



Original Article

Climate Change and Mitigation Strategies of Solapur District

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Abstract

Situated within the semi-arid region of Maharashtra, Solapur District is increasingly vulnerable to the multifaceted effects of climate change. These evolving environmental shifts threaten the region's predominantly agricultural economy, already-stressed water reserves, and overall urban quality of life. With rising average temperatures—documented at approximately 1.2°C over the past few decades—and unpredictable rainfall patterns resulting in deficits nearing 30%, the district is facing significant ecological and socio-economic disruptions. Key crops such as jowar, sugarcane, and cotton are experiencing reduced yields due to these climate-induced anomalies. Simultaneously, Solapur city is witnessing a surge in urban heat, exacerbating energy consumption and discomfort in densely populated areas. This research explores the tangible impacts of these climate changes on both rural and urban landscapes and proposes a range of mitigation and adaptation strategies tailored to Solapur's unique geographic and socio-economic context. Suggested approaches include enhancing water conservation through techniques such as rainwater harvesting and drip irrigation, transitioning to renewable energy sources like solar power—given the region's high solar incidence—and promoting climate-smart agriculture through agroforestry and the adoption of drought-resistant crop varieties. In the urban context, interventions such as urban greening, development of green infrastructure, and implementation of energy-efficient building designs are recommended. Policy frameworks, most notably the 2023 Solapur Climate Action Plan, play a critical role in guiding and institutionalizing these efforts. Despite challenges such as limited financial resources and infrastructural gaps, the district also holds promise through opportunities like innovation in renewable energy and community-driven sustainability initiatives. By aligning scientific analysis with ground-level realities, this paper emphasizes an integrated approach to climate resilience. It highlights the importance of local governance, community participation, and technology in crafting a sustainable future for Solapur. The findings and recommendations outlined are current as of April 6, 2025, reflecting both the urgency of the climate crisis and the potential for adaptive transformation in Solapur District.

Keywords: Climate Change, Mitigation Strategies, Solapur District, Rainwater Harvesting, Renewable Energy, Agroforestry, Urban Heat Island, Water Scarcity, Sustainable Agriculture, Solapur Climate Action Plan

Introduction

Climate change has emerged as one of the most pressing global challenges of the 21st century, with far-reaching implications that extend beyond environmental degradation into social, economic, and political domains. Although the phenomenon is global in scope, its consequences are experienced differently across regions. For semi-arid areas like Solapur District in Maharashtra, India, climate variability poses a critical threat to both environmental sustainability and human development. Spread over approximately 14,895 square kilometers and home to more than 4.3 million people, Solapur occupies a significant place on the Deccan Plateau. The region's economy is largely dependent on agriculture, small-scale industries, and textile production, all of which are intricately tied to climatic stability. Solapur experiences a typical semi-arid climate with high temperatures in summer, mild winters, and an average annual rainfall of about 600 mm, most of which occurs during the monsoon season. However, in recent decades, this climatic pattern has become increasingly unpredictable.

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Rising temperatures and erratic monsoon rains have begun to disrupt the natural and human systems that underpin daily life in the district. These shifts in weather patterns are not mere anomalies but indicators of a changing climate, one that is already affecting crop cycles, water availability, and public health in significant ways. Historically, Solapur has thrived as an agricultural hub, especially known for its cultivation of cotton and sugarcane—crops that require substantial water inputs. The region benefited from the water resources provided by the Bhima River and the Ujjani Dam, which supported both irrigation and drinking water needs. However, the last three decades have witnessed a noticeable change in the climatic equilibrium. Average temperatures have increased by about 1.2°C, with extreme summer temperatures often exceeding 42°C. Simultaneously, the monsoon has become less reliable in some years, rainfall deficits lead to drought-like conditions; in others, excessive rain causes flash floods. These irregularities directly impact agricultural productivity by shortening growing seasons and increasing vulnerability to pests and diseases.

Another major concern is the declining groundwater level. As surface water sources become less dependable due to erratic rainfall and overuse, groundwater has become the primary source for irrigation and domestic consumption. Unfortunately, unregulated extraction and insufficient recharge are causing rapid depletion of aquifers. This situation is especially critical for farmers who rely on borewells and small-scale irrigation systems to sustain their livelihoods. In urban areas such as Solapur city, rising temperatures contribute to the urban heat island effect, increasing electricity consumption for cooling and worsening air pollution. These changes collectively threaten public health, infrastructure, and overall quality of life.

