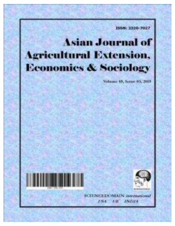

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Identifying Sustainability Assessment Indicators for Assessing the Sustainability of Smallholder Integrated Farms in Coastal West Bengal, India

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Authors' contributions

This work was carried out in collaboration between all authors. All authors designed the study, authors PD and RG performed the statistical analysis and wrote the first draft of the manuscript. Author SS corrected the draft. All authors read and approved the final manuscript.

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ABSTRACT

Smallholder integrated farming system (IFS) is debated as an alternative to conventional external input driven commercial farming in developing nations. The sustainability of IFS is the key to secure sustainable livelihoods of millions of small and marginal farmers and they need to be monitored and assessed precisely. This asks for a valid set of sustainability assessment indicators that envisage the social, economic and ecological dimensions of sustainability and are validated by the agri-

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experts working in a specific agroclimatic zone. The present study was conducted to screen sustainability assessment indicators for IFS, in the context of coastal agroclimatic zone of West Bengal, India. Guided by an indicator framework, a pool of 87 indicators were scouted and given to the local agri-experts for rating their relevance against a 4-point scale. Based on the weighted mean score of the indicators, ease of access to them, cost of their measurement, clarity of the indicators to the experts and their redundancy, local agri-experts screened 52 indicators covering the social, economic and ecological dimensions of sustainability. The important selected Ecological indicators were Biomass availability, Soil organic Carbon, Depth of ground water table, Soil macronutrient etc. Similarly, important Economic indicators were Cost of cultivation, Ownership of land, Input sources, Off-farm income etc. and Social indicators were Gender equity, Adherence to local culture, Workload of women and Balanced nutrition etc. In this study, we outlined the methodology of selecting these sustainability assessment indicators of IFS with special reference to the context of developing nations that resulted in a rich pool of contextual sustainability indicators for the coastal agroclimatic zone of West Bengal, India. We also discussed some core methodological and logistic issues associated with this. Adaptation of this methodology of indicator screening might be used in different contexts of smallholder systems for monitoring farm-level sustainability of IFS.

Keywords: Smallholder systems; integrated farming system; indicator framework; sustainability indicators.

1. INTRODUCTION

In the 21st Century, human managed systems like agriculture is facing major challenges to satisfy the sustainable development goals [1]. The role of agriculture as a surplus generating mechanism for other industries in the late 20th century broadened its scope after the introduction of Green Revolution technologies and gradually became a backbone for other industries. As a result, agricultural production and its links with multiple natural and other human managed systems have created new meanings to the relationship between farming system and human actions [2,3,4]. There are two parallel and antithetic paradigms of farming operates globally – commercial farming driven by high external input among the resourceful farmers achieving higher returns to scale [5,6] marketability, productivity, government subsidy etc., and smallholder resource-poor subsistence farming resorting to traditional ways of farming leading to low profitability, marketability and stability of the farming systems. The compelling objectives of these farming systems are their urge for better agro-economic returns, fulfillment of diverse family needs, adjustment for resource scarcity, and ability to cope with the climatic stresses [7] and changing government policies. Together, these factors challenge agricultural sustainability in the long run [8,9] often result in farmers' expulsion from their ancestral occupation. As a response, farmers in many developing countries have continuously improvised diverse farm management decisions to achieve sustainability of their livelihoods. They have designed or adopted different forms of sustainable intensification in their farms, integrated farming system (IFS) being one of them. IFSs use innovative methods and traditional knowledge to adapt with the changes in technology, climate, and socio-economic environment with a conscious employment of 'reuse, recycle and redesign' principles in their farms [10,11]. Examination of sustainability in these IFSs is an issue of practical concern and there is increasing demands for such evaluation tools of agricultural sustainability [12,13]. Over the last two decades, several sustainability assessment tools have been developed for agriculture [14,15]. Such assessments must be preceded by the selection of valid indicator sets, based on which sustainability assessment may be undertaken.

This context demands more attention in smallholder farming systems that have come out as an important focus in the international development dialogues for their huge number and thus holding the potential to curb hunger and malnutrition among the rural populace [16]. Investment in smallholder systems ensures that the growth is inclusive, pro-poor, and environmentally sustainable [17]. It is also considered to be an effective way to bring positive economic growth and poverty reduction, with enhanced resilience to natural disasters [18]. As a logical extension, integration in smallholder farming system is considered as a means of sustainable intensification of natural resources [19] and higher farm output is be expected from lesser use of natural resources.

