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CONSTRUCTION AND STANDARDIZATION OF PERMACULTURE LIVELIHOOD SECURITY INDEX FOR PADDY-AGROFORESTRY SYSTEMS

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ABSTRACT

Permaculture livelihood security is a holistic and sustainable approach of paddy bases agroforestry farmers in achieving long-term security and resilience in one's livelihood by integrating permaculture principles and practices which involves the application of permaculture principles, such as observing and interacting with natural systems, designing for resilience, utilizing renewable resources and valuing diversity, to develop livelihood systems that are ecologically sound, socially just and economically viable.At this juncture the need for an instrument to measure the Permaculture livelihood security was development was recognized. Hence, a standardized index was developed which can helps in measuring the Permaculture livelihood security of farmers. The process began with identification of 96 indicators classified under different dimensions and given to 30 experts for judgement. Only those indicators with relevancy rating score more than 0.85 were selected for inclusion in the study. Index was fulfilled the criteria of Kaiser-Meyer-Olkin test value (0.856) and Bartlett test of sphericity value (0.000).Hence the present data was acceptable for factor analysis, Principal Component Analysis was carried out by using SPSS; total eight components were extracted for index. By considering the PCA cut off point (factor loading >0.6), finally 53 indicatorswere retained and 27 indicatorswere eliminated.Content validity of the index was established with expert judgement and further criterion validity was established with principal component analysis. The reliability values of index were greater than the standard value of alpha 0.7 as recommended by Cronbach. It supports policymakers and extension agencies in designing targeted interventions, promoting sustainable permaculture practices, and improving farmers' income, resilience, and overall livelihood security.

Key words: *permaculture livelihood security; index; principal component analysis*

INTRODUCTION

Agroecology presents a promising alternative to industrial agriculture by offering a means to avoid the adverse social and ecological impacts of input-intensive farming methods. However, transitioning to agroecological production is a multifaceted endeavour that necessitates contributions from beyond scientific institutions. Among the agroecological movements, permaculture stands out as it possesses a widespread global presence and employs a distinctive approach to system design (Ferguson and Morales, 2010).

When permaculture is mentioned, it is frequently found as an item on a list of alternative agricultural frameworks, the value of which is either explicitly in question (Gomiero *et al*., 2011; Bavec *et al*., 2009), or positive but nonspecific (Leaky, 2012; Lovell *et al*., 2010). Permaculture is elsewhere associated positively, albeit in passing, with agroforestry, perennial polycultures, agroecosystem design, ecosystem mimicry, and agrobiodiversity (Francis and porter, 2011 and Torre and Hellwinckel, 2010).While the principles and practices encompassed by permaculture have been utilized by different cultures throughout history, the term "permaculture" as we know it today was coined by Bill Mollison and David Holmgren in the 1970s in Tasmania. This approach to design emphasizes the harmonious integration of plants, animalsand structures, emphasizing self-sufficiency, ecological balanceand the responsible use of resources (Krebs and Bach, 2018). Permaculture is the deliberate planning and upkeep of agriculturally productive systems that exhibit the diversity, stability and resilience found in natural ecosystems. It involves integrating the landscape and human activities to meet various material and non-material needs, such as food, energyand shelter, in a sustainable manner. By adopting

permaculture principles, individuals and communities strive for a harmonious coexistence with nature, ensuring long-term productivity and environmental well-being (Bell, 2004; Khodifad et al., 2025; Dhananjaya et al., 2025; Khodifad et al., 2025; Bora & Das, 2023).

