in the present context in this region, financial capital is the most influential and strong asset of the SAPs. Although social capital is effective, it is weak and reverses the strength of SAP. Therefore, the model and indicators would be a practical scientific framework for researchers, policymakers, and the value creators in this value chain. Most importantly, in studies where the SAP of the farmers would be used as an independent variable to assess their readiness for various challenges, such as resilience in more organic-centric agriculture, climate changes, and political and economic situations impacting their livelihood and farming. This model and the approach used to produce and apply this model in real-life scenarios would be insightful for future researchers.

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