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A district level sustainability of rice farming in hilly region of Manipur

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Abstract
Rice farming is an important occupation and its sustainability is important for ensuring the livelihood of the country, India. This study examined the three dimensions of sustainability *i.e.*, economic, social and ecological sustainability at macro level. It has estimated that in economic sustainability, 80% of the hill districts were moderately sustainable and cent percent of the districts were moderately and highly sustainable in case of social and ecological sustainability, respectively. Hence, it can be stated that the state performed well ecologically which is due to better performance of hill districts but economically, it should be hypothesized to put better in the state.

Keywords: Sustainability, economic, social, ecological, India

Introduction
The issue of sustainability in agriculture came into the forefront after the publication of Brundtland Commission Report (WECD, 1987) [5]. The sustainable agriculture is the main pillar for sustainable livelihoods and food security of the farmers which integrates three main goals *i.e.,* economic, social and ecological sustainability. Economic efficiency is essential to guide the use of resources both in human and natural under technological conditions to meet the developmental needs of the society. Social sustainability vis-à-vis agriculture deals with the quality of life of the farmers who depends on agriculture for their livelihood and ecological security to maintain or improve the resource base of the economy. The social dimension shifts the emphasis from individual rights and economic wealth to community right and social welfare of all human beings. The environmental or ecological dimension represents a system for providing integrity and preservation of ecosystem (Sadler, 1990) [3] and is concerned with the continued productivity and functioning of ecosystem (Brown *et al.,* 1987) [1]. These three dimensions of agricultural sustainability are often discussed together as their goals overlaps, impact and influence each other.
The social and ecological benefits of sustainable agricultural practices do not translate into immediate economic gains. There are trade-offs between these dimensions. Looking at the issue of sustainability of agriculture, a district level analyzing of the indicators of sustainability is necessary. This study has largely focused on rice farming as agriculture in India is a rice-based system. Hence, the present study is on attempt to find out whether the rice farming is economically, socially and ecologically sustainable at district level?

Methodology
Manipur is one of the North Eastern States of India located in between 95°58′E to 94°45′E longitudes and 23°50′N to 25°42′N latitudes. It consists of nine districts *i.e.,* five hill districts and four valley districts. Secondary data pertaining to different sustainability indicators of the districts were collected from the various publications of the Directorate of Economics and Statistics, Department of Agriculture, and Directorate of Settlement and Land Revenue, Government of Manipur, India.
Sustainability of different districts were assessed based on the three dimensions *i.e.,* economic, social and ecological indicators. Each of the dimensions was studied through measurement of different indicators. The selection of indicators under each of the dimensions was based on the ability to measure each of the dimensions and the ability of the dimensions to influence the level of indicators.

Sustainability index
The sustainability index (SI) for each of the three dimensions was constructed based on the Human Development Index (HDI) developed by UNDP (1990) [4]. Weights of the indicators were

calculated based on the method of Iyenger and Sudarshan (1982) [2] (Annexure 1). The overall sustainability of the districts was assessed by constructing Sustainability index (SI) by averaging of the three sustainability indices. Based on the values of sustainability indices, the districts were categorized into four such as i) least sustainable (0.00 to 0.25) ii) moderately sustainable (0.26 to 0.50) iii) sustainable (0.51 to 0.75) and iv) highly sustainable (0.76 to 1.00).

Results

Sustainability of different districts

The economic, social and ecological sustainability indices ranged from 0.16 to 0.34, 0.29 to 0.47 and 0.76 to 0.97, respectively, which reflects wide variation within each sustainability dimensions across the districts (Table 1). Among the five districts, Ukhrul district ranked first in economic and social sustainability but in case of ecological sustainability, Tamenglong district topped the list. Churachandpur district topped as the forest coverage (93.52 %) was larger among the hill districts of Manipur. Churachandpur (0.16) and Chandel (0.298) were at the bottom in case of economic and social sustainability, respectively. But, ecologically, Senapati district was the worst performing among the hill districts of Manipur as the forest coverage (70.41%) was lower as compared to other hill districts of Manipur.

