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An Economic Insights of Agricultural Sustainability in the Himalayan Districts of Jammu and Kashmir, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The agriculture scenario has witnessed a tremendous change after the independence of the Indian subcontinent. It had undergone number of reforms to protect both supply and demand side interests. The food security was ensured by increasing its production and the country has emerged as one of the top producers of number of commodities. The commercialization of agriculture shifted

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subsistence farming to a more market-oriented approach, where agricultural production is primarily aimed at generating income and participating in the market economy which involves increased scale of production, adopting modern technologies and focusing on cash crops and high – value commodities. However the unscientific use of these resources and indispensable application of inputs has led to several drawbacks like labour migration, shift to monoculture practices, decline in the water table, vulnerabilities in terms of food security during market fluctuations. Creating concerns of sustainability needs an immediate attention. Sustainability is to be assured to ensure food supply and for the balanced economic growth. Agricultural sustainability in Jammu and Kashmir is influenced by various factors. It provides production environment to a number of niche crops including apple, walnut, saffron, vegetables, major agriculture products etc., But its agriculture faces the unique environmental, social and economic challenges, despite known for their rich ecological diversity. Though essential, the urbanization results in the shift of productive land to undesirable use which may lead to ecological implications. This background necessitated a comprehensive attempt to examine the sustainability of agriculture in relationship with various economic, ecological and social indicators with an intention to come up with findings having greater policy implications for long term sustenance of agrarian economy in J&K. Shopian(0.604) ranked first among all the districts in terms of Agricultural sustainability, followed by Jammu(0.598) and Kathua(0.564) and least performing districts were found to be Srinagar(0.406), followed by Ramban(0.413) and Kupwara(0.420). The calculated Composite Sustainability Index helps us to differentiate the districts based on their index value under various categories of the sustainability level.

Keywords: Agricultural sustainability; ecological security; economic efficiency; social equity.

1. INTRODUCTION

Since independence agricultural system had undergone number of reforms especially to protect both supply and demand side interests. Food production has increased mani-fold and the country has emerged as one of the top producers of number of commodities. After commercialization, the agricultural system is poised for greater technical transformation and global value chain integration and also shifted the subsistence farming to a more market-oriented approach, where agricultural production is primarily aimed at generating income and participating in the market economy which involves increased scale of production, adopting modern technologies and focusing on cash crops and high – value commodities. However, the unscientific use of these resources and indiscriminate application of inputs has led to several issues including the depletion of water table and shifting of productive lands to commercial use. In the United Nations report "Our Common Future" the phrase "sustainable development" was first used [1]. Sustainability is often understood through the lens of the three pillars: environmental, economic and social. Multiple definitions exist for "sustainable development." But "the stability over time of both economy and environment" was summed up well by Emas [2]. Environmental Sustainability involves managing natural resources and ecosystems in a way that ensures their longevity and minimizes negative impacts on the environment. Economic sustainability focuses on creating systems that can thrive in the long term, providing sufficient resources and opportunities for people's well-being. Social sustainability aims to ensure that all individuals have access to basic human rights, including education, healthcare, and equal opportunities. Ecological security is a situation in which species and human habitats are safe, wildlife migration routes are unimpeded, and sufficient ecological services are made available to support human existence and economic activity [3]. Sustainability and sustainable livelihood security are intertwined concepts that promote a harmonious relationship between people and the environment, ensuring that current needs are met without compromising the well-being of future generations. Achieving these objectives requires collaboration and actions at individual, community, corporate, and governmental levels. The concept of environmental security introduced in 1987 by the World Commission on Environment and Development report "Our Common Future" [4], gave rise to the term "ecological security."

Contingent upon variety of factors, agriculture has progressed differently across different states/UT's of India. Jammu and Kashmir provides production environment to a number of crops including apple, walnut, saffron, vegetables, major agriculture products etc.,

J&K's agriculture faces the unique environmental, social and economic challenges and thus creating concerns of sustainability. Accordingly, this study has made an attempt to examine sustainability of agriculture in relationship with various economic, ecological and social indicators with an intention to come up with findings having greater policy implications for long term sustenance of agrarian economy in J&K.

2. MATERIALS AND METHODS

The sustainability index is a composite indicator that can be used to assess the sustainability of Agriculture. The ecological, economic and social aspects of a region are aggregated to obtain a measure of sustainability of the agricultural system. It explains how and to what extent the three pillars of sustainability- Ecological security, Economical efficiency and Social equity are kept in check by careful management. The Sustainability Index technique is simply an abstraction of the related approach that supports the UN Development Program's Human Development Index. A set of variables given in the Table 1 under each aspect has been taken and standardized by employing a procedure adapted for constructing Human Development Index. For instance, indices of various variables were aggregated after putting weights to construct an index for economic security. Similarly indices of three different pillars of sustainability were aggregated to construct a composite index for agricultural sustainability. Saleth [5] mentioned the important components of sustainable development in general, and sustainable growth of agriculture in particular, are ecological, economics, and equity both within and across generations.

