ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating: 4.97
IJAFS 2025; 7(8): 428-435
www.agriculturaljournals.com
Received: 08-06-2025
Accepted: 05-07-2025

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Statistical analysis of crop diversification in Ahilyanagar district of Maharashtra

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DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i8f.642

Abstract
The present study examined the spatio-temporal crop diversity of the Ahilyanagar district. The investigation relies on data gathered from the District Statistical Abstract of Ahmednagar and utilizes Gibbs and Martin's Index to assess the intensity of variation in crop diversity across tahsils. The result reveals that the northern tahsils such as Akole, Sangamner, Kopargaon, Rahata, Shrirampur, Newasa, Shevgaon, Pathardi, and Rahuri experienced high diversification, while in the southern semi-arid tahsil like Nagar, Parner, Shrigonda, Karjat, and Jamkhed indicates moderate diversification, where jowar cultivation dominated in 2013-14. However, in 2023-24, the picture has completely changed. Nagar, Parner, Shrigonda, Karjat, and Jamkhed tahsils have also jumped in high diversification. The tahsils, which have a heavy reliance on a single crop, are shifting to growing a variety of crops.

Keywords: Crop diversification, gibbs and martin index, cropping patterns

Introduction
Crop diversity refers to the cultivation of various crops within a particular area (Gibbs & Martin, 1962) [10]. A higher degree of diversification is observed when numerous crops are grown in a given area. In contrast, crop specialization refers to the practice of growing a limited number of crops. Crop diversification, much like crop concentration, is a significant tool in the study of agriculture and land use. It indicates the variation in crops cultivated within a particular region. A higher degree of diversification is observed when numerous crops are grown in a given area, each occupying an approximately equal share of the total cultivated land.

In contrast, crop specialization refers to the practice of growing a limited number of crops. Essentially, while diversification involves utilizing the land for multiple crop types, specialization focuses on just one or two primary crops (Jasbir Singh, 1976). According to the principle, "Greater competition leads to more diversification, whereas reduced competition results in specialization or monoculture practices. Several techniques, including the Herfindahl Index (HI), Ogive Index (OI), Composite Entropy Index (CEI), and Gibbs-Martin Index (GMI), are employed to analyze crop diversification. However, Gibbs & Martin's method is a widely used tool for studying crop diversification. Many scholars have utilized Gibbs & Martin's method to calculate crop diversification, such as Bhatia, S. S. (1967), Raju, V. T., & Reddy, A. A. (1990), Pingali, P., & Rosegrant, M. W. (1995), Chand, R., & Chauhan, S. (2002), Joshi, P. K., Gulati, A., & Tewari, L. (2004), Singh, R. P., Singh, K. M., & Jha, A. K. (2006), Birthal, P. S., & Joshi, P. K. (2007), Mehta, R. (2009), Kumar, P., & Jain, R. (2012), and Sharma, R., & Thakur, D. R. (2019) [2, 3, 10, 11, 13, 15, 16, 17, 19, 20, 21].

As agriculture continues to face challenges from price volatility and climate change, crop diversification, as measured by the GMI, provides vital insights for achieving sustainable economic returns. The Ahilyanagar district is well known for agriculture in the Maharashtra state, where agriculture serves as the primary *engine of growth*. Approximately 75.42% of the total workforce's livelihood is derived from agriculture. Therefore, an attempt has been made to investigate spatial-temporal crop diversity in Ahilyanagar district to tackle the challenges of price volatility and climate change.

