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Role of Agricultural Infrastructure for Promoting Diversified Agriculture: A Study of Kathua District in Union Territory of J&K

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Abstract

In densely populated countries like India, expanding agricultural land is a daunting task. To overcome this challenge, enhancing agricultural infrastructure and diversifying the agriculture sector are crucial for improving agricultural productivity. Agricultural diversification not only reduces the risk of crop failure but also enhances the financial situation of farmers, making it a key strategy for agricultural sector growth. Furthermore, it positively impacts social and environmental conditions within communities. This study focuses on examining agricultural infrastructure and diversification at the block level in the Kathua District. Using the Gibbs-Martin index, agricultural diversification was assessed, while a composite index measured the level of agricultural infrastructure. The findings reveal that in the Kathua District, there is no direct correlation between agricultural infrastructure and diversification. Some blocks, such as Barnoti, Billawar, and Kathua, exhibit a perfect positive association between infrastructure and agriculture diversification. Conversely, blocks like Marheen, Nagri, and Dinga Amb demonstrate a perfect negative association. These results indicate the need to address specific challenges and requirements in each block to foster sustainable agricultural growth. This approach will benefit farmers and contribute to the overall socio-economic and environmental well-being of the communities in the Kathua District.

***Key words*:** Agriculture diversification, Agricultural infrastructure, Gibbs-Martin index

Similar to Indian culture, Indian agriculture is incredibly diverse and multifaceted. India is a global leader in the production of numerous agricultural products. No other nation in the world has as many food and non-food crops as India has [1]. India's agriculture of the twenty-first century is structurally completely different from that of the 1970s. India's agricultural GDP increased from 25 billion $ to 101 billion $ between the 1970s and 2000, and grains were the primary driver of this expansion. However, Indian agriculture's output increased from 101 billion to 367 billion dollars between 2000 and 2014. Highly valuable agricultural products including horticulture, dairy, poultry, inland fisheries, etc. are responsible for all of this expansion.

Our nation has a population of more than 1.3 billion people, and in a few years, it will surpass all other countries in terms of population. The majority of our nation's land is occupied by marginalized and small farmers. This makes it exceedingly challenging to cover more land with crops [2]. Although our nation's total food grain production in 2019–20 was 291.95 million tons, second only to China in the globe, the demand for food grains would reach 345 million tons by 2030 [3]. Agriculture infrastructure development and diversification are required to be given top attention to address all of these issues. Most of the small and marginalized farmers in our nation practice a special kind of mixed farming. This farming combines horticulture, livestock farming, and agriculture for food grains. Although not as frequently as the aforementioned combination, other allied agricultural activities are also carried out in our nation [4]. To lower the risk of crop failure and to meet the needs of the family's food security, many farmers choose agriculture diversification over specialization. Agriculture diversification makes it easier for farmers to react to market demands, lowers market and natural disaster risk, increases self-sufficiency, and enhances the farmers' ability to live sustainably in terms of their economy, society, and environment. The two factors most responsible for India's agricultural growth are inequitable prices and agricultural diversification [5-6].

India's diversified terrain, climatic circumstances, and cultural practices all influence the country's agricultural environment. The country's extensive and diverse agricultural production not only feeds its enormous people but also makes a substantial contribution to the world market [7-8]. There are a number of variables influencing the growth and diversity of Indian agriculture. The nation's plethora of natural resources, which include fertile soil, an abundance of water supplies, and

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a favourable climate, create a strong basis for agricultural output. In this environment, the importance of agricultural infrastructure cannot be disregarded. Improved production, lower post-harvest losses, and easier transit of agricultural goods are all made possible by adequate infrastructure, which includes transportation networks, irrigation facilities, storage and processing facilities, and market links. Additionally, having access to dependable energy, technology, and information helps farmers adjust to shifting market needs and make wise judgements about crop selection and production techniques [9-10].

The improvement of agricultural infrastructure will naturally increase productivity and raise farmers' standards of living. Farm productivity is increased and production costs are decreased when there is good infrastructure. Agricultural infrastructure has a significant impact on how agriculture expands and diversifies. Infrastructure plays a crucial role in agriculture since it facilitates the supply of input and output agricultural goods during cultivation and reduces post-harvest waste [11-13]. Infrastructure that is specifically designed for one crop will aid in the specialization of that crop in that region's agriculture, whereas infrastructure that is more broadly designed, such as roads, electricity, irrigation facilities, etc., will encourage diversification [14-15]. The current study focuses on the degree of agricultural diversification at the block level in the Kathua District as well as the effects of the district's agricultural infrastructure facilities on this process. This study is very important as no such study has been done before in the Kathua District of the Union territory of Jammu and Kashmir and it will help in the sustainable growth of the farming sector in the Kathua District.

