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A GEOGRAPHICAL ASSESSMENT OF WATERSHED DEVELOPMENT PROGRAMME WORKS AND CROPPED AREA IN SATARA DISTRICT

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ABSTRACT

Watershed Development Programmes (WDP) have become an effective approach for strengthening agriculture in regions where rainfall is uneven and water scarcity affects cultivation. Satara district of Maharashtra provides a suitable setting for such a study because it shows sharp contrasts in relief and climate—from the high-rainfall, forested Western Ghats to the semi-arid eastern plateau. These physical differences strongly influence both the distribution of watershed works (such as check dams, percolation tanks, contour bunding, nala deepening and farm ponds) and the pattern of cropped area across tahsils. The present study assesses the tahsil-wise distribution of WDP works and examines their interrelationship with cropped area and cropping intensity in Satara district. The study is based on secondary data collected from the Satara District Socio-Economic Abstract (2024), District Agricultural Statistics (2025), Census and district reports. Statistical techniques such as works per village, percentage share, Z-score classification, and supporting measures (LQ and IDI where required) were applied to identify spatial intensity and regional variation. GIS (ArcGIS 10.5) was used for thematic mapping and spatial interpretation. The results show a clear geographical linkage between watershed development intensity and agricultural land use. Semi-arid tahsils such as Khatav, Phaltan, Man, Koregaon and Karad exhibit higher concentration of watershed works and also contribute a large share of cropped area with comparatively higher cropping intensity. Khatav tahsil stands out with very high watershed work intensity and the highest share of cropped area, indicating strong effectiveness of decentralized watershed interventions in supporting cultivation. In contrast, Mahabaleshwar tahsil and parts of the western hilly zone record low cropped area and low relationship due to steep slopes, dense forest cover and limited cultivable land, despite high rainfall. Tahsils like Wai, Khandala, Patan and Satara show a moderate relationship where agricultural performance is influenced by mixed physical constraints, uneven implementation and varying land-use conditions.

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INTRODUCTION

Watershed development programme works play a decisive role in shaping agricultural land use and cropped area patterns in Satara district. The district's marked physiographic diversity, ranging from the high-rainfall Sahyadri ranges to the semi-arid plateau region, has resulted in spatial variations in the implementation of watershed interventions such as check dams, percolation tanks, contour bunding, and nala deepening. These variations have directly influenced the extent and intensity of cropped area across tahsils. Tahsils like Karad, Man, and Satara, where watershed development works are more widely implemented, exhibit higher cropped area coverage and better agricultural stability. In contrast, tahsils such as Mahabaleshwar, Wai, and Khandala show relatively limited cropped area due to steep slopes, forest cover, and lower scope for effective watershed intervention. Statistical techniques including Z-score analysis, Location Quotient, Irrigation Development Index, and correlation analysis confirm a positive relationship between watershed development works and cropped area expansion. The findings further indicate that decentralized and small-scale watershed works have a stronger impact on sustaining cultivation compared to large centralized projects. Thus, watershed development programmes emerge as a key geographical determinant of cropped area distribution and agricultural development in Satara district.

NEED OF THE STUDY

Watershed Development Programme (WDP) works have emerged as a vital instrument for strengthening agriculture and expanding cropped area in regions experiencing rainfall uncertainty and water stress. Satara district, with its sharp geographical contrast between the high-rainfall Western Ghats and the semi-arid eastern plateau, presents a unique setting for examining the spatial impact of watershed interventions. Due to this physiographic diversity, the distribution and effectiveness of watershed development works are highly uneven across tahsils. Areas such as Karad, Man, and Satara have benefited more from systematic watershed interventions, while tahsils like Mahabaleshwar, Wai, and Khandala face natural and topographical constraints that limit their agricultural expansion.

Despite the large-scale implementation of watershed development programmes in the district, comprehensive geographical studies linking watershed works with cropped area patterns remain limited. Understanding how different types of watershed interventions influence agricultural land use, crop stability, and spatial variation in cropped area is therefore essential. Such an analysis is important not only for identifying regional imbalances but also for improving the effectiveness of future watershed planning.