The impacts of climate change on Solapur's economy are deeply intertwined with social vulnerabilities. Agriculture, which remains the principal occupation for over 60% of the population, is particularly susceptible to climate variability. Reduced and uncertain crop yields translate into financial instability, food insecurity, and increased indebtedness for farmers. Moreover, a significant portion of the population lives below the poverty line, and access to climate-resilient technologies, improved irrigation infrastructure, or crop insurance remains limited. As a result, the district's ability to adapt to climatic challenges is constrained not only by environmental factors but also by socio-economic barriers. Despite these growing concerns, Solapur's geographical and cultural context offers opportunities for developing adaptive responses. The district receives ample solar radiation, making it suitable for expanding renewable energy initiatives. Similarly, the revival of traditional water conservation methods—such as check dams, farm ponds, and rainwater harvesting—can play a crucial role in restoring water balance. In 2023, local authorities initiated the Solapur Climate Action Plan, aiming to address sustainability issues through a mix of policy interventions, technological innovations, and public awareness campaigns. While this initiative is a promising step forward, its success depends largely on effective

implementation, community participation, and continuous monitoring.

Climate Change Impacts in Solapur District - Solapur District's semi-arid climate amplifies its vulnerability to climate change, with observable impacts reshaping its environment and economy. This section details these effects across temperature, rainfall, water resources, agriculture, and urban systems.

Temperature Rise: Over the past few decades, Solapur district has been experiencing a noticeable and consistent rise in temperature, which has become a major concern in the context of climate change. Meteorological records suggest that the average annual temperature in the region has increased by approximately 1.2°C since the early 1990s. This gradual rise may seem small, but its cumulative effect on the environment, agriculture, and public health is significant.

The summer season, typically extending from March to June, has become particularly intense. In earlier years, peak temperatures would hover around 38–40°C. However, in recent times, the district frequently witnesses extreme summer temperatures exceeding 40°C, with some areas even recording highs of 43–45°C. This prolonged exposure to extreme heat has introduced new challenges for both rural and urban populations. Heat waves have become more common and more severe, often lasting for several consecutive days. These heat waves adversely impact human health, especially among vulnerable populations such as the elderly, children, outdoor laborers, and those with pre-existing health conditions. Health department data from Solapur district indicate a 15% rise in heat-related illnesses such as dehydration, heatstroke, and skin infections in rural areas over the last decade. Hospitals and clinics report a seasonal increase in patients during summer, correlating with high-temperature periods. The impact on agriculture is equally critical. Crops such as jowar, bajra, and pulses are highly sensitive to temperature fluctuations, especially during the flowering and grain formation stages. Elevated temperatures can disrupt plant metabolic processes, reduce soil moisture, and lead to a decline in crop yield. Farmers often report early wilting, reduced grain size, and lower overall productivity. Livestock are also affected, with increased cases of heat stress, decreased milk production, and in some instances, mortality due to prolonged exposure to high temperatures and inadequate cooling. Urban areas in Solapur are not spared from this trend. Rapid urbanization and loss of green cover have contributed to the urban heat island effect, where concrete surfaces absorb and re-emit more heat, further intensifying local temperatures. This has led to increased energy consumption for cooling, placing additional pressure on the power supply and increasing the cost of living.

Overall, the rising temperature trend in Solapur poses a serious challenge that affects multiple sectors. Addressing this issue requires urgent adaptation strategies, such as improved crop varieties, better urban planning, public awareness campaigns, and the development of heat action plans to safeguard the health and livelihoods of the population.