Study area

The district of Kathua is located in the J&K UT's southernmost region. It is encircled by Punjab on the south, Himachal Pradesh on the east, Samba and Udhampur on the north, Pakistan on the west, and Doda on the northeast. The district covers a total area of 250200 hectares. The three principal rivers, Sewa, Ujh, and Ravi, drain it. The rivers Sewa and Ujh are both tributaries of the Ravi River. There are 19 blocks and 11 tehsils in the Kathua district. Kathua, Nagri, Keerian Gandial, Marheen, Hiranagar, Barnoti, Nagrota Gujroo, Mandli, Billawar, Baggan, Basohli, Duggan, Duggain, Bani, Lohai Malhar, Mahanpur, Dhar Mahanpur, Bhoond, and Dinga Amb are the district's nineteen blocks. The agro-climatic conditions throughout the district vary, ranging from subtropical in the Plains to temperate in the Mountainous. The South West Monsoon and, in winter, western disturbances are the main sources of precipitation for the district region [16-17]. The district has a population of 616435 people as of the 2011 Census, of which 326109 are male and 290326 are female [18].

MATERIALS AND METHODS

From the Department of Agriculture, Kathua; the Village Amenity Directory; and Census data, block-level secondary data were gathered. Numerous statistical tools, like percentage, average, etc., have been used to analyze the data. Gibbs-Martin index has been used to measure agriculture's level of diversification, and a composite agricultural infrastructure index has been used to assess the importance of infrastructure. The following list of parameters is used to calculate the composite index:

1. Fertilizer distribution centers
2. Pesticides distribution centers
3. Seeds distribution centers
4. Number of machineries distributed under various schemes for the year 2019-20
5. Percentage of villages with tractor
6. Percentage of villages under for agricultural use
7. Percentage of villages with pucca road
8. Number of Horticultural nurseries
9. Percentage of villages under mobile phone coverage
10. Irrigation Intensity

a) Irrigation intensity was calculated by using the formula:

$$\frac{Net\ irrigated\ area}{Net\ sown\ area} \times 100$$

b) Gibbs-Martin index of diversification = $1-\frac{\sum x^2}{(\sum x)^2}$

In this case, x represents the proportion of each crop's cropped area to the total cropped area. The index value ranges from 0 to 1. A perfect agricultural specialization value will be 0 and a perfect diversification value will be 1 [19].

c) The composite index for calculating the agricultural infrastructure is as follows:

$$\text{Composite index} = \frac{X_i - MinX_i}{MaxX_i - MinX_i}$$

In this case, the i^{th} variable is X_i, and the variables' maximum and minimum values are represented by Min X_i and Max X_i [20-22].

To divide the various index values into high, medium, and low categories. It uses the standard deviation approach.
High Category value: Mean + half of standard deviation
Low Category value: Mean – half of standard deviation
The value that falls between the high and low categories is the medium range [21].

RESULTS AND DISCUSSION

A. *Agriculture diversification*

Different crops that are grown in various seasons are used to calculate agricultural diversification. Maize, wheat, and paddy are the three main crops farmed in the Kathua District. Out of which, maize is planted more in the Kandi and mountainous areas, where good irrigation facilities are lacking, whereas paddy is concentrated more in the district's plains. Wheat is sown as the Rabi crop all over the district, but its concentration declines in high mountainous areas due to the bitterly harsh winters there. The following list of several crops grown in the Kathua district:

1. Paddy
2. Wheat
3. Maize
4. Pulses (Both in Rabi and Kharif season)
5. Oilseeds (Both in Rabi and Kharif season)
6. Green Fodder (Both in Rabi and Kharif season)
7. Vegetables
8. Fruits (Both Dry and Fresh Fruits)

Depending on the various agroclimatic conditions, the district is home to various varieties of pulses, oilseeds, and green fodder. The following pulses are grown in the district during the Kharif season:

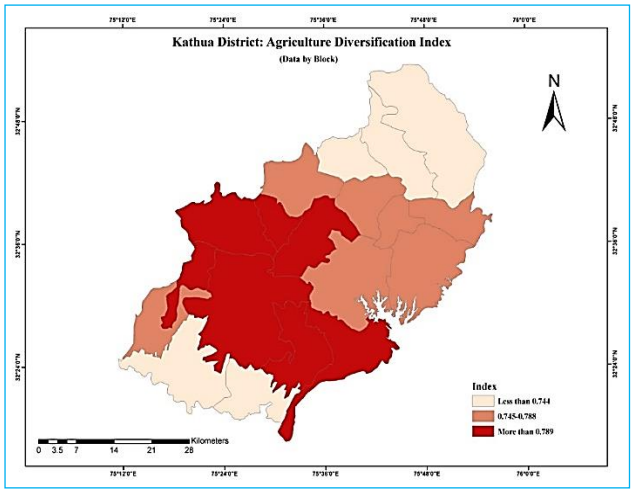
a. Red Gram (Arhar)
b. Black Gram (Urad)
c. Green Bean (Mung)
d. Horse Gram (Kulthi) etc.

Pulses grown during the Rabi season include chickpea, lentil, urad, moong, etc.

Fresh fruits are readily available throughout the district, however the concentration of dry fruits is only found in the High Mountainous region. Like apples, pears, apricots, and the like are found in the mountainous area while mangoes, watermelons, guavas, and other fruits are found in the plains and the Kandi area. The following table shows block-wise the Gibbs-Martin index of Diversification and the percentage of different crops in each block:

Table 1 Block-wise percentage of cropped area and diversification index

	(X) Percentage of the cropped area occupied by											
Blocks	Paddy	Maize	Pulses (Kharif)	Oilseeds (Kharif)	Green fodder (Kharif)	Wheat	Pulses (Rabi)	Oilseeds (Rabi)	Green fodder (Rabi)	Vegetables	Fruits	Diversification index
Baggan	9.590	35.52	1.92	1.04	0.81	18.34	1.23	5.06	1.84	1.23	23.44	0.772
Bani	1.090	39.53	2.05	0.00	0.00	11.60	0.92	12.83	2.85	0.85	28.28	0.732
Barnoti	18.218	17.02	2.60	3.09	2.27	31.84	2.23	2.77	4.35	6.78	8.84	0.819
Basohli	20.366	16.25	0.53	4.81	2.41	37.19	3.04	3.74	1.20	0.92	9.56	0.779
Bhoond	17.524	20.69	1.92	1.89	2.15	35.16	1.52	1.80	2.73	1.18	13.43	0.782
Billawar	24.963	12.62	2.31	2.51	1.98	30.71	3.18	5.30	4.09	3.32	9.02	0.811
Dhar Mahanpur	20.176	19.39	1.27	0.09	1.17	34.31	0.94	0.55	1.78	1.39	18.93	0.767
Dinga Amb	3.768	23.46	3.74	5.16	4.03	35.24	1.58	3.20	2.01	6.20	11.62	0.795
Duggain	10.867	33.34	0.59	0.49	0.69	30.17	0.44	4.64	2.85	0.98	14.95	0.760
Duggan	3.732	27.28	4.17	0.00	0.00	7.07	0.57	9.99	4.11	0.86	42.21	0.728
Hiranagar	25.089	12.68	2.10	1.84	1.78	37.65	1.17	0.92	2.77	4.77	9.23	0.766
Kathua	20.957	12.40	3.20	3.54	3.32	35.85	2.18	3.12	2.81	6.22	6.40	0.799
Keerian Gandial	19.732	13.34	2.13	2.91	3.78	36.50	0.87	5.77	1.36	5.39	8.21	0.794
Lohai Malhar	1.763	45.44	1.95	0.06	0.70	8.97	0.64	5.02	2.22	1.98	31.28	0.683
Mahanpur	18.588	14.00	1.28	5.06	2.28	37.44	1.73	0.70	0.92	0.81	17.20	0.772
Mandli	18.087	18.15	2.25	1.40	1.86	29.28	3.51	9.73	4.05	2.82	8.86	0.827
Marheen	37.303	4.45	1.06	2.18	1.01	38.66	0.99	1.76	2.84	3.99	5.75	0.703
Nagri	42.623	0.24	0.64	0.35	1.60	37.19	1.01	0.53	4.11	5.83	5.89	0.671
Nagrota Gujroo	26.650	12.05	3.09	2.41	1.68	30.75	2.12	6.59	3.98	2.95	7.73	0.805



