Measurement of Regional Disparity in Dimensions of Agricultural Sustainability in Kolhapur District, Maharashtra

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Abstract

The present study estimates the regional disparity in dimensions of agricultural sustainability in study area of Kolhapur district. The ecological security, economic efficiency, and social security indicators of sustainable agricultural development were seen as good tools to measure the sustainability of development projects and programs. As per the finding of the study, only 5.5 % of farmers out of the total respondents were practicing sustainable agricultural practices and systems. The results shown wide regional disparity in sustainable agricultural index as the range of SAI values was 0.684 to 0.350. The study found the Karveer has highest SAI value of 0.684 and Chandgad has lowest of 0.350. Three blocks from study area namely Chandgad, Shirol, and Radhanagari having SAI value lower than 0.400 and Shahuwadi block has decent 0.486 SAI value during the study period. The SAI value as a policy tool aids in the launching of inter-regional urgencies for agricultural allocation of resources and highlights the activities and programs relevant to each area for sustainable agricultural development. Therefore, agricultural intensification is very crucial for bringing sustainable agricultural development to the study area.

Keywords: Regional disparity; sustainable Agricultural Index; Ecological Security; Economic efficiency; Social equity; Sustainability

1. INTRODUCTION

The close connection with water, soil, ecosystems, and biodiversity, agriculture in India plays a unique role in sustainable development. Agriculture has historically been the mainstay of social and economic growth. It accounts for nearly 15% of GDP (ESM, 2022), and two-thirds of the population is dependent on agriculture with an estimated population of approximately 1027 million (Census of India, 2011). The Brundtland Commission defined sustainable development as the "ability to make development sustainable in order to ensure that it meets the needs of the present without compromising future generations' ability to meet their own

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needs" (WCED, 1987). Agriculture must become more environmentally viable and undergo an upsurge in order to satisfy rising demand and effectively aid in decreasing poverty and hunger elimination. One of the goals, Zero Hunger, for instance, explicitly mentions eliminating hunger from the globe by promoting sustainable agricultural development. The different elements associated with agricultural sustainability form the basis for its assessment. Sustainable development (SD) and sustainable development of agriculture (SDA) are the advancements in ecology, economy, and inter- and intra-generational equity (Barbier, 1987) (E, 1992) (MS, 1991). Any approach used to develop a metric for sustainable agricultural development (SDA) should incorporate the ecological security index (ESI), economic efficiency index (EEI), and social equity index (SEI) (Deshmukh & Patil, 2020).

The notion of sustainable agriculture arose as a result of extensive research into the effects of the overuse of fertilizers, insecticides, and chemical pesticides, which polluted waterways and triggered illnesses damaging to livestock individuals, and aquatic organisms. (Hossain S. S., 1994) (Asaduzzaman, 1996) (Hossain & Kashem , 1997) (Rahman & Thapa, 1999). Therefore, there is a growing emphasis on sustainable agriculture in response to concerns about the adverse environmental and economic impacts of conventional agriculture (Hansen, 1996). Agrochemicals are being used unnecessarily and unstably, which has increased production costs, increased reliance on outside energy and inputs, decreased soil productivity, contaminated surface, and groundwater, and had negative consequences on human and animal health (Edwards, 1989) (Conway, 1985) (Biswas, 1994). An attempt has been to assess the regional disparity in the agricultural sustainability of selected blocs of the Kolhapur district by using sustainable agricultural index methodology with the help of primary data.

2. MATERIALS AND METHODS

For this study, both primary and secondary data sources were used. The primary data from 400 respondents has been collected and used to assess agricultural sustainability by using a pre-tested interview schedule for selected blocks of the Kolhapur district. The three domains of sustainable development have been covered namely ecological security, economic efficiency, and social equity.

2.1 Selection of sample blocks and cultivators from study area

To select representative blocks of Kolhapur district, the study used the cluster sampling technique and selected five blocks out of twelve blocks by using four borders and one canter methodology adopted by NSSO. As per taro Yamane’s (1967) formula, 400 respondents have been selected out of 285,892 cultivators from each of the blocks of the Kolhapur district.

2.2 Respondent sampling procedure from selected villages

A total of 29 sample villages were selected on clustered sampling from 578 villages of 12 blocks/tehsils of Kolhapur districts, in which compulsorily one central and other four border villages have been selected. The distribution of sample households at the village level is based on proportionate to population method.