Summarily, the rationale of the study hinges on three observations – one, presence of large number of smallholder integrated family farms globally; two, their ability to improve farm-level sustainability; and three, capacity of these farms to produce surplus nutritious food to feed the world population.

Sustainability, in the context of integrated farming system, is being debated of late since recursive fragmentation in land holding in developing countries has triggered huge diversification and resource integration as a survival strategy for the smallholders. Sustainability of these systems has mostly envisaged environmental sustainability with relatively lesser focus on the social and economic dimensions of the farming systems. Nevertheless, need of sustainability measurement covering all the three major dimensions have direct impact on a farming system's performance at the micro and macro level. Literature also suggests that there is ample scope to combine these dimensions together to measure agricultural sustainability [20].

An indicator is a quantitative or qualitative measure derived from a series of observed facts against which performance of a system is assessed and compared with other systems. The implication is that the sustainability assessment of IFS will be able to describe and compare farm sustainability across time and space. Sustainability assessment must ground on sound indicator sets and their selection is critically dependent on a pragmatic set of screening criteria. FAO, IFAD and WFP [21] suggest criteria for choosing indicators should include policy relevance, validity or analytical soundness, and accessibility to users at an appropriate scale. The indicators are ideal when they are easily understandable to the end-users, local service providers and policy makers.

In this article, we wanted to screen a locally valid set of sustainability assessment indicators that can be used in future occasions for assessing sustainability of smallholder integrated farming systems in coastal agroclimatic zones of West Bengal state of India. For this, we proposed a theoretical framework for scouting an initial set of sustainability indicators for the smallholder integrated farms of coastal West Bengal, India. Then, we employed local agri-experts to rate these indicators' relevance and screened them based on the rating score and a set of pre-defined criteria.

2. METHODOLOGY

2.1 Study Area

Based on climate, soil and physiography, there are six agro-climatic Zones of West Bengal state of India. South 24 Parganas district comes under the Coastal Saline Zone, one of the biggest Zones covering part or whole of 6 districts of West Bengal. A large area of Indian Sunderbans falls under this district. The climate is tropical moist sub-humid with 1796.2 mm rainfall, and wide range of air temperature (maximum 35.0°C, minimum 15.6°C). Cropping intensity of the area is 143%, rice being the main crop grown over different land terrains and the seasons. *Aus* (spring paddy), sesame and green gram in pre-kharif (early wet season), jute and *aman* rice in kharif (wet season) and wheat, different oilseeds and pulses, and potato in *rabi* (winter season) are important crops of the region. South 24 Parganas (22°32′N to 22.53°N & 88°20′E to 88.33°E) has an area of 8165.05 km^2 with a population of 81,53,176 (sixth highest in India), of which 74.39% stay in rural areas. Percentage of households below the poverty line is 37.21, much higher than the state and the country average (26% and 29%). The district is one of the poor districts of West Bengal having large number of resource poor marginal farmers. Natural resource is fragile and highly prone to degradation in Sunderbans. Salinity and inundation during monsoon is the major challenge for agricultural production of the region. Monocropping and migration of rural youth for employment during the lean agricultural months are very common in the region. Land fragmentation is common and diversification of farm enterprises is often taken up by the farmers as a risk averting mechanism. The region is also extremely vulnerable against the climatic variations and extremes.

2.2 Indicator Selection for Sustainability Assessment

Sustainability is now widely measured through indicators to compare performance of different systems and it is increasingly being recognized as a useful instrument in policy analysis and generating public opinion [22]. Here, we provide a detailed description of the steps associated with the selection of sustainability indicators as it applies to the IFSs in selected areas of coastal West Bengal, India. The methodology is described in two steps – first, the development of a theoretical framework from which indicators are scouted; second, screening of those scouted indicators by agri-experts to arrive at final indicator suite.

2.2.1 Preliminary selection of indicators

In the real world, sustainability is an abstract and contested notion. Defining sustainability of agricultural system is even more difficult on account of its multiple system interface and anthropogenic involvements. We developed an adapted theoretical framework, which explains the agricultural sustainability, incorporating both ecological and livelihood framework that envisage social, economic and ecological dimensions of farm level sustainability [Fig. 1].

