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Climate Change Impacts on Agriculture for Dhule District, in Maharashtra

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Abstract: This paper assesses observed and projected climate-change-related impacts on agriculture in Dhule district (north Maharashtra), synthesizes local evidence on rainfall variability, groundwater trends, crop vulnerability, and livelihood implications, and proposes prioritized adaptation pathways for farmers, local government and NGOs. Using a mixed-methods literature synthesis (local studies, district reports, IMD gridded products, groundwater surveys, and recent news on crop damages), we find that increasing rainfall variability, recurring drought episodes, declining groundwater in parts of the district, and more frequent extreme weather events are already destabilizing crop yields and smallholder incomes. Priority adaptation actions include integrated watershed recharge, diversification to drought-tolerant crops and millets, expansion of micro-irrigation, improved climate services and reforms to insurance/credit delivery. Key evidence sources include district agricultural profiles, IMD gridded rainfall datasets and local studies of Dhule's agricultural-climate linkages.

Keywords: *Dhule in Maharashtra, Climate Change, Agriculture, Rainfall Variability, Groundwater, Adaptation, Cotton, Millets.*

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I. INTRODUCTION

Agriculture in Dhule district is predominantly rainfed and supports a majority of local livelihoods. Major crops include cotton, jowar (sorghum), bajra (pearl millet), groundnut, maize and soybean, with limited paddy cultivation in parts of Sakri taluka. Climate change — manifesting as changes in monsoon timing, increased inter-annual variability, rising frequency of heat extremes and episodic intense rainfall events — poses a substantial risk to production stability and farmer incomes in the district. This paper consolidates available empirical evidence for Dhule and nearby Khandesh region, links observed climate trends to agricultural outcomes, and lays out context-relevant adaptation and policy recommendations. [1]

II. STUDY AREA: DHULE DISTRICT

Dhule sits in north-western Maharashtra (Khandesh), with semi-arid to sub-humid climate zones and mean annual rainfall that varies across talukas (district average ~500–600 mm). Agriculture is the main livelihood—about two-thirds of net sown area is cropped and major kharif crops are cotton and millets; rabi includes wheat, gram and some oilseeds. Groundwater constitutes a critical buffer for dry spells but shows spatially heterogenous depletion and quality issues. Institutional initiatives include watershed projects and periodic state/national schemes for micro-irrigation and crop insurance.[2][5]

III. DATA & METHODS (APPROACH USED TO PREPARE THIS PAPER)

This paper is a focused research synthesis combining:

- Peer-reviewed and grey literature specifically on Dhule or the Khandesh region (trend analyses, district studies).
- District government and planning documents (district profile, NABARD PLP) for cropping patterns and area statistics.
- Groundwater and aquifer reports from the Central Ground Water Board (CGWB) for observed water-table trends. [3][6]
- IMD gridded rainfall datasets and published analyses of Maharashtra rainfall variability to infer monsoon trend directions relevant to Dhule.[4]

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- Recent regional news documenting crop damages from extreme weather to illustrate recent shocks.

➢ *Constraints and Limitations*

The paper synthesizes available published and official sources rather than conducting new primary field surveys or statistical re-analysis; where local station-level time series are required for rigorous trend estimation, IMD gridded products and referenced district studies were used in lieu of raw station archives. Where possible, claims are supported with district-specific reports and recent local studies.

IV. OBSERVED CLIMATE TRENDS AFFECTING DHULE AGRICULTURE

➢ *Rainfall Variability and Monsoon Irregularity*

Multiple studies indicate increasing inter-annual and intra-seasonal variability of the southwest monsoon over Maharashtra and the Khandesh region. Trend analyses that include Dhule find no simple uniform increase in mean annual rainfall; instead, variability has risen (higher coefficient of variation), with more years of deficit and occasional intense rainfall events. This variability is directly relevant to Dhule's largely rainfed cropping systems because delayed onset or uneven distribution of seasonal rains reduces planting windows and crop establishment.[5]

➢ *Temperature and Heat Extremes*

Regional analyses for Maharashtra report increasing frequency of hot days and heat waves during the pre-monsoon and post-monsoon periods. Higher temperatures exacerbate crop water stress, shorten crop phenophases (reducing yields), and increase evapotranspiration demand—factors that compound damage during deficient rainfall years. (IMD datasets and regional studies document these warming signals across Maharashtra.) [4]