The present study is undertaken with the following needs:

1. To understand the spatial variation in the distribution of watershed development programme works across Satara district, ranging from well-implemented tahsils (Karad, Man, Satara) to comparatively less-covered tahsils (Mahabaleshwar, Wai, Khandala).

2. To examine the influence of watershed development works on cropped area distribution and agricultural intensity across different tahsils.
3. To assess the relative contribution of various watershed interventions, such as check dams, percolation tanks, contour bunding, and nala deepening, in sustaining cultivation and enhancing cropped area.
4. To identify spatial imbalances in watershed development that contribute to unequal agricultural growth and land-use disparities in semi-arid regions.
5. To provide a geographical explanation of the relationship between watershed development works and cropped area using statistical measures such as Z-score, Location Quotient (LQ), and Irrigation Development Index (IDI).
6. To highlight the significance of decentralized and small-scale watershed works, which show stronger effectiveness in improving soil moisture availability and supporting sustained cropping.
7. To generate useful insights for regional planning and policy formulation aimed at balanced watershed implementation, equitable resource distribution, and sustainable agricultural development.
8. To employ GIS-based mapping and spatial analysis for visualizing the interrelationship between watershed development programme works and cropped area patterns in Satara district.

STUDY AREA

The present study is conducted in Satara district of Maharashtra, located in the western part of the state between 17°05′ to 18°11′ North latitude and 73°33′ to 74°54′ East longitude, covering a geographical area of 10,480 sq. km. Administratively, the district is divided into eleven tahsils, namely Karad, Satara, Phaltan, Man, Khatav, Koregaon, Patan, Wai, Khandala, Jawali, and Mahabaleshwar. According to Census 2011, Satara district has a total population of 30.03 lakh, of which 24.33 lakh (about 81%) reside in rural areas, distributed across 5.28 lakh households. Geographically, Satara district represents a transitional region marked by pronounced physical diversity. The western part of the district forms part of the Western Ghats, characterized by steep slopes, dense forest cover, and very high rainfall, particularly in tahsils such as Mahabaleshwar and Jawali. The central part of the district comprises fertile river basins of the Krishna, Koyna, and Nira rivers, covering tahsils like Karad, Satara, and Koregaon, where agricultural activity is relatively intensive. In contrast, the eastern region, including Man, Khatav, and Phaltan, consists of semi-arid plateaus and plains that frequently experience drought conditions. Rainfall distribution in the district is highly uneven, ranging from over 6000 mm in the Western Ghats to less than 600 mm in the eastern drought-prone tahsils, resulting in sharp agro-climatic contrasts. Agriculture forms the backbone of the district's economy, with major crops including sugarcane, cereals, pulses, oilseeds, and horticultural crops, all of which are strongly influenced by water availability and moisture conditions. To address water scarcity and support agriculture, Satara district has witnessed the implementation of a large number of watershed development programme works, along with irrigation infrastructure. The district has 121 irrigation projects, comprising 11 major, 17 medium, and 93 minor schemes, along with numerous decentralized watershed interventions such as check dams, percolation tanks, contour bunding, and nala deepening. These works are unevenly distributed across tahsils and play a significant

role in determining the extent and intensity of cropped area. The pronounced variation in physiography, rainfall, watershed development works, and agricultural land use makes Satara district an ideal region for examining the spatial relationship between watershed development programme works and cropped area from a geographical perspective.