Permaculture is highly relevant in today's agricultural landscape due to its ability to promote sustainable food production, environmental conservation, climate change adaptation, localized and community-cantered agricultureand regenerative practices. By mimicking natural ecosystems, permaculture offers a holistic approach that maximizes yields while minimizing negative environmental impacts. It emphasizes practices such as companion planting, soil health improvement, water conservation and carbon sequestration. Furthermore, permaculture encourages localized food production, community engagement and empowerment, fostering food security and resilience. In a world grappling with climate change, environmental degradationand food insecurity, permaculture provides a practical and comprehensive framework for creating sustainable and regenerative agricultural systems (Vinaya & Gadde, 2026; Vinaya & Gadde, 2025; Vinaya et al., 2022). Keeping all this in view, present study is undertaken to develop an index to measure the permaculture livelihood security of farmers. The standardized Permaculture Livelihood Security Index (PLSI) provides a reliable and scientific tool to assess and compare livelihood security among farmers in paddy-based agroforestry systems, enabling evidence-based research and evaluation. It supports policymakers and extension agencies in designing targeted interventions, promoting sustainable permaculture practices, and improving farmers' income, resilience, and overall livelihood security.

METHODOLOGY

The study was conducted during 2022–23 to 2024–25 in RI-Bhoi district of Meghalaya, specifically in the Bhoirymbong C&RD Block. A total of 90 farmers were purposively selected based on the criterion that they possessed agro-forestry lands with a consolidated area of not less than one acre. Three villages—Thadnongiaw, Kudungulu, and Liarkhla—were included in the study, with 30 respondents selected from each village, making a total sample of 90 farmers. The collected data were scored, compiled, tabulated, and analyzed using appropriate statistical tools to derive meaningful results and draw valid conclusions.

Permaculture Livelihood Security" was operationally defined as a holistic and sustainable approach of paddy based agroforestry farmers in achieving long-term security and resilience in one's livelihood by integrating permaculture principles and practices which involves the application of permaculture principles, such as observing and interacting with natural systems, designing for resilience, utilizing renewable resources and valuing diversity, to develop livelihood systems that are ecologically sound, socially just and economically viable.

The judges' responses (30) were collected by administering structured questionnaires. The ranks assigned by the judges were converted into weightages using the methodology proposed by Alfare and Duufuaa, (2008). Further, the mean of these indicators was calculated and taken as a weightage of that specific indicator. The statements representing particular indicators of permaculture livelihood security were selected by sending the statements to the experts/judges, for taking their response. On the basis of the recommendations given by the experts, final selection of statements of each indicator was done. Principal component anlaysis was administered for assigning weightage by using SPSS software.

RESULTS AND DISCUSSION

Step-I.a Defining the Construct

Construct is a concept with added meaning deliberately adopted for specific scientific purpose (Kerlinger, 1996). Here the construct "Permaculture livelihood security" can be operationally defined as a holistic and sustainable approach of paddy bases agroforestry farmers in achieving long-term security and resilience in one's livelihood by integrating permaculture principles and practices which involves the application of permaculture principles, such as observing and interacting with natural systems, designing for resilience, utilizing renewable resources and valuing diversity, to develop livelihood systems that are ecologically sound, socially just and economically viable.

Step-I.b Initial selection and editing of suitable indicators within different dimensions of the construct

A number of indicators under each dimension of the construct were collected from literatures viz. magazines, published reports, research papers, review articles, related manuals and web resources. Personal discussions were also held with the domain experts to finalize the indicators. The indicators were further edited according to the fourteen

criteria given by Edward (1957). A total of 96 indicators were framed different dimensions of the construct (Table 1)

Table 1: A scheme illustrating the number of indicators selected by theme and research dimension

Sr. No.	Themes	Research dimensions	Indicators
1	**Agro-ecology system**	1. Agro-Ecological Landscape	8
2	**Permaculture System**	1.Permaculture Design 2.Paddy Based agro-forestry System 3.Inter cropping 4. Crop protection measures 4. Soil and water conservation measures 5. Resource use 6. Cell grazing	10 12 12 4 10 11 2
3	**Livelihood security**	1. Economical security 2. Food security 3.Technological aspects 4. Psychological aspects 5. Societal aspects 6. Environmental aspects	4 4 4 4 4 7

