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Measuring Agricultural Sustainability of Jorhat District, Assam: Applying Composite Indicators Approach

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ABSTRACT

The diverse geoecological setting of Jorhat district has it's impact on the agricultural sector of the area. The purpose of the study is to assess the micro-geoecological zone-wise variation in the status of agricultural sustainability of the district. To analyze agricultural sustainability, a composite indicators approach has been adopted. 36 indicators have been selected covering economic, social, and environmental aspects of agricultural sustainability. The study covers 340 households from 24 villages in the district. The Agricultural Sustainability Index, based on selected indicators, shows that among the three geoecological zones, the Northern Floodplain Zone has the highest agricultural sustainability (index score 0.478) whereas, the Undulating Flood free Zone records the lowest agricultural sustainability (index score 0.418) in the district. The highest economic security (index score 0.539), social security (index score 0.456), and environmental sustainability (index score 0.440) of the Northern Floodplain Zone favor to maintain agricultural sustainability. The study tries to give a new insight into household and village-level agricultural sustainability measurement based on various site- specific indicators.

Keywords Agricultural sustainability measurement, Composite indicators approach, Agricultural sustainability index, Jorhat.

INTRODUCTION

Out of 17 Sustainable Development Goals (SDG) of the United Nations, 11 numbers of SDGs like; no poverty, zero hunger (Mollier *et al.* 2017), decent work and economic growth, life on land, good health and well-being (Ladha *et al.* 2020) climate action (Campbell *et al.* 2018) are directly or indirectly related with agricultural sustainability (Viana *et al.* 2022). The global increasing food demand on one hand, and the harmful impact of modern agricultural activities on the environment on the other; have stressed the sustainable development of agriculture (Tilman and Michael 2015, Davis *et al.* 2016). Measurement of agricultural sustainability is a challenging task. The definition of agricultural sustainability varies from time to time and the experts have not yet come to a common ground of agreement (de Olde *et al.* 2017). But different definitions stress three common components of agricultural sustainability; i.e. economic, environmental, and social (Pham and Carl 2014, Sajjad and Iffat 2016). The complex interaction between these three components also leads to difficulty in measurement. At the same time, the achievement of social,

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economic, and ecological sustainability at the same time may not be easy. It is pointless to achieve environmental sustainability without fulfilling the food and fiber demand and eradicating poverty. Multiple processes and elements, associated with agriculture, make it even more difficult to measure agricultural sustainability (Lampridi *et al.* 2019). Many tools and methodologies have been developed to ascertain the level of agricultural sustainability (Paz *et al.* 2020, Abd-Elmabod *et al.* 2020). However, there is not any universally accepted method for agriculture sustainability measurement.

Agricultural sustainability analysis can be done in three basic dimensions: Normative, spatial, and temporal. The influence and importance of each component (economic, environmental, and social) are different at different spatial levels. At the national and international levels, the social or institutional aspect is the primary deciding component; while at community and farm levels all the three components play equal roles. However, the correct measurement of agricultural sustainability over an extensive region may not be possible; as the physical, climatic, and socio-economic characteristics change over a large area. Therefore, agricultural sustainability analysis of a small region can be assessed in a better way (Sajjad and Iffat 2016). There are a few works on the assessment of agricultural sustainability using the primary information collected from the households directly (Moore *et al*. 2014). A few studies in India have tried to analyse the district level agricultural sustainability based on primary data collected from farmers (Sajjad and Iffat 2016, Chand *et al.* 2015, Purushothaman *et al.* 2013, Ghosh and Chakma 2019).

The indicator method of agricultural sustainability analysis uses multiple relevant indicators to assess the level of agricultural sustainability temporally or spatially. Several attempts have been carried out by different agencies and organizations to identify universally accepted indicators to measure sustainability. The most widely used method of selecting sustainability indicators is the Pressure State Response (PSR) model developed by the Organization for Economic Cooperation and Development (OECD) (Jatav and Naik 2023, Suresh *et al.* 2022, Zhou *et al.* 2013, Troian *et al*. 2021). Following this model, the United Nations Commission on Sustainable Development (CSD) identifies certain indicators. Based on the PSR model OECD developed the Driving Force State Response (DSR) framework to identify an appropriate set of indicators. Driving force indicators are those that affect the farm management practices; state indicators are helpful to identify the effects on the natural environment and the actions that are taken to rectify and reduce the effects are determined by response indicators. The set of indicators that is effective for national-level sustainability measurement, may not be useful for a district-level analysis. Therefore, the identification of site and time-specific indicators is a prerequisite. Forming composite indicators based on multidimensional indicators help in summarizing the level of agricultural sustainability.