➢ *Groundwater Trends and Water Security*

CGWB aquifer and groundwater management reports for Dhule document spatially variable declines in depth-to-water (DTW) in several talukas (notably parts of Sindkheda, Shirpur, Sakri and Dhule blocks) and identify areas with critical water levels. Declining groundwater increases irrigation costs and reduces the reliability of wells during droughts, directly weakening farmers' capacity to cope with monsoon failure.[1][3][6]

➢ *Recent Extreme-Event Impacts (Illustrative)*

News reporting from 2025 documents heavy rain and wind events that damaged ~2,348 hectares of crops in Dhule and neighboring districts, demonstrating the real-time vulnerability of farmers to episodic extremes (wind damage, lodging, flash floods, and post-event pest/disease outbreaks). These one-off shock events compound chronic stresses (droughts, groundwater decline).

V. AGRICULTURAL IMPACTS (CROP-LEVEL AND SOCIO-ECONOMIC)

➢ *Crop Vulnerability and Yield Stability*

- Cotton: A major cash crop in Dhule and north-Maharashtra. Cotton is sensitive to both dry spells (during flowering and boll formation) and to excessively wet conditions (which increase pest incidence and boll rot). Observations and farm surveys show income volatility when climatic extremes strike.
- Millets (jowar, bajra) and maize: These cereals are more drought-tolerant than many cash crops, but their yields still decline sharply in prolonged drought years and with shifted monsoon timing. Farmer responses often include area reduction or late sowing.
- Pulses and oilseeds: Crop failures and reduced quality in wet-dry transitional years are reported; pulses provide important protein and are risk buffers but are also rainfall-sensitive.[8]

➢ *Livelihoods and Coping*

A large share of households depends on agriculture — both as cultivators and as agricultural laborers. Climate shocks increase the need for distress sales, reduce daily wages, and push some households toward seasonal migration or indebtedness. Availability of formal insurance and timely relief is uneven; farmer dissatisfaction with insurance payouts has been reported across Maharashtra, highlighting gaps in financial protection.[7]

➢ *Water Access and Input Costs*

Declining groundwater depth and variability in surface water availability increase pumping costs and erode the ability to apply life-saving irrigation during critical crop stages. This disproportionately affects smallholders with limited capital access for deepening wells or installing pumps.

VI. ADAPTATION OPTIONS AND BEST PRACTICES FOR DHULE

Based on the synthesis of local studies, district programs, and relevant literature, the following adaptation measures are recommended as priority, grouped by theme.

➢ *Water Management & Landscape Measures*

- Integrated watershed management and recharge: Constructing and maintaining check dams, percolation tanks, contour bunds and farm ponds to capture monsoon runoff and raise groundwater. These measures are highly relevant in Dhule's terrain and have local precedent.
- Micro-irrigation: Scale up drip and sprinkler irrigation for high-value and water-sensitive crops to improve water-use efficiency. NABARD and state subsidy programs can help adoption. 6.2 Crop and farming system adjustments.[7]

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- Diversification & drought-tolerant crops: Promote short-duration, drought-tolerant varieties of millets, improved sorghum cultivars and resilient oilseed/pulse varieties to spread risk and preserve soil moisture
- Staggered sowing and crop rotation: Use seasonal advisories to optimize sowing windows; rotate with legumes to restore soil fertility.
- Soil health and agroecological practices: Mulching, cover crops, organic matter additions and agroforestry to increase soil moisture retention and resilience.

➢ *Institutional & Financial Measures*

- Improved climate services & extension: Localized seasonal forecasts, SMS advisories, and farmer field schools to translate forecast information into sowing, input and pest-management decisions.[2]
- Insurance & credit reforms: Improve timeliness and fairness of crop insurance (PMFBY) payouts, quicker loss assessment (panchanama) and flexible credit to support recovery. Recent farmer protests in the state underscore the need for improved delivery.