There are distinct benefits of integrating the livelihoods framework with ecological framework [23]. While ecological framework captures the causal chains in an agricultural system, the livelihood framework is capable of capturing changes in socioeconomic and biophysical conditions [24,25]. Integrated farms embody interactions between farm assets, and the livelihood strategies pursued by the farm family are based on structures, processes and vulnerabilities associated with the farm environment. We amalgamate the Sustainable Livelihoods framework with the Drivers-Pressure-State-Impact-Response framework [22], where “drivers” corresponds to “livelihood context”, “pressure” to “livelihood strategies”, “state” to “livelihood assets”, “impact” to “livelihood outcomes”, and “response” to changes in livelihood strategy, vulnerability context, and policy/structures and processes [23]. This model helps us identify sustainability indicators covering social, economic and ecological dimensions of sustainability which might then be screened by experts for future use.

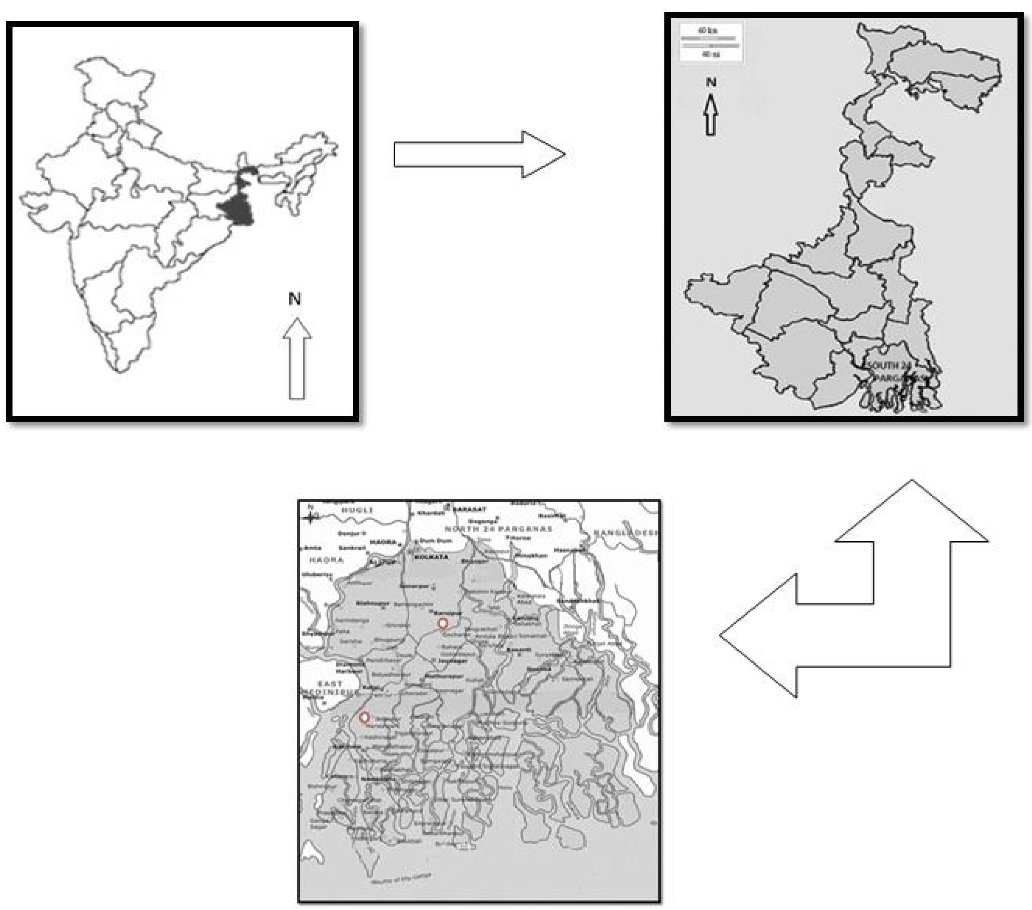

Fig. 1. The study locations: India map - highlighting West Bengal; West Bengal map highlighting South 24 Parganas district; South 24 Parganas map highlighting the study areas