The present study tries to identify a set of site-specific indicators based on the DSR framework, covering the three aspects of agricultural sustainability, i.e. economic, environmental, and social. Based on the selected indicators, a new composite index of agricultural sustainability has been formed, which would be helpful for household-level agricultural analysis of small areas and under similar geoecological conditions.

MATERIALS AND METHODS

Study area

Jorhat district is situated in the Assam state of India. The administrative boundary of Jorhat district was newly demarcated in 2016, by excluding the Majuli subdivision in the north. The new geographic co- ordinates of the district extend from 93° 56’ 24’’ E to 94° 38’ 24’’ E longitude and from 26° 18’ 36’’ E to 26° 58’ 48’’ E latitude (Fig. 1). Declaration of Majuli as a separate district has brought certain changes in the working composition and different aspects of the agricultural sector of present Jorhat district. About 40% of the total workers of the district is directly or indirectly engaged in agricultural activities for their livelihood (Census of India, Assam 2011). According to Jorhat district statistical handbook data, 2021; out of the total geographical area, 60% of the area is under agricultural use (Directorate of Economics and Statistics, Govt of Assam, Land Utilization

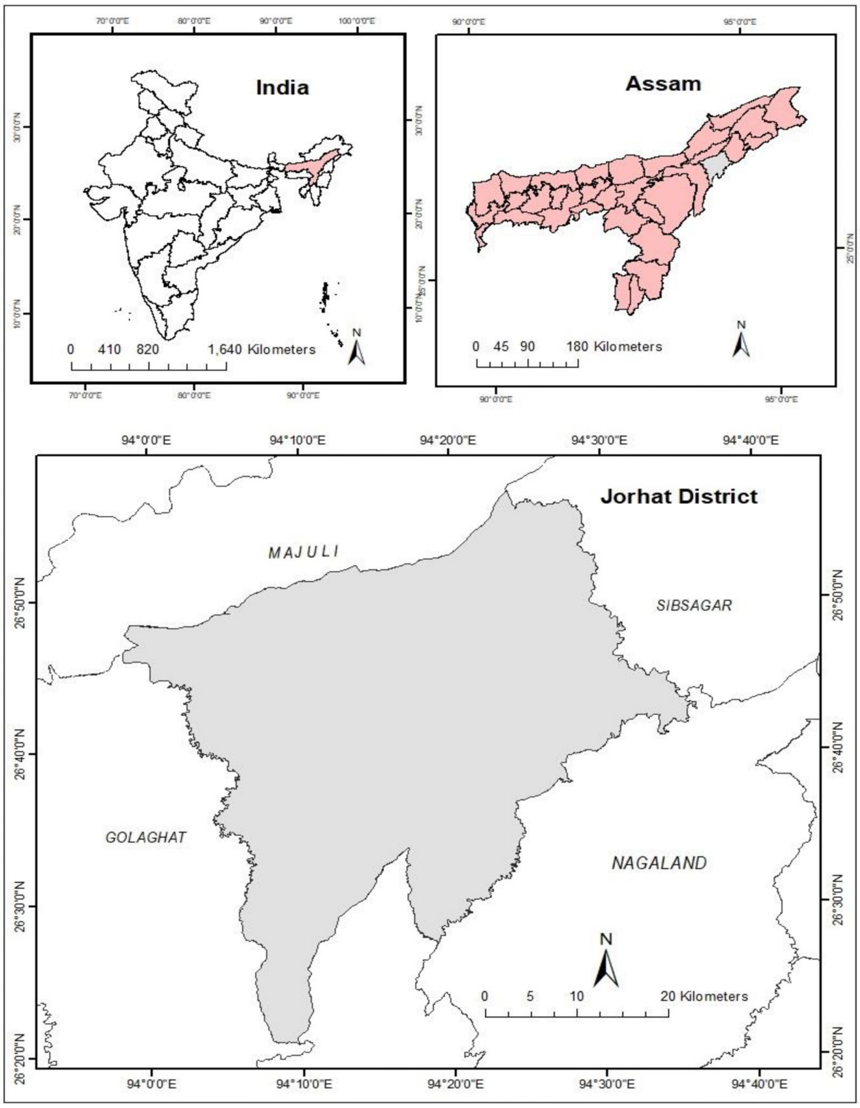

Fig. 1. Location of the study area, Jorhat.

