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RESEARCH PAPER

Agricultural Sustainability in the North Eastern Region of India: A Sustainable Livelihood Security Index (SLSI) Approach

Ankur Jain*, Neela Madhaba Sheekha**, Sandip Tanu Mandal***

Abstract: This paper offers an economic analysis of agricultural sustainability in the North Eastern Region (NER) of India by calculating the sustainable livelihood security index (SLSI) of each state. The SLSI serves as an important indicator for educating farmers and other stakeholders about sustainable agriculture production. This paper focuses on the NER as this region has received meagre attention in policy perspectives and is deprived in terms of various socio-economic and ecological indicators as compared to the rest of India. The findings show that various components of the SLSI, such as the ecological security index, economic efficiency index, and social equity index, have wide interstate variations. The agricultural sector in the NER has largely been neglected, with the state failing to adopt inclusive policies to uplift small and marginal farmers. The region suffers from severe poverty and malnutrition, improper management, over-exploitation of natural resources, and population explosion. These issues are a threat to agricultural sustainability. The study aims to identify the key factors that influence agricultural sustainability for inclusive and sustainable agricultural development. The findings show that the value of the SLSI ranged from 0.37 to 0.56 among the North Eastern states, which shows low agricultural sustainability. The indicators reveal that Tripura ranks first, with an SLSI score of 0.56, followed by Sikkim (0.50) and Assam (0.44). Manipur stood last in the SLSI ranking of North Eastern states, with a score of 0.37, which evidently shows the need for policy changes to enhance the sustainable development of agriculture.

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1. INTRODUCTION

The agricultural sector plays an important role in ensuring inclusiveness and sustainability for future generations. The sector not only provides a livelihood for 48 per cent of the rural workforce (Dev 2018), but it also ensures food and nutrition security (International Food Policy Research Institute 2015) and reduces poverty and malnutrition (World Bank 2008). The World Health Organization (WHO) aims to end food insecurity and improve nutrition by promoting sustainable agriculture at the global level (WHO n.d.). The Food and Agriculture Organization (FAO) defines sustainable agriculture as "the successful management of resources for agriculture to satisfy the changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources" (FAO 1991, 277). Therefore, a balance between social equity, ecological security, and economic efficiency is needed for sustainability in agriculture (Swaminathan 1991; Saleth and Swaminathan 1993; Hatai and Sen 2008; Singh and Hiremath 2010; Sajjad, Nasreen, and Ansari 2014; Deshmukh and Patil 2020).

In the North Eastern Region (NER) of India, the agricultural sector lacks a focus on growth, social equity, and sustainable livelihoods. The sector has not been able to adopt inclusive policies to uplift small and marginal farmers. The region suffers from severe poverty and malnutrition, improper management and over-exploitation of natural resources, and population explosion (Barah 2007; Konwar 2015) Historically, economic development in the region has lagged behind that of the rest of the country in terms of gross domestic product (GDP) as well as per capita GDP between 1993–94 and 2002–03 (Birthal *et al.* 2006).

Roy *et al.* (2014) found that the region's agricultural productivity was so low from 1972–73 to 2011–12 that it can be considered a food deficit region. Thus, it needs to use inputs and sustainable agricultural practices judiciously. Based on sustainability indicators such as pest management, fertilizer use, soil health, water conservation, biodiversity, and efficient use of inputs, Veluguri, Ramanjaneyulu, and Jaacks (2019) assess the Indian agricultural sector's dependence on natural resources. They found that Arunachal Pradesh (5%) is the only high-performing state in the NER, with the most vulnerable states in the region being Meghalaya (47%), Assam (43%), and Nagaland (42%). Factors like natural calamities, a large

percentage of smallholders, limited use of agri-inputs, low crop diversification, and negligible seed/variety replacement threaten the sustainability of the region's livelihoods (Barah 2007).

There is a pressing need to develop the NER, particularly its agricultural sector, by implementing the right agricultural policies. The region has the potential to increase its farm income and enhance its food and nutrition security. It is rich in natural resources, has abundant water, and has a favourable climate for agricultural production (Barah 2007; Birthal 2010). In addition, the region shares international borders with Bhutan, China, Myanmar, and Bangladesh, giving it an advantage in the international trade of agricultural products. Unfortunately, agricultural production in the NER is yet to realize its full growth potential, and the marketing of its products remains inadequate. The literature has identified the constraints that limit agricultural output in the NER, such as a lack of system-specific production technologies, a lack of infrastructure, and unfavourable agrarian policies (Birthal *et al.* 2006; Birthal 2010; Syiem and Raj 2015; Dev 2018). Hence, the region has failed to convert its strengths into growth opportunities, and it lags behind the rest of the country. High population growth, with a large proportion of small and marginal farmers, forms the context for any effort targeting livelihood sustainability in the NER (Barah 2007; Dev 2018). Farmers in this region use low-input agricultural practices that result in low yield (Barah 2007). In an estimation of the income and consumption of small and marginal farmers for the *NSS Situation Assessment Survey 2013*, Dev (2018) states that the income they earn is not sufficient to meet their daily consumption requirements. Hence, non-farm employment opportunities need to be promoted for inclusive and sustainable agricultural growth in the region.

These issues are a threat to the sustainability of agricultural livelihoods. There is a dearth of literature on agriculture sustainability in the NER that quantifies sustainability at the state level. This study contributes to policymaking in the region by informing the allocation of investment projects according to social equity, ecological security, and economic efficiency requirements. Measuring agricultural sustainability in the NER can contribute toward improving regional imbalances and serve as an important micro-indicator for analysing progress towards sustainability.

