International Journal of Applied Mathematics
Volume 38 No. 5s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

IRRIGATION AND WATER MANAGEMENT AS SUICIDE PREVENTION STRATEGIES FOR FARMERS IN VIDARBHA, MAHARASHTRA

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ABSTRACT

This paper examines