Let X_{ijk} denotes the value of the variable selected, its j^{th} indicator/component of k^{th} district taken for the study and CSI_{ijk} denote the index for the same i^{th} variable, j^{th} component of k^{th} district that are under the consideration. Then, For the variables having the positive implications,

$$CSI_{ijk} = \frac{(X_{ijk}) - \min(X_{ijk})}{\max(X_{ijk}) - \min(X_{ijk})} \quad \text{---------- (I)}$$

For the variables having the negative implications,

$$CSI_{ijk} = \frac{\max(X_{ijk}) - (X_{ijk})}{\max(X_{ijk}) - \min(X_{ijk})} \quad \text{---------- (II)}$$

Here, the i – variables, j – indicators/components, k – districts

Table 1. Sustainability indicators and its variables

1.	**Ecological indicator**
(i)	Population Density
(ii)	Cropping Intensity (%)
(iii)	Net Area Irrigated to Net Cropped Area (%)
(iv)	Average Size of Land Holding (Ha)
(v)	Area Under Foodgrains to Gross Cropped Area (%)
(iv)	Area Under Fruits & Vegetables to Gross Cropped Area (%)

2.	**Economic indicator**
(i)	Credit Deposit Ratio (%)
(ii)	Fruit Production (Lakh Mt)
(iii)	Food Grains Yield (000's Quintals)
(iv)	Net Cropped Area Per Bank Branch (Ha)
(v)	Employment In SSI Units Per Lakh Population (No.)
(iv)	Credit Outstanding of Banks Per Gross Cropped Area (Rs/Ha)

3.	**Social indicator**
(i)	Literacy Rate (%)
(ii)	Density of PACS (Ha)
(iii)	Villages Electrification (%)
(iv)	Density of Marketing Society (Ha)
(v)	Population Per Medical Institution (No.)
(iv)	Road Density (Length **/** 100 Sq.Km Area)

By using the above two equations, we can obtain the index value of each of the variables. The mean of indices of these aggregate values gives us the index value of the j^{th} component/indicator and the same is done for the other two component or the indicators that are taken for the study. Later, the CSI index is calculated by taking the average of the index values of the three components/indicators (ESI, EEI & SEI) of each districts. Weights of the indicators were calculated based on the method of Iyengar and Sudarshan [6].

The index value of 1.000 is given to the districts which are better performing and the value 0.000 for the least performing districts in terms of sustainability. Once the composite index for the three indicators are calculated, the districts are ranked according to the value of the index, higher ranks are assigned to the districts having high index value and the districts are categorized into i) least sustainable (0.00 to 0.25) ii) moderately sustainable (0.26 – 0.50) iii) sustainable (0.51 to 0.75) and iv) highly sustainable (0.76 to 1.00).

In order to assess the association of different variables under each efficiency measures viz., ecological, economic and social, correlation coefficients were estimated by using Pearson correlation.

Path analysis is a statistical method used in the field of social sciences, particularly in the realm of structural equation modeling (SEM), to explore and quantify the relationships between variables. It allows researchers to examine complex causal relationships and interactions among variables by visually representing and quantifying the direct and indirect effects of variables on one another [7]. Researchers construct a conceptual model of the relationships among variables based on existing theory or previous research. This model is then converted into a statistical model, specifying which variables are related to each other and in what way (direct or indirect effects). When applied to a Sustainable Index (SI), it helps us to identify the variables that have contributed maximum to the three dimensions of sustainability.

The steps to estimate the direct and indirect effects are as follows.

1. Standardize both effect(Y) and causal variables (Xs) as (x*) = (x-m) / SD, where, x* is the standardize value, x is the original value, m is the mean and SD is the standard deviation.
2. Regress effect variable (Y) on the standardized variables (X*) which gives the partial regression coefficients (direct path coefficients).
3. The path coefficient (direct effect) from cause X1 to the effect Y is given as,
4. $Y = \sigma X1/\sigma Y1$, where s is the standard deviation.
5. The indirect contribution of X1 to Y includes X1 through X2, X3., etc. The equation below shows the splitting process for causal variables with one effect variable Y.

   r [X1,Y] = a + r [X1,X2]b + r [X1, X3]c …….etc.,

   r [X2,Y] = r [X2,X1]a + r [X2, X3]b + c …….etc.,

   r [X3,Y] = r [X3,X1]a + r [X3,X2]b + c ….etc.,

where a,b,c are the partial regression coefficients and r(X1,X2), r(X1, X3)….are the correlation coefficients. The above equation shows the partition of each of the correlation from (X1 to Y), (X2 to Y), etc., into their component paths.

- Due to direct effect of X1 on Y
- Due to indirect effect of X1 on Y via X2
- Due to indirect effect of X1 on Y via X3, etc.,

3. RESULTS AND DISCUSSION

3.1 Composite Agricultural Sustainability

The indices of all the three indicators are calculated and are presented in the Tables 2,3 and 4. The composite sustainability index and the ranking of the districts have been provided in the Table 5. In 2010-11, the districts which were more sustainable in terms of ecological security were Kathua, Jammu and Reasi in decreasing order of ranking. But in 2020-21 this scenario have been changed and the districts Kathau, Samba and Udhampur ranked at first three places and the least sustainable districts were found to be Kulgam, Bandipora and Ganderbal. This is in line with the findings of Swaminathan [8] that agriculture is entering a tough yet exciting phase and sustainable nutrition security will be attainable if natural resources are used in a way that balances current and long-term development goals.

Table 2. Ecological security index (2020-2021)

DISTRICTS	Average size of land holding	Population density	Cropping intensity	Area under fruits & vegetables to GCA	Net area irrigated to NCA	Area under foodgrains to GCA
ANANTNAG	0.123	0.768	0.534	0.219	0.750	0.451
BANDIPORA	0.185	0.010	0.175	0.183	0.645	0.880
BARAMULLA	0.338	0.826	0.019	0.371	0.517	0.630
BUDGAM	0.169	0.539	0.472	0.227	0.841	0.560
DODA	0.508	1.000	0.262	0.032	0.028	0.944
GANDERBAL	0.031	0.000	0.582	0.241	1.000	0.497
JAMMU	0.677	0.449	0.644	0.011	0.796	0.998
KATHUA	0.877	0.818	1.000	0.005	0.398	0.906
KISHTWAR	0.277	0.914	0.248	0.005	0.150	0.964
KULGAM	0.200	0.103	0.400	0.279	0.778	0.249
KUPWARA	0.246	0.710	0.000	0.225	0.551	0.787
POONCH	0.831	0.783	0.698	0.003	0.087	0.923
PULWAMA	0.231	0.565	0.662	0.379	0.761	0.243
RAJOURI	1.000	0.820	0.909	0.002	0.036	0.986
RAMBAN	0.554	0.848	0.263	0.000	0.007	1.000
REASI	0.631	0.876	0.716	0.000	0.000	0.950
SAMBA	0.985	0.722	0.896	0.000	0.460	0.945
SHOPIAN	0.369	0.268	0.035	1.000	0.764	0.000
SRINAGAR	0.000	0.475	0.347	0.384	0.935	0.470
UDHAMPUR	0.923	0.851	0.984	0.052	0.097	0.978