VII. RECOMMENDATIONS (ACTIONABLE, SHORT TERM → LONG TERM)

- Immediate (1 year): Strengthen extension for sowing-window advisories using IMD/State gridded forecasts; accelerate timely panchanama and insurance settlement after extreme events
- Medium (1–3 years): Scale micro-irrigation subsidies to smallholders; implement targeted groundwater recharge projects in critical talukas; promote drought-tolerant seed systems and farmer training.
- Long (3–7 years): Institutionalize district climate monitoring (station density, local downscaled forecasts), mainstream climate risk-informed crop planning in the district agricultural plan, and expand market/processing linkages for drought-resilient crops (millets, pulses).[9][13][14]

Table 1 Parameter Table for Dhule District (Climate, Rainfall, Water Resources)

Parameter	Value / Reading	Period/ Notes/ Taluka-wise if Available	Source/ Remarks
Long-term normal annual rainfall	608.4 mm	1998–2020	Central ground water resources
Standard deviation of annual rainfall	173.05 mm	1998–2020	Central ground water resources
Coefficient of variation (rainfall)	27.07%	1998–2020	Central ground water resources
Rainfall trend (decline rate)	–1.526 mm/year	1998–2020	Central ground water resources

Table 2 Taluka-Wise Decadal Average Rainfall (2002 - 2011)

Dhule: 589.5mm	589.5mm	2011-2020	Central ground water resources
Sakri	648.2mm	2002-2011	Central ground water resources
Shirpur	874.8mm	2002-2011	Central ground water resources
Sindkheda	589.5mm	2002-2011	Central ground water resources

Here, are the two graphs one showing the annual rainfall trend (2011–2020) and another showing taluka-wise decadal average rainfall (2002–2011) — based fully on the table values you provided.[9][10][11]

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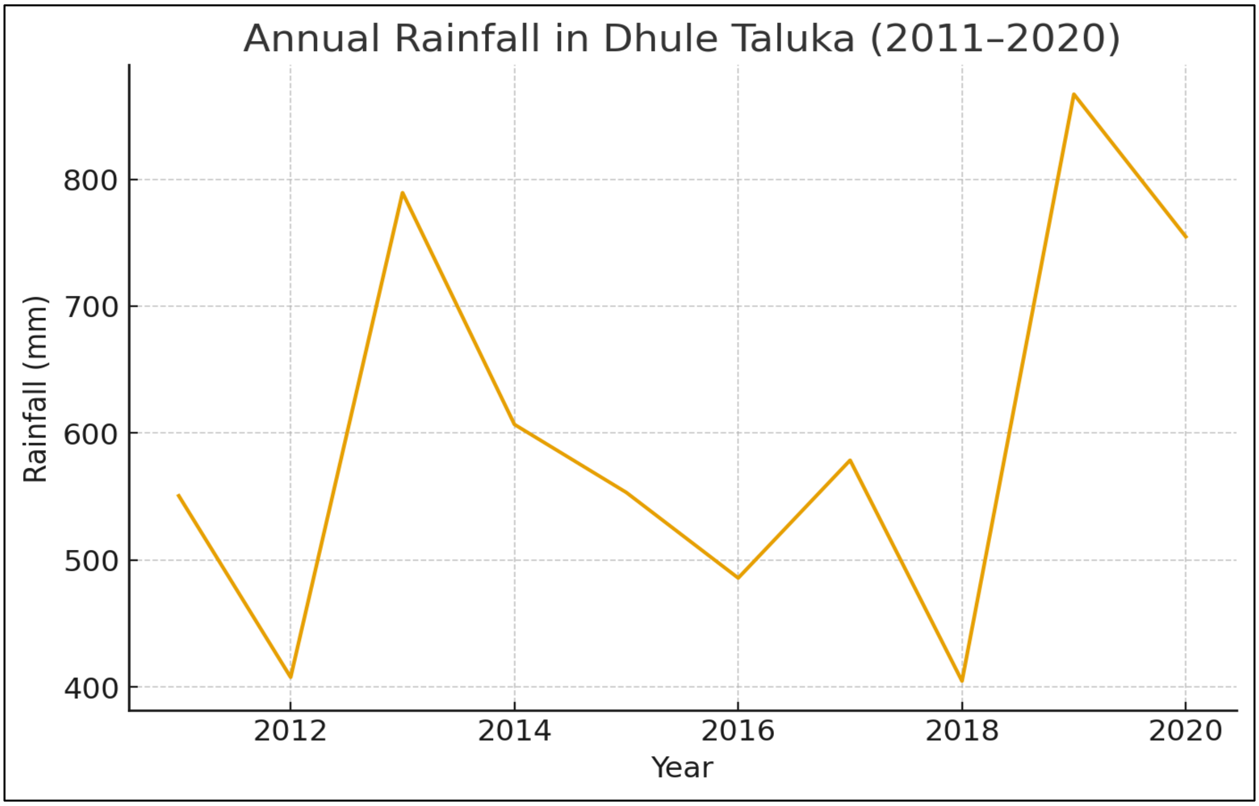