Statistics 2020-21). Though different types of crops are cultivated in the district, the major cultivation is paddy. About 67.9% of the total cultivable area of the district is under paddy crop cultivation (Directorate of Economics and Statistics, Govt of Assam, Agriculture Statistics 2017). Winter paddy alone covers 67.1% area of the district. It indicates the dominance of one crop. Increase in chemical fertilizer consumption (Neog 2018), gradual decrease in paddy production, conversion of wetlands into agricultural and habitat land (Acharjee and Sarma 2012), dominance of one crop (winter paddy) since decades, decrease in annual rainfall and changes in agricultural work composition; all these factors in the area, demand an in-depth study of the sustainability status of agriculture as it is an important aspect of longterm agricultural profitability.

The district has a diverse geoecological setup. In the north, along the Brahmaputra River, a newer alluvial floodplain covers an extensive area of the

Table 1. Geoecological zone wise major characteristics, Jorhat.

Criteria	Zone I Northern alluvial floodplain zone	Zone II Alluvial plain zone	Zone III Undulating flood free zone	Zone IV Southern hilly and forest cover zone	Source
Average elevation	59- 90m	90- 109m	110- 144m	145- 440m	SRTM- DEM (USGS Earth explorer)
Average slope	0-1 degree	1.1-3 degrees	3.1-9 degrees	9.1-49 degrees	SRTM- DEM (USGS Earth explorer)
Drainage density	High	Medium	Low	Very Low	SRTM- DEM (USGS Earth explorer)
Geology	New alluvium deposits	New alluvium deposits	Old alluvium deposits	Sedimentary deposits	NBSS & LUP, Jorhat
Average annual rainfall	144- 159 cm	143- 133cm	125- 133 cm	126- 124 cm	Water Resource Department, Jorhat
Soil character	Silt clay loam to clay loam	Silt loam to silty clay loam	Sandy to silt loam	Sandy loam	NBSS & LUP, Jorhat
Land use pattern	Predominantly paddy cultivation	Paddy+ Tea cultivation	Predominantly tea cultivation	Forest cover	Landsat- 8 (USGS Earth explorer)

Source: Estimated by author.

district, while the southern region is an extension of the Naga-Patkai hill range of Nagaland. Besides physical and climatic variability, variation in land use patterns along different parts is noticed. Based on elevation, slope, drainage density, geology, spatial variation in average annual rainfall, soil character, and land use pattern; the district is divided into four geoecological zones by using the weighted overlay method in GIS software environment. The weights of the parameters are assigned by the Analytic Hierarchy Process (AHP). The four geoecological zones of the district are; Zone I Northern Alluvial Floodplain Zone, Zone II Alluvial Plain Zone, Zone III Undulating Flood Free Zone, and Zone IV Southern Hilly & Forest Cover Zone. Major geoecological characteristics of each zone are presented in Table 1. Based on the geoecological condition, the adopted agricultural systems are different in each zone. As in Zone IV, agriculture is not practiced due to forest cover and sparce settlement, therefore the other three zones have been considered to analyze agricultural sustainability. Geoecological zone-wise analysis of the agricultural sustainability of the area would clarify the status of agricultural sustainability and the micro level variability which would be beneficial for future policy making.

Data source and collection

Primary data have been collected between 2022-23, for the analysis of agricultural sustainability in the area. The process of the collection of primary data includes the following stages: (i) division of the district into geoecological zones based on major physical, climatic, and land-use characteristics, (ii) selection of 5% sample villages from each geoecological zone by using stratified sampling technique considering the factors like percentage of cultivators to the total population, distance from the nearest town, caste composition, nearness to the river, (Fig. 2) (iii) from each selected villages, 10-12% of the households are selected randomly, (iv) from each household two members are selected to fill one interview schedule, (v) cross-check of collected information has been done by conducting focused group discussion comprising farmers from different socio-economic backgrounds. The interview schedule has included questions related to basic background information and questions covering the three aspects (economic, ecological, and social) of agricultural sustainability. The questions are structured in a manner to get the required information correctly. The study includes 24 villages and 340 households to collect the required data. There is 100% response recorded from the sample households. The maps presented in the study area were prepared using GIS software.