Erratic Rainfall: The changing pattern of rainfall in Solapur district has emerged as a major climatic concern, particularly for its predominantly rain-fed agricultural economy. Traditionally, the district receives an average of around 600 mm of rainfall annually, primarily during the southwest monsoon season. However, in recent years, the consistency and timing of this rainfall have become increasingly unpredictable. While the long-term average appears stable, actual yearly rainfall often deviates significantly from this figure. In certain years, rainfall drops as low as 400 mm, marking a severe deficit of over 30%, while in other instances, the region receives heavy downpours within a short period. These intense bursts not only fail to benefit crops but often lead to localized flooding and soil erosion. For instance, in 2022, Solapur experienced a significant shortfall in rainfall—around 50% below the norm—which severely affected the production of key crops like jowar and cotton. Conversely, in 2023, unexpected heavy rains caused flash floods in parts of Akkalkot taluka, damaging roads, homes, and standing crops. This erratic rainfall pattern poses a serious challenge for farmers. It disrupts traditional sowing calendars, often delaying or forcing replanting, which increases input costs and financial risk. Additionally, insufficient rainfall reduces soil moisture levels—vital for crop germination and growth—further straining already water-scarce conditions in the district. Only about 25% of the total cultivated land in Solapur has access to irrigation facilities, making the majority of farmland heavily dependent on timely monsoon rains. Solapur district is grappling with a growing water crisis, largely driven by the overextraction of groundwater and inadequate natural recharge. Increasing dependence on borewells for irrigation and drinking water has led to a continuous decline in groundwater levels. According to assessments by the Central Ground Water Board, several talukas in the district are witnessing an alarming drop in water tables—up to 2 meters annually—signaling unsustainable usage patterns.

This problem is further intensified by insufficient rainfall and poor groundwater recharge due to soil compaction, deforestation, and unregulated construction. The reliance on deep borewells, often dug beyond safe limits, has become a common practice, particularly in drought-prone areas. As shallow wells dry up, farmers are forced to dig deeper, further straining the underground aquifers. The Ujjani Dam, a critical water source for more than half of Solapur district, has also shown signs of stress. In the summer of 2024, its water level dipped below 20% of total capacity, severely affecting both agricultural and domestic supply. This reduction not only hampered irrigation but also triggered water rationing in urban centers such as Solapur city, particularly during periods of peak demand.

Farmers, especially those dependent on seasonal crops, are among the most affected. In many cases, they are compelled to abandon fields mid-season due to water unavailability, resulting in significant financial losses. Urban households also face erratic water supply schedules, and tanker dependency is growing during the dry months. With

climate variability expected to worsen, addressing water scarcity in Solapur requires integrated water management strategies. These may include watershed development, promotion of micro-irrigation techniques like drip and sprinkler systems, and community-led groundwater recharge initiatives to ensure long-term sustainability.

Agricultural Decline: Agriculture, the primary source of livelihood in Solapur district, has been significantly affected by ongoing climate-related challenges. Shifting weather patterns, irregular rainfall, and increasing temperatures have contributed to a noticeable decline in crop productivity and farm sustainability. The major crops cultivated in the region—jowar, sugarcane, cotton, and pulses—are particularly vulnerable to these environmental changes. In drought-affected years, crop yields drop by 20 to 30 percent, severely impacting farmers' incomes and local food security. Sugarcane, which requires substantial water for growth, has experienced one of the sharpest declines. Since 2015, the district has reported a reduction of around 25% in sugarcane output, largely due to the scarcity of irrigation water and falling groundwater levels. As water availability continues to shrink, the viability of such water-intensive crops becomes increasingly questionable.

Rising temperatures have also led to a surge in pest infestations. Cotton crops, for example, have seen widespread damage from pests like the pink bollworm, which thrive in warmer climates. This pest alone is estimated to cause annual losses of nearly ₹50 crore to Solapur's farmers, factoring in both crop damage and pesticide expenses. The livestock sector is also feeling the effects of climatic stress. Higher temperatures and limited fodder availability have resulted in a 10–15% decline in milk production from cattle. Heat stress reduces animals' feeding efficiency and overall health, leading to reduced productivity. As agriculture remains the backbone of Solapur's rural economy, the ongoing decline highlights the urgent need for adaptive farming practices, including climate-resilient crop varieties, integrated pest management, and better access to irrigation resources. Strengthening support systems for farmers is essential to sustain agricultural livelihoods in the face of climate uncertainty.