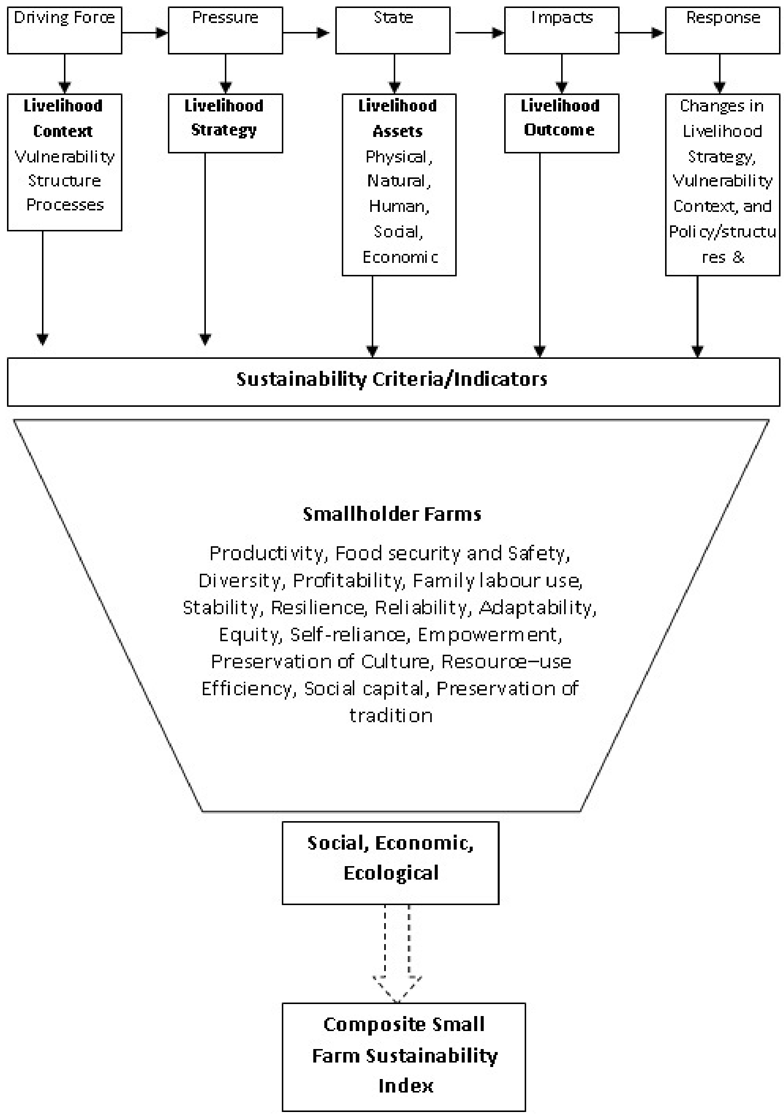

Fig. 2. The synthesized indicator framework developed from ecological and livelihoods framework

2.2.2 Selection of experts

Agri-experts were selected based on three criteria who – i) had at least 10 years of working experience; ii) were associated with a government or private organization in agri-allied sector e.g. as an extension agent of government agriculture department, faculty members of universities, Krishi Vigyan Kendra's subject matter specialist and professionals of nonprofit organizations; and iii) had 5 years of experience of sustainable agriculture while working in their respective positions.

2.2.3 Final selection of indicators

An indicator is a quantitative or qualitative measure derived from a series of observed incidents against which performance of a system is assessed. It also helps us compare the relative positions of studied systems [24]. The indicators that assess a complex system like integrated farms should be the proxies and their validity depends on how we conceptualize the farming system. OECD [22] proposed five principles for selection of indicators – i) ability to envisage the issues of assessment, ii) capability of diagnosing problems, iii) ability of discovering patterns, iv) efficiency in developing solutions, and v) capacity of driving informed action. For the present study, we preferred indicators which are easily understandable to the end-users, i.e. the farmers, local service providers and policy makers.

First, guided by the synthesized indicator framework [Fig. 1], we scouted 85 indicators from the existing literature, and from the experts – individually and through group discussion. These experts rated these 85 indicators covering social, economic and ecological dimensions of sustainability against a 4-point Likert type scale (4=highly acceptable; 3=moderately acceptable; 2= less acceptable; 1=least acceptable). After that, we removed the less important indicators from the list based on the weighted mean score of indicators as rated by the 26 agri-experts. The weighted mean score was calculated as 'number of responses recorded under a point of the rating scale' multiplied by its value (1/2/3/4) and then divided by the total number of responses. Further, we judged the indicators against four criteria namely, the availability of data, cost of measurement of the indicator, clarity of the indicator to the rater, and redundancy among the indicators. This process resulted in the selection of 52 indicators that might be used to develop sustainability indices in the future. The complete set of screened indicators is listed in Tables 1a, 1b, 1c.