Selection of indicators

In this study, the composite indicators method is used to analyze agricultural sustainability. The main

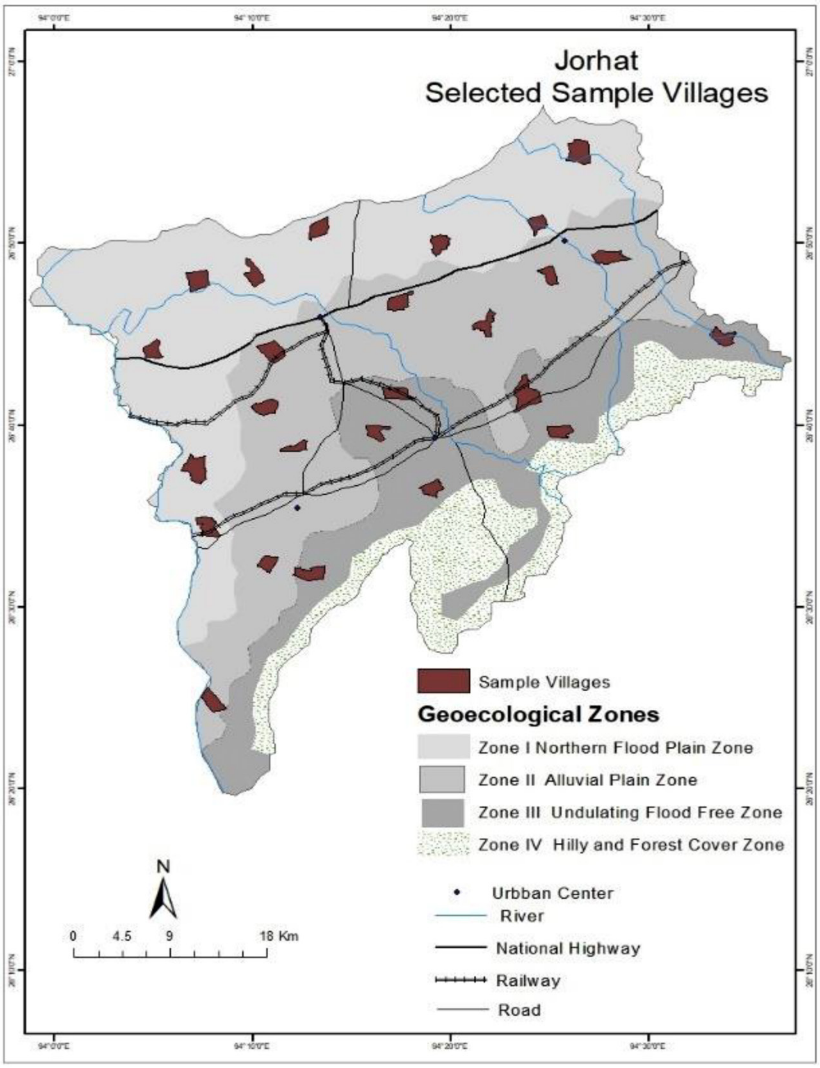

Fig. 2. Geoecological zone wise location of sample villages.

benefit of this method is that a researcher can measure agricultural sustainability in any level without having sufficient data (Jatav and Naik 2023). Studies have identified criteria for identifying the agricultural sustainability indicators. Important criteria for deciding agricultural sustainability indicators are relevance, measurability, accessibility, problem specific, unambiguity. In the current study, the indicators are selected based on their relevance at the farm level, accessibility, measurability, and other related studies (Gan *et al.* 2017, Jatav *et al.* 2022, Jatav and Nayak 2023, Mazumder 2023). Three components of agricultural sustainability; i.e. economic security, social security, and environmental sustainability; are taken into consideration for the analysis of agricultural sustainability as all three components are important in farm-level analysis. The selected indicators are identified as negative indicators or positive indicators based on their estimated relation with the components of agricultural sustainability. A total of 36 indicators are selected for this study to analyze the spatial variation of agricultural sustainability in the district.

Table 2. Selected indicators under economic component of agricultural sustainability.