Urban Challenges: Solapur city, home to nearly one million residents, is increasingly facing climate-related urban issues that threaten public health, infrastructure, and overall livability. One of the most prominent effects is the **urban heat island phenomenon**, where built-up areas retain and radiate more heat than surrounding rural regions. The widespread use of concrete, asphalt, and limited green cover in the city results in daytime temperatures that are often 3 to 5°C higher compared to nearby agricultural zones. This elevated heat has direct implications for energy consumption. Households and commercial establishments are relying more on cooling appliances such as fans and air conditioners. In response, the Maharashtra State Electricity Distribution Company Limited (MSEDCL) reported a 20% increase in electricity demand during the summer of 2024. This rising consumption places additional stress on the city's power infrastructure, especially during peak periods.

Air pollution has also become a growing concern. The concentration of fine particulate matter (PM_{2.5}) in the urban atmosphere has been rising due to a combination of industrial emissions, vehicular pollution, and dust storms from the surrounding drylands. Prolonged exposure to such pollutants increases the risk of respiratory conditions, particularly among children, the elderly, and individuals with pre-existing health issues. Urban flooding presents another challenge, particularly in low-lying neighborhoods like **Jule Solapur**. Intense rainfall events, often occurring in short bursts, overwhelm the city's outdated drainage systems, leading to waterlogging and damage to roads, homes, and public utilities.

Addressing these urban challenges requires integrated solutions such as increasing urban green spaces, improving drainage infrastructure, enforcing emission regulations, and adopting climate-sensitive city planning to make Solapur more resilient to ongoing and future climatic shifts. These impacts highlight Solapur's precarious position, where climate change compounds existing vulnerabilities like poverty and resource dependence. Immediate action is essential to safeguard its future.

Mitigation Strategies for Solapur District

Mitigating climate change in Solapur requires tailored strategies addressing water, energy, agriculture, and urban challenges. Below are proposed measures:

Water Resource Management: Effective management of water resources is essential for addressing the growing water scarcity in Solapur district. One of the most practical and sustainable solutions is **rainwater harvesting**, particularly during the monsoon season. By capturing and storing rainwater, communities can significantly improve groundwater recharge and reduce their dependence on declining aquifers. Encouraging the use of rooftop rainwater harvesting systems at the **household level** can help families collect and store water for domestic use or infiltration into the soil. At a larger scale, **community-based harvesting structures**, such as check dams and recharge pits, can collect surface runoff and allow it to seep into the ground, replenishing local water tables. These systems are especially beneficial in drought-prone areas, where every drop of rainfall is valuable.

In the past, **traditional water conservation structures** like percolation tanks and village ponds played a vital role in groundwater recharge across rural Solapur. Many of these systems, particularly in talukas like **Mohol**, have fallen into disrepair due to neglect and changing land use patterns. Reviving and maintaining these traditional tanks, with support from local governing bodies and community participation, can greatly enhance water retention capacity and help mitigate seasonal shortages. Integrating rainwater harvesting into government schemes, agricultural planning, and urban development policies will ensure long-term sustainability. Promoting public awareness, training programs, and incentives for adoption can make this age-old practice a powerful modern-day solution to Solapur's pressing water challenges.

Watershed Development: Watershed development plays a vital role in improving water conservation and agricultural sustainability, especially in semi-arid regions like Solapur. In hilly and undulating areas such as Sangola taluka, constructing check dams, bunds, and contour trenches helps in capturing rainwater runoff, reducing soil erosion, and enhancing groundwater recharge. These small-scale, decentralized structures slow down the flow of water during the monsoon season, allowing it to percolate into the soil and replenish underground aquifers. The retained moisture benefits surrounding agricultural lands, particularly those dependent on rainfall. It is estimated that around 30% of the district's rain-fed farmlands can see improved productivity through effective watershed interventions.

Besides conserving water, such measures help in stabilizing slopes, reducing land degradation, and promoting vegetation growth. To maximize the impact, local community involvement, regular maintenance, and integration with rural development programs are essential components of successful watershed management in the region.