3. RESULTS AND DISCUSSION

3.1 Selection of Indicators by Experts

Tables 1a, 1b, 1c present the list of indicators based on the judgement of agri-experts made against the screening criteria. Based on the weighted mean scores we ordered the indicators in descending order. The final selection was based on five screening criteria, namely weighted score (>2.5=selected and <2.5=discarded), farm level availability of the indicators (Yes=selected and No=discarded), cost of measurement (High=selected and Low=discarded), clarity in perception of the experts (Clear=selected, Unclear=discarded), and redundancy (Non-redundant=selected and discarded otherwise). '1' represents selection and '0' as discard. The impact of these indicators was also described by '+' for positive, '-' for negative and 'C' for the conditional. 'Conditional' impact was assigned to the indicators when effect of the indicators on the system was assumed to be guided by some conditions, as suggested by the experts. However, selection of the indicators was not dependent on the simultaneous positive outcomes against all five criteria. We gave more emphasis on cost of measurement and redundancy of indicators because of the resource constraints in our research project, which is true for many sustainability projects in developing countries. Nevertheless, for the other three criteria, selection of an indicator was done only if at least two of the criteria provided positive outcome. For example, if we consider 'animal species diversity' we see that weighted score was below 2.5 but the other two criteria, i.e., clear perception of the indicator of the judges and availability of the indicator provided positive outcome. Given below is the list of indicators which were rated and selected by the experts based weighted mean score and four pre-decided criteria.

As a result of rating and selection, 22 ecological indicators were selected by the experts. Ecological indicators such as – Biomass availability, Soil organic carbon, C:N ratio, Depth of ground water table etc. received highest mean weighted scores. These indicators were also common in many indices used in sustainability assessment tools such as MOTIFS [26], COSA [27], and ESI [28]. Indicators such as GHG emission, Soil micronutrient were discarded due to their high cost of measurement. Similarly, we found 17 economic indicators screened for assessing economic sustainability of the IFSs. Cost of cultivation, Ownership of land, Input sources – internal vs. external, Off-farm income, System production etc. received high weighted mean indicator scores. The discarded indicators mostly had low weighted indicator scores. Fifteen social indicators were selected for assessing social sustainability of the integrated farms. Gender equity, Adherence to local culture, Workload on women, Balanced nutrition, Food security, etc. received high weighted mean scores. Some other indicators which were found to be unique to our study were – Diversity of production, Usage of fallow system, Livestock density, Mixed farming practices, and Crop rotation. Similarly, for economic indicators, the unique indicators were – System productivity, Income diversity, Improvement in working and living condition, Labour productivity, Diversity of production and Reinvestment of farm return. From the set of social indicators we found unique indicators such as – Work load of women, Food security, Farming experience, Participation in groups, and Control of resources by women were found to be unique indicators which are not commonly used in sustainability assessment frameworks.

Table 1a. Selection of ecological indicators by experts against the five criteria

Indicators	Weighted score	Overall Rank*	Criteria for indicator selection						Effect on the system
			High	Ease of access	Cost of measurement	Clarity of perception	Redundancy (-)	Decision	
GHG emissions	3.42	1	1	0	0	0	0	Discarded	+
Biomass availability	3.24	4	1	1	1	0	0	Selected	+
Soil- organic Carbon	3.16	7	1	1	1	1	0	Selected	+
C/N ratio	3.16	7	1	1	1	1	0	Selected	+
Depth of ground water table	3.13	8	1	1	1	0	0	Selected	+
Use of organic manure	3.13	9	1	1	1	1	1	Discarded	+
Soil - Micronutrient	3.08	11	1	0	0	0	0	Discarded	+
Usage of fallow system	3.04	12	1	0	0	0	0	Discarded	+
Water use efficiency	3.0	16	1	0	0	0	0	Discarded	+
Fungicide application	3.0	17	1	1	1	0	1	Discarded	-
Physical inputs and efficient use of input	3.0	18	1	0	0	0	0	Discarded	+
Soil macronutrient- NPK	2.96	20	1	1	1	1	0	Selected	+
Cover crop & Mulching	2.96	21	1	1	1	1	0	Selected	+
Use of alternative crop	2.95	24	1	0	1	0	1	Discarded	+
Soil salinity	2.88	28	1	1	1	0	1	Discarded	-
Use of green manures	2.84	29	1	1	1	1	0	Selected	+
Energy vs. efficiency - Direct / Indirect	2.83	30	1	0	0	0	0	Discarded	+
Quality of irrigation water	2.83	31	1	1	1	1	0	Discarded	+
Crop rotation	2.75	36	1	1	1	1	0	Selected	+
Crop diversification	2.73	37	1	1	1	1	0	Selected	+
Diversity of production	2.73	38	1	1	1	1	0	Selected	+
Earthworm density in soil	2.72	39	1	1	1	1	0	Selected	+
Conservation tillage	2.72	40	1	1	1	1	1	Discarded	+
Soil EC	2.69	44	1	1	1	1	0	Selected	-
Crop productivity	2.68	45	1	1	1	0	0	Selected	+
Use of chemical fertilizer	2.68	47	1	1	1	1	0	Selected	-