Study Area

Ahmednagar is one of the agricultural development districts in Maharashtra, covering approximately 12,56,500 hectares of agricultural land, and it has a geographical area of 17,418 sq. km, which supports a population of about 45,43,083 (Census, 2011) [22]. The study area extends between 18°2' to 19°9' N latitude and 73°9' to 75°5' E longitude. The district comprises fourteen tahsils, encompassing 1,581 villages. Agriculture is a growth engine for the district's economy. Approximately 75.42% of the total workforce's livelihood is derived from agriculture. The district is situated in the semi-arid climatic zone, where rainfall is scanty, and the amount of rainfall rapidly declines towards the east. In the last two decades, the net sown area (NSA) changed dramatically, increasing from 13,03,590 hectares to 15,72,298 hectares between 2013-14 and 2023-24, respectively. The land use pattern, as well as the cropping pattern, was changed; the area under jowar was sharply decreased and replaced by sugarcane, fodder crops, fruits, and vegetables.

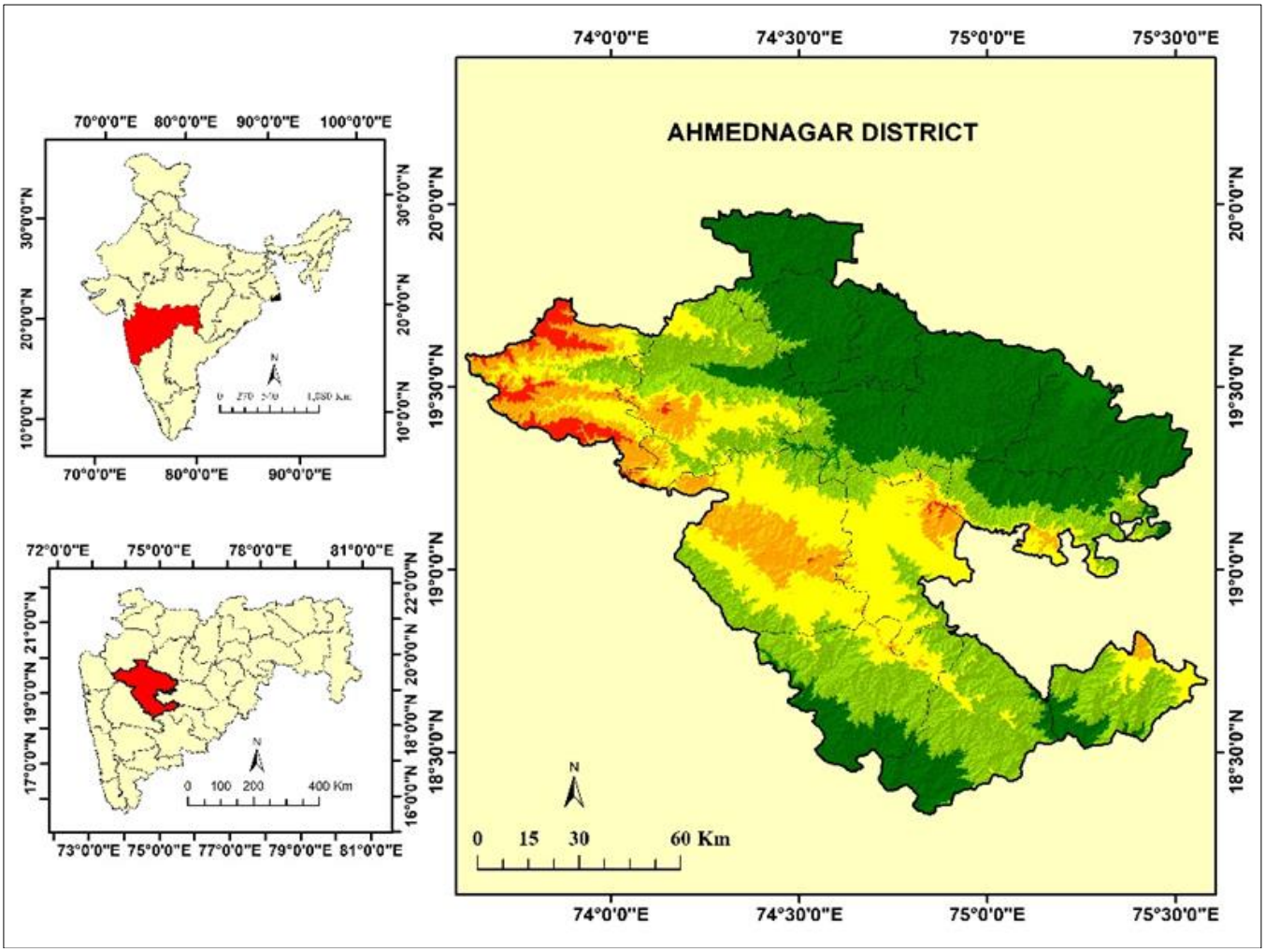


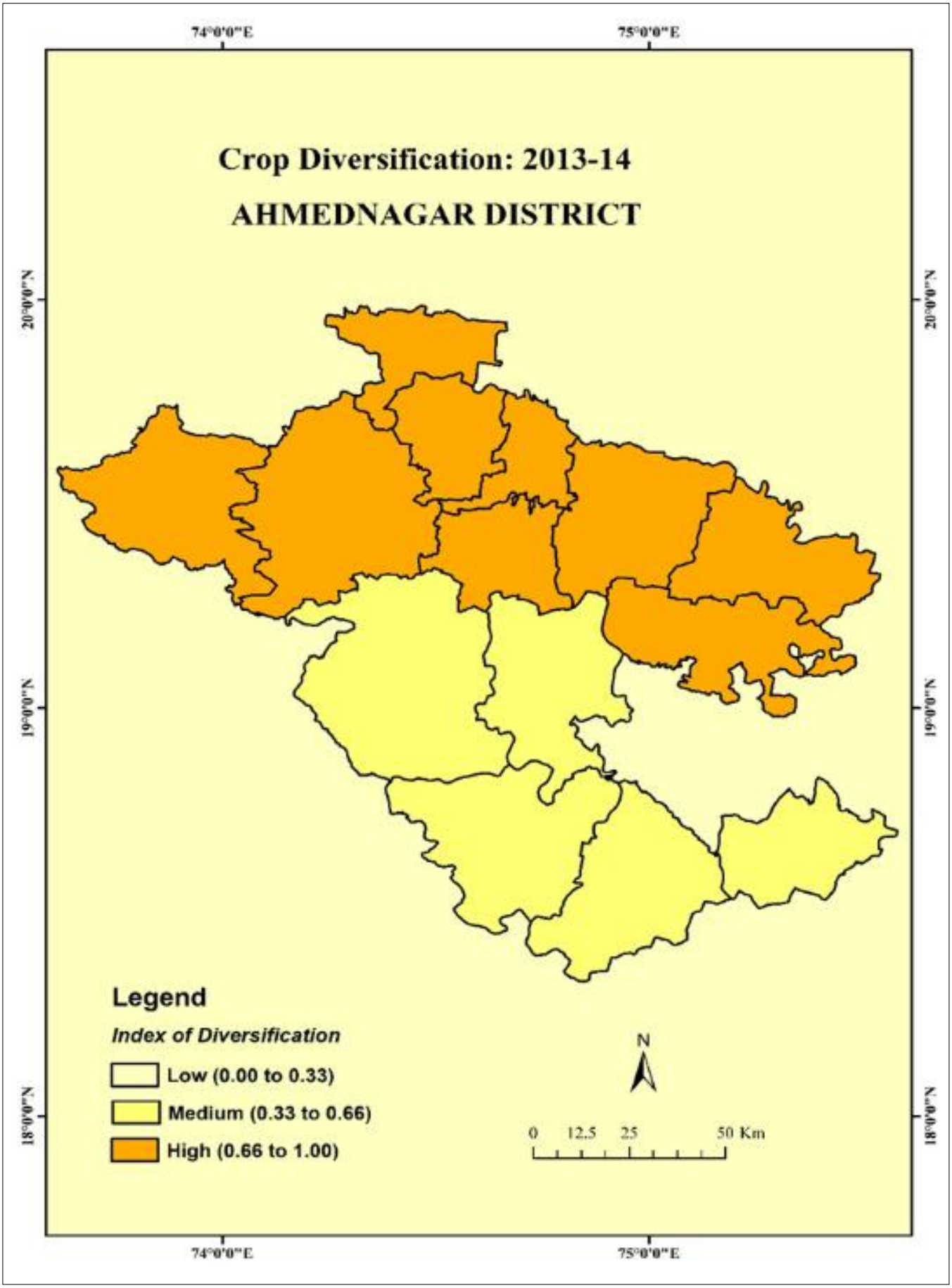
Fig 1: Location of Study Area

Database and Methodology

The present study used data from published reports on the District Statistical Abstract of Ahmednagar for the years 2013-14 and 2023-24 to examine crop diversification [9]. To measure the extent of diversification in cropping patterns, the "Gibbs and Martin Index of Diversification (1962) [10]" has been employed. The formula used to compute this index is:

$$\text{Index of Diversification} = 1 - \frac{\Sigma X^2}{(\Sigma X)^2}$$

This formula, 'X,' denotes the percentage share of each crop in the total cultivated area. When a region grows only one crop exclusively, indicating monoculture, the index value is zero. In contrast, if the area is equally distributed among many crops, signifying maximum diversification, the index nears one.


74°0'0"E
75°0'0"E
Crop Diversification: 2013-14
AHMEDNAGAR DISTRICT
20°0'0"N
19°0'0"N
18°0'0"N
Legend
Index of Diversification
Low (0.00 to 0.33)
Medium (0.33 to 0.66)
High (0.66 to 1.00)
N
0 12.5 25 50 Km