Renewable Energy Adoption: Solapur district, receiving sunlight for more than 300 days annually, offers significant potential for harnessing solar energy. The region's climatic advantage makes it ideal for the expansion of renewable energy infrastructure, especially solar-based systems. Large-scale projects, such as the 50 MW solar power plants in Pandharpur, demonstrate the feasibility and effectiveness of clean energy initiatives in the region. To further reduce dependency on conventional fossil fuels like coal, promoting the installation of rooftop solar panels in residential, institutional, and industrial buildings is essential. Government incentives, subsidies, and awareness programs can accelerate adoption at the grassroots level, making solar energy more accessible and affordable for the public.

Wider implementation of solar power not only helps in cutting carbon emissions but also supports sustainable development, energy security, and long-term environmental benefits for Solapur's urban and rural communities alike.

Energy Efficiency: Improving energy efficiency is a key strategy for reducing greenhouse gas emissions and promoting sustainable development in Solapur. The district, known for its textile industry and growing urban infrastructure, can achieve substantial energy savings through retrofitting old systems with modern, efficient technologies.

Upgrading existing textile mills and government buildings by installing LED lighting, energy-efficient motors, and machinery can significantly cut power consumption. Industry assessments suggest that such improvements could reduce overall energy-related emissions by **up to 15%**. These interventions not only lower operational costs but also enhance productivity and environmental performance. Encouraging the use of energy-efficient appliances through policy support, financial incentives, and awareness campaigns can help scale up adoption across both public and private sectors. Implementing these measures will not only reduce pressure

on the power grid but also support Solapur's transition toward a cleaner, low-carbon economy.

Case Study: Solapur Climate Action Plan - In response to growing environmental and climate-related challenges, Solapur launched its Climate Action Plan (CAP) in January 2023, becoming one of the first Tier-2 cities in India to adopt a structured and comprehensive strategy for climate resilience. Developed in collaboration with WRI India (World Resources Institute), this initiative reflects the city's commitment to sustainable urban development and environmental stewardship. The CAP outlines a multi-sectoral approach, addressing six key areas critical to the city's sustainability: urban heat management, sustainable mobility, water conservation, air quality improvement, waste management, and renewable energy adoption. With a long-term vision, the plan aims to reduce greenhouse gas emissions by 20% by the year 2035, compared to current levels.

One of the central components of the plan is urban heat mitigation, which includes increasing the city's green cover by 15%. This involves planting trees along streets, in public parks, and around residential areas to reduce surface temperatures and improve air quality. Solapur's expanding urban landscape, dominated by concrete and asphalt, has contributed to heat island effects, making this action crucial for improving liveability. To tackle emissions from the transportation sector, the CAP promotes the adoption of electric public transport, particularly by expanding the fleet of electric buses. This shift is expected to reduce fossil fuel dependency, lower air pollutants, and enhance mobility, especially for low-income groups who rely heavily on public transit. Waste management is another major focus area. The city aims to strengthen solid waste segregation at source, promoting composting, recycling, and reducing landfill usage. Awareness campaigns and decentralized waste processing facilities are being considered to support these efforts, helping reduce methane emissions and improve sanitation. On the **energy front**, the plan encourages both large-scale solar power generation and household-level renewable energy use. Public buildings are being retrofitted for energy efficiency, and incentives are being proposed for rooftop solar installations, which will reduce grid pressure and carbon output.

Despite its progressive framework, the CAP faces several implementation challenges. Funding constraints, lack of technical expertise, and limited community participation are among the key hurdles. Engaging citizens and local stakeholders in climate actions remains a critical need. Without broad public support and behavioral change, policy-level efforts may fall short of their potential impact. However, the Solapur Climate Action Plan represents a replicable model for other mid-sized and semi-arid cities in India. Its localized strategies are designed not just to address climate risks but also to improve the quality of life, economic resilience, and public health outcomes for its citizens. As the city continues to build capacity and align with national climate goals, the CAP sets a strong foundation for a sustainable urban future.

Challenges and Opportunities- as Solapur moves toward building climate resilience, it faces a complex mix of challenges and opportunities that will shape the success of its climate initiatives. The region, being semi-arid and predominantly agrarian, requires tailored strategies that address both environmental and socio-economic realities. One of the most pressing challenges is limited financial resources. Many of the climate mitigation and adaptation projects—such as solar installations, electric transportation, and water infrastructure—require significant capital investment. For a district with competing development priorities and constrained budgets, securing sustained funding remains a hurdle. Although national schemes exist, the flow of funds is often delayed or insufficient to meet local needs.