Sl. No.	Indicators	Estimated impact on economic security	Way of measurement	Unit of measurement
1	Yield per unit of land	+	Average paddy production in per unit of land	Quintal/ *Bigha**
2	Total crop production	+	Average annual production of paddy	Quintal
3	Income from farm	+	Average annual family income from crop+ by products+ Livestock	Rupees
4	Input output ratio	-	Average annual production cost per unit of land/ Profit per unit of land	*Bigha**
5	Market demand/ price	+	Average local rate per quintal of paddy	Rupees
6	Wage to labors	+	Average wage per day	Rupees
7	Labor employment	+	Average number of labours employed per year (Tilling+ harvesting+Post harvesting)	Person
8	Man- land Ratio	-	Average family member/ Agricultural land	Ratio
9	Off farm income	+	Average annual income outside farm	Rupees
10	Distance to town		Average distance to nearest town	Kilometer
11	Agriculture training	+	Percentage of farmer have got agriculture related training	%
12	Awareness about minimum support price	+	Percentage of farmer who have knowledge about minimum support price	%
13	Average farm size	+	Average cultivable land per household	*Bigha**
14	Ownership of agri machinery	+	Percentage of farmer won agri machinery	%
15	Irrigation facility	+	Percentage of farmer who are able to use irrigated water when needed	%

**Bigha* is a local land measurement unit in Assam. 1 hectare= 1.4811 *Bigha.*

Economic component: A total of 15 indicators have been selected to construct the Economic Security Index (ESI). The selected indicators, their probable effect on economic security and the way of measurement are given in the Table 2.

Social component: Under the social component, 10 indicators have been identified to construct the Social Security Index (SSI). Their probable effects on social security, the way of measurement and units of measurement are given (Table 3).

Environmental component: To construct the Envi-

Table 3. Selected indicators under social component of agricultural sustainability.

Sl. No.	Indicators and assigned sign	Estimated impact on social security	Way of measurement	Unit of measurement
1	Food self sufficiency	+	Percentage of farmer who do not have to borrow or buy major food grains	%
2	Gender equality	-	Difference between male female labor wage per day (male wage- female wage)	Rupees
3	Farmers knowledge	+	Percentage of literate farers	%
4	Access to support system	+	Percentage of farmers getting support from KVK/AAU/NBSS& LUP/ RRI.	%
5	Tenure right	+	Percentage of female cultivators	%
6	Joint family	+	Percentage of household lives in joint family	%
7	Working member	+	Percentage of people between age (15- 45 years)	%
8	Female participation	+	Percentage of women participates in different agriculture activities	%
9	Membership to agriculture credit societies	+	Percentage of household having membership in credit societies	%
10	Sex ratio	+	Number of females per 1000 of male	Ratio

Table 4. Selected indicators under environmental component of agricultural sustainability.

Sl. No.	Indicators	Estimated Impact on environmental security	Way of measurement	Unit of measurement
1	Use of chemical fertilizer	-	Percentage of farmer use chemical fertilizer	%
2	Use of chemical pesticides	-	Percentage of farmer use chemical pesticides	%
3	Soil base saturation	+	*1 Average soil base saturation	%
4	Soil pH	+	*2 Soil pH	Average value
5	Ground water potential	+	Potentiality	High-1 Medium- 0.5 Low- 0
6	Water use efficiency	-	Percentage of farmers use ground water irrigation	%
7	Livestock ownership	+	Percentage of farmer possess livestock	%
8	Agroforestry system	+	Percentage of household having agro- forestry system	%
9	Use of organic fertilizer	+	Percentage of farmer use organic fertilizer	%
10	Crop rotation	+	Percentage of farmer practice crop rotation	%
11	Ecological literacy	+	Average score for ecological awareness questions	Average score

*1, *2 Source: Soil Atlas of Jorhat, 2020, NBSS &LUP Jorhat.

ronmental Sustainability Index (ENSI), 11 indicators are selected. Their estimated impact on environmental sustainability and way and units of measurement are presented in Table 4.

Normalization of values

Before construction of Agricultural Sustainability Index (ASI), the standardization of values of different indicators is needed. There are different methods of standardization or normalization of data with different units of measurement (Jatav *et al.* 2023a). Normalization of values into the same scale is helpful in comparison of data with different units and in minimization of the variability in the values (Jatav *et al.* 2023b). In the present study the values of different indicators measured in different parameters are standardized on same range between 0 to1, by following minimum- maximum approach (Iyengar and Sudarshan 1982) (equations 1-2). Where, 1 represents the highest value and 0 represents the lowest values of particular indicator.