Fig 1 Annual Rainfall in Dhule Taluka (2011-2020)

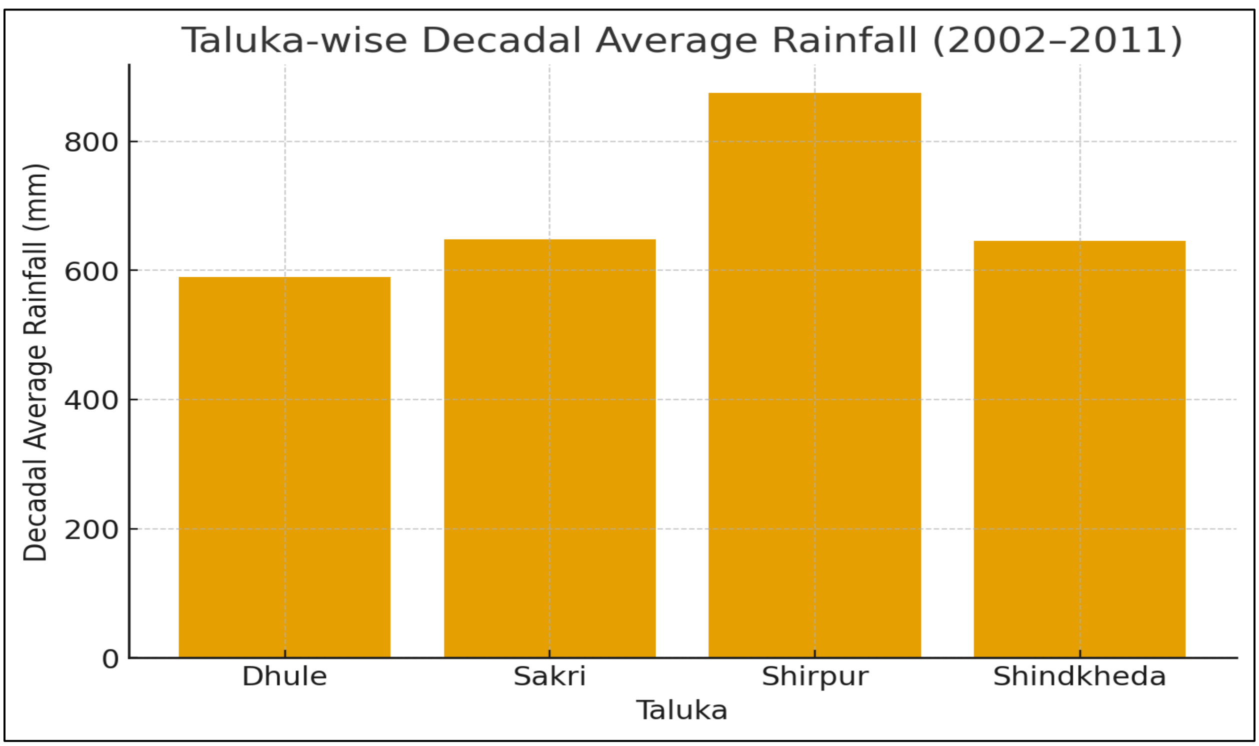

Fig 2 Taluka-Wise Decadal Average Rainfall (2002-2011)

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VIII. DISCUSSION

The convergence of higher monsoon variability, localized groundwater decline, and more frequent extremes creates both chronic and acute risks for Dhule's agriculture. While structural investments (watershed recharge, micro-irrigation) address medium-term resilience, short-term actions (accurate advisories, input support aftershocks, timely insurance payouts) are essential to prevent distress and protect livelihoods. Interventions need to be spatially targeted: talukas with critically declining groundwater and historically low rainfall (for example, parts of Sindkheda, Shirpur and Sakri) should receive priority for recharge and drought-proofing. Local studies and district plan already advocate many of these measures; the challenge is scaling and institutional coordination.[11][12]

IX. CONCLUSIONS

Evidence synthesized for Dhule district shows that climate change is already affecting agricultural stability via increased rainfall variability, episodic extremes, and groundwater stress. Impacts are crop- and livelihood-specific, with cotton and other cash crops particularly vulnerable.

A mix of technical (watershed recharge, micro-irrigation, drought-tolerant crops), institutional (climate services, insurance reforms) and financial measures (credit, subsidies) is required. Prioritization should be data-driven, targeting the driest talukas and the most vulnerable households while strengthening district-level climate monitoring and farmer advisory systems.[11][12][13][14]

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