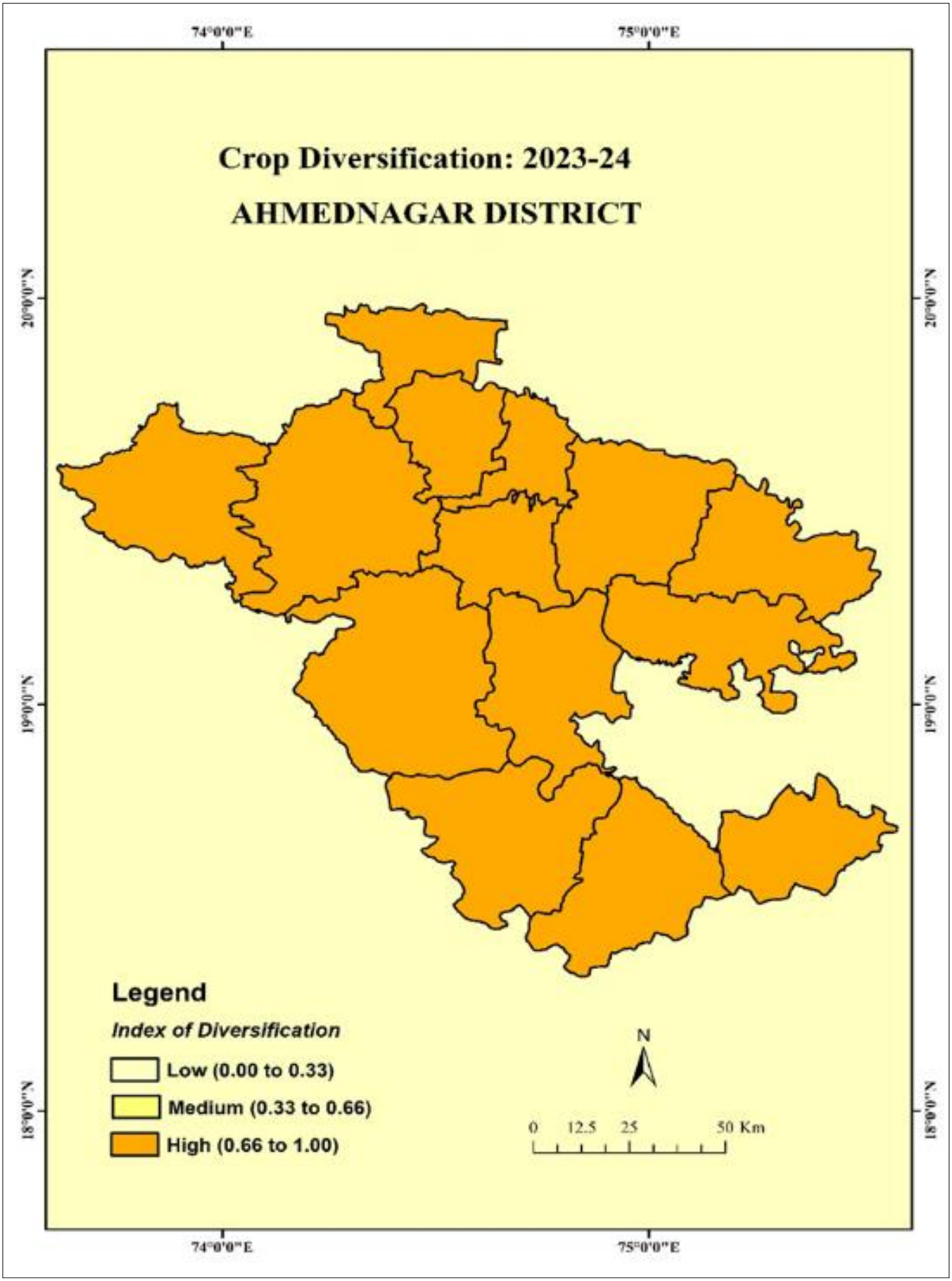


Fig 2: Crop Diversification 2023-24

Table 3: Crop Diversification during 2013-14 to 2023-24

Index of Diversification	Level of Diversification	2013-14	2023-24
0.66 to 1.00	High	Akole, Sangamner, Kopargaon, Rahata, Shrirampur, Newasa, Shevgaon, Pathardi, Rahuri	Kopargaon, Rahata, Akole, Sangamner, Shrirampur, Newasa, Rahuri, Shevgaon, Pathardi, Nagar, Parner, Shrigonda, Karjat, Jamkhed
0.33 to 0.66	Medium	Nagar, Parner, Shrigonda, Karjat, Jamkhed	-
0.00 to 0.33	Low	-	-

(Source: Computed by Researcher)

Spatio-Temporal Trends in Crop Diversification

In 2023-24, the crop diversification index shows that Rahata (0.85), Kopargaon (0.83), Rahuri (0.83), Newasa (0.81), and Sangamner (0.75) have high diversity, while Karjat (0.40), Jamkhed (0.47), Shrigonda (0.47), Nagar (0.53), and Partner (0.54) recorded low diversity. It is mainly because jowar accounts for more than 45% of TCA; this means that other crops cover the remaining 55% of TCA. It indicates that crop specialization (jowar). The southern part of the study area experienced very low rainfall and limited irrigation facilities, which led to the support of jowar cultivation. According to the 2023-24 results, Karjat (0.87), Shrigonda (0.87), Nagar (0.86), Jamkhed (0.75), and Partner (0.83) exhibit high diversity. It reveals a sharp decline in jowar (17% of TCA) and an increase in sugarcane, cotton, fodder crops, and fruits and vegetables. This is due to the rise in the prices of sugarcane, fruit, and vegetables. On the other hand, Newasa (0.85), Shrirampur (0.84), Sangamner (0.83), Rahuri (0.83), and Kopargaon (0.80) recorded high crop diversity.