Table 1: Selection of Sample Cultivators

Name of Sample Blocks	Total Cultivators (Rural)	% Share of Cultivators	Sample Cultivators	Number of Villages	Selected Villages (5% out of total villages)
1. Shahuwadi	51695	18.08	74	133	7
2. Shirol	39680	13.88	53	54	3
3. Chandgad	59242	20.72	83	156	8
4. Radhanagari	60569	21.19	85	114	5
5. Karveer	74706	26.13	105	121	6
Total	285892	100	400	578	29

Source: *District Census Handbook of Kolhapur. Part XII B Series 27, Village, and town wise primary census abstract.*

2.3 Analytical Farmwork of Estimation of the Sustainable Agricultural Index (SAI) In the Study Area

Let X_{ijk} and SAIijk represent the value of ith variable, jth component and kth block and index for ith variable representing the jth component of the SAI of kth block, respectively. Then, we have, for positive implication used equation (1) and for negative implication used equation (2)

$$SAI_{ijk} = \frac{Xk_{ijk} - Mink_{ijk}}{Maxk_{ijk} - Mink_{ijk}}$$

$$SAI_{ijk} = \frac{Maxk_{ijk} - Xk_{ijk}}{Maxk_{ijk} - Mink_{ijk}}$$

SAI_{EEI}, SAI_{SEI} and $SAI_{ESI} = \sum \frac{SAI_{ijk}}{n}$ Where n=12

Where,
i = variables (1,2,3………. I)
j = components (1,2,3………. J)
k = blocks (1,2,3………. K)

The numerator in equation (1) and (2) shows that, it measures the extent by which the kth block did better in the ith variable representing the jth components/domain of SAI as compared to the blocks showing the worst performance in that component, and the denominator indicates the range i.e., the difference between the maximum and the minimum values of the variable representing a given component (Beeralainni & Patil, 2023). The equation (3) exhibits that three component indices of SLSI, viz., ESI, EEI and SEI were calculated for all variables, taking simple mean by assigning equal weights to the indices of their respective variables. The SLSI has range of 0 to 1 in which a value closer to zero shows low level of sustainability and value near to 1 denotes high level of sustainability.

2.4 *Selection of Domain and Indicators of Agricultural Sustainability*

The appropriate indicators must be selected in order reflect the extent of agricultural sustainability in given region. The current study is based on three domains namely Economic efficiency, Ecological security, and social equity. Four indicators have been selected for each domain/component of the agricultural sustainability. The following table depicts the domain, indicators, criterion of selection and their impact on sustainability of agriculture.

Table 2: Selection of Domain and Indicators for Assessing Agricultural Sustainability in Study Area.

Domain	Indicator	Type	Criterion
Economic Efficiency	Foodgrain Production (Qt)	+Ve	Food Security
	Irrigated Land (Acres)	+Ve	Agricultural output
	Milk Production (Monthly/Lit)	+Ve	Major source of income in Rural areas
	Fertilizer consumption (Qt)	+Ve	Nutritional requirements of crop
Ecological Security	Human Density (In Numbers)	-Ve	Pressure on natural resources and pollution
	Micro Irrigation (%)	+Ve	Water saving
	Non-chemical farmers (%)	+Ve	Less land degradation and water/soil pollution
	Total Livestock (In Numbers)	-Ve	Emission of CH4 and high-water use
Social Equity	Marginal Operational Holdings (%)	-Ve	Uneven distribution of land and disparity in income of farmers
	Total Literacy (%)	+Ve	Educational status and adoption of new techniques in practicing agriculture
	Agricultural Workers (%)	-Ve	Dependency of agricultural sector
	Access to soil testing (%)	+Ve	Equality in the facilities of soil testing

Source: (Deshmukh & Patil, 2022)

The primary data have been collected for twelve indicators of three domains to assess the regional disparity in the dimensions of the agricultural sustainability in selected blocks of Kolhapur district.

3. RESULTS AND DISCUSSION

The study is based on both primary data which was collected through the self-structured questionnaire, personal interview, and observation method. In this research investigation, researcher has collected primary data selected farmers from selected research area.