Given the entrenched problems of the region, the study aims to identify the key indicators of agricultural sustainability for inclusive and sustainable agricultural development. The paper proceeds by discussing the data collection and methodology adopted for determining the sustainable

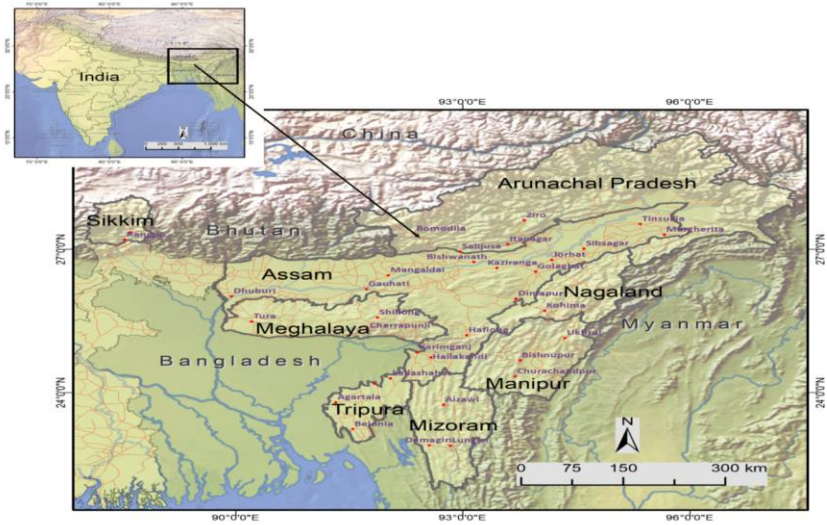
livelihood security index (SLSI) in Section 2. Section 3 measures the status of sustainable livelihood agriculture and is followed by a discussion in Section 4. Finally, Section 5 gives the conclusions and policy implications.

2. DATA, METHODOLOGY, AND SELECTION OF VARIABLES FOR THE STUDY

2.1 Description of the Study Area

The (NER) comprises eight states, namely, Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, and Tripura. Agriculture in the NER is characterized as subsistence, low-input, and technically backward (Alam 1993; Birthal *et al.* 2006).

Figure 1: Location of the Study Area



Source: Authors'

The region is economically backward, with agriculture serving as the main source of occupation. The region is marked by inter-state socio-economic inequalities (Alam 1993; Padhi *et al.* 2020). The NER faces several challenges, such as the prevalence of traditional subsistence agriculture and hill agriculture (Alam 1993; Birthal *et al.* 2006; Jeeva, Christopher, and Mishra 2006; Barah 2007; Birthal 2010). Shifting cultivation (*jhum*) is still prevalent in the NER, although it is considered economically unfeasible and environmentally destructive (Bezbaruah 2006). In addition, the region's growth potential is limited by poor infrastructure such as poorly developed

roads and markets (Alam 1993; Birthal 2010; Ghosh 2019). None of the markets in the NER is part of the e-NAM (Electronic Nation Agriculture Market). Moreover, the region lacks economies of scale. In the NER, though the average farm holding size is more than the national average, with Nagaland and Arunachal Pradesh reporting the largest average farm holdings in the region, in some states, such as Tripura, Manipur, Meghalaya, and Mizoram, the percentage share of small and marginal farmers is greater than that in all of India. This shows the disparity in landholding size within the NER. Even though the region is well endowed with natural and human resources, it lags behind the national average in terms of socio-economic conditions. There is high multidimensional poverty and inequality, poor sanitation facilities (drinking water, electricity, and toilets), poor infrastructure (road and rail density), low levels of education, and low per capita monthly expenditure (Konwar 2015).

2.2 Data Sources

Secondary data for this study were collected from the *Population Census of India* (2011), Government of India; North Eastern Region (NER) Databank; North Eastern Development Finance Corporation Ltd. (NEDFi); and *Agriculture Statistics at a Glance*, Government of India; *Basic Statistics of North Eastern Region* (2015), *Basic Road Statistics of India* (2013–14 and 2014–15) and the human development reports of the North Eastern States.

2.3 Methodology

Various approaches are used to measure the sustainable development of the agricultural sector, such as agroecosystem analysis (Conway 1985), mathematical programming–based simulations (Parikh 1988), dynamic programming (Saleth 1991), and carrying-capacity evaluations (Food and Agriculture Organization 1984). However, these methodologies require time series data, which are not available periodically. Further, they lack transparency and do not capture every dimension of agricultural sustainability. The SLSI approach is simpler, more transparent, and more information efficient. The SLSI, developed by the United Nations Development Programme (UNDP), is a widely used methodology. It is a relative approach underlying the human development index (Saleth and Swaminathan 1993; Hatai and Sen 2008; Singh and Hiremath 2010; Deshmukh and Patil 2020). It is a composite index of the social equity index (SEI), economic efficiency index (EEI), and ecological security index (ESI). It takes into account multiple dimensions of social security, economic efficiency, and ecological security to measure the relative

livelihood sustainability status of a given cross-sectional set of entities (UNDP 1992).

Assuming *Xijk* and *SLSIijk* are the values of the *i*th variable, the *j*th component of the *k*th state and the index for the *i*th variable represent the *j*th component of the SLSI of the *k*th state, respectively.

$$SLSI_{ijk} = \frac{X_{ijk} - \underset{k}{Min}\, X_{ijk}}{\underset{k}{Max}\, X_{ijk} - \underset{k}{Min}\, X_{ijk}} \qquad (1)$$

$$SLSI_{ijk} = \frac{\underset{k}{Max}\, X_{ijk} - X_{ijk}}{\underset{k}{Max}\, X_{ijk} - \underset{k}{Min}\, X_{ijk}} \qquad (2)$$

$$SLSI_{jk} = \frac{\sum_{i=1}^{I} SLSI_{ijk}}{I} \qquad (3)$$

where *i* = variables (1, 2, 3……*I*)

j = component (1, 2, 3…..*J*)

k = states (1, 2, 3……..*K*)