The high spatio-temporal crop diversity has been observed at the tahsil level compared to the district, with crop diversification index values of 0.80 and 0.90, respectively, in 2013-14 and 2023-24. It reveals that overall diversity has changed significantly, but tahsil-level diversity has noted a drastic change, especially in the southern part (Table 3). The results indicate that Karjat (0.47), Shrigonda (0.40), Partner (0.29), Jamkhed (0.28), and Nagar (0.23) show an increase in index value, which is due to the rapid rise in the high-value crops like sugarcane, cotton, fruits, and vegetables. The cropping pattern changed due to improved irrigation facilities, the adoption of drip irrigation, the use of high-yielding variety seeds, mechanization, the application of chemical fertilizers, a high market price, and government policies.

Table 4: Crop Diversification Change during 2013-2014 to 2023-24

Sr. No.	Tehsils	Index of Diversification		Change	Change
		2013-14	2023-24		
1	Akole	0.70	0.81	0.11	Increased
2	Sangamner	0.75	0.83	0.08	Increased
3	Kopargaon	0.83	0.80	-0.03	Decreased
4	Rahata	0.85	0.82	-0.03	Decreased
5	Shrirampur	0.69	0.84	0.15	Increased
6	Newasa	0.81	0.85	0.04	Increased
7	Shevgaon	0.73	0.77	0.04	Increased
8	Pathardi	0.71	0.87	0.16	Increased
9	Nagar	0.53	0.86	0.23	Increased
10	Rahuri	0.83	0.83	0.00	No Change
11	Parner	0.54	0.83	0.29	Increased
12	Shrigonda	0.47	0.87	0.40	Increased
13	Karjat	0.40	0.87	0.47	Increased
14	Jamkhed	0.47	0.75	0.28	Increased
	District	0.80	0.90	0.10	Increased

(Source: Computed by Researcher)