Step-II Selection of indicators for Permaculture livelihood securityIndex under different dimensions after Relevancy test (Content validation)

All the collected statements or indicators (Table 1) under different dimensions may not be equally relevant to measure the Permaculture livelihood security. So, these indicators were subjected to undergo the scrutiny of the experts to determine their extent of relevancy for establishing the content validity and their screening for final inclusion in the index. The experts were scientists, researchers, professionals of relevant domain from various Agricultural Universities and Institutes, Govt. departments, NGOs etc. For the critical evaluation, 96 indicators were sent to 60 judges along with necessary instructions. The judges were requested to indicate the degree of relevancy of each indicator on a three-point continuum viz., Most relevant, relevant, and irrelevant with scores 3, 2, and 1, respectively. Out of 60, only 30 judges responded. Finally, the scores given by 30 judges were considered for computing the Relevancy Weightage (RW) and Mean Relevancy Score (MRS) and Overall Mean Relevancy Score (OMRS) of all the indicators having Relevancy Weightage (RW) greater than 0.85 and Mean Relevancy Score (MRS) greater or equal to Overall Mean Relevancy Score (OMRS) i.e.,2.55 were considered for final selection of indicators or statements (Madhu *et al*., 2021). With the help of this process, in the first stage out of 96 indicators total 83 indicators were sorted which were further rewritten and modified as per the suggestions given by experts.

Step-III. Determination of Index Values

It is required to assign specific weights (Index Values) to each dimension of the Permaculture livelihood security on their perceived significance. Ninety (90) paddy based agro forestry farmers were purposively selected from the RI-Bhoi district of Meghalaya. The index values were determined by principal component analysis. Following steps were followed to determine the values.

(1) Kasier-Meyer-Olkin (KMO)

Regarding validity, KMO measure of sampling adequacy is a measure of whether or not the distribution of value is adequate for conducting factor analysis. This measure varies between o and 1, value closer to 1 is better. As per KMO measure, a measure of >0.9 is marvelous, >0.8 is meritorious, >0.7 is middling, >0.6 is mediocre, >0.5 is miserable and <0.5 is unacceptable (Meena, 2018). For the present study KMO values of >0.6 scores were considered. The data of present study found sampling adequacy values of was 0.856.These values indicate meritorious as per table 2. Which indicates that the data set was suitable (>0.6) for factor analysis.

Table 2: KMO and Bartlett test

Index	Test name		Value
Permaculture livelihood security	Kasier-Meyer-Olkin measure of sampling adequacy test		.856
	Bartlett test of sphericity	Approx..Chi-square	282.783
		df	86
		Sig.	.000

(2) Bartlett test of sphericity

It is a statistical test for overall significance of the correlation within correlation matrix which uses Chi-square distribution. It is a measure of the multivariate normality of the set of distributions. It also tests whether the correlation matrix conducted within the factor analysis is an identity matrix. Factor analysis is meaningless with an identity matrix. According to George and Mallery (2003) a significant value of <0.05 indicates that the data do not produce an identity matrix, thus there is a significant correlation among variables also suitable for multivariate normal and acceptable for factor analysis. The index data of the present study found a significant value of 0.000, indicating that there is a significant correlation among variables hence the present data was acceptable for factor analysis as per Table 2.

(3) Principal component analysis and selection of indicators

The results of the principalcomponents analysis carried out on the matrix composed by 83 variables observed at the level of 30 respondents. The Keiser–Meyer–Olkin measure of sampling adequacy and Bartlett'stest of sphericity ($p < 0.001$) indicated the appropriateness of the selected model. PCA extracted eight axes with absolute eigen-value > 1.