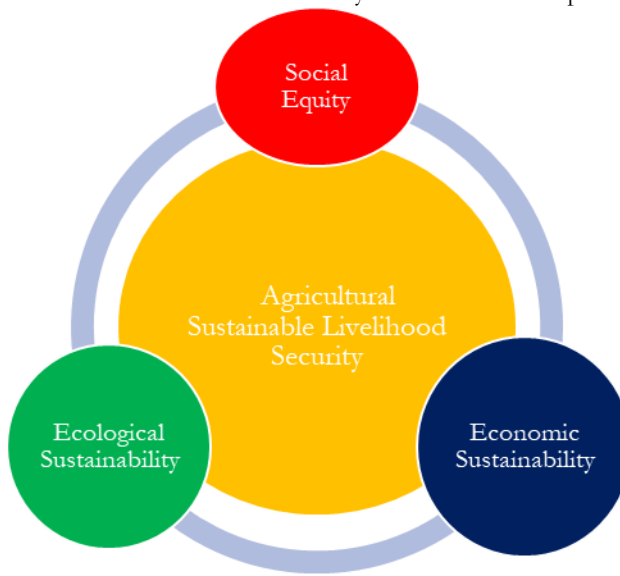
Equation (1) is used to measure the SLSI when there is a positive relationship between the chosen variable and the SLSI; equation (2) is used when there is a negative relationship between the chosen variable and the SLSI; equation (3) represents the simple mean of the various components of the SLSI such as the SEI, EEI, and ESI. Equal weight is assigned to all the variables selected for calculating the SLSI. Simple arithmetic means are computed at two stages to arrive at the final value of the SLSI. In the first stage, the simple arithmetic mean is computed to find the value of the various components of the SLSI. In the second stage, the arithmetic mean of various components is computed to capture the value of the SLSI. The value of the SLSI lies between 0 and 1, where values close to 0 indicate low sustainability, and those near 1 mean high sustainability.

2.4 Selection of Variables for Agricultural Sustainability

Agricultural sustainability is inter-linked with diverse social, economic, and ecological indicators; identifying the right indicators that have the greatest impact is a significant challenge (Swaminathan 1991; Saleth and Swaminathan 1993; Hatai and Sen 2008; Singh and Hiremath 2010; Sajjad,

Nasreen, and Ansari 2014; Deshmukh and Patil 2020). The challenge in conducting such an assessment lies in selecting the appropriate variables for the analysis. Figure 2 shows the relationship between these indicators and livelihood sustainability. Any indicator linked to low sustainability threatens livelihood security and vice-versa.

Figure 2: The Sustainable Livelihood Security Index and Its Components



Source: Authors' compilation

To address this challenge, we selected 12 variables from the three components of agricultural sustainability based on the literature review and identified the implications of these variables for sustainable economic development. The selected variables reflect the overall social, economic, and ecological aspects of agricultural systems in the NER. Table 1 lays out the components, criteria, and indicators for evaluating the SLSI in the NER.

Ecological Security: It is assessed by examining four key variables. These are population density (per square km) in 2011, forest cover under gross area (%) in 2019, cropping intensity (%) in 2014–15, and total water bodies (lakh hectares). Human development (health, education, and skills) helps improve standards of living and furthers sustainable economic development. Human resource development can help overcome the

sluggish pace of agricultural productivity and growth. However, high population density can also put pressure on overall ecological security. And so, it is selected as an indicator. Forest cover plays an important role in maintaining the ecological balance and contributes significantly to the NER's economy. Forest activities ensure food security and livelihoods for those living around the forest. Hence, we consider it one of the criteria for ecological security. Cropping intensity indicates the number of crops a farmer grows in a given agricultural year on the same field. Due to the development of irrigation facilities, more areas have been brought under cultivation, and farming communities can now raise more than one crop on the same land in the same year. In assessing agricultural sustainability in the context of ecological security, the cropping intensity variable plays a significant role. Irrigation plays a key role in both stabilizing agricultural production and increasing cropping intensity and has an associated effect on increasing productivity and improving the region's food security. Barah (2007) highlights that the NER states produce diversified crops using fewer chemical fertilizers and have the potential to go organic throughout the year. In line with Hatai and Sen (2008) and Sajjad *et al.* (2014), we use the cropping intensity variable to measure ecological security. Water bodies play an important role in maintaining the ecological balance and providing irrigation facilities for the agricultural sector. Hence, this is an important variable for measuring ecological sustainability.

Economic Efficiency: It is captured by four variables: yield rate of rice (kg per hectare) in 2017, per capita output of food grains (kg per annum), gross irrigated area (thousand hectares) in 2015–16, and per capita NSDP at constant prices in 2018–19, with 2011–12 as the base year. Rice is the staple food in the NER. The yield rate of rice is an important variable in determining economic efficiency as it is a major crop cultivated in the NER. An increase in the per capita output of food grains can ensure food security and reduce poverty in select states in the region. Gross irrigated area is also an important variable in measuring the EEI, because with an increase in the gross irrigated area, cropping intensity increases as well. This leads to an increase in the production of total food grains and generates employment opportunities for those who depend on the primary sector for their livelihood. Per capita income is an indicator of human development that measures the overall standard of living in an economy. Therefore, an increase in per capita income can increase economic efficiency.

Table 1: Components, Criteria, and Indicators for Evaluating the SLSI in the NER

Component	Criteria	Indicator (+/-ve)
Ecological security	Puts pressure on resources Reduces pollution and provides resources Ensure crop diversification and soil health Maintains ecological balance	Population density (-ve) Forest cover (+ve) Cropping intensity (+ve) Total water bodies (+ve)
Economic efficiency	Agriculture production Food security Cropping pattern Income	Rice yield (+ve) Per capita output of food grains (+ve) Gross irrigated area (+ve) Per capita NSDP at constant prices (+ve)
Social equity	Women's empowerment Poverty and inequality Infrastructure Agriculture mechanization	Female literacy (+ve) Population under BPL (-ve) Rural road connectivity (+ve) Villages electrified (+ve)

Source: Authors' own criteria adopted from literature

Social Equity: The variables selected to measure social equity are female literacy (%) in 2011, population below the poverty line (BPL) in 2011–12, rural road connectivity (km) in 2011, and village electrification (%) in 2013. The female literacy rate encourages women to participate in the process of nation-building and can stabilize the growth rate of the population as education leads to lower birth rates and slows population growth. The percentage of the BPL population captures inequality in accessing resources. It measures the extent of hardships an individual faces in terms of ownership of assets, income, indebtedness, employment facilities, access to hygiene, food consumption, housing facilities, etc. Rural road connectivity is a crucial element of rural infrastructure and economic growth. Poor road connectivity reflects the backwardness of a region. Village electrification is a major concern in the NER. The lack of electricity supply has frozen the growth rate of different sectors in the economy. Thus, it is a prerequisite of social equity for achieving agricultural livelihood security.