Table 1: Ranking of different hill districts of Manipur across sustainability dimensions

Sl. No.	Hill Districts	Economic sustainability		Social sustainability		Ecological sustainability		Overall Sustainability	
		Index value	Ranks	Index value	Ranks	Index value	Ranks	Index value	Ranks
1	Senapati	0.29	II	0.44	II	0.76	V	0.50	III
2	Tamenglong	0.26	IV	0.33	IV	0.97	**I**	0.52	IV
3	Churachandpur	0.16	V	0.46	III	0.84	III	0.49	V
4	Chandel	0.28	III	0.29	V	0.89	II	0.48	VI
5	Ukhrul	0.34	I	0.47	I	0.77	IV	0.53	I

Table 2: Relative sustainability status of different hill districts of Manipur, India

Sl. No.	Districts	Economic sustainability		Social sustainability		Ecological sustainability		Relative overall sustainability	
		Index value	Ranks	Index value	Ranks	Index value	Ranks	Index value	Ranks
1	Senapati	0.07	II	0.24	III	0.13	V	0.14	II
2	Tamenglong	0.05	IV	0.12	IV	0.18	I	0.12	IV
3	Churachandpur	0.04	V	0.25	II	0.15	III	0.13	III
4	Chandel	0.06	III	0.09	V	0.16	II	0.10	V
5	Ukhrul	0.08	I	0.26	I	0.14	IV	0.16	I

In overall, Ukhrul district (0.53) was comparatively sustainable than all the other hill districts of Manipur, followed by Tamenglong (0.52) districts, whereas, Chandel (0.48) districts was the least sustainable hill district in Manipur when equal and appropriate weights were assigned. Ukhrul turned out to be the best district in comparison to other hill districts because its performance on economic indicators was better than other hill districts of Manipur though it did not fare well in case of ecological indicators.

Table 3: Distribution of hill districts of Manipur across different sustainability categories

Category	Hill districts			
	ES	SS	ELS	OS
Column no	1	2	3	4
LS (0.00 to 0.25)	CP	-	-	-
MS (0.26 to 0.50)	S, TM CD, UK	S, TM, CP, CD, UK	-	S, CP, CD
SU (0.51 to 0.75)	-	-	-	TM, UK
HS (0.76 to 1.00)	-	-	S, TM, CP, CD, UK	-

Note: ES = Economic sustainability, SS = Social sustainability, ELS = Ecological sustainability, OS = Overall sustainability S = Senapati, TM = Tamenglong, CP = Churachandpur, CD = Chandel, UK = Ukhrul.

In terms of economic sustainability, majority of the hill districts of Manipur were in moderately sustainable (80%) category. Socially, cent percent of the total hill districts turned out to be moderately sustainable. Ecologically, ccent percent of the total hill districts were highly sustainable. In terms of overall sustainability, 60% of the total hill districts were moderately sustainable and the remaining was in sustainable category (Table 3, column 4). Hence, it can be stated that the overall performance of different hill districts of Manipur was not satisfying. Though the state performed well in terms of ecological sustainability which is primarily due to better performance of hill districts, only 20 % of the districts scored less than 0.26 in case of economic sustainability, which was hypothesized to put better in North Eastern states. (Table 3).

Conclusion

Economically, majority of the hill districts of Manipur were in either moderately sustainable or least sustainable category. Socially, all of the hill districts turned out to be moderately sustainable and ecologically, cent percent of the hill districts were highly sustainable category. In terms of overall sustainability, 3/5th of the total hill districts were moderately sustainable and the remaining was in sustainable category i.e., about 60% of the hill districts were moderately sustainable. Hill districts performed better in case of ecological sustainability. Thus, to maintain the sustainability, efforts should be put to improve economic indicators in hill districts by enhancing per capita income and promoting livestock rearing. Social sustainability may be improved by increasing female literacy, extent of rural electrification and investment on rural development schemes by the State Government. Therefore, the study suggests that there is a scope of improving the economic and social sustainability by implementing the suitable means as suggested above in the study area.

Annexure

Annexure I

Construction of district level sustainability index

Step 1: Normalization of the indicators

$$X_{ijk} = \frac{x_{ijk} - \min(x_{ijk})}{\max(x_{ijk}) - \min(x_{ijk})} \quad \ldots . i$$

$$X_{ijk} = \frac{\max(x_{ijk}) - (x_{ijk})}{\max(x_{ijk}) - \min(x_{ijk})} \quad \ldots . ii$$