Table 3: Total variance of the variables

Component	Initial Eigen value			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total	%Variance	Cumulative %
1	61.243	73.787	73.787	61.243	73.787	73.787	29.071	35.025	35.025
2	5.587	6.732	80.519	5.587	6.732	80.519	11.743	14.149	49.174
3	4.902	5.907	86.425	4.902	5.907	86.425	11.087	13.358	62.531
4	2.877	3.467	89.892	2.877	3.467	89.892	7.909	9.529	72.060
5	2.352	2.833	92.725	2.352	2.833	92.725	7.304	8.800	80.860
6	1.952	2.352	95.077	1.952	2.352	95.077	6.411	7.724	88.584
7	1.895	2.283	97.360	1.895	2.283	97.360	6.368	7.673	96.257
8	1.223	1.473	98.834	1.223	1.473	98.834	2.139	2.577	98.834
9	.922	1.111	99.945						
10	.044	.055	100.00						

The extracted proportion of variance (73%) is highconsidering the huge number of input variables. The number ofvariables with loading > |0.6| decreased rapidly from the component C 1 to C8. The variables factor loading > 0.6 were selected (53) final inclusion of Index and 30 indicators were eliminated.

Table 5: The final Permaculture Livelihood Security Index with 53 indicators

Sr. No.	Indicators/ Item statement	weightage
Agro-Ecological Landscape		
1	Direction of the field should be considered in the preparation of field and production of crop.	0.994
2	Degree of land inclination should be considered in the preparation of field and production crop.	0.994
3	Cropping Intensity should be considered in the selection and production of crops	0.797
4	Cropping area is considerable aspect in the selection and production of the crops.	0.534
Permaculture Design		
5	I design the farming system for solving the problem and improvement over existing situations.	0.620
6	I observe the ecological landscape and use my experience in designing farming system	0.575
7	Environmental factors (Soil, water and air) should consider and observed in permaculture practices.	0.578
8	I consider the efficiency and needs in land use for conservation of the input use.	0.994
9	Recycling of outputs (Organic matter, Seeds, Water, etc) into the system helps in sustainability of the soil.	0.740
Paddy Based Agro-forestry System		
10	I cultivate Paddy along with vegetables, fruit, forestry and livestock for crop diversification.	0.939
11	Agroforestry systems offer multiple sources of income through the production of timber, fruits, nuts, medicinal plants, fodder, and other non-timber forest products.	0.439

Sr. No.	Indicators/ Item statement	weightage
12	Sowing of seeds in optimum depth helps in early and uniform germination and seedling establishment.	0.623
13	Planting of seedlings with one meter height helps in early establishment of trees.	0.446
14	Growing fodder grass on Paddy bunds helps in stabilization of bunds and diversification.	0.839
15	Adjustment of plant population under moisture stress results optimum yield	0.115
16	Agroforestry systems contribute to food security and resilience by diversifying agricultural production	0.994
17	The integration of trees in agricultural landscapes helps to mitigate the negative impacts of extreme weather events.	0.839
18	Market gardening helps in gaining substantial income.	0.347
Inter cropping		
19	I grow two/more crops for better usage of proximity.	0.797
20	Plantation of legume crops between the rows of tree species helps in maintenance soil fertility	0.790
21	Intercropping allows efficient utilization of soil and water in efficient way.	0.994
22	Intercropping prevents soil erosion and formation of crust.	0.551
Crop protection measures		
23	Seed treatment helps in protection against pests and diseases and inducing drought tolerance.	0.406
24	Growing of trap crops helps in controlling of pest	0.835
25	Bio-control and bio-chemicals, ashes, homemade organic spray is helpful integrated pest management.	0.946
Soil and water conservation measures		
26	Contour farming helps in controlling soil erosion and management of crops.	0.513
27	Minimum-tillage helps in retaining water, prevents carbon loss and improves soil quality.	0.946
28	Mulching helps in adding nutrients and organic matter to the soil, reduce erosion and evaporation and absorbs rainfall.	0.789
29	Mulching suppresses weed growth, moderate temperatures and protect against frost.	0.647
30	Preparation of recharge pits helps in harvesting of rain water.	0.835
Resource use		
31	Saved, propagated, or found seeds used as inputs in permaculture.	1.000
32	Naturally growing trees are encouraged for diversification.	0.946
33	Compost used as manure in the soil which adds nutrients to the soil.	0.837
34	Residue of the crops (straw, stubbles and leaves *etc*.) helpful in preparation of mulching material	0.839
35	Harvested rain water can be used for the irrigation and livestock.	0.994
Cell grazing		
36	Allowing of livestock grazing reduces unwanted plants and add nutrients to soil.	0.837
37	Grazing of livestock between different fields prompt a better ecology and allow plant growth.	0.839
Economical security		
38	I have good ownership of resources like land/housing/pond that help me earning good income.	0.994
39	Permaculture practices increases production and yields of crop in my farm.	0.837
40	Permaculture practices increases my dairy and livestock production.	0894
Food security		
41	Paddy based agro-forestry enhances the availability of nutrition in our daily diets.	0.790
42	Growing leguminous pulse crops assures source of protein in our diet.	0.458
Technological aspects		
43	I find permaculture practices easy and convenient to adopt.	0.994
44	I find permaculture technologies having more adaptive and mitigative measures to soil degradation.	0.946
45	I find intensive agriculture responsible for occurrence of acidification, nitrification, desertification and soil contamination	0.994
Psychological aspects		
46	I find paddy based agro-forestry increases/sustain family income and upgrade standard of living.	0.635
47	I feel that permaculture practices in agriculture can help in sustaining the natural resources.	0.839
48	My opinion is that excessive exploitation by human on natural resources brings the shock in the sustainability	0.790