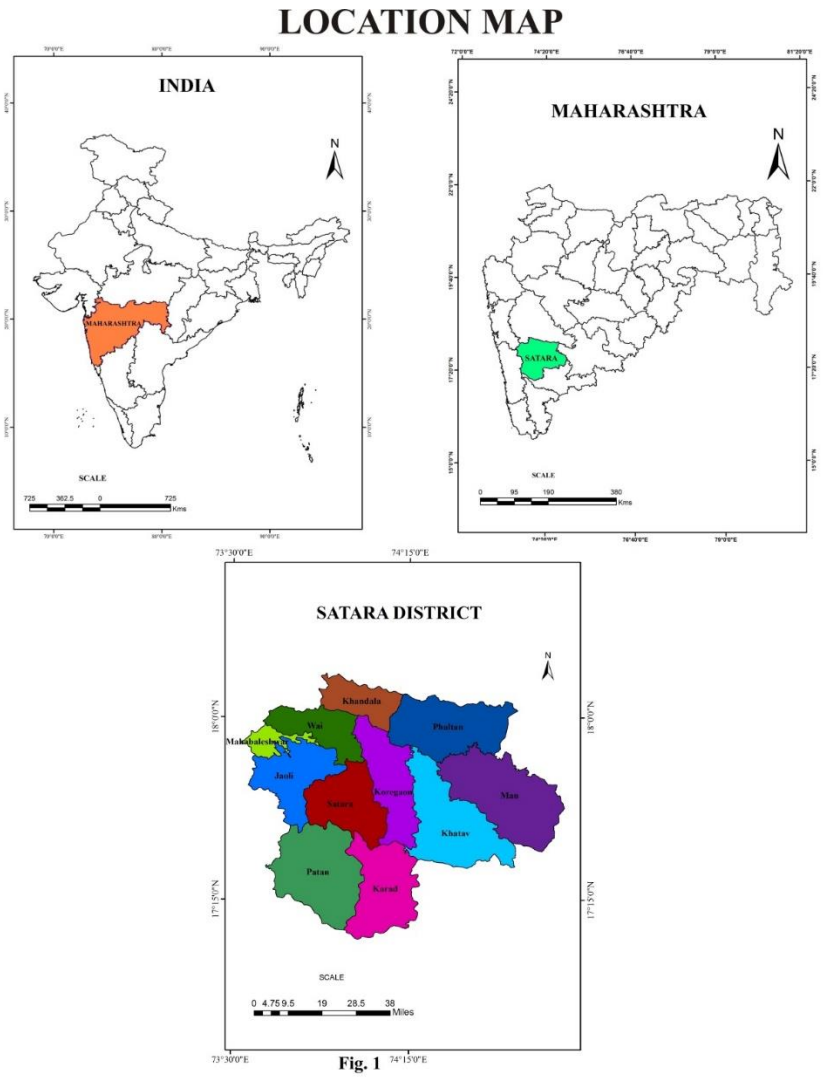

Fig. 1

OBJECTIVES OF THE STUDY

1. **To analyze the spatial distribution of Watershed Development Programme works across different tahsils of Satara district.**
2. **To examine the tahsil-wise distribution and variation of cropped area in relation to watershed development interventions.**
3. **To evaluate the relationship between the intensity of watershed development programme works and changes in cropped area using geographical and statistical techniques.**

DATABASE AND METHODOLOGY

The present study is based on secondary data collected from standard and reliable government sources. Information on Watershed Development Programme (WDP) works and village coverage was

taken from the Satara District Socio-Economic Abstract (2024), while cropped area and geographical area data were obtained from District Agricultural Statistics (2025). Supporting background information was referred from the Census of India (2011) and district-level reports wherever required.

For analysis, the study uses two main sets of variables. The first set relates to watershed development, including taluka-wise WDP works, selected villages covered, works per village, and Z-score for classifying the intensity of WDP implementation. The second set relates to agricultural land use, including cropped area, geographical area, cropping intensity, and percentage share of cropped area. These indicators help in understanding how watershed works are linked with agricultural expansion and intensity across tahsils.

The following computations were carried out:

Works per Village

Works per Village = WDP Works / Selected Villages

Cropping Intensity(%)

Cropping Intensity = Cropped Area / Geographical Area * 100

Percentage Share of WDP Works / Cropped Area

% Share = Tahsil Value / District Total * 100

Z-score (for WDP Work Intensity Classification)

$$Z = \frac{X - \bar{X}}{\sigma}$$

Z-score values were used to group tahsils into high, moderate, and low categories of watershed work intensity.

To understand the interrelationship, taluka-wise values of WDP intensity (works per village and Z-score) were compared with cropped area distribution (cropping intensity and share of cropped area). Based on this combined interpretation, tahsils were classified into low, moderate, high, and very high relationship categories. Finally, GIS techniques (ArcGIS 10.5) were used to prepare thematic maps and support spatial interpretation of the relationship between watershed development programme works and cropped area distribution. This combined approach of statistical analysis and spatial mapping provides a clear geographical explanation of how watershed interventions influence agricultural land use in Satara district.