3. RESULTS

As most of the population in the NER depends on the agricultural sector either directly or indirectly, it is pertinent to make agriculture economically and ecologically sustainable. There are a lot of constraints that limit the development of the agricultural sector in the NER, such as the presence of hilly areas, the practise of shifting cultivation, and a lack of technology, markets, and infrastructure. This sector has huge untapped potential for development, which can improve people's livelihoods. Measuring agricultural sustainability in this region can improve regional imbalances and serve as an important micro-indicator for analysing progress towards sustainability.

Tables 2–4 show the raw data used to calculate the ecological, economic, and social equity variables for the region. Large variations among all the selected 12 variables can be seen in this table.

Table 2: Ecological Variables Selected to Study Agricultural Sustainability in the North Eastern Region

States	Ecological Security			
	Population density/km sq.	Percentage of forest cover in GA 2019	Cropping intensity 2014–15 (%)	Total water bodies (lakh hectare)
Arunachal Pradesh	17	79.63	132.8	3.18
Assam	398	36.11	144.4	1.35
Manipur	115	75.46	100	0.10
Meghalaya	132	76.33	120	0.10
Mizoram	52	85.41	100	0.02
Nagaland	119	75.31	130.3	0.67
Sikkim	86	47.1	176	0.03
Tripura	350	73.68	189.3	0.18

Source: Government of India (2018), NEDFi (n.d.), Census (2011)

Table 5 shows the variations in the individual indices of the selected variables for calculating the ESI, EEI, and SEI. In the population density

index, Arunachal Pradesh and Mizoram are the best-performing states with a low population density and Tripura and Assam are the worst-performing states with the highest population density. The pressure on natural resources due to the large populations in Assam and Tripura has resulted in the degradation of the ecological balance. Forests play a pivotal role in the socio-economic development of the NER. There is a large tribal population in this region that depends on forest resources for their livelihoods (Viswanathan 2015). In terms of forest cover, the states of Arunachal Pradesh and Mizoram rank the highest. Sikkim and Assam have the least proportion of area under forest cover. Tripura and Sikkim perform the best in terms of cropping intensity; Manipur and Mizoram show very low cropping intensity. This is in support of Birthal's (2010) findings, which show that cropping intensity in most states except Assam and Arunachal Pradesh is low, at 104 to 120 per cent. Most of the agriculture sector in the region is rainfed. In terms of water bodies, Arunachal Pradesh and Assam are the richest states, while Mizoram and Sikkim lack water resources. Cultivation in the post-rainy season is restricted due to under-developed irrigation infrastructures (Birthal 2010).

Table 3: Economic Variables Selected for Agricultural Sustainability in the North Eastern Region

States	Economic Efficiency			
	Rice yield (2017) (Kg per ha)	Per capita output of food grain (Kg/annum)	Gross irrigated area 2015–16 ('000 Ha)	Per capita NSDP at constant price 2018–19 at 2011–12 base (in INR)
Arunachal Pradesh	1767.68	249.77	56	93191
Assam	2171.03	173.37	388	60470
Manipur	2567.66	263.19	73	49579
Meghalaya	2740.25	117.91	127	66223
Mizoram	1650.48	62.96	31	100934
Nagaland	1649.19	255.87	114	73276
Sikkim	1856	145.39	16	232968
Tripura	2962.77	227.56	117	81057

Source: Government of India (2018), NEDFi (n.d.), Census (2011)

Rice occupies more than 65 per cent of the gross cropped area in Assam, Manipur, and Tripura and 33–50 per cent in other states (Birthal 2010). The EEI shows that the rice yield index is highest in Tripura and Meghalaya while Mizoram and Nagaland are the worst performers. There is ample scope for improving the yield of rice in Mizoram and Nagaland. According to Roy *et al.* (2015), a supply-demand analysis of food grains production and requirement in this region reveals that Nagaland, Arunachal Pradesh, Manipur, and Tripura are 'surplus category states' whereas Meghalaya, Mizoram, Assam, and Sikkim have a deficit in food grain production. In terms of the food security index, Manipur and Arunachal Pradesh are the best performers while Mizoram and Meghalaya lack food security the most. The irrigation index shows that Assam and Meghalaya have the best irrigation facilities in the region while Mizoram and Sikkim lack adequate irrigation facilities. There are wide variations in the income index across the NER; Sikkim and Mizoram have the high per capita incomes while Assam and Manipur have the lowest per capita incomes.

Table 4: Equity Variables Selected for Agricultural Sustainability in the North Eastern Region

States	Social Equity			
	Female literacy index	Pop BPL	Rural road (2011) (Km)	Villages Electrified (as of 31 March 2013)
Arunachal Pradesh	57.7	34.7	21,555	75.5
Assam	66.3	32	2,41,789	96.1
Manipur	72.4	36.9	19,133	86.3
Meghalaya	72.9	11.9	11,984	86.3
Mizoram	89.3	20.4	9,810	93.5
Nagaland	76.1	18.9	34,146	70.1
Sikkim	75.6	8.2	4,630	100
Tripura	82.7	14.1	33,772	92.9

Source: Government of India (2018), NEDFi (n.d.), Census (2011)

Among social equity variables, Tripura and Mizoram have the highest female literacy rates while Arunachal Pradesh and Assam report the lowest female literacy levels. The literacy rates of all the NER states, except Arunachal Pradesh (65.38) and Assam (72.19), surpass all-India levels (74.04) (Konwar 2015). There exists a wide disparity in socio-economic achievements across NER states and across urban and rural areas. If the

problems of poor economic growth, low overall development, and gender disparities are not properly addressed, the region may fall into the trap of a vicious quadrant instead of moving to a virtuous one (Nayak 2009). Poverty in the NER is highest in Manipur and Arunachal Pradesh and lowest in Sikkim and Meghalaya. According to 2009–10 estimates, Manipur had the highest magnitude of poverty followed by Assam. Meanwhile, Sikkim had the lowest magnitude of poverty. While 30% of people in India live below the poverty line, the corresponding figures for Manipur and Assam were as high as 47.1 per cent and 37.9 per cent, respectively. During 2009–10, all other states in the region had poverty levels below the national average (Nayak 2009).