Sr. No.	Indicators/ Item statement	weightage
Societal aspects		
49	I actively participate in the social and organizational activities.	0.594
50	My community work together and helps in increasing skills and knowledge on permaculture practices.	0.331
Environmental aspects		
51	I find agriculture affected by intensive agriculture practices like monocropping, fertilizer and chemical applications	0.746
52	I faced intensive farming caused land degradation/crop loss or reduction in crop production.	0.837
53	I find the used of forest-based energy leads to climate sustainability of soil.	0.839

Stage IV: Validity of the Index

Validity was concerned with whether the test indicatorswere relevant to the measurement of the intended content area. Content validity was determined by expert's judgment. The index was validated to ensure their dependability in analyzing agricultural performance of small and marginal farmers. A number of measures were adapted to establish the content validity for the indicatorswhich were observed through related literature review and discussion with experts from different disciplines and experts' judgement to assess and analyze the permaculture livelihood security of the farmers. Further the criterion related reliability and validity was established by calculating principal component analysis.

Stage 4: Reliability of the Index

Internal consistency reliability method was used to testthe reliability. The Cronbach Alpha coefficient obtainedfor the index was found to be 0.888, which indicatesgood internal consistency of indicators in the index (Cronbach, 1951).

Categorization

The obtained index value ranged from 0 to 1.Based on the values obtained, the agricultural scientistswere categorized into 5 classes- very low, low, medium,high and very high based on the range obtained. Thehighest score among the respondents was 1.00 whilelowest score was 0.115 (Table 5).

Sr. No	Categorization	Class Interval
1	Low Permaculture Livelihood Security	0.11-3.33
2	Medium Permaculture Livelihood Security	3.34-6.66
3	High Permaculture Livelihood Security	6.67-1.00

CONCLUSION

The present study was aimed at constructing the index to measure the permaculture livelihood security of farmers. The effective aspect of permaculture livelihood security index consisted of 53 indicators with high reliability and more validity. The standardized Permaculture Livelihood Security Index (PLSI) is a scientifically validated tool for assessing and comparing livelihood security among farmers in paddy-based agroforestry systems. It aids policymakers and extension agencies in designing targeted interventions to promote sustainable practices and enhance farmers' income, resilience, and overall livelihood security. It also can be used outside of the study area perspective with necessary modifications.

CONFLICT OF INTEREST

Authors have declared that no competing interests exist.

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