WATERSHED DEVELOPMENT PROGRAMME WORKS

Watershed development refers to a systematic approach for conserving rainwater, improving soil moisture, and enhancing land productivity within a drainage basin. In Satara district, the implementation of watershed development programme works shows considerable spatial variation due to differences in physiography and rainfall. Semi-arid tahsils such as Khatav, Phaltan, and Man record higher intensity of watershed works, while Mahabaleshwar, Wai, and Khandala show lower coverage because of steep slopes and forest dominance. The predominance of small-scale and decentralized watershed interventions highlights their effectiveness in supporting agriculture and influencing cropped area patterns in the district.

Table No. 1
DISTRIBUTION OF WATERSHED DEVELOPMENT PROGRAMME WORKS IN SATARA DISTRICT (2025)

Sr. No.	Taluka	Selected Villages	WDP Works	Works per Village	% Share of WDP Works	Z-Score
1	Mahabaleshwar	110	88	0.80	6.69	−0.87
2	Wai	67	92	1.37	7.00	−0.80
3	Khandala	44	74	1.68	5.63	−1.04
4	Phaltan	128	170	1.33	12.93	+0.55
5	Man	106	119	1.12	9.05	−0.20
6	Khatav	89	199	2.24	15.13	+1.04
7	Koregaon	91	136	1.49	10.34	+0.12
8	Satara	53	69	1.30	5.25	−1.15
9	Jaoli	151	78	0.52	5.93	−1.00
10	Patan	324	151	0.47	11.48	+0.34
11	Karad	218	139	0.64	10.57	+0.16
Total / Avg.		**1381**	**1315**	**1.19**	**100.00**	**0.00**

Source: Satara District Socio-Economic Abstract, 2024

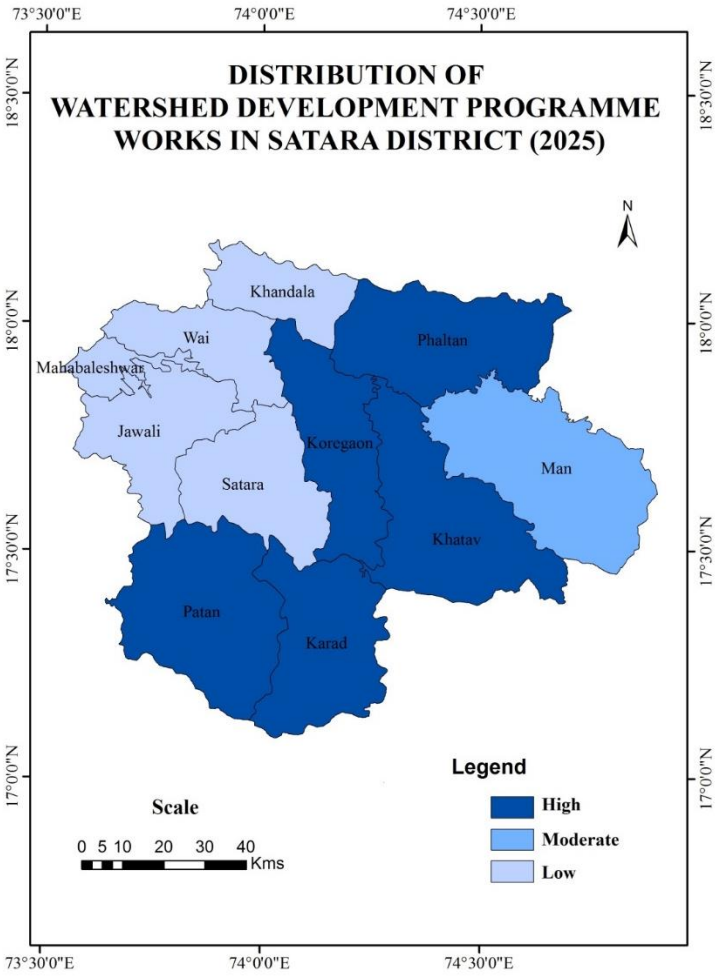

Fig.No. 2

The distribution of watershed development programme works in Satara district shows clear spatial variation, which can be grouped into high, moderate, and low intensity categories based on Z-score values (table no. 1 and Fig.no.2). High-intensity tahsils include Khatav, Phaltan, Patan, Koregaon, and Karad, where Z-scores are positive. Among these, Khatav stands out with the highest Z-score and the maximum