Indicators	Weighted score	Overall Rank*	Criteria for indicator selection						Effect on the system
			High	Ease of	Cost of	Clarity of	Redundancy	Decision	
Erosion control	2.67	48	1	0	0	0	0	Discarded	+
Land productivity	2.67	51	1	1	1	1	1	Discarded	+
N use efficiency	2.65	52	1	1	1	1	0	Discarded	+
Cropping sequence	2.65	53	1	1	1	1	0	Discarded	+
Weed Infestation	2.64	55	1	1	1	1	0	Discarded	-
Microbial biomass in soil	2.63	57	1	0	0	1	0	Discarded	+
Nitrate content in ground water and crop	2.63	58	1	0	0	0	0	Discarded	-
Plant species diversity	2.62	60	1	1	1	0	0	Selected	+
Soil pH	2.62	61	1	1	1	1	0	Selected	**C****
Incidence of insect pest/ Diseases infestation	2.62	62	1	1	1	1	0	Selected	-
Microbial diversity	2.52	68	1	0	0	0	0	Discarded	+
Soil compaction	2.5	69	1	0	0	0	0	Discarded	-
Heavy metal contamination	2.5	70	1	0	0	0	0	Discarded	-
Integrated pest management	2.5	71	1	1	1	1	0	Selected	+
Livestock density	2.48	73	0	1	1	1	0	Selected	+
Water logging	2.43	78	0	0	0	0	0	Discarded	-
Improved water resource management	2.38	79	0	0	0	0	0	Discarded	+
Effective crop root depth/deep vs. shallow	2.36	80	0	0	0	0	0	Discarded	+
Usage of herbicide, insecticide	2.36	81	0	1	1	1	0	Selected	-
Protein levels in crop	1.86	84	0	0	0	0	0	Discarded	**C****

** Refers to the rank among all indicators screened by the experts*
***refers to conditional which means effect of the marked indicator on the system is guided by some conditions*

Table 1b. Selection of economic indicators by experts against the five criteria

Indicators	Weighted score	Overall rank*	Criteria for indicator selection						Effect on the system
			High	Ease of access	Cost of measurement	Clarity of perception	Redundancy (-)	Decision	
Cost of cultivation	3.41	2	1	1	1	1	0	Selected	-
Ownership of land	3.27	3	1	1	1	1	0	Selected	+
Input sources- external vs. internal	3.19	6	1	1	1	1	0	Selected	**C****
Off-farm income	3.04	14	1	1	1	1	0	Selected	+
System production (Rice equivalent)	3.0	19	1	1	1	0	0	Selected	+
System net return	2.96	23	1	1	1	1	0	Selected	+
Physical yield	2.83	32	1	1	1	0	0	Selected	+
Income Diversity	2.79	34	1	1	1	0	0	Selected	+
Monetary income from the farm	2.77	35	1	1	1	0	0	Selected	+
Diversity of production	2.72	41	1	1	1	1	0	Selected	+
Benefit-cost ratio	2.71	42	1	0	1	0	0	Selected	+
Capital productivity	2.71	43	1	1	1	0	0	Selected	+
Marketable surplus	2.68	46	1	1	1	1	0	Selected	+
Cost of cultivation	2.67	50	1	1	1	1	0	Selected	+
Labour productivity	2.57	63	1	1	1	1	0	Selected	+
Availability of market	2.54	65	1	1	1	1	0	Selected	+
Wage rate for farm labourer	2.54	66	1	1	1	1	0	Selected	+
System productivity	2.5	72	1	1	1	1	1	Discarded	+
Average crop production	2.46	75	0	1	1	1	1	Discarded	+
Mandays created	2.46	76	0	1	1	1	0	Selected	+
Food grain production per capita	2.36	82	0	0	0	0	1	Discarded	+