Source: Department of Agriculture, Kathua

Fig 1 Level of agricultural diversification: high, medium, and low

In the district of Kathua, wheat accounts for 31.94 percent of the gross cultivated land, followed by paddy and maize, which take up 21.23 and 16.16 percent of the total area, respectively. The value of the diversification index is relatively high in each block of the Kathua District. The various agro-climatic conditions are the fundamental cause of this. While the mountainous region of the district has a temperate climate, the plains and the Kandi area have a subtropical climate. Because of this, farmers from various climatic regions grow a variety of crops, promoting agriculture diversification. The number of small and marginal farmers is particularly large in Kathua District, as it is throughout the nation, and as a result, the farmers plant a variety of crops to address the issue of crop failure. In the Kathua district, the majority of the blocks depend on rainfall to irrigate their crops. This is another key factor in Kathua's high level of agricultural diversification, as the region's unpredictable monsoon forces farmers to cultivate a variety of crops to handle the problem.

Using the standard deviation approach, the blocks have been divided into three groups based on their level of agricultural diversification: high, medium, and low, which is shown in (Fig 1).

The following categories describe the value of agriculture diversification according to the Gibbs-Martin index:

Blocks with high diversification index value: Barnoti, Billawar, Dinga Amb, Kathua, Keerian Gandial, Mandli and Nagrota Gujroo

Blocks with medium Diversification index value: Baggan, Basohli, Bhoond, Dhar Mahanpur, Duggain, Hiranagar, and Mahanpur

Blocks with low Diversification index value: Bani, Duggan, Lohai Malhar, Marheen, Nagri.

Bani, Duggan, Lohai Malhar of the low index value category lies in the mountainous area of the district. Different crops cannot be grown in these blocks due to the harsh climate and terrain. Because of this, these blocks have less agriculture diversification [23]. Nagri and Marheen, on the other hand, belong to the District's plains. As the irrigation facilities and other infrastructure are very good compared to the other blocks of the district, the farmers are here more focused on profit generation, which lowers the index of agricultural diversification. Since the majority of the agricultural land in this block is irrigated, crop failure is an essentially nonexistent problem.

Due to the fact that the majority of these blocks are located in the Kandi region, the blocks of Barnoti, Billawar, Dinga Amb, Kathua, Keerian Gandial, Mandli, and Nagrota Gujroo have high agriculture diversification index values.

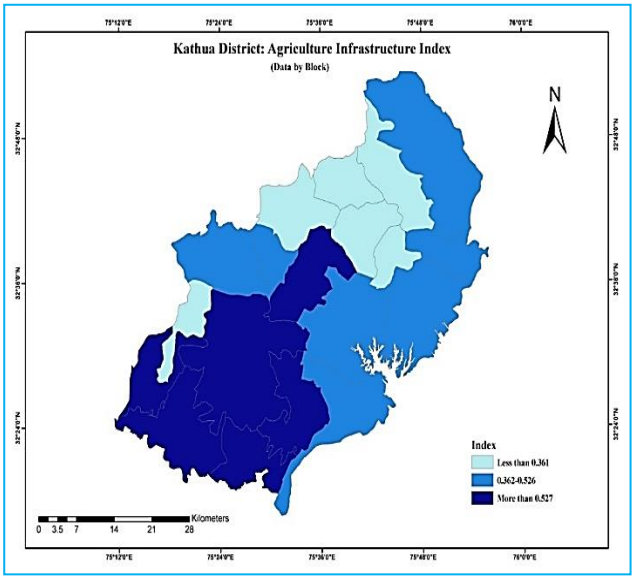
Farmers in the Kandi region produce more crops to lower the chance of crop failure because the irrigation systems there are insufficient [24]. The farmers are forced to produce various crops that can be protected from the monkeys' attack because of the large monkey population in each of these blocks [25].

B. *Agricultural infrastructure*

From the pre-harvest stage to the post-harvest stage, infrastructure is crucial to agriculture at every stage of crop development. The production of the crops is increased by better agricultural infrastructure, which ultimately benefits the farmers' financial situation. Ten indicators to calculate the composite index for agricultural infrastructure are selected in our study and these are Fertilizer distribution centers, Pesticides distribution centers, Seeds distribution centers, Number of machinery distributed under various schemes for the year 2019-20, Percentage of villages with tractor, Percentage of villages under for agricultural use, Percentage of villages with pucca road, Number of Horticultural nurseries, Percentage of villages under mobile phone coverage, Irrigation Intensity. All of these variables are crucial for the overall development of the agricultural infrastructure and the farmers' standard of living.