Table 3. Economic efficiency index (2020-2021)

DISTRICTS	Food Grains Production (000's quintals)	Fruit Production (lakh MT)	Credit Deposit ratio (%)	NCA/bank Branch (ha)	Employment in SSI Units/Lakh Population	Credit Outstanding of Banks/GCA (Rs/ha)
ANANTNAG	0.217	0.725	0.446	0.450	0.498	0.184
BANDIPORA	0.193	0.059	0.554	0.215	0.107	0.175
BARAMULLA	0.248	1.000	0.723	0.371	0.210	0.375
BUDGAM	0.295	0.475	0.723	0.242	0.370	0.142
DODA	0.150	0.023	0.277	0.179	0.041	0.046
GANDERBAL	0.093	0.287	0.566	0.535	0.313	0.107
JAMMU	1.000	0.042	0.000	0.679	0.724	0.063
KATHUA	0.714	0.053	0.157	0.146	1.000	0.015
KISHTWAR	0.039	0.021	0.120	0.240	0.040	0.059
KULGAM	0.057	0.581	0.566	0.183	0.088	0.304
KUPWARA	0.203	0.491	0.928	0.098	0.037	0.191
POONCH	0.370	0.036	0.157	0.116	0.134	0.021
PULWAMA	0.100	0.546	0.675	0.397	0.689	0.218
RAJOURI	0.708	0.069	0.145	0.027	0.114	0.045
RAMBAN	0.106	0.023	0.229	0.000	0.000	0.156
REASI	0.204	0.004	0.181	0.351	0.028	0.018
SAMBA	0.305	0.000	0.265	0.398	0.979	0.015
SHOPIAN	0.000	0.701	1.000	0.214	0.099	1.000
SRINAGAR	0.029	0.050	0.217	1.000	0.672	0.395
UDHAMPUR	0.425	0.035	0.072	0.209	0.226	0.000

Table 4. Social equity index (2020-2021)

DISTRICTS	Villages Electrified	Road density	Population Per Medical Institution	Density of PACS	Density of Marketing Society	Literacy Rate (%)
ANANTNAG	1.000	0.233	0.527	0.062	0.761	0.289
BANDIPORA	0.534	1.000	0.636	0.108	0.818	0.069
BARAMULLA	0.981	0.251	0.790	0.116	0.848	0.355
BUDGAM	0.986	0.729	0.774	0.832	1.000	0.062
DODA	1.000	0.000	0.980	0.638	0.927	0.357
GANDERBAL	1.000	0.944	0.824	0.785	0.802	0.129
JAMMU	1.000	0.567	0.506	0.852	0.680	1.000
KATHUA	0.968	0.242	0.953	0.000	0.000	0.645
KISHTWAR	0.000	0.068	1.000	0.350	0.902	0.066
KULGAM	0.984	0.815	0.932	0.113	0.938	0.170
KUPWARA	0.894	0.258	0.818	0.111	0.693	0.351
POONCH	0.907	0.188	0.908	0.491	0.898	0.427
PULWAMA	1.000	0.413	0.697	0.574	0.756	0.316
RAJOURI	0.940	0.245	0.873	0.629	0.834	0.476
RAMBAN	1.000	0.136	0.968	0.529	0.864	0.000
REASI	0.860	0.120	0.915	0.609	0.863	0.133
SAMBA	1.000	0.326	0.869	-	-	0.930
SHOPIAN	0.929	0.943	0.852	0.654	0.935	0.222
SRINAGAR	1.000	0.366	0.000	1.000	-	0.519
UDHAMPUR	0.962	0.168	0.869	0.607	0.778	0.487

Table 5. Ranking of the districts

DISTRICTS	ESI	RANK	EEI	RANK	SEI	RANK	SI	RANK
ANANTNAG	0.460	9	0.403	6	0.709	17	0.524	9
BANDIPORA	0.336	19	0.217	13	0.769	10	0.441	16
BARAMULLA	0.450	12	0.473	2	0.764	14	0.562	4
BUDGAM	0.453	10	0.356	7	0.802	6	0.537	6
DODA	0.452	11	0.121	18	0.840	2	0.471	15
GANDERBAL	0.375	18	0.311	9	0.798	8	0.495	11
JAMMU	0.563	5	0.422	3	0.807	5	0.598	2
KATHUA	0.638	1	0.325	8	0.729	15	0.564	3
KISHTWAR	0.415	16	0.092	19	0.765	13	0.424	17
KULGAM	0.324	20	0.288	12	0.825	3	0.479	13
KUPWARA	0.413	17	0.310	10	0.537	19	0.420	18
POONCH	0.534	6	0.138	17	0.800	7	0.491	12
PULWAMA	0.465	8	0.415	4	0.768	11	0.549	5
RAJOURI	0.602	4	0.184	14	0.807	4	0.531	7
RAMBAN	0.434	13	0.088	20	0.716	16	0.413	19
REASI	0.512	7	0.138	16	0.766	12	0.472	14
SAMBA	0.636	2	0.308	11	0.582	18	0.509	10
SHOPIAN	0.429	14	0.508	1	0.876	1	0.604	1
SRINAGAR	0.428	15	0.409	5	0.379	20	0.406	20
UDHAMPUR	0.626	3	0.161	15	0.794	9	0.527	8