For positive indicators (Larger- better- type):

$$N_{iz} = \frac{Xiz\text{-}Min\ (Xiz)}{Max\ (Xiz)\text{-}Min\ (Xiz)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

For negative indicators (Smaller- better- type):

$$N_{iz} = \frac{Max\ (Xiz)\text{-}Xiz}{Max\ (Xiz)\text{-}Min\ (Xiz)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where, N_{iz} is the standardized value of i^{th} indicator in the z^{th} geoecological zone, xiz is the actual value of i^{th} indicator in the z^{th} geoecological zone; and max(Xiz) and min (Xiz) are the maximum and minimum values of i^{th} indicator in z^{th} geoecological zone, respectively. For the positive indicators the equation 1 is applied and for negatively assigned indicators the equation 2 is applied. For the indicators which are measured in percentage covering all samples, the minimum and maximum values are regarded as 0% and 100% respectively. The actual values of each indicator are the average/ mean values of the respective geoecological zone. For maximum and minimum values, household level maximum and minimum are considered.

Assignment of weights

To construct an index based on multiple indicators, appropriate weights have to be assigned to each indicator. There are two main methods for assignment of weights. In the current study, statistical weight method (Iyengar and Sudarshan 1982) is adopted to assign weights to different indicators (equation 3). In this method, the variance of values of a particular indicator over the entire region determines the indicator's weight. The weight is inversely related to the variance of the values of the concerned indicator of agricultural sustainability in the respective region (Feyissa *et al.* 2018).

$$Wti = \frac{1}{\sum_{i=1}^{n} \frac{1}{\sqrt{\text{var Niz}}}} \times \sqrt{\text{var (Niz)}} \quad ....3$$

Where, Wti is the weight of i[th] indicator; and var (Niz) is variance of standardized values of ith indicator in the all geoecological zones.

The calculated weights will be used to construct the composite component index S_z for the z^{th} geoecological zone (equation 4).

$$Sz = \sum_{i=1}^{n} Niz \times Wti \quad ....4$$

Formulation of agricultural sustainability index (ASI)

The Agricultural Sustainability Index (ASI) for each geoecological zone is computed as the average of all three component indices: Economic Security Index (ESI), Social Security Index (SEI) and Environmental Sustainability Index (ENSI). Finally, the geoecological zones are categorized relatively on the basis of composite index score (ASI) as highly sustainable, moderately sustainable and low sustainable.

RESULTS AND DISCUSSION

Economic security index (ESI)

Among the three geoecological zones of the district, Zone I has the highest economic security with an ESI score of 0.5390 (Table 5). Therefore, Zone I can be regarded as more economically sustainable than two other zones. By cross-indicator analysis of the economic security index, the main factors behind the comparatively high economic security of the region are the high market price of agricultural production, getting agricultural training, awareness about MSP, ownership of agricultural machinery, and availability of comparatively high irrigation facility. On the other side, due to the worse conditions in crop production, less off-farm income, longer distance to the nearest towns, less awareness about MSP, less ownership of machinery, and minimum level of irrigation facilities in Zone III, the economic security of agriculture is the least. Though ranks 2[nd], Zone II performs comparatively better in indicators like; crop production, income from farm and outside farm, labor employment, man- land ratio, and average farm size than Zone I. The ESI score of Zone II (0.5382) is slightly less than that of Zone I. Overall ESI score for the district is 0.490.

Table 5. Geoecological zone wise ESI scores.

Sl. No.	Indicators	Northern new alluvial floodplain zone (Zone I)	Alluvial plain zone (Zone II)	Central undulating flood free zone (Zone III)
1	Yield per unit of land	0.0503	0.0589	0.0384
2	Total crop production	0.0128	0.0288	0.0096
3	Income from farm	0.0417	0.0421	0.0241
4	Input output ratio	0.0297	0.0297	0.0119
5	Market demand/ price	0.0713	0.0535	0.0535
6	Wage to labors	0.0212	0.0159	0.0358
7	Labor employment	0.0245	0.0430	0.0258
8	Man- land ratio	0.0316	0.0503	0.0484
9	Off farm income	0.0241	0.0301	0.0100
10	Distance to town	0.0206	0.0309	0.0103
11	Agriculture training	0.0879	0.0675	0.0800
12	Awareness about minimum support price	0.0336	0.0172	0.0146
13	Average farm size	0.0199	0.0208	0.0026
14	Ownership of agri machinery	0.0353	0.0242	0.0147
15	Irrigation facility	0.0346	0.0252	0.0140
	Economic security index (SSI)	0.5390	0.5382	0.3937
	Rank	1	2	3

Source: Authors' estimation.