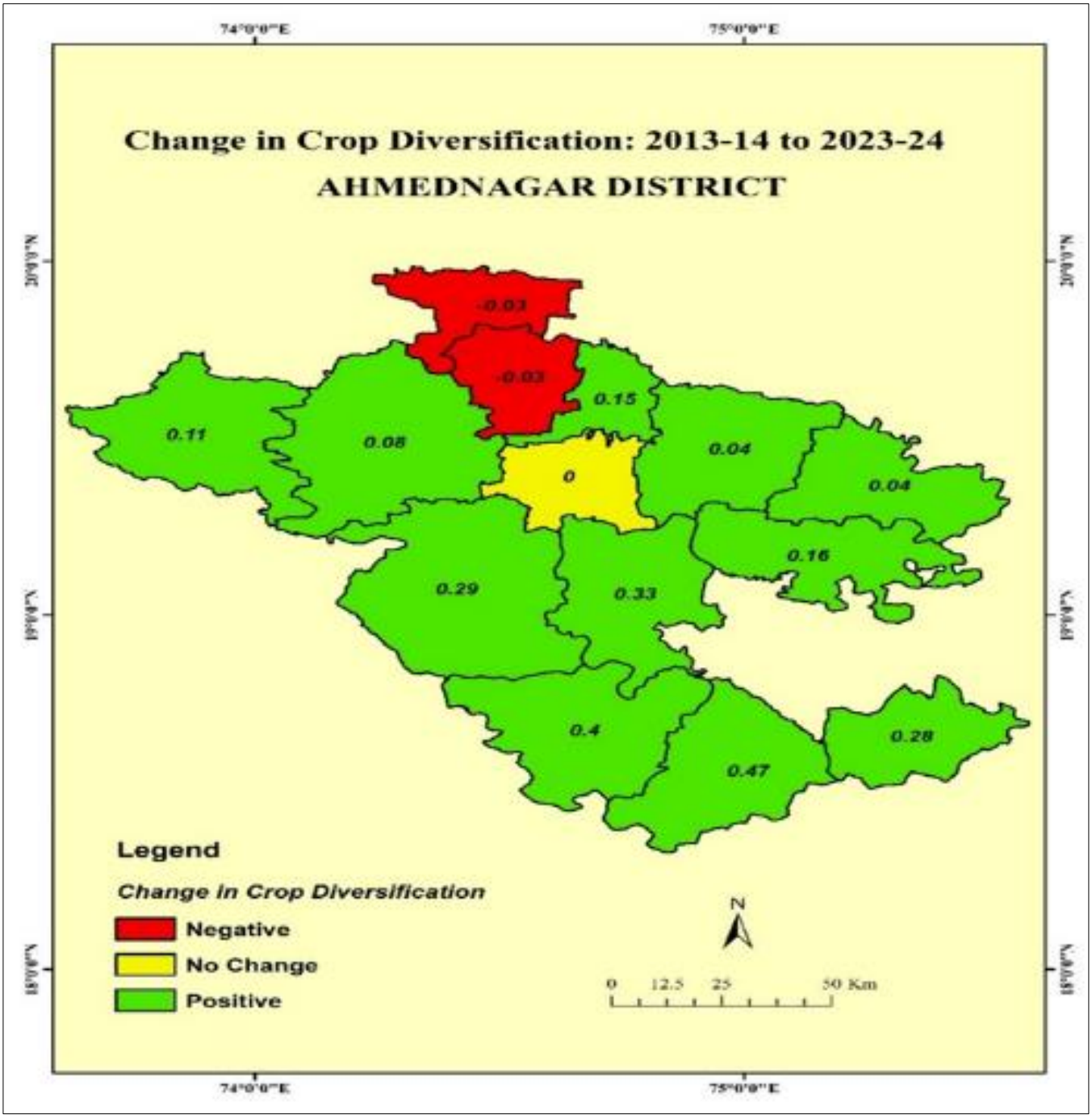


Fig 3: Change in Crop Diversification during 2013-14 to 2023-24

Conclusion

The results reveal the spatial-temporal distribution of crop diversification; the northern tahsils, such as Akole, Sangamner, Kopargaon, Rahata, Shrirampur, Newasa, Shevgaon, Pathardi, and Rahuri, contained high diversification. On the other hand, the southern semi-arid tahsils, such as Nagar, Parner, Shrigonda, Karjat, and Jamkhed, showed moderate diversification in 2013-14. However, within decades, the picture has completely changed. Nagar, Parner, Shrigonda, Karjat, and Jamkhed tahsils also show high diversification in 2023-24. The increase in the irrigation facilities helps grow diverse, high-value crops. The tahsils, which have a heavy reliance on a single crop, are shifting to produce a variety of cash crops. It also reveals a periodic shift in cropping patterns, particularly in southern tahsils. The southern tahsils were primarily dependent on single crop jowar, and the consistent fall rainfall increased the risk of crop failure, adversely affecting farmers' incomes. Therefore, farmers are shifting from jowar to various high-value crops, which ensure economic returns.

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Table 1: Crop Diversification in 2013-14

Tehsils	Rice	Wheat	Jowar	Bajara	Gram	Tur	Mung	Sugarcane	Cotton	Groundnut	Sunflower	Soyabean	Fodder Crops	Total Fruits	Total Vegetables	Total NSA	$\frac{\Sigma X^2}{(\Sigma X)^2}$	$1-\frac{\Sigma X^2}{(\Sigma X)^2}$