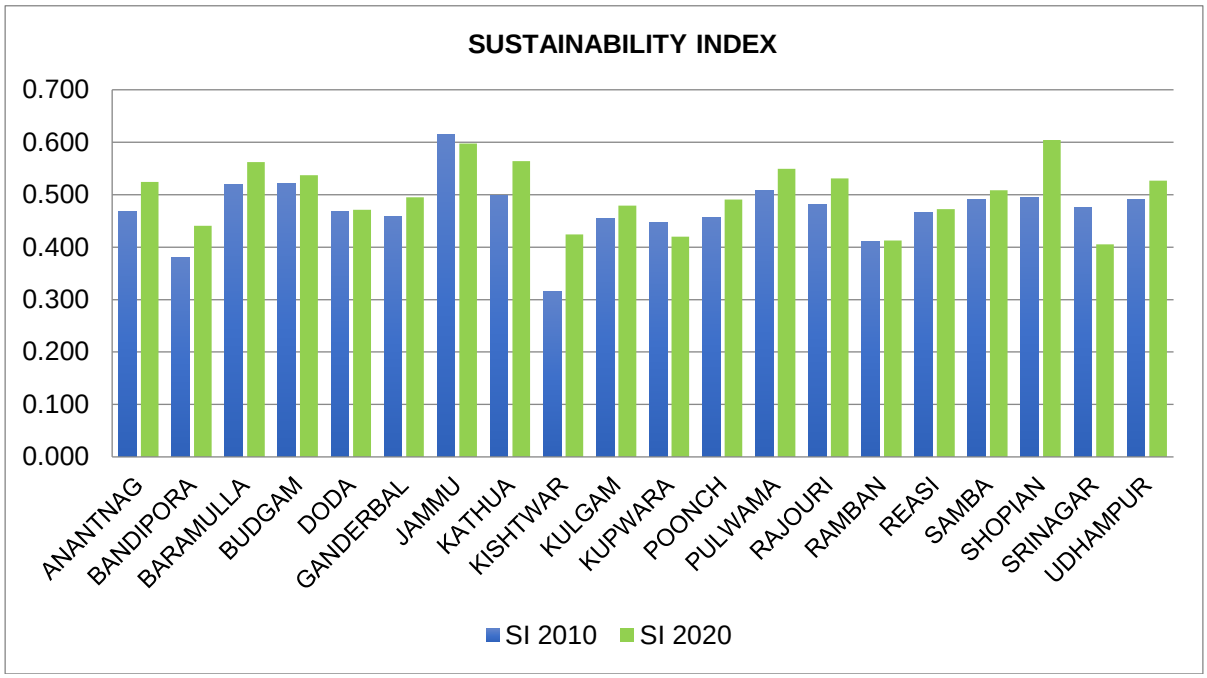

Fig. 1. Performance of the districts in the Sustainability Index (2020-2021)

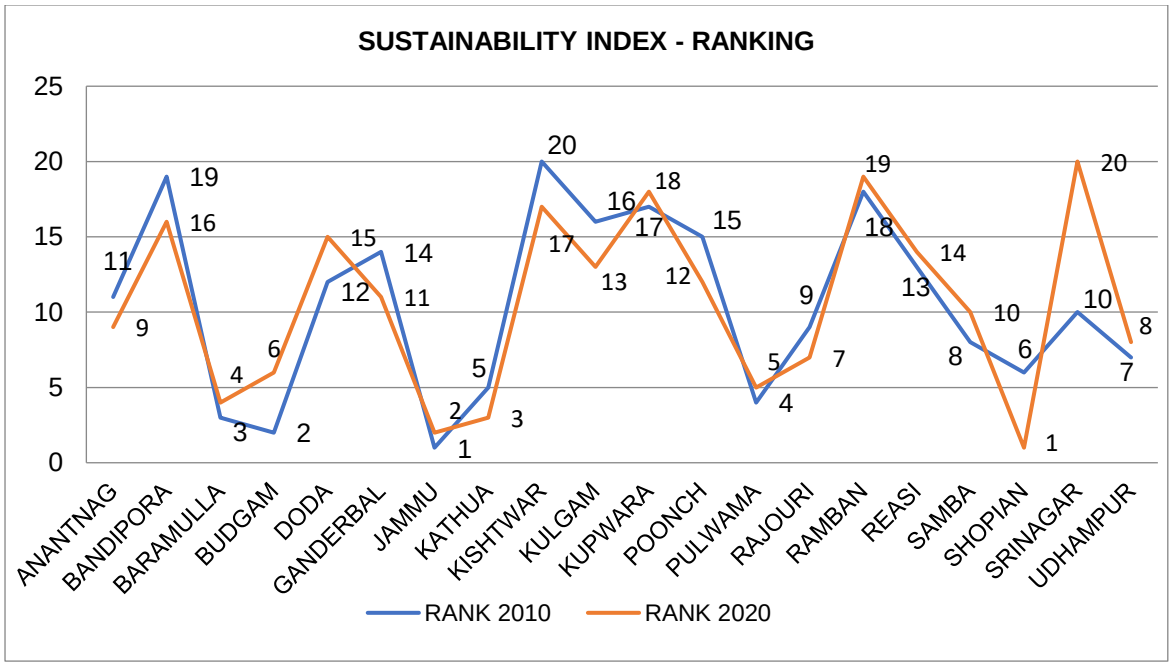

Fig. 2. RANKING OF THE DISTRICTS (2010-2011 & 2020-2021)

The ranking of the districts are shown in the Fig. 2. The changes in the ecological parameters forced Jammu to step down three ranks and now it is placed at 5th position among the 20 districts. Shopian district which ranked 12th during 2010-11, saw a steep progress in a decade and has now placed at the 1th position which may be due to the fact that it had developed in terms of fruits and vegetables production, providing credit to the welfare of the farmers, more employment opportunities in SSI units etc., The second and the third places were occupied by Baramulla and Jammu respectively and the least performing districts in economic aspects are Doda, Kishtwar and Ramban.