Another obstacle is the low level of awareness in rural areas regarding climate change and its long-term effects. Many farmers and villagers are more concerned with immediate agricultural and livelihood challenges, making it difficult to promote proactive climate-smart practices. Without widespread understanding and engagement, community-based adaptation measures may see limited success. Administrative bottlenecks and bureaucratic delays also slow down project implementation. Long approval cycles, lack of technical manpower, and coordination gaps between government departments further compound the issue.

Despite these constraints, numerous opportunities are emerging. Solapur's climate and geography offer immense scope for solar energy expansion. With over 300 sunny days annually, the district can emerge as a hub for solar innovation, attracting clean energy investments and creating green jobs. In the agricultural sector, there is growing potential for climate-resilient farming techniques and research. Institutions can work on drought-resistant crop varieties, water-saving irrigation methods, and sustainable soil management to help farmers adapt to shifting weather patterns.

Partnerships represent another promising avenue. Collaborating with non-governmental organizations (NGOs), academic institutions, and international climate funds can bring in technical expertise, financial aid, and community outreach. These partnerships can fill critical gaps in knowledge and resources, helping scale up local climate action. With strategic planning and collaborative efforts, Solapur can position itself as a regional leader in climate resilience, setting an example for other Tier-2 cities and semi-arid regions across India.

Conclusion- Climate change is no longer a distant or abstract concern—it is an immediate and pressing reality for regions like Solapur, where environmental vulnerabilities intersect with socio-economic challenges. This study has explored how rising temperatures, irregular rainfall patterns, growing water scarcity, declining agricultural productivity, and intensifying urban stress are reshaping the district's ecological and human landscape.

Over the past few decades, Solapur has experienced a noticeable rise in temperature, with summer peaks crossing 45°C. This extreme heat affects not only



human health but also livestock and crop productivity. Similarly, unpredictable monsoons—ranging from prolonged dry spells to sudden floods—have destabilized the agricultural calendar. Crops like jowar, cotton, sugarcane, and pulses suffer both from drought-induced yield reductions and pest attacks, pushing farmers into financial uncertainty.

Despite these challenges, the district has shown a strong commitment to climate action, particularly through the launch of the Solapur Climate Action Plan (CAP) in 2023. This comprehensive strategy, developed in partnership with WRI India, addresses six key sectors: urban heat, mobility, air quality, water, waste, and energy. Its goal of reducing emissions by 20% by 2035 is ambitious but achievable with coordinated efforts. Key initiatives such as expanding electric public transport, improving waste segregation, increasing green cover, and promoting renewable energy highlight a shift toward sustainable urban planning. However, there are multiple opportunities that Solapur can tap into. With more than 300 sunny days a year, the district is well-positioned to become a solar energy leader. Expanding rooftop solar programs, scaling up solar farms, and incentivizing green energy adoption can reduce dependence on fossil fuels while creating local employment opportunities. In agriculture, there is great scope for innovation through drought-resistant crop varieties, micro-irrigation, and organic farming practices. These can boost resilience and profitability, especially for small and marginal farmers.

Moreover, strategic partnerships with NGOs, research institutions, and international climate funds can provide much-needed expertise, technology, and financial resources. Civil society engagement, community-led initiatives, and school-level awareness campaigns can also play a key role in building a climate-conscious population. Capacity-building and skill development programs targeted at youth and farmers will further enhance local resilience. In this context, Solapur has the potential to emerge as a model for climate resilience among India's Tier-2 and semi-arid cities. The integration of scientific planning, grassroots participation, and policy support is essential for long-term success. Sustainable development in the region must strike a balance between economic growth and environmental protection. It is not just about reducing emissions or saving water—it is about securing livelihoods, preserving natural resources, and ensuring intergenerational equity.

To conclude, climate change presents a formidable challenge, but also a powerful opportunity. For Solapur, the journey toward resilience and sustainability is not only necessary but entirely possible. With consistent effort, innovative thinking, and inclusive governance, the district can create a future that is not only climate-resilient but also more equitable, prosperous, and sustainable for all its residents.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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