Table 6. Geoecological zone wise SSI Scores.

Sl. No.	Indicators	Northern new alluvial floodplain zone (Zone I)	Alluvial plain Zone (Zone II)	Central undulating flood free zone (Zone III)
1	Food self sufficiency	0.0133	0.0094	0.0077
2	Gender equality	0.0099	0.0099	0.0049
3	Farmers knowledge	0.0271	0.0242	0.0214
4	Access to support system	0.0164	0.0129	0.0107
5	Tenure right	0.0173	0.0115	0.0142
6	Joint family	0.0287	0.0242	0.0233
7	Working member	0.0414	0.0471	0.0443
8	Female participation	0.0141	0.0090	0.0092
9	Membership to agriculture credit societies	0.0289	0.0318	0.0260
10	Sex ratio	0.2598	0.2656	0.2627
	Social security index (SSI)	**0.4569**	**0.4456**	**0.4243**
	Rank	**1**	**2**	**3**

Source: Authors' estimation.

Table 7. Geoecological zone wise ENSI scores.

Sl. No.	Indicators	Northern new alluvial floodplain zone (Zone I)	Alluvial plain zone (Zone II)	Central undulating flood free zone (Zone III)
1	Use of chemical fertilizer	0.1050	0.1145	0.1164
2	Use of chemical pesticides	0.1010	0.1116	0.1116
3	Soil base saturation	0.0614	0.0491	0.0552
4	Soil pH	0.0295	0.0324	0.0206
5	Ground water potential	0.0123	0.0061	0.0000
6	Water use efficiency	0.0080	0.0121	0.0201
7	Livestock ownership	0.0246	0.0164	0.0126
8	Agroforestry system	0.0390	0.0415	0.0506
9	Use of organic fertilizer	0.0340	0.0243	0.0357
10	Crop rotation	0.0153	0.0051	0.0042
11	Ecological literacy	0.0106	0.0213	0.0106
	Environmental sustainability index (ENSI)	**0.4405**	**0.4344**	**0.4377**
	Rank	1st	3rd	2nd

Source: Authors estimation.

Social security index (SSI)

In terms of social sustainability in agriculture, Zone I ranks first with an SSI score of 0.4569. Cross-indicator analysis shows that Zone I performs better in six social security indicators than in two other zones. Zone II has a higher score than Zone I in terms of percentage of working members, membership to agriculture credit societies, and sex ratio. With an SSI score of 0.4456, the social sustainability of Zone II is lesser than that of Zone I. Though in seven indicators Zone III scores the lowest, in the percentage of working members, female participation and sex- ratio; the zone performs better. The overall SSI score for the district is 0.442 (Table 6).

Environmental sustainability index (ENSI)

Comparatively less zonal disparity is seen in terms of ENSI. The highest environmental sustainability is recorded in Zone I followed by Zone III. According to the cross-indicator analysis, the factors responsible for the highest environmental sustainability in Zone I are; comparatively high soil base saturation, groundwater potential, livestock ownership, and higher adoption of crop rotation system. The Zone II has substantially lower environmental sustainability. The main reason for comparatively lower environmental sustainability in Zone II is the higher use of chemical fertilizers and pesticides, lower soil base saturation, and lower use of organic fertilizer. The overall score of ENSI for the district is 0.438 (Table 7).

Agricultural sustainability index (ASI)

The agricultural sustainability index is computed based on three main components of agricultural sustainability indices; ESI, SSI and ENSI. The result shows that Zone I is the most sustainable zone

Table 8. Geoecological zone wise ASI scores.

Composite index	Northern new alluvial floodplain zone (Zone I)	Alluvial plain zone (Zone II)	Central undulating flood free zone (Zone III)	Average
ESI	0.539	0.538	0.393	**0.490**
SSI	0.456	0.445	0.424	**0.442**
ENSI	0.440	0.434	0.437	0.438
ASI	**0.478**	**0.472**	**0.418**	**0.457**
Ranks	1st	2nd	3rd	

Source: Author's estimation.