The social aspects of sustainability shows that few districts have shown a better growth while others remained stagnant in terms of growth. Ramban district which ranked 9th in 2010-11, have been placed in 16th rank as it could not perform well in terms of literacy, health, marketing societies, farmers welfare etc., Kupwara was identified as poorly developed districts in the socio-economic sector due to their lack of better infrastructure facilities and the poor literacy level [9]. The same scenario of Kupwara have been reported in 2020-21, as it lacks proper banking infrastructure and credit facilities compared to other districts and also the employment rate in SSI units are also very low. The first three ranked districts are Shopian, Doda and Kulgam and the least ranked districts are Srinagar, Kupwara and Samba. In 2010-11, Jammu, Budgam and Baramulla occupied the first three ranks, whereas in 2020-21, Shopian, Jammu and Kathua appeared more sustainable. Shopian ranked 14th in terms of ecological security, though it ranks first both in economic and social equity, which place this district at rank 1. Meanwhile the least sustainable district is Kupwara, due to its poor performance in all the three dimensions of sustainability.

In 2010-11, 17 districts turned out to be moderately sustainable, while Baramulla, Budgam and Jammu were categorized under sustainable level. But in 2020-21, this scenario have drastically changed , half of the districts were moderately sustainable and the other half were under sustainable category, implying that the overall performance of different districts was not satisfying yet few districts such as Anantnag, Kathua, Pulwama, Rajouri, Samba, Shopian and Udhampur have performed better and so they have shifted from moderately sustainable category to sustainable category in 2020-21 and it is represented in the Fig. 1 and the different level of sustainability of the districts are shown in the Fig. 3.

Agriculture growth is a multifaceted process. The horticulture products of J&K State are well-known in India and beyond [10] as its clearly seen that Shopian covers maximum cropped area under fruits and vegetables, and this district together with Baramulla produces maximum surplus of fruits and vegetables.

3.2 Association of Different Variables on Agricultural Sustainability

In the context of agricultural sustainability, the Ecological Security Index serves as a tool to evaluate the impact of agricultural practices on the surrounding ecosystem and to ensure that agricultural activities are conducted in a way that maintains the long-term health and productivity of the environment [11]. The Correlation coefficient of the variables with the overall sustainability index have been calculated and presented in the Table 6. A fair and a positive correlation was observed between Average Size of Land Holding, Cropping Intensity, Area Under Fruits & Vegetables to Gross Cropped Area, Food Grains production (0.512*), Fruit Production, Employment in SSI Units Per Lakh Population (0.396), Villages Electrification, Road Density, Literacy Rate (0.445*) with the overall agricultural sustainability. While agriculture makes up the bulk of the western Himalayan economy, horticulture plays a significant role due to the abundance of delicious fruits growing in Kashmir [12]. A negative correlation was also observed between the population density (0.063), area under food grains, Density of Marketing Society with the overall agricultural sustainability. Though essential, the urbanization results in the shift of productive land to undesirable use which may lead to ecological implications [13].

3.3 Direct and Indirect Effect of Different Variables on Various Indicators

Among all the causal variables of ecological security, irrigated area had the maximum direct positive effect (0.117) on the ecological sustainability, followed by average holding size (0.104) and cropping intensity (0.098) which implies that these variables are important for improving the ecological sustainability of the districts. Fig. 4 shows the direct and the indirect effect of the variables on the ecological sustainability. The irrigated area plays a crucial role in enhancing the agricultural sustainability by providing consistent water supply to crops, improving productivity, and mitigating the adverse effects of climate variability. The value of total effect (0.533) of variable X1 on ecological security indicates the addition of both the direct and the indirect effects of the variable X1. The indirect effect is caused by the variable X1 on the indicator through other variables X2, X_3, X_4, X_5 and X_6. Similarly the indirect effect of population density on ecological security is caused via average holding size, cropping intensity, area under food grains, area under fruits and vegetables and the irrigated area. Which is in line with the findings, the long-term viability of the agricultural sector as a whole can be greatly enhanced by careful management on smaller farms [14].