works per village, reflecting its semi-arid nature and strong need for water conservation measures. Phaltan and Patan also show higher concentrations of watershed works due to recurrent drought conditions and large agricultural areas requiring moisture support. In these tahsils, watershed development has been actively promoted to stabilize agriculture and improve soil moisture availability.

Moderate-intensity tahsils include Man, which shows a Z-score close to zero. Although Man is drought-prone, the moderate category reflects a balance between the number of villages and watershed works, indicating steady but not intensive implementation. These areas represent transitional zones where watershed development is present but still has scope for expansion to fully support agricultural needs. Low-intensity tahsils comprise Mahabaleshwar, Wai, Khandala, Satara, and Jaoli, all showing negative Z-scores. Mahabaleshwar and Jaoli, despite receiving heavy rainfall, have low watershed work intensity due to steep slopes, dense forest cover, and limited cultivable land. Wai, Khandala, and Satara also record lower values because of terrain constraints, urban influence, or reliance on other irrigation sources. In these tahsils, natural conditions and land-use patterns restrict the implementation of large-scale watershed interventions. Totally, the table clearly indicates that watershed development programme works are more concentrated in semi-arid and drought-prone tahsils where water scarcity directly affects agriculture. This spatial pattern highlights the geographical logic behind watershed planning in Satara district and underlines the role of watershed development in supporting agricultural sustainability.

CROPPED AREA

The distribution of cropped area in Satara district reflects the combined influence of physiography, rainfall variability, and watershed development programme works. Marked regional contrasts exist between the high-rainfall Western Ghats and the semi-arid eastern plateau, resulting in uneven agricultural land use. Tahsils with better coverage of watershed interventions, such as Karad, Satara, Man, and Khatav, record higher cropped area and cropping intensity due to improved soil moisture and water availability. In contrast, tahsils like Mahabaleshwar and Patan show lower cropping intensity because of steep slopes, forest cover, and limited cultivable land.

Table No. 2

DISTRIBUTION OF CROPPED AREA IN SATARA DISTRICT (2025)

Sr. No.	Tahsil	Cropped Area (ha)	Geographical Area (ha)	Cropping Intensity (%)	% Share of Cropped Area
1	Mahabaleshwar	4,899	22,190	**22.1**	**0.76**
2	Wai	39,659	61,909	**64.1**	**6.16**
3	Khandala	35,665	53,608	**66.5**	**5.54**
4	Phaltan	70,277	119,029	**59.0**	**10.92**
5	Man	91,267	150,787	**60.5**	**14.18**
6	Khatav	96,392	136,457	**70.7**	**14.97**
7	Koregaon	61,056	94,840	**64.4**	**9.48**
8	Satara	71,996	87,953	**81.9**	**11.19**
9	Jaoli	39,984	86,895	**46.0**	**6.21**
10	Patan	54,903	140,364	**39.1**	**8.53**
11	Karad	77,553	104,211	**74.4**	**12.05**
Total / Avg.		**643,651.2**	**1,058,243**	**60.8**	**100.00**