3.1. Block Wise Ecological Security Index (ESI) of Selected Research Area of Kolhapur District

The selected research area's ecological security is determined by four indicators such as population density (per km2), adoption of environmentally friendly agricultural practices (%), total livestock (numbers), and adoption of micro irrigation (%). In terms of the variables chosen, human resources are critical to breaking the stagnation in agricultural growth and productivity. As a result, the variable population density was chosen for its ability to represent the level of human impact on overall ecological security (Hatai & Sen, 2008). The excessive use of chemical fertilisers causes degradation of soil and contamination of water, the proportion of non-chemical farmers was chosen as an ecological security indicator. The greater the proportion of non-chemical farmers, the greater the level of agricultural sustainability in the study area. Because many studies indicate that livestock contributes to methane (CH4) emissions along with substantial water use, total livestock is shown to be a negatively influencing variable on ecological security (Karemulla, Venkatakumar, & Samuel, 2017). Micro irrigation adoption is taken as an ecological security indicator because it reduces the consumption of water by many folds, and reduces problems occurring like soil salinity and water logging problem. The adoption of a micro irrigation system is one of the important sustainable agricultural practices.

Table 3: Block-Wise Ecological security indicators in the study area

Blocks	Population Density *(In Numbers)*	Non-chemical farmers *(%)*	Total Livestock *(In Numbers)*	Micro Irrigation *(%)*
Shahuwadi	169	1.8	197	2.5
Shirol	707	0.3	164	13.5
Chandgad	190	1.7	477	5
Radhanagari	211	0.8	227	1
Karvir	1351	0.8	280	12
Kolhapur District	473	5.4	1345	33.5

Source: *Field Work-2022 and District Statistical Handbook-2011*

Based on the above primary data collected for various ecological security indicators the Ecological Security Index (ESI) of each indicator was computed in Table 03 by using the normalization formula of the sustainable agricultural index.

Table 4: Block Wise Ecological Security Index (ESI) of selected blocks of the study area

Blocks	Population Density Index	Non chemical farmers Index	Total Livestock Index	Micro Irrigation Index
Shahuwadi	1.000	1.000	0.895	0.120
Shirol	0.545	0.000	1.000	1.000
Chandgad	0.982	0.933	0.629	0.320
Radhanagari	0.964	0.333	0.799	0.000
Karvir	0.000	0.333	0.000	0.880
Kolhapur District	0.698	0.520	0.665	0.464

Source: *Authors Calculation.*

The analysis revealed that the Kolhapur district's population density index was 0.698, the non-chemical farmers' index was 0.600, the total livestock index was 0.665, and the micro irrigation index was 0.464. The findings demonstrate that human and livestock densities are low in the study area due to very high index values. The study also discovered that they have a negative connection with long-term agricultural development.

3.2. Block Wise Economic Efficiency Index (ESI) of Selected Research Area of Kolhapur District

The economic efficiency index was constructed for selected research areas using primary data for the year 2022. Economic efficiency can be measured by variables such as the production of food grains in quintals, crop irrigation in acres, monthly production of milk in litres, and fertilizer consumption by the study's selected respondents. The production of food grains guarantees the availability of food in the study area. Irrigation is a major input in agriculture; the more land that is irrigated, the higher the yield and earnings of the farmers. Milk production is one of the key allied activities in rural areas which enhance the rural income. Rural women are involved in milk production, which provides earnings to the rural poor and improves their standard of living. Fertilisers are essential in crop nutrition. It has the potential to increase soil production and productivity. As a result, considering all the criteria the variables are chosen for the construction of the study area's economic efficiency index in 2022.

Table 5: Block-Wise Economic efficiency indicators in the study area

Block	Foodgrain Production (Qt)	Irrigated Land (Acres)	Milk Production (Monthly/Lit)	Fertilizer consumption (Qt)
Shahuwadi	216.5	302.8	27810	548.4
Shirol	371.75	163.07	13545	1409.77
Chandgad	931.35	161.005	20070	1353.04
Radhanagari	366.62	297.77	26400	1157.81
Karvir	1556.48	524.41	50490	2713.47
Kolhapur District	3442.7	289.811	138315	7182.49

Source: *Field Work-2022*

Table 6: Block Wise Economic efficiency index (ESI) of selected blocks of the study area

Block	Foodgrain Production Index	Irrigated Land Index	Milk Production Index	Fertilizer consumption Index
Shahuwadi	0.000	0.390	0.386	0.000
Shirol	0.116	0.006	0.000	0.398
Chandgad	0.533	0.000	0.177	0.372
Radhanagari	0.112	0.376	0.348	0.281
Karvir	1.000	1.000	1.000	1.000
Kolhapur District	0.352	0.354	0.382	0.410