** Refers to the rank among all indicators screened by the experts*
***refers to conditional which means effect of the marked indicator on the system is guided by some conditions*

Table 1c. Selection of social indicators by experts against the five criteria

Indicators	Weighted score	Overall rank*	Criteria for indicator selection						Effect on the system
			High	Ease of access	Cost of measurement	Clarity of perception	Redundancy (-)	Decision	
Gender equity	3.21	5	1	0	1	0	0	Discarded	+
Adherence to local culture	3.09	10	1	0	1	1	0	Discarded	**C****
Workload of women	3.04	13	1	1	1	1	0	Selected	-
Balanced Nutrition	3.0	15	1	0	1	0	0	Discarded	+
Food security	2.96	22	1	1	1	1	0	Selected	+
Farming experience	2.92	25	1	1	1	1	0	Selected	+
Social equity	2.91	26	1	1	1	0	1	Discarded	+
Educational level of the household members	2.88	27	1	1	1	1	1	Selected	+
Participation in groups	2.83	33	1	1	1	1	0	Selected	+
Control of resources by women	2.67	49	1	1	1	1	0	Selected	+
Nutritional /Health status	2.65	54	1	1	1	1	0	Selected	+
Economic orientation of the farms	2.64	56	1	1	1	1	0	Selected	+
Access of women to farm profits	2.62	59	1	1	1	1	1	Selected	+
Access to resources and services by women	2.54	64	1	1	1	1	1	Discarded	+
Improved quality of rural life	2.52	67	1	1	1	1	0	Discarded	**C****
Farmers knowledge and awareness of resource conservation	2.46	74	0	1	1	1	0	Selected	+
Working and living condition	2.46	77	0	1	1	1	0	Selected	+
Health status	2.24	83	0	1	1	1	0	Selected	+

** Refers to the rank among all indicators screened by the experts*
***refers to conditional indicator, which means effect of the indicator on the system is guided by some conditions*

The indicator framework helped us initially scout a wide range of indicators covering ecological, economic and social dimensions of farm sustainability. This helped us achieving a basis for constructing a valid assessment tool in future. The validation was furthered by using expert rating and screening by some functional criteria. It is argued, that a sound assessment tool may not always be judged on the basis of its scientific rigour, but also by its functionality in real life situation. The indicators screened for the ecological and economic assessment were expected and commonly found in many assessment tools. For example, soil fertility, biomass production and sustainable farming practices are some of the important indicators commonly used in the ecological assessment. Similarly, cost-benefits, asset holding and off-farm income are some of the common indicators used to assess the economic performance of a farm. However, gender sensitive indicators such as gender equity, workload of women and cultural value to farming is somewhat novel among the social indicators. This showed the deep understanding of the agri-experts in the social dimension of farming apart from their appreciation of ecological and economic aspects of farming.

The local agri-expert driven indicators provided a comprehensive and precise measurement of sustainability in integrated farming systems [29]. Conceptually, expert screening of sustainability indicators is a derivative of reductionist approach and widely accepted in sustainability assessment practices. The limitation of this approach is that many of such exercises are meant to achieve policy goals only, and not to mean empowering farmers, they scarcely ground on the grassroots realities [30]. This works well when the assessment outcome does not affect the lives of farmers negatively. Moreover, the expert panel worked under a particular set of conditions in coastal saline zone of West Bengal, hence, under different systems and productive objectives elsewhere, a different set of indicators might be selected. This is one of the contextual limitations of the study.