Source: Satara District Socio-Economic Abstract, 2025

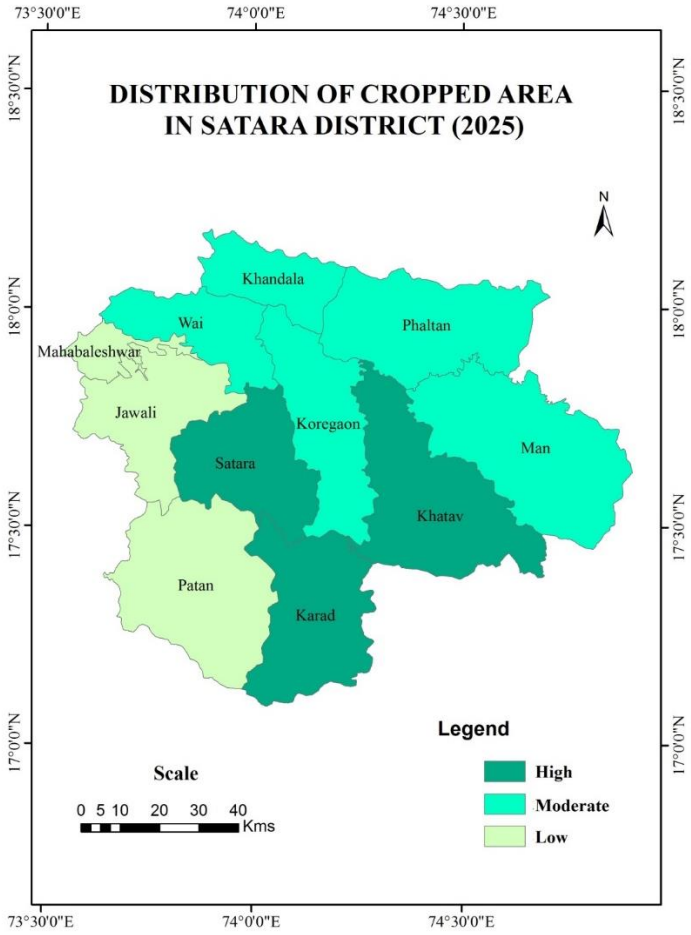

Fig.No. 3

The distribution of cropped area in Satara district shows clear spatial variation, reflecting differences in physiography, rainfall, soil conditions, and the effectiveness of watershed development programme works (table no. 2 and Fig. 2). Based on cropping intensity and share of cropped area, the tahsils can be broadly classified into high, moderate, and low cropped area categories. Tahsils falling in the high cropped area and high cropping intensity category include Satara, Karad, and Khatav. These tahsils record cropping intensity above the district average and contribute a large share of the total cropped area. The favourable river basin location, better soil moisture conditions, and higher concentration of watershed and irrigation interventions have supported intensive agriculture in these areas. Assured water availability has enabled multiple cropping and the cultivation of water-intensive crops such as sugarcane, resulting in higher agricultural stability. The moderate category consists of Man, Phaltan, Koregaon, Wai, and Khandala. These tahsils show reasonably high cropped area but relatively moderate cropping intensity. Most of these regions lie in the semi-arid zone, where agriculture is dependent on rainfall supplemented by watershed works and minor irrigation schemes. While watershed interventions have helped expand cultivated land, limitations such as erratic rainfall and soil constraints prevent very high cropping intensity. The low cropped area category includes Mahabaleshwar, Jaoli, and Patan. Mahabaleshwar records the lowest cropping intensity due to steep slopes, dense forest cover, and its dominance as a hill and tourism region, leaving little land available for cultivation. Jaoli and Patan also show low to moderate cropping intensity because of rugged terrain, forested areas, and dispersed

agricultural land. In these tahsils, physiographic constraints limit the effectiveness of watershed works and restrict agricultural expansion. Totally, the table clearly indicates that tahsils with better coverage of watershed development programme works and favourable physical conditions exhibit higher cropped area and cropping intensity. This pattern highlights the strong geographical relationship between watershed development and agricultural land use in Satara district.

THE INTERRELATIONSHIP BETWEEN WATERSHED DEVELOPMENT PROGRAMME WORKS AND CROPPED AREA DISTRIBUTION IN SATARA DISTRICT

The distribution of cropped area in Satara district is closely linked to the spatial pattern of watershed development programme works. Variations in physiography, rainfall, and the intensity of watershed interventions have created noticeable differences in agricultural land use across tahsils. Areas with higher concentration of watershed works generally show greater cropped area and higher cropping intensity, while regions with limited or uneven watershed development remain agriculturally weaker. This relationship highlights the crucial role of watershed development programmes in shaping cropped area distribution and agricultural sustainability in Satara district.