Source: *Authors Calculations.*

3.3. Block Wise Social Equity Index (ESI) of Selected Study Area of Kolhapur District

The social equity index was developed using indicators such as the percentage of agricultural workers to total workers, total literacy, marginal operational holdings, and soil testing. The percentage of agriculture workers to total workers is regarded as a negative indicator of agricultural sustainability because the majority of working populations rely on agriculture, implying that they are experiencing disguised unemployment with zero marginal productivity. Literacy is critical to being able to think critically and make prudent choices in different areas of the economy. Total literacy refers to literacy among both males and females in the country, and it is critical because it aids in the acquisition of new abilities, the use of modern seeds and fertilizers, knowledge of production and input costs, details about insurance for agriculture schemes, and so on. Agricultural literacy revolves around analytical thinking and judgment about the effect of farm operations on the country's economic environment.

Table 7: Block Wise Social equity indicators in the study area of Kolhapur District

Block	Agricultural Workers *(%)*	Total Literacy *(%)*	Marginal Operational Holdings *(%)*	Access to soil testing *(%)*
Shahuwadi	67.15	66.9	37.8	8.3
Shirol	62.12	80.2	52.8	3.5
Chandgad	78.2	66.2	63.9	3.8
Radhanagari	75.9	71.3	44.7	6.5
Karvir	36.1	86.2	70.5	10.0
Kolhapur District	63.894	74.16	55.3	32.0

Source: *Field Work-2022*

Table 8: Block Wise Social equity index (ESI) in the study area of Kolhapur District

Block	Agricultural Workers Index	Total Literacy Index	Marginal Operational Holdings Index	Access to soil testing Index
Shahuwadi	67.15	66.9	37.8	8.3
Shirol	62.12	80.2	52.8	3.5
Chandgad	78.2	66.2	63.9	3.8
Radhanagari	75.9	71.3	44.7	6.5
Karvir	36.1	86.2	70.5	10.0
Kolhapur District	63.894	74.16	55.3	32.0

Source: *Authors Calculation.*

The marginal land size is a problem because it restricts the operations like automation of agriculture, fewer profit margins, less output, restrictions in taking commercial crops, subsistent level of farming, etc. Taking all this into account we have taken it as a negative indicator of social equity. The study found that soil testing plays a decisive role in sustainable agricultural practices. According to the data, only 32% of farmers have access to soil testing which shows societal or infrastructural inequality.

3.4. Composite Sustainable Agricultural Index (SAI) of Selected Research Area of Kolhapur District

The sustainable agricultural index (SAI) is estimated with the help of average raw data of twelve indicators and three components for the year 2022. The indices values estimated are displayed in the following table such as the ecological security index (ESI), economic efficiency index (EEI), social equity index (SEI), and the composite index of the sustainable agricultural index (SAI). The sustainable agricultural index can be utilised to set inter-regional targets for assigning resources for agriculture and prioritises the programmes and initiatives required by every block for growth in agriculture that is sustainable. The possible obstacles and policy consequences of the sustainable agricultural index approach have attracted considerable attention.

Table 9: Estimation of sustainable agricultural index of study area of Kolhapur District

Blocks	Ecological Security Index (ESI)	Economic Efficiency Index (EEI)	Social Equity Index (SEI)	Composite Sustainable Agricultural Index (CSAI)
Shahuwadi	0.754	0.194	0.509	0.486
Shirol	0.636	0.130	0.406	0.391
Chandgad	0.716	0.270	0.162	0.350
Radhanagari	0.524	0.279	0.390	0.398
Karvir	0.303	0.999	0.750	0.684
Kolhapur District	0.587	0.375	0.423	0.462