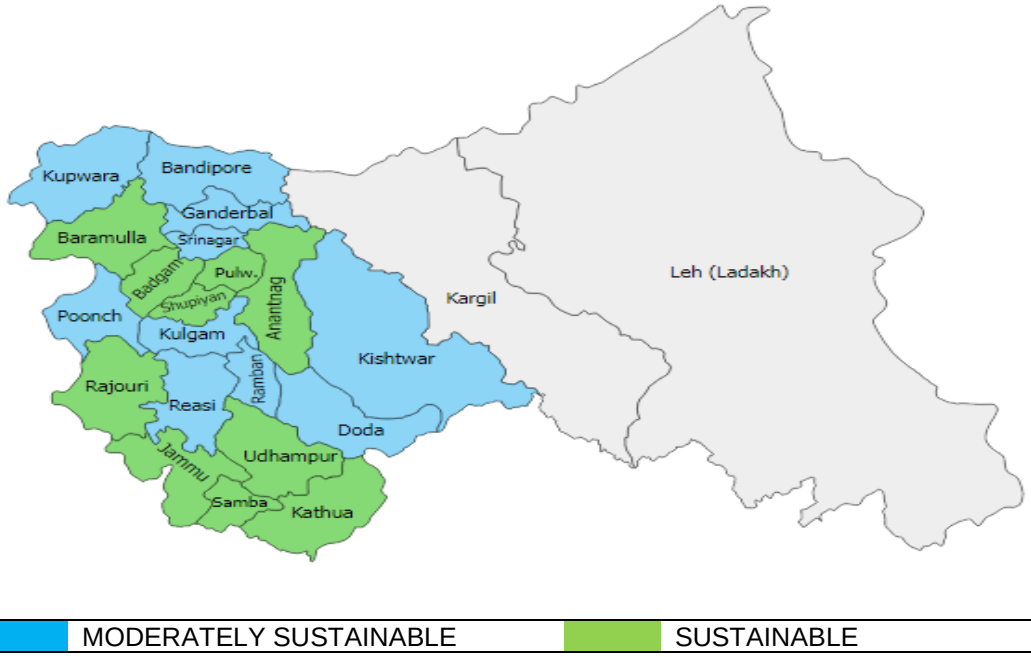

Fig. 3. Map showing sustainability level of the districts (2020-2021)

Table 6. Association of various variables on agricultural sustainability (Pearson correlation Coefficient)

VARIABLES		CSI
X1	Average Size of Land Holding	0.305
X2	Population Density	-0.063
X3	Cropping Intensity (%)	0.323
X4	Area Under Fruits & Vegetables to Gross Cropped Area (%)	0.314
X5	Net Area Irrigated to Net Cropped Area (%)	0.240
X6	Area Under Foodgrains to Gross Cropped Area (%)	-0.280
Y1	Food Grains Yield (000's Quintals)	.512*
Y2	Fruit Production (Lakh Mt)	0.386
Y3	Credit Deposit Ratio (%)	0.136
Y4	Net Cropped Area Per Bank Branch (Ha)	0.036
Y5	Employment in SSI Units Per Lakh Population (No.)	0.396
Y6	Credit Outstanding of Banks Per Gross Cropped Area (Rs/Ha)	0.246
Z1	Villages Electrification (%)	0.316
Z2	Road Density (Length /100 Sq.Km Area)	0.388
Z3	Population Per Medical Institution (No.)	0.25
Z4	Density of PACS (Ha)	0.042
Z5	Density of Marketing Society (Ha)	-0.174
Z6	Literacy Rate (%)	.445*

**. Correlation is significant at the 0.05 level (2-tailed)*
***. Correlation is significant at the 0.01 level (2-tailed)*

In India, the availability of institutional financing for farming and related industries has grown significantly [15]. Because of the many ways in which it aids farmers, this is a highly effective strategy for accelerating the expansion of the agricultural industry [16]. Fig. 5, shows the direct and the indirect effect of all the variables under economic efficiency with the economic indicator. Among the various causal variables of economic efficiency, employment in SSI units had the maximum direct and positive effect (0.101) on the economic sustainability, followed by Fruit production (0.093) and credit deposit ratio (0.084) which emphasis the need for the focus

on these variables to improve the agricultural sustainability. Employment in SSI units helps in the diversification of the income that reduces the economic vulnerability of farming families and these units are engaged in processing of agricultural products into value added products which lead to reduced post-harvest losses and increased income for farmers. The direct effect of fruit production and its indirect effects through the other variables such as credit-deposit ratio, foodgrains production, bank branches, employment in SSI units and credit outstanding of banks.

The social equity indicator had six causal variables and its direct and the indirect effect on the ecological sustainability have been represented in the Fig. 6. Among them road connectivity (0.104) had the maximum direct and positive effect on the social sustainability, followed by net cropped area under marketing society (0.083) and Literacy Rate (0.074) which indicates the need for the focus on these variables for their improvement. Road connectivity plays a significant role in improving agricultural sustainability by facilitating better access to markets, inputs, information, and resources for farmers. Better road connectivity can attract agribusinesses and agro-industrial activities to rural areas. Well-planned road connectivity can reduce the need for expanding agricultural land into ecologically sensitive areas. The value of total effect (0.146) of variable X1 on ecological security indicates the addition of both the direct and the indirect effects of the variable X1. Kashmir division has maximum area and better productivity of fruits compared to the Jammu division. It has been revealed that the average holdings size in the state is smaller than the national average. The average size of the land is 1.13 hectares (ha) in Udhampur and 0.26 hectares (ha) in Srinagar, across all districts which are expected to effect on farm sustainability factors. Improvement of the rural poor's standard of living should be a top priority, which would help greatly in the fight against such economic and social issues as poverty, hunger, and malnutrition [17].

A strong and negative correlation was observed between area under fruits & vegetables and area under foodgrains (0.877**). This is due to shifting agricultural priorities based on market demand, dietary preferences and other economic factors. This is supported by a study done on various districts of Karnataka, shown that there was a positive association between the agricultural development and infrastructural facilities with the socio-economic development [14]. While the study finds no correlation between agricultural progress and infrastructure development, it does find a strong positive correlation between infrastructure and societal progress [18], which reflects our case, as strong positive correlation between density of PACS and density of a marketing society (0.841**) is a indicative of cooperative efforts within the agricultural sector, where farmers are collaborating both for credit and needs and for marketing their produce [19,20]. Thus, Ecological, economic, and social equity are crucial factors that significantly influence agricultural sustainability. The harmonious integration of these three dimensions is essential for creating a resilient and sustainable agricultural system [21].