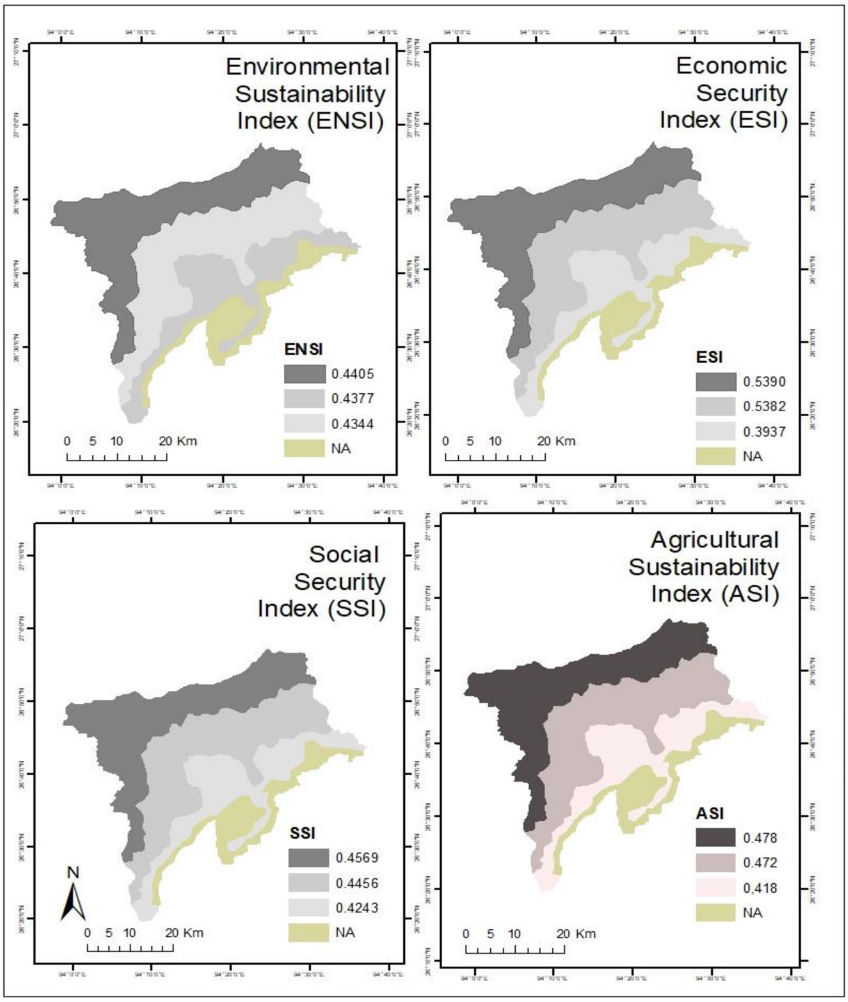

Fig. 3. Geoecological zone wise ENSI, ESI, SSI & ASI.

among the three others (ASI score 0.478) (Fig. 3). In all three aspects of agricultural sustainability, this zone is the most sustainable in the district. The least sustainable zone is the Zone III (ASI score 0.418). Though the environmental sustainability of Zone III is comparatively better, the score of economic sustainability is very poor than the other two zones. The score of Agricultural Sustainability Index of Zone II is slightly lower (0.472) than that of Zone I, and this is because of the lowest environmental sustainability in this zone. Without meeting environmental sustainability, agricultural sustainability cannot be maintained. The average ASI score for the whole district is 0.457 (Table 8).

CONCLUSION

Agricultural sustainability measurement using farm-level primary data will be very helpful in understanding the status of the agricultural sector at the grassroots level. The study tried to analyze the impact of micro-level geoecological variation on agricultural sustainability. The study attempts to give an insight into a set of indicators that will be helpful in the household and village-level analysis of agricultural sustainability. The result shows that the highest agriculturally sustainable zone is Zone I with comparatively high levels of economic and social sustainability in terms of agriculture. Though having high environmental sustainability, the agricultural sustainability of Zone III is the least due to lower economic sustainability. The study shows that the micro-level geoecological changes can also affect the level of agricultural sustainability. The study also indicates that in microregions, achievement of economic security and environmental sustainability can assure sustainability in agriculture. The policymakers can consider these factors in agricultural policymaking and implementation. The set of indicators and the ASI can also be implemented in other similar regions.

Though the study uses household-level primary data for agricultural sustainability analysis, the collected data is based on a limited sample size. The soil quality analysis is based on secondary data. Though cross-examination was carried out in focused group discussion, it is not an easy task to get the exact quantitative information from the farmers about their annual production, farm income, quantity of chemical fertilizer used. The study has used the statistical method of weighting the indicators, which has certain limitations. The temporal analysis using this methodology will be very time-consuming. Besides, the geoecological zonation is based on the secondary data available from different official sources.

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