Table 5: Individual Indices to Capture the Ecological, Economic, and Equity Indices for Agricultural Sustainability in the North Eastern Region

States	**Ecological Security Index**				**Economic Efficiency Index**				**Social Equity Index**			
	PDI	FCI	CII	TWBI	RYI	FSI	II	YI	FLI	PBPLI	RRI	VEI
Arunachal Pradesh	1	0.88	0.37	1	0.09	0.93	0.1	0.2	0	0.08	0.07	0.18
Assam	0	0	0.5	0.42	0.4	0.55	1	0.1	0.27	0.17	1	0.87
Manipur	0.74	0.8	0	0.02	0.7	1	0.2	0	0.46	0	0.06	0.54
Meghalaya	0.69	0.81	0.22	0.02	0.83	0.27	0.3	0.1	0.48	0.87	0.03	0.54
Mizoram	0.91	1	0	0	0	0	0	0.3	1	0.57	0.02	0.78
Nagaland	0.73	0.79	0.34	0.21	0	0.96	0.3	0.1	0.58	0.62	0.12	0
Sikkim	0.82	0.22	0.85	0	0.16	0.41	0	1	0.56	1	0	1
Tripura	0.13	0.76	1	0.05	1	0.82	0.3	0.2	0.79	0.79	0.12	0.76

Source: Authors' calculation

Note: PDI: population density index, FCI: forest cover index, CII: cropping intensity index, TWBI: total water bodies index, RYI: rice yield index, FSI: food security index, II: irrigation index, YI: income index, FLI: female literacy index.

The condition of rural roads in the NER is abysmal. The rural road index is very low in all the states except Assam. Access to electricity is a basic amenity and acts as an index of industrialization (Nayak 2013). The villages in Assam and Sikkim have good electricity facilities while those in Arunachal Pradesh and Nagaland have poor electricity facilities.

Table 6: Agricultural Sustainability in the North Eastern Region

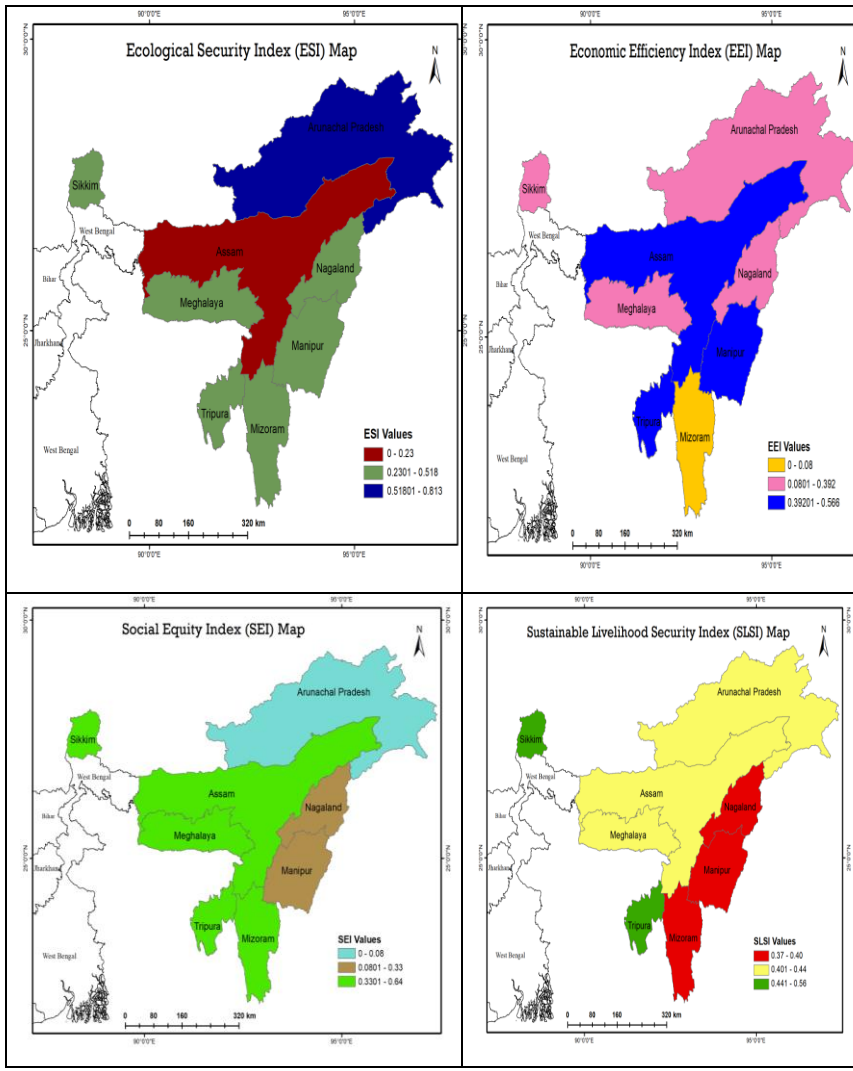
States	ESI	ESI Rank	EEI	EEI Rank	SEI	SEI Rank	SLSI	SSLI Rank
Arunachal Pradesh	0.81	1	0.34	6	0.08	8	0.41	5
Assam	0.23	8	0.50	2	0.58	4	0.44	3
Manipur	0.39	7	0.46	3	0.27	7	0.37	8
Meghalaya	0.44	6	0.37	5	0.48	5	0.43	4
Mizoram	0.48	4	0.08	8	0.59	3	0.38	7
Nagaland	0.52	2	0.34	7	0.33	6	0.40	6
Sikkim	0.47	5	0.39	4	0.64	1	0.50	2
Tripura	0.48	3	0.57	1	0.62	2	0.56	1