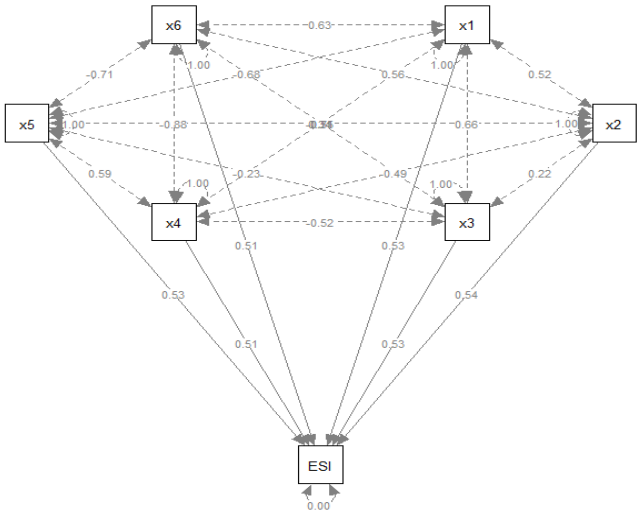

Fig. 4. Direct and indirect effect of different variables on ecological security

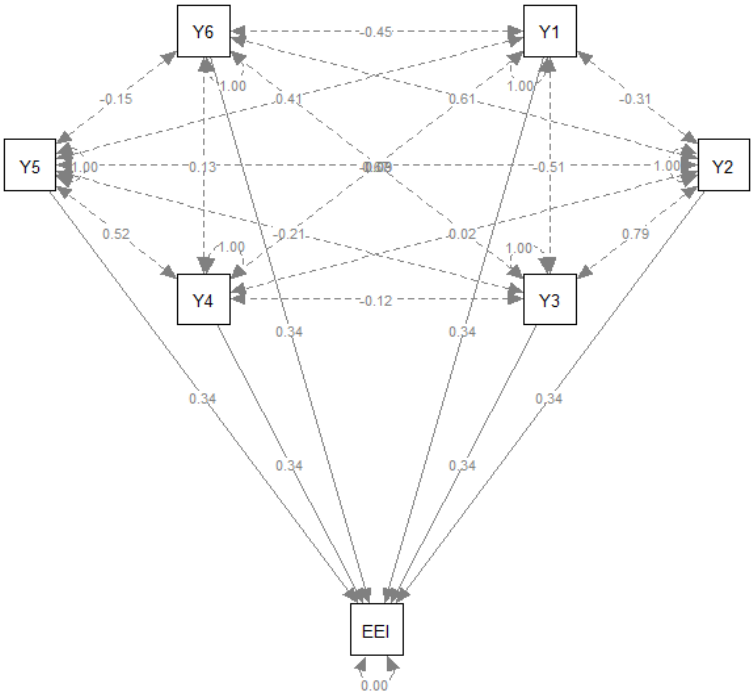

Fig. 5. Direct and indirect effect of different variables on economic efficiency

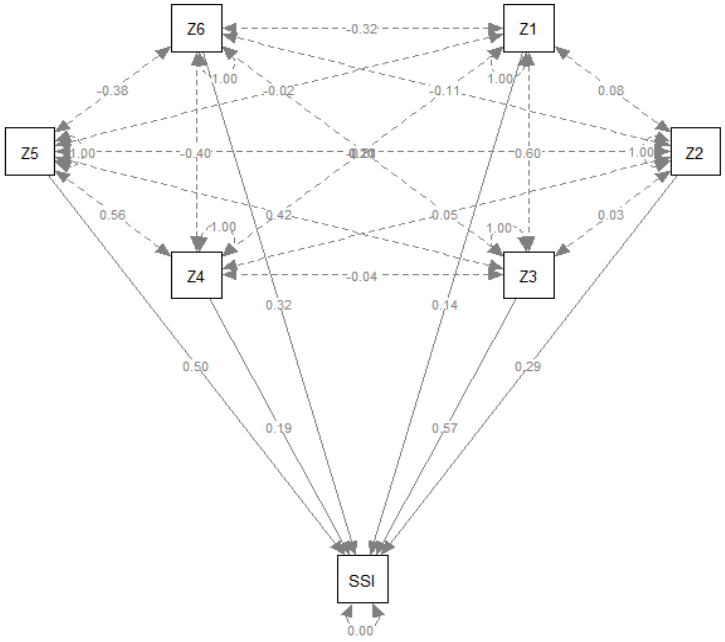

Fig. 6. Direct and indirect effect of different variables on social equity

Ramban have the least literacy rate of about 59.34 percent, followed by Ganderbal (60.48 percent). Therefore encouragement of education among new generation is highly required to achieve the desired results in farm and non-farm activities. Kupwara was identified as poorly developed districts in the socio-economic sector due to their lack of better infrastructure facilities and the poor literacy level [14]. The same scenario of Kupwara have been reported in 2020-21, as it lacks proper banking infrastructure and credit facilities compared to other districts

and also the employment rate in SSI units are also very low. Agriculture is entering a tough yet exciting phase. Sustainable nutrition security will be attainable if natural resources are used in a way that balances current and long-term development goals. Agriculture growth is a multifaceted process. Unless there is a systemic approach to all links in the production, marketing, and consumption chain, both producers and consumers will not receive the full benefits of increased production (Swaminathan 1988). The successful implementation of these policy measures will require collaboration among various stakeholders, including government agencies, research institutions, NGOs, and local communities [22].

4. CONCLUSION

The study of agricultural sustainability in Jammu and Kashmir reveals a complex and dynamic interplay between ecological, socio-economic, and climatic factors that shape the region's agricultural landscape. The unique geographical characteristics, including diverse climatic zones and varying altitudes, present both opportunities and challenges for achieving sustainable agricultural practices that ensure food security, environmental health, and rural livelihoods. Ultimately, the pursuit of agricultural sustainability in Jammu and Kashmir represents a commitment to the well-being of both the land and its people. It requires a long-term vision that transcends immediate gains and focuses on the enduring prosperity of future generations. Through prudent policy implementation, robust research, and the active involvement of all stakeholders, the region can aspire to achieve a harmonious balance between agricultural productivity, ecological security, and the preservation of its natural heritage. As Jammu and Kashmir moves forward on this journey, it stands poised to exemplify a model of agricultural sustainability that can inspire other regions facing similar challenges worldwide.