3.2 Some Methodological Issues

Although the soundness of expert driven approach of sustainability assessment lies with the inclusivity of a wide range of judges who primarily work in the local ecosystems, there are a number of operational issues that need to be considered and addressed before applying the methodology in other contexts. One of the most challenging of these all is developing a theoretical framework from which initial indicators are to be scouted. This is dependent on the objective of the project/initiative for which assessment is taken up. For e.g. if the project is on payment for ecosystem services to the farmers, ecological indicators are given overwhelming priority. As a consequence, ecological frameworks might be consulted upon (e.g. ESI). Deciding upon the number of experts whose responses against a scale would be recorded is also critical. It is argued that more than 26 judge responses are fare for this purpose [31] because it could disguise inter-response variation important to developing appropriate indicators for the farming system. Qualification of experts is also important, because only formal training as academician is not enough to ensure that an expert understands a whole set of indicators. An agronomist might not understand the economic and social indicators precisely and rate them superficially. Thus, only the experts, who have worked on agroecology or in interdisciplinary projects, should be preferred in such measurement. The number of response category was also preferred to be 4, instead of 5, since a neutral point might provide respondents with a space to hide away from giving either a positive or negative response. Setting up the screening criteria for indicator selection is another challenge. Although there are guidelines for some assessment schemes [21] one cannot go free while setting up indicator selection criteria. Following OECD's [21] principles we (i) allowed practical assessment of the most diverse agricultural activities, quantitative socio-economic and environmental measurements in varied farm settings, and at the specific scale of the rural establishment; and ii) integrated sufficient and appropriate indicators relative to the ecological, socio-cultural, economic and decision-making aspects relevant to local sustainable development. Apart from the weighted score of the indicators, we used several other criteria, which might differ from project to project. For example, in a project, where logistic and resource constraint is not serious, cost of measuring indicators might not be very important (and might be dropped). Similarly, if the project is public funded and is supported by government statistical services, access to data becomes easier and hence be dropped from the criteria of screening. Specifically, screening the ecosystem indicators was difficult to work with since migratory animals, watershed structures, prevailing canals etc. can travel freely off farm boundaries. This means that number of respondents, nature of response categories, and choice of some indicators may be flexible, but exhaustive in nature, and a 'one size fits for all' approach cannot work perfectly for all sustainability assessment projects.

Development of smallholder farmers is one of the important means to reduce poverty and support livelihoods of millions in developing nations. However, the lack of sustainability of such farming systems is often linked with factors such as input self-sufficiency, reduced risk, integration with markets for outputs, ownership of land and access to financial and extension services. Agroecological practices and integrated farms emerge as an alternative way of farming to achieve long-term sustainability in smallholder systems. In this research, we have shown the methodology of identification and screening of sustainability indicators that can be used by policy for meaningful intervention in smallholder integrated farms across the globe. By incorporating the perception of local experts in the indicator selection process we have shown how scientific and objective indicators can come together with unique, location-specific, easily accessible and measurable indicators to form an indicator pool from which sustainability indices may be developed in future. This does not only help in identification of functional and valid indicators but also empowers the local experts to script the sustainability policy that affects them.

4. CONCLUSIONS AND IMPLICATIONS

In course of identification of sustainability indicators, we have developed a theoretical framework by the amalgamating ecological framework with livelihoods framework, from which 87 sustainability indicators were scouted. This framework may be used for a wide range of situations in developing nations. Local agri-experts rated the relevance of these 87 indicators against a 4-point scale. Based on their rating score, ease of access to them, cost of their measurement, clarity of the indicators to the experts and their redundancy, 52 indicators were finally selected covering the social, economic and ecological dimensions of farm sustainability. The indicators varied widely, ranging from ecological indicators such as Biomass availability, Soil organic Carbon, Depth of ground water table, Soil macronutrient, economic indicators such as Cost of cultivation, Ownership of land, Input sources, Off-farm income, and social indicators were Gender equity, Adherence to local culture, Workload of women and Balanced nutrition etc. The study provides us with an idea of the relevant sustainability indicators in smallholder systems in the coastal agroclimatic zone. Based on these 52 indicators, one may take up future projects on sustainability assessment of IFSs in diverse locations to test its tenability and possible modifications. Also, the outcome of this research will provide a user-friendly understanding of the indicator screening process for sustainability assessment in smallholder IFSs. However, since the selected indicators are still at the conceptual level, it needs to be tested in diverse field situations to establish its efficacy in assessing sustainability of different farming systems. One may also set up decentralized information generation system against these selected indicators and feed them into a computable database over a protracted period of time. The database will be able to generate near real-time analytics on farm sustainability and help the policy to undertake informed decision to support small farms.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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