Table 2 Block wise composite index value of Agriculture infrastructure

Blocks	Index value of Fertilizers distribution centers	Pesticides distribution centers	Machinery distributed under various schemes (2019-20)	Seed distribution centers	Irrigation intensity	Villages under power supply for agricultural use (%)	Villages with pucca roads (%)	Villages under mobile phone coverage (%)	Horticulture nursery	Villages with tractors (%)	Composite index
Baggan	0.021	0.043	0.184	0.03	0.01	1.000	0.62	1.000	0	0.000	0.291
Bani	0.064	0.087	0.122	0.08	0.07	1.000	0.62	0.400	1	0.183	0.364
Barnoti	0.511	0.522	0.714	1.00	0.44	0.079	0.81	0.790	1	0.579	0.645
Basohli	0.128	0.130	0.367	0.06	0.00	1.000	1.00	1.000	0	1.000	0.468
Bhoond	0.064	0.043	0.122	0.06	0.38	1.000	0.85	1.000	0	0.333	0.385
Billawar	0.383	0.391	0.592	0.33	0.10	1.000	0.67	1.000	1	0.647	0.612
Dhar Mahanpur	0.021	0.043	0.102	0.03	0.03	1.000	0.62	1.000	0	0.000	0.284
Dinga Amb	0.106	0.130	0.224	0.06	0.06	1.000	0.98	0.572	0	0.262	0.338
Duggain	0.000	0.000	0.041	0.11	0.00	1.000	0.00	1.000	0	0.000	0.215
Duggan	0.021	0.043	0.122	0.00	0.13	1.000	0.43	0.077	0	0.000	0.182
Hiranagar	0.830	0.826	0.776	0.69	0.22	0.063	0.62	0.679	1	0.720	0.643
Kathua	0.745	0.739	1.000	0.50	0.34	1.000	0.48	1.000	1	0.509	0.731
Keerian Gandial	0.298	0.304	0.000	0.25	0.26	1.000	0.24	1.000	1	0.237	0.459
Lohai Malhar	0.000	0.000	0.837	0.00	0.01	1.000	0.07	0.000	1	0.000	0.291
Mahanpur	0.043	0.043	0.204	0.11	0.08	1.000	0.74	1.000	0	0.917	0.414
Mandli	0.191	0.174	0.224	0.14	0.30	1.000	0.71	1.000	0	0.611	0.435
Marheen	1.000	1.000	0.510	0.97	0.62	0.000	0.55	0.886	0	0.629	0.617
Nagri	0.532	0.478	0.286	0.81	1.00	1.000	0.67	0.294	1	0.611	0.668
Nagrota Gujroo	0.043	0.043	0.163	0.25	0.21	1.000	0.48	1.000	0	0.755	0.394



Source: Department of Agriculture and Village Amenity Directory, Kathua

Fig 2 Agricultural infrastructure's composite index value

Chemical or organic fertilizers provide the nutrients that are lost or replaced in the soil as a result of anthropogenic or natural activities. It significantly increases the crop's yield. Because of this they are one of the most crucial elements in agricultural activities [26]. Since the 1960s, our nation's production of main crops has expanded by three to four times. The farmers' usage of pesticides is largely responsible for this accomplishment. Pesticides shield crops from weeds, diseases, and pests, allowing them to grow more food in a smaller area of land [27]. Tractors, combine harvesters, power tillers, land levelers, drum seeders, seed drills, chaff cutters, diesel ploughs, paddy wheat threshers, etc. are some of the farm equipment available. By lowering the amount of labour and demanding efforts on the farms, it benefits the farmers. It supports large-scale farming, which boosts farm income. As a result, there is an increase in farmer cooperation. Roads contribute to lowering the cost of transporting agricultural products. Additionally, it aids in getting agricultural products to remote places.

The standard deviation approach has also been used to classify the agricultural infrastructure's composite index value which is shown in (Fig 2).

Blocks with high composite index value for agricultural infrastructure: Barnoti, Billawar, Hiranagar, Kathua, Marheen and Nagri.