POLICY MEASURES:

- New generations of farm youth are shying away from agriculture and looking for urban-centric vocations due to factors such as capital insufficiency, lack of adequate infrastructural support, and agriculture being carried out as a subsistence option of livelihood. Therefore districts such as Kishtwar, Poonch, Rajouri and Udhampur should be provided with credit facilities through the establishments of cooperative banks, PACS, marketing societies etc.
- The credit exposure to the agriculture and its allied sectors in the state stands at 14% which is less compared to the national benchmark of 18%. Therefore credit to agriculture should be increased in the districts like Reasi, Samba, Udhampur and Kathua.
- Districts such as Srinagar, Anantnag, Ganderbal, Baramulla which are known for tourist attractions should be given awareness, not only to the people of that region, but also to the tourists who are also responsible for the maintenance of the ecosystem.
- Develop contingency plans and support systems to help farmers cope with extreme weather events, such as floods, landslides, and snowfall. Districts such as Bandipora, Pulwama, Srinagar, Baramulla and Budgam are more prone to flood effects. Therefore target specific plans should be designed.
- Encourage the adoption of agroecological practices such as crop rotation, cover cropping, agroforestry, and integrated pest management.
- Provide incentives or subsidies for farmers who implement sustainable practices that reduce chemical inputs and improve soil health. Districts with less forest coverage can be provided with the practice of agroforestry system which maintains the ecological system as well as provide us with biomass yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Brundtland G. Our common future: Report of the 1987 World Commission on Environment and Development; 1987.
2. Emas, Rachel. The Concept of Sustainable Development: Definition and Defining Principles;2016. 2015;10.13140/RG.2.2.34980.22404.
3. Newbold T, Hudson LN, Arnell AP, Contu S, De Palma A, Ferrier S, Hill SLL, Hoskins AJ, Lysenko I, Phillips H.R.P. Has Land Use Pushed Terrestrial Biodiversity beyond the Planetary Boundary? A Global Assessment. Science**3.** 2016;53:288–291.
4. Burton, I. Report on reports: Our common future: The world commission on environment and development. Environment: Science and Policy for Sustainable Development. 1987;29(5):25-29.
5. Saleth RM. Agricultural sustainability status of the agro-climatic subzones of India: Empirical illustration of an indexing approach. Indian Journal of Agricultural Economics.1993;48(3):543-550.
6. Iyengar N S, Sudharshan P. A Method of classifying regions from multivariate data. Economic and Polictical Weekly. 1982;17 (50).
7. Duncan OD.Path analysis: Sociological examples. American journal of Sociology.1966;72(1):1-16.
8. Swaminathan MS. From Stockholm to Rio de Janeiro: The Road to Sustainable Agriculture. Monograph No. 4. MS Swaminathan Research Foundation (MSSRF), Chennai; 1991.
9. Narain, Prem, Sharma SD, Rai, SC, Bhatia VK. Statistical Evaluation of Socio-economic Development of Different States in India. Journal of Indian Society of Agricultural Statistics. 2007;61:328-335.
10. Shafi Bhat, Lone FA, Shafiq. Evaluation of long-term trends in apple cultivation and its productivity in Jammu and Kashmir from 1975 to 2015. GeoJournal. 2021;86. DOI: 10.1007/s10708-019-10112-3
11. Gary R, Sands, Terence H, Podmore A. Generalized environmental sustainability index for agricultural systems. Agriculture, Ecosystems & Environment. 2000;79(1): 29-41.
12. Rasool R, Shafiq M U, Ahmed P, Ahmad P. An analysis of climatic and human induced determinants of agricultural land use changes in Shupiyan area of Jammu and Kashmir state, India. Geo Journal; 2016. Available:https://doi.org/10.1007/s10708-016-9755-6.
13. Saraf, Wani SA, Wani MH, Rauf SA, Baba SH, Shaheen FA. Economics of saffron cultivation in Kashmir. Acta Horticulturae. 2018;165-176. DOI:10.17660/ActaHortic.2018.1200.27
14. Narayan SB. Sustainable Agricultural Development and Organic Farming In India. Golden Research Thoughts. 2012; 1(11):1-4.
15. Baba SH, Wani M, Shabir, Bilal, Qammer NA. Institutional Credit to Mountain Agriculture: Issues of Structural Changes and Impact in Jammu & Kashmir. Agricultural Economics Research Review. 2014;27. 111. DOI:10.5958/0974-0279.2014.00013.5.
16. Devi Suman. Agricultural Credit In India. International Research Journal of Commerce and Law Agricultural Economics Research Review. 2015;2(7).
17. Samantaray LL. A study on the current trend of agricultural productivity in india and its future prospects. International Journal of Humanities Social Sciences and Education. 2015;2(4): 16-21.
18. Rather, Javeed, Shafi Bhat, Mohammad, Andrabi, Zameer. Inter District Dimensions of Socio- Economic Development in Jammu and Kashmir State: A Geographical Analysis. 2017; 6(1).92-101.
19. Digest of Statistics. Directorate of economics and statistics, planning and development department, Srinagar, Government of Jammu and Kashmir; 2020.
20. Directorate of Economics and Statistics, UT administration of Jammu & Kashmir. Planning development and monitoring department, J&K, Available:https://ecostatjk.nic.in/ (Accessed on April, 2023).
21. Indicators of Regional Development DES/Indl.1512003; Directorate of Economics and Statistics, Planning and Development Department, Srinagar, Government of Jammu and Kashmir; 2011.

22. Ministry of Statistics and Program Implementation: Government of India. 2021. Ministry of Statistics and Program Implementation|Government of India.
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