Where,
X_{ijk} = Normalized indicators of i[th] variable, j[th] component of k[th] district
i = Variables (1, 2, 3, …,i)
j = Components (1, 2, 3… j)
k = Districts (1, 2, 3… k)
Equation (i) was used for the variables with positive effect and equation (ii) for the variables with negative effect.
Step 2: Absolute composite sustainability index (CSI) were calculated as a simple means of the indices of their respective variables,

$$\text{Absolute CSI}_{jk} = \frac{\sum X_{ijk}}{i} \quad \ldots . iii$$

Where,
j = 1, 2, 3,……j, and
k = 1, 2, 3,……,k

Step 3: Relative composite sustainability index (CSI) for each district was calculated as a weighted mean of the component indices obtained from Equation (iii), *i.e.*

$$\text{Relative CSI}_{jk} = \frac{\sum W_{jk} CSI_{ijk}}{j} \quad \ldots . iv$$

Where,
W_{jk} = the weight assigned to the j[th] component of CSI of k[th] district, (W_{ik} +…+ W_{jk} = 1).
The approach used to derive the weighing scheme can be described in the following steps as:

a) Variances of the normalized indicators (Xijk) are calculated
b) Square roots of the variances ($\sqrt{var\ X_{jk}}$) are calculated
c) The reciprocals of the square root of variances ($\frac{1}{\sqrt{var\ Xjk}}$) are calculated
d) Sum of the reciprocals of the square root of variances are calculated

$$C = \frac{1}{1/\sqrt{\text{Var } X_1} + 1/\sqrt{\text{Var } X_2} + \ldots\ldots\ldots\ldots\ldots + 1/\sqrt{\text{Var } X_{jk}}} \quad \ldots . v$$

e) Weights were calculated as the ratio of the sum of the reciprocals of square root of variance and the square root of variance

$$W_j = \frac{C}{\sqrt{\text{Variance } X_j}} \quad \ldots . vi$$

(Iyenger and Sudarshan, 1982) [2]
Step 4: The overall sustainability was constructed by taking the average of the three sustainability indices.

$$OS_{jk} = \frac{ES_{jk} + SS_{jk} + ELS_{jk}}{3} \quad \ldots . vii$$

Where, ES_{jk} = Economic Sustainability across the districts
SS_{jk} = Social sustainability across the districts
ELS_{jk} = Ecological sustainability across the districts

Annexure II: Descriptive statistics of different economic sustainability indicators

Districts	RP (kg/ha)	PF (MT/ annum)	CI (%)	FC (kg/ha)	LA (million)	PCI (`/annum)	PDS (MT)	LD (no./sq. km)
Hill districts	**2088.74**	**4.08**	**135.46**	**10.66**	**0.09**	**20473.40**	**26.51**	**23.90**
Senapati	2057.14	3.73	136.50	20.20	0.08	17500	47.37	50.08
Tamenglong	2058.66	5.13	122.40	8.58	0.07	23603	15.66	14.48
Churachandpur	1594.10	2.63	119.14	10.32	0.12	19725	32.99	18.87
Chandel	2322.56	5.01	141.39	7.46	0.07	19246	16.04	22.49
Ukhrul	2411.25	3.92	157.88	6.78	0.08	22293	20.50	13.59

Note: ES = Economic sustainability, RP = Rice productivity, FC = Fertilizer consumption, CI = Cropping Intensity, LA = Labour availability, PF= Per capita output of food grains, PCI = Per capita income, PDS = Public Distribution System, LD = Livestock density.

Annexure III: Descriptive statistics of social sustainability indicators

Districts	FL (%)	IM (%)	VE (%)	TC (no./sq. km)	EO (%)	CS (no.)	RD (` in lakh)	RR (km)
Hill districts	70.23	7.21	64.61	1352	4.21	441	3909.77	93.80
Senapati	68.07	9.17	60.13	2120	5.88	554	6472.26	92
Tamenglong	63.69	9.10	66.08	648	2.51	270	1760.03	163
Churachandpur	78.50	9.68	45.59	1334	5.86	586	6575.13	65
Chandel	63.96	4.70	84.57	1693	2.83	166	1331.92	65
Ukhrul	76.95	3.38	66.67	966	3.97	631	3409.53	84

Note: SS = Social sustainability, FL= Female literacy, IM = Infant mortality, VE = Village electrification, TC = Telecommunication, EO = Employment in organized sector, CS = Cooperative society, RD = Expenditure on rural development programme, RR = Rural road connectivity

Annexure IV: Descriptive statistics of different ecological sustainability indicators

Districts	PD (no./sq. km)	FA (%)	CI (%)	LD (no./sq km)	AR (thousand ha)
Hill districts	47.00	83.55	135.46	23.90	14.56
Senapati	59.00	70.41	136.50	50.08	16.83
Tamenglong	32.00	89.07	122.40	14.48	9.32
Churachandpur	60.00	93.52	119.14	18.87	23.83
Chandel	44.00	84.49	141.39	22.49	8.04
Ukhrul	40.00	80.26	157.88	13.59	14.76

Note: ELS = Ecological sustainability, PD = Population density, FA = Forest area cover, CI = Cropping intensity, LD = Livestock density, AR = Area under rice

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