Source: Authors' calculation

The results of this study reveal that the sustainability indexes for the NER states ranged from 0.23 to 0.81 for ESI, 0.08 to 0.56 for EEI, and 0.08 to 0.64 for SEI. This demonstrates that the agricultural systems of all the states have considerable variations in their ecological, economic, and social equity indicators. The SLSI ranged from 0.37 to 0.56. This shows the poor status of agricultural sustainability in NE India. When we consider the ESI, Arunachal Pradesh and Nagaland are the best performers while Manipur and Assam are the worst ones. Therefore, it is suggested that environmentally friendly policy measures be adopted in Manipur, Assam, and all other states where the ESI value is low. In the case of EEI, Tripura and Assam are the best performers while Nagaland and Mizoram stand last. This is due to the low per capita income, less area under irrigation, deficit in the demand-supply of food grains, and low productivity of rice in these states. Hence, economic policies should be improved upon in states where the value of the EEI is low, and measures related to enhancing income and increasing investment in the agriculture sector should be taken. In the case of the SEI, Sikkim and Tripura are the best performers and Manipur and Arunachal Pradesh are the worst. This is due to severe poverty, low literacy, and poor infrastructure. Therefore, measures such as providing better education, especially for women, strengthening poverty alleviation programmes, and developing infrastructure, such as roads in rural areas and electricity in villages, should be given priority to improve the SEI. Overall agricultural sustainability is represented by the SLSI, which shows that Tripura and Sikkim are the best performers and Mizoram and Manipur the

worst. There is a pressing need to improve overall agricultural sustainability in Manipur and Mizoram and other states where the SLSI is low.

Figure 3: ESI, The EEI, SEI and SLSI Maps of the North Eastern States



Source: Authors' calculation

4. DISCUSSION

There is a consensus among researchers that a robust operational definition of agricultural sustainability based on indicators and indices is a prerequisite

for the proper design, implementation, and monitoring of agricultural policies targeting agriculture sustainability at the farm level. The SLSI can be considered an important indicator in policymaking and decision-making surrounding sustainable agricultural production. The NER has a lot of potential for the development of agriculture and allied sectors, as this region has both geographical and climatic advantages. Agricultural growth can improve the livelihoods of people in the region. The factors of low livelihoods, backwardness, and poor agricultural productivity have strong relationships with each other; this is reflected in the SLSI indices of the selected states. Efforts should be made to adopt new technologies and educate farmers about them. In particular, policies should aim to enhance the yield effect of high agricultural growth by improving access to high-quality seeds in this region and by encouraging the development of new varieties through biotechnology research. There is not much literature on agricultural research in the NER. We suggest that more research be conducted on the region, especially on agriculture and allied sectors. Land and water management and resource-use efficiency should be given priority to increasing cropping intensity. There is a need to increase public spending to improve rural road connectivity and post-harvest market infrastructures such as cold storage and rural godowns; this would help farmers progress towards sustainable agriculture.

5. CONCLUSION

Agricultural sustainability in the NER is facing challenges due to low agriculture productivity, low crop diversification, fragmentation of landholdings, poor infrastructure, and few employment opportunities. The situation in Manipur, Mizoram, and Nagaland, when we consider all the components of the SLSI, is distressing. The SLSI reveals regional disparities in ecological, economic, and social equity variables in the NER. Tripura ranks first, with an SLSI value of 0.56. Manipur and Mizoram are ranked seventh and eighth, respectively. The states with low SLSI values should be given priority in policymaking according to the values of the components of the SLSI. The conditions of Nagaland, Manipur, and Mizoram indicate an urgent need to improve ecological, economic, and social equity parameters in these states.

5.1 Limitations of This Study

Construction of the SLSI using time series data could help improve the progress of different development interventions aimed at sustainable development in general and livelihood security in particular. Future research agendas could include the evaluation of the SLSI at the district level in the

NER. This study does not include allied sectors such as livestock, fisheries, and sericulture. Efforts should be made to measure sustainability at the farm level, as conditions in hilly terrains are very different from those in the plains. There is a dearth of time series databases related to these ecological, economic, and social indicators, particularly in the NER. The selected variables for measuring the SLSI are comprehensive but not exhaustive; other variables can be looked at for measuring sustainability. The weights assigned to the different variables in measuring various components of the SLSI are not calculated using scientific methods as all the variables considered in SLSI are given equal weights.

5.2 Policy Implications

The SLSI and its components can be used to eradicate regional imbalances in social equity, ecological security, and economic efficiency. In states that have a low ESI, such as Assam and Manipur, policymakers must give priority to ecological restoration by emphasizing afforestation, cropping intensity, and crop diversification practices. Some states, such as Nagaland and Mizoram, are the worst performers in terms of EEI, which indicates that policymakers need to address food security and agriculture productivity, expand irrigation sources, and promote more employment opportunities. In terms of social equity, the worst performing states are Arunachal Pradesh and Mizoram; these states require policymakers to invest in social infrastructures such as female literacy, roads in rural areas, the capacity and distribution of electricity in rural areas, and welfare programmes to alleviate poverty. Policymakers must evaluate the SLSI and its components periodically to progress towards agriculture sustainability so that the potential to increase farm income and enhance food and nutrition security can be reached in this region.

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REFERENCES

Alam, K (Ed). 1993. *Agricultural Development in Northeast India Constraints and Prospects*. New Delhi: Deep and Deep Publications.

Barah, B C. 2007. "Strategies for Agricultural Development in Northeast India: Challenges and Emerging Opportunities." *Indian Journal of Agricultural Economics* 62 (1): 1–19. https://ideas.repec.org/a/ags/inijae/204500.html.

Bezbaruah, M P. 2006. "Agricultural Development in the North-East: Status, Assessment and Prospects." *Indian Journal of Agricultural Economics* 61 (3): 561–570. https://ageconsearch.umn.edu/record/204484.

Birthal, Pratap Singh. 2010. "Unlocking the Potential of Agriculture in North-eastern Hill Region of India." *Indian Journal of Agricultural Economics* 65 (3): 1–15. https://ideas.repec.org/a/ags/inijae/204687.html.