Blocks with medium composite index value for agricultural infrastructure: Bani, Basohli, Bhoond, Keerian Gandial, Mahanpur, Mandli and Nagrota Gujroo.

Blocks with low composite index value for agricultural infrastructure: Baggan, Dhar Mahanpur, Dinga Amb, Duggain, Duggan and Lohai Malhar.

Out of all the blocks Baggan, Dhar Mahanpur, Dinga Amb, Duggan, Duggain, Lohai Malhar, have the low composite index value. The majority of these blocks come from high mountainous areas with harsh weather. Given that they are all located in the district's plain areas, the blocks of Barnoti, Billawar, Hiranagar, Kathua, Marheen, and Nagri have high composite index scores. In comparison to the other blocks, these have better irrigation facilities, road networks, electricity facilities, etc.

C. *Association between agriculture infrastructure and agriculture diversification*

From the various studies conducted throughout the world on the relationship between agriculture diversification and agricultural infrastructure, it has been highlighted that there is no direct relationship between diversification and infrastructure. It is the same in the case of Blocks of District Kathua. Infrastructure facilities focusing on particular crops will promote Agriculture specialization but general infrastructure facilities promote diversification. The following table will illustrate the relationship between Diversification and Agricultural infrastructure.

From the (Table 3), it has been determined that a direct positive relationship between agricultural infrastructure and agriculture diversification exists in the blocks of Barnoti, Billawar, Kathua, Basohli, Mahanpur, and Lohai Malhar. Infrastructure and diversity have a perfect inverse connection in the blocks of Marheen, Nagri, and Dinga Amb. The blocks of Hiranagar and Bani have high infrastructural index values and low agricultural diversification index values, in contrast to Keerian Gandial, Mandli, Nagrota Gujroo, Baggan, Dhar Mahanpur, and Duggain, which have high agricultural diversification value but low agriculture infrastructure value. Infrastructure for agriculture doesn't necessarily have a direct bearing on agricultural diversification. Climate, terrain, socioeconomic traits of farming families, and other elements, in addition to the agricultural infrastructure, influence the degree of diversification.

Table 3 Association of agricultural infrastructure and agricultural diversification on a block-by-block basis

Categories	Blocks under several categories of agricultural diversification index	Blocks under several categories of agricultural infrastructure index
High	Barnoti, Billawar, Dinga Amb, Kathua, Keerian Gandial, Mandli and Nagrota Gujroo	Barnoti, Billawar, Hiranagar, Kathua, Marheen and Nagri.
Medium	Baggan, Basohli, Bhoond, Dhar Mahanpur, Duggain, Hiranagar, and Mahanpur	Bani, Basohli, Bhoond, Keerian Gandial, Mahanpur, Mandli and Nagrota Gujroo
Low	Bani, Duggan, Lohai Malhar, Marheen and Nagri	Baggan, Dhar Mahanpur, Dinga Amb, Duggain, Duggan and Lohai Malhar

CONCLUSION

Agriculture diversification, as a solution to many agricultural issues, contributes to a rise in sustainable development. Kharif crops, rabi crops, fruits, and vegetables are chosen in the district of Kathua to determine the level of agricultural diversity on a block-by-block basis. Mandli has the highest agricultural diversification index value among all the blocks, as per the Gibbs-Martin technique. The index value for this block is 0.827. The blocks of Barnot, Billawar, Nagrota Gujroo, Kathua, Dinga Amb, etc. come after Mandli block. These blocks' respective agriculture diversification index values are 0.819, 0.811, 0.805, 0.799, and 0.795. The district's Nagri Block, followed by the Lohai Malhar, Marheen, Duggan, and Bani blocks, has the lowest diversification index value. These blocks' respective index values are 0.671, 0.683, 0.703, and 0.732. In terms of the agricultural infrastructure's composite index value, the blocks of Kathua, Nagri, Barnoti, and Hiranagar rank highest, while the blocks in Duggan, Duggain, Dhar Mahanpur, and Baggan have the lowest index values. Regarding the relationship between agricultural diversification and agricultural infrastructure, the blocks of Mahanpur, Bhoond, Barnoti, Billawar, Kathua, Basohli, Duggan, and Lohai Malhar have a direct and favorable relationship. Additionally, there is a negative relation between agricultural infrastructure and agricultural diversification in the Marheen, Nagri, and Dinga Amb blocks. It implies that in Kathua district there is no direct relationship among blocks for agriculture diversification and agriculture infrastructure.

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