Kopargaon	0	6386	3949	5158	6525	49	17	6539	0	126	326	18181	2341	587	6017	56201	0.17	0.83
Rahata	0	4639	3915	4200	8261	0	0	9832	3655	92	0	11865	2172	392	1502	50525	0.15	0.85
Akole	7808	2913	400	14093	2430	141	68	3986	0	2879	0	5342	42621	140	2355	85176	0.30	0.70
Sangamner	74	4240	7978	41655	3655	574	408	6179	4914	370	147	4929	3851	1998	9259	90231	0.25	0.75
Shrirampur	0	2836	4075	7027	48818	7	0	11618	3862	292	68	9117	3667	321	1449	93157	0.31	0.69
Newasa	0	4229	10636	10098	8188	2688	109	30483	30484	61	32	5421	1674	454	2430	106987	0.19	0.81
Rahuri	0	4964	7155	3854	3580	45	0	14693	16580	215	210	2849	3200	486	2194	60025	0.17	0.83
Shevgaon	0	1825	32601	23010	2676	1166	69	7593	10278	72	25	0	491	327	1264	81397	0.27	0.73
Pathardi	0	601	35205	44462	2978	1829	0	4740	23213	339	0	0	284	314	157	114122	0.29	0.71
Nagar	0	5612	86233	10701	12136	1653	4461	1674	907	204	146	3307	671	200	1179	129084	0.47	0.53
Parner	0	10676	82408	9783	7057	327	1056	2121	0	45	0	2430	988	622	5257	122770	0.46	0.54
Shrigonda	0	2833	91534	2474	8456	156	109	20662	351	4	5	0	341	443	2446	129814	0.53	0.47
Karjat	0	128	82634	4783	3109	120	750	7367	6107	42	12	0	209	570	1690	107521	0.60	0.40
Jamkhed	0	14	55188	4679	2806	2249	1185	1544	4345	1	10	2417	902	554	686	76580	0.53	0.47
District	7882	51896	503911	185977	120675	11004	8232	129031	104696	4742	981	65858	63412	7408	37885	1303590	0.20	0.80