Source: *Authors Calculations.*

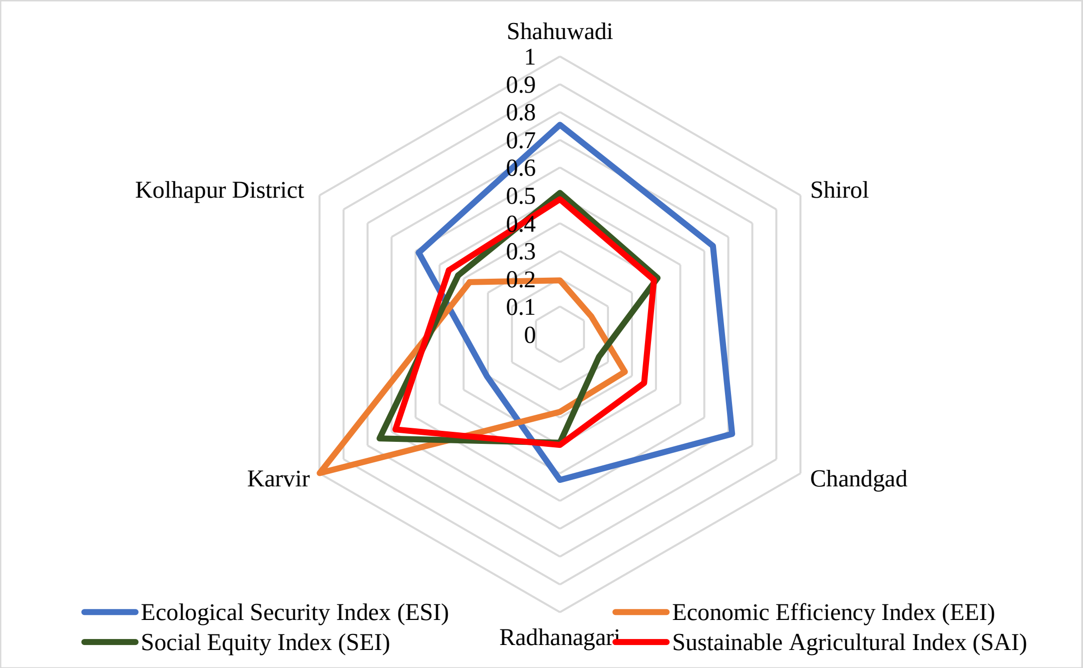

Figure 1: Ecological security, Economic efficiency, social equity, and Sustainable Agricultural Index of study area based on primary data.

According to the block-wise evaluation of sustainable agricultural development, Shahuwadi (0.754) and Chandgad (0.716) performed best for the ecological security index, while Karvir (0.303) and Radhanagari (0.524) performed worst. Similarly, Karvir (0.999) ranked highest for the economic efficiency index (EEI), while other blocks fell below the 0.30 index value. When it comes to the social equity index, Karvir (0.750) and Shahuwadi (0.509) performed better, while Chandgad (0.162) had the lowest social equity of every block in the study area. The sustainable agricultural index is a composite index of ecological security, economic efficiency, and social equity. During the investigation period, Karvir (0.684) and Shahuwadi (0.486) were the best performers, while Chandgad (0.350) was the worst performer.

3.5 Component-Wise Thematic Areas for Sustainable Agriculture Enhancement in The Study Area

The table demonstrates each block that must focus on the various components in the study area of Kolhapur district, namely ESI, EEI, and SEI. Karvir block require instantaneous ecological attention; there is an urgent need to increase the forest area by trees being planted, regulate pollution, hinder overpopulation, and so on. Similarly, in terms of economic efficiency indicators, Shahuwadi, Shirol, Chandgad and Radhanagari need immediate intervention. This may include the technological advancement of the farming sector by increasing irrigation area, resulting in increased output from agriculture, suitable and appropriate fertiliser application, and so on.

Table 10: Priority areas in the components of sustainable agricultural development in Kolhapur district

Blocks	ESI	EEI	SEI
Shahuwadi		**Ŧ**	
Shirol		**Ŧ**	
Chandgad		**Ŧ**	**Ŧ**
Radhanagari		**Ŧ**	**Ŧ**
Karvir	**Ŧ**		
Kolhapur District		**Ŧ**	

Source: *Compiled by Author Based on Index Value* (Note: "**Ŧ**" indicates that immediate attention is required in the respective components of sustainable agricultural development in study area)

In terms of the social equity indicator, Chandgad, and Radhanagari exhibit greater inequality in society; to address the disparities in society, the policymakers could implement regulations aimed at the expansion of quality education, improved medical care, and appropriate rural amenities for the region's social and economic growth in the study area of Kolhapur district.

4. CONCLUSION

The policy makers must focus on various aspects of sustainable agricultural development in the district. According to the empirical analysis, the Kolhapur district of Maharashtra has a medium development status because SAI values range from 0.400 to 0.600. However, there is significant room for improvement in the indices' values by focusing on all three domains related to agricultural sustainability at the same time. As a policy tool, SAI detects not only the regions that require immediate response but also specifically identified thematic areas where attempts can be concentrated to achieve sustainability. This, in turn, aids in the launch of inter-regional urgencies for agricultural allocation of resources and highlights the activities and programs relevant to each area for sustainable agricultural development.

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