Birthal, Pratap Singh, Awadhesh K Jha, Pramod Kumar Joshi, and D K Singh. 2006. "Agricultural Diversification in North Eastern Region of India: Implications for Growth and Equity." *Indian Journal of Agricultural Economics* 61 (3); 328–340. https://ideas.repec.org/a/ags/inijae/204466.html.

Census of India. 2011. *Population Census of India, 2011.* Office of Registrar General, Ministry of Home Affairs, Government of India. https://censusindia.gov.in/census.website/.

Convoy, Gordon R. 1985. "Agroecosystem Analysis." *Agricultural Administration* 20(1): 31–35. https://doi.org/10.1016/0309-586X(85)90064-0.

Deshmukh, M S and Digvijay R Patil. 2020. "Economic Analysis of Agricultural Sustainability in Satara District of Maharashtra." *Agricultural Situation in India* 77 (3): 11–21.

Dev, S Mahendra. 2018. "Transformation of Indian Agriculture? Growth Inclusiveness and Sustainability." Working Paper 2018-026. Mumbai: Indira Gandhi Institute of Development Research.

FAO. 1984. "Potential Population Supporting Capacities of Land in the Developing Countries." Rome: Food and Agriculture Organization.

FAO. 1991. "Sustainable Agriculture and Rural Development in Asia and Pacific." Regional Document No. 2, FAO/Netherlands Conference on Agriculture and the Environment, Hertogenbosch, The Netherlands, 15–19 April. Rome: Food and Agriculture Organization.

Ghosh, Sujan. 2019. "Is the Indian Government Impeding Infrastructure Development in North East India?" *Economic & Political Weekly* 54 (17).

Government of India. 2013. *Basic Road Statistics of India, 2012–13*. New Delhi: Ministry of Road Transport and Highways, Government of India.

Government of India. 2018. *Agricultural Statistics at a Glance, 2018*. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

Government of India. 2020. *Economic Survey, 2019–20*. New Delhi: Economic Division, Ministry of Finance.

Government of India. 2015. "Basic Statistics of the North Eastern Region." Shillong: North Eastern Council Secretariate and Ministry of Development of North Eastern Region.

Hatai, L D and Chandra Sen. 2008. "An Economic Analysis of Agricultural Sustainability in Orissa." *Agricultural Economics Research Review* 21 (2): 273–282. https://ageconsearch.umn.edu/record/47682.

International Food Policy Research Institute. 2015. "2014–2015 Global Food Policy Report." Washington, D.C.: International Food Policy Research Institute. http://dx.doi.org/10.2499/9780896295759.

Jain, Ankur. 2018. "Analysis of Growth and Instability in Area, Production, Yield and Price of Rice in India." *Social Change and Development* 15 (2): 46–66.

Jeeva, Solomon Retna Dhas Nadar, Roytre Christopher, and Bhanu Prakash Mishra. 2006. "Traditional Agricultural Practices in Meghalaya, North East India." *Indian Journal of Traditional Knowledge* 5 (1): 7–18. http://nopr.niscair.res.in/bitstream/123456789/6792/1/IJTK%205%281%29%20%282006%29%207-18.pdf

Konwar, Paranan. 2015. "Socio-economic Conditions, Inequality and Deprivations in North East India." Munich Personal RePEc Archive. https://mpra.ub.uni-muenchen.de/id/eprint/65407.

NSSO. 2012. *National Sample Survey 2011–2012* (68th Round). New Delhi: National Sample Survey Organization, Ministry of Statistics & Programme Implementation, Government of India.

Nayak, Purusottam. 2009. "Human Development in Northeastern Region of India: Issues and Challenges." *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.1464204.

Nayak, Purusottam. 2013. "Development and Deprivation in Meghalaya." *SSRN Electronic Journal.* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2342684

NEDFi. n.d. North Eastern Development Finance Corporation Databank. https://databank.nedfi.com/.

North Eastern Council and Government of India. 2017. "North Eastern Council Regional Plan (2017–18 to 2019–20)." https://necouncil.gov.in/sites/default/files/about-us/Final%20Regional%20Plan%20NEC%2025_04_2017.pdf.

Padhi, Balakrushna, M K Khan, and Lalhriatchiani. 2020. "A Poverty Decomposition Analysis for the Northeastern Region of India." *Review of Development and Change* 25 (2): 237-55. https://doi.org/10.1177/0972266120979429

Parikh, J K (Ed). 2013. *Sustainable Development of Agriculture*. Springer Science and Business Media.

Roy, A, D S Dkhar, A K Tripathi, N U Singh, D Kumar, S K Das, and A Debnath. 2014. "Growth Performance of Agriculture and Allied Sectors in North East India." *Economic Affairs* 59: 783–95.

Roy, A, N U Singh, D S Dkhar, A K Mohanty, S B Singh, and A K Tripathi. 2015. "Food Security in North East Region of India: A State-wise Analysis." *Agricultural Economics Research Review* 28: 259–266. https://doi.org/10.5958/0974-0279.2015.00041.5.

Sajjad, Haroon, Iffat Nasreen, and Shahzad Ali Ansari. 2014. "Assessing Spatiotemporal Variation in Agricultural Sustainability Using Sustainable Livelihood Security Index: Empirical Illustration from Vaishali District of Bihar, India."

Agroecology and Sustainable Food Systems 38 (1): 46–68. https://doi.org/10.1080/21683565.2013.820251.

Saleth, R M. 1991. "Measuring Sustainability in a Regional and Resource-Specific Context: The Case of a Groundwater Aquifer System." Discussion Paper No. 46, Indira Gandhi Institute of Development Research, Bombay.

Saleth, R M. 1993. "Developing Indicators of Sustainable Development at the Global Level: Approach, Framework and Empirical Illustrations." Delhi: Institute of Economic Growth.

Saleth, R M and M S Swaminathan. 1993. "Sustainable Livelihood Security at the Household Level: Concept and Evaluation Methodology." In Proceedings of an Interdisciplinary Dialogue on Ecotechnology and Rural Employment, Chennai, 12–15 April, 105–122.