(Source: District Statical Abstract of Ahmednagar: 2014)

Table 2: Crop Diversification in 2023-24

Tehsils	Rice	Wheat	Jowar	Bajara	Gram	Tur	Mung	Sugarcane	Cotton	Groundnut	Sunflower	Soyabean	Fodder Crops	Total Fruits	Total Vegetables	Total NSA	$\frac{\Sigma X^2}{(\Sigma X)^2}$	$1-\frac{\Sigma X^2}{(\Sigma X)^2}$
Kopargaon	0	8513	1094	1002	5328	56	181	7397	1680	306	0	25495	10576	530	10022	72180	0.20	0.80
Rahata	0	8689	3474	1183	10385	97	64	18246	1422	512	0	25323	16522	653	4115	90685	0.18	0.82
Akole	17260	5476	449	1392	3207	11	10	1980	0	1213	44	19773	5255	927	16264	73261	0.19	0.81
Sangamner	16	5290	4886	14522	4237	63	206	4525	2783	2058	5	21067	30658	424	15537	106277	0.17	0.83
Shrirampur	0	8772	908	203	5950	52	54	5389	5754	191	2	15627	10920	359	9730	63911	0.16	0.84
Newasa	0	17894	1549	3940	5475	3968	342	30554	29796	607	0	12179	20228	674	20815	148021	0.15	0.85
Rahuri	0	9806	2827	3752	2812	408	20	10707	17143	517	0	8300	16772	333	12278	85675	0.17	0.83
Shevgaon	0	10804	3681	2990	6467	9563	426	11217	46866	649	5	1537	4913	417	9859	109394	0.23	0.77
Pathardi	0	8509	21922	15047	10003	13017	3146	3419	33377	1732	0	2985	10762	461	11822	136202	0.13	0.87
Nagar	0	9390	24792	6215	10399	4754	6527	1130	1121	234	117	19556	16736	659	23457	125087	0.14	0.86
Parner	0	5194	38877	17713	7655	2170	16099	3834	116	335	0	12507	26020	580	48006	179106	0.13	0.83
Shrigonda	0	8544	17653	12029	5479	5562	1832	26443	7445	1795	33	2197	24965	5500	32744	152221	0.13	0.87
Karjat	0	10081	30556	7061	12136	15330	328	15138	5452	196	3	247	18728	474	18217	133947	0.13	0.87
Jamkhed	0	2055	41006	667	6495	7176	2269	2680	387	120	0	22275	3523	453	7222	96328	0.25	0.75
District	17276	119020	193674	87716	96028	62227	31504	142659	153342	10465	209	189068	216578	12444	240088	1572298	0.10	0.90

(Source: District Statical Abstract of Ahmednagar: 2024)