The interrelationship between watershed development programme works and cropped area distribution becomes evident when taluka-wise data are examined together. Areas with strong watershed coverage demonstrate higher cropped area share and more intensive land use, while areas with weaker or uneven watershed implementation remain agriculturally less developed. Thus, watershed development emerges as a key geographical factor influencing the spatial pattern of cropped area in Satara district and forms an essential foundation for sustainable agricultural development.

TABLE No. 3
INTERRELATIONSHIP BETWEEN WATERSHED DEVELOPMENT PROGRAMME WORKS AND CROPPED AREA DISTRIBUTION IN SATARA DISTRICT (2025)

Sr. No.	Taluka	WDP Works	Works per Village	Z-Score (WDP)	Cropped Area (ha)	Cropping Intensity (%)	% Share of Cropped Area	Relationship Category
1	Mahabaleshwar	88	0.80	−0.87	4,899	22.1	0.76	Low
2	Wai	92	1.37	−0.80	39,659	64.1	6.16	Moderate
3	Khandala	74	1.68	−1.04	35,665	66.5	5.54	Moderate
4	Phaltan	170	1.33	+0.55	70,277	59.0	10.92	High
5	Man	119	1.12	−0.20	91,267	60.5	14.18	High
6	Khatav	199	2.24	+1.04	96,392	70.7	14.97	Very High
7	Koregaon	136	1.49	+0.12	61,056	64.4	9.48	High
8	Satara	69	1.30	−1.15	71,996	81.9	11.19	Moderate–High
9	Jaoli	78	0.52	−1.00	39,984	46.0	6.21	Low
10	Patan	151	0.47	+0.34	54,903	39.1	8.53	Moderate
11	Karad	139	0.64	+0.16	77,553	74.4	12.05	High
Total / Avg.	—	**1315**	**1.19**	**0.00**	**643,651**	**60.8**	**100.00**	—

Source: Satara District Socio-Economic Abstract (2024); District Agricultural Statistics (2025), **Computed by Researcher**

Table No. 3 clearly give details the interrelationship between watershed development programme works and cropped area distribution across different tahsils of Satara district. The table shows that tahsils with a higher intensity of watershed development works generally record larger cropped areas and higher cropping intensity. Khatav tahsil stands out with the highest number of WDP works, the highest works-per-village ratio, a strong positive Z-score, and the highest share of cropped area, indicating a very high relationship between watershed works and agricultural expansion. Phaltan tahsil, Man tahsil, Koregaon tahsil, and Karad tahsil also fall in the high relationship category, where effective watershed interventions have improved soil moisture conditions and supported stable cultivation.

In contrast, Mahabaleshwar tahsil and Jaoli tahsil show a low relationship due to steep slopes, forest cover, and limited cultivable land, resulting in low cropped area and cropping intensity despite rainfall availability. Wai tahsil, Khandala tahsil, Patan tahsil, and Satara tahsil exhibit a moderate to moderate–high relationship, reflecting partial benefits of watershed works influenced by terrain, urban pressure, or uneven implementation. Totally, the table confirms a strong geographical linkage between watershed development programme works and cropped area distribution in Satara district, emphasizing that well-distributed and decentralized watershed interventions play a crucial role in enhancing agricultural land use and regional agricultural stability.

CONCLUSIONS

The research study clearly reveals a strong geographical interrelationship between watershed development programs and the distribution of cultivated area in Satara district. Significant variations in topography and rainfall have led to uneven implementation of watershed development works, consequently shaping agricultural land use patterns across the tahsils. Semi-arid tahsils such as Khatav, Phaltan, Man, Koregaon, and Karad exhibit a higher intensity of watershed development works, and correspondingly, higher cultivated area and cropping intensity, demonstrating the effectiveness of decentralized and small-scale watershed interventions. Conversely, in hilly and forest-dominated tahsils like Mahabaleshwar and Jawali, despite high rainfall, the cultivated area is low due to topographical limitations and scarcity of arable land. Tahsils with moderate watershed coverage show moderate agricultural performance, influenced by both natural and anthropogenic factors. Totally, these findings demonstrate that watershed development programs play a crucial role in improving soil moisture, increasing cultivated area, and strengthening agricultural resilience. Therefore, balanced and region-specific watershed planning is essential for sustainable agricultural development and regional equity in Satara district.

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