Singh, P K and B N Hiremath. 2010. "Sustainable Livelihood Security Index in a Developing Country: A Tool for Development Planning." *Ecological Indicators* 10 (2): 442–451. https://doi.org/10.1016/j.ecolind.2009.07.015.

Swaminathan, M S. 1991. "From Stockholm to Rio de Janeiro: The Road to Sustainable Agriculture (Monograph No. 4)." Madras: MS Swaminathan Research Foundation.

Syiem, Rebekka, and Saravanan Raj. 2015. "Access and Usage of ICTs for Agriculture and Rural Development by the Tribal Farmers in Meghalaya State of North-East India." *Journal of Agricultural Informatics* 6 (3): 24–41. https://doi.org/10.17700/jai.2015.6.3.190.

Veluguri, Divya, G V Ramanjaneyulu, and Lindsay Jaacks. 2019. "Statewise Report Cards on Ecological Sustainability of Agriculture in India." *Economic & Political Weekly* 54 (26–27): 19–27.

Vishwanathan, K U. 2015. "Is Growth in Agriculture Propelled by Its Allied Sectors in Northeast India?" *Agricultural Economics Research Review* 28: 69–80. https://doi.org/10.5958/0974-0279.2015.00023.3.

World Bank. 2008. "World Development Report 2008: Agriculture for Development." Washington, DC: World Bank.

World Health Organization. n.d. "Sustainable Development Goals (SDGs)." https://www.who.int/health-topics/sustainable-development-goals#tab=tab_3.

APPENDIX

Table 5: Socio-economic Profile of the North Eastern States of India

Components	Year	Units	AP	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Sikkim	Tripura	All India
Geographical area	2011	Sq km	83,743	78,438	22,327	22,429	21,081	16,579	7,096	10,486	32,87,263
Total population	2011	Lakhs	13.8	311.6	27.2	29.6	10.9	19.8	6.1	36.7	1,210.20
Sex ratio	2011	Nos.	938	958	992	989	976	931	890	960	940
Population density	2011	Nos.	17	398	115	132	52	119	86	350	382
Literacy rate	2011	%	65.38	72.19	79.21	74.43	91.33	79.55	81.42	87.22	74.04
Total forest area	2011	Sq km	51,540	26,832	17,418	9,496	16,717	9,222	5,841	6,294	6,92,027
Total road length	2011	Km	21,555	2,41,789	19,133	11,984	9,810	34,146	4,630	33,772	46,90,342
Total persons below the poverty line (NSSO 68th Round)	2011-12	%	34.67	31.98	36.89	11.87	20.4	18.88	8.19	14.05	21.92
Reporting area for land utilization statistics	2014-15	Th ha	7,228	7,844	2,117	2,242	2,039	1,652	442	1,049	3,07,813
Net sown area	2014-15	Th ha	225	2,827	383	286	145	384	77	255	1,40,130
Gross cropped area	2014-15	Th ha	299	4,083	383	343	145	500	136	483	1,98,360
Agricultural	2014-15	Th ha	423	3,364	390	1,056	367	694	97	272	1,81,886
Cropping intensity	2014-15	%	132.8	144.4	100	120	100	130.3	176	189.3	141.6

Source: Census (2011), Government of India (2018), NSSO (68th Round) (2012)

Table 6: Sector-wise Share of Contribution in GDP in the North Eastern States of India (%).

Sector	AP		Mizoram		Nagaland		Meghalaya		Manipur		Assam		Tripura		Sikkim	
	2011-12	2018-19	2011-12	2019-20	2011-12	2018-19	2011-12	2019-20	2011-12	2018-19	2011-12	2018-19	2011-12	2018-19	2011-12	2018-19
Primary	44.1	31	20.8	23.2	31.4	26	22.32	19.42	19.77	15.7	31.88	27.3	33.48	36.79	8.35	8.38
Secondary	17.2	24.7	19.8	25.6	12.4	12.3	32.97	16.89	15.4	16.9	21.59	25.7	14.11	16.25	62.83	64.14
Tertiary	38.7	44.3	59.4	51.3	56.2	61.7	44.72	63.69	64.84	67.4	46.53	47	52.4	46.96	28.82	27.48
Total GSVA	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: Northeast Databank (https://databank.nedfi.com/)

Table 7: State-wise Annual Growth of Gross State Domestic Product at Constant Prices (2011–12) (as of 15 March 2020)

	Percentage Growth over the Previous Year							
State	**2012–13**	**2013–14**	**2014–15**	**2015–16**	**2016–17**	**2017–18**	**2018–19**	**2019–20**
Arunachal Pradesh	2.14	9.2	16.57	-0.99	3.55	8.12	4.59	NA
Assam	2.91	4.88	6.92	15.67	5.74	13.18	7.97	NA
Manipur	0.61	8.64	8	7.73	4.01	3.88	6.44	NA
Meghalaya	2.19	1.83	-2.74	2.38	5.29	9.26	9.04	9.48
Mizoram	7.15	16.21	24.59	9.44	10.32	4.8	1.3	11.64
Nagaland	5.68	7.19	4.39	1.82	6.75	5.34	7.05	NA
Sikkim	2.29	6.07	7.9	9.93	7.15	6.95	7.05	NA
Tripura	8.67	9.32	18.17	-0.66	14	10.17	10.85	NA

Source: Northeast Databank (https://databank.nedfi.com/)

Table 8: Operational Holdings by Size Group among the North Eastern States (%), 2015–16

State	**Marginal**	**Small**	**Semi-medium**	**Medium**	**Large**	**All holdings**
Arunachal Pradesh	24.0	21.2	25.6	23.2	5.9	100
Assam	68.1	18.1	10.8	2.9	0.1	100
Manipur	51.0	32.4	14.8	1.8	0.0	100
Meghalaya	52.8	25.9	17.2	4.0	0.1	100
Mizoram	50.1	30.6	15.4	3.6	0.3	100
Nagaland	4.0	14.7	31.7	37.6	11.9	100
Sikkim	65.8	18.9	11.2	3.6	0.5	100
Tripura	87.9	8.4	3.2	0.4	0.0	100
All India	68.5	17.7	9.5	3.8	0.6	100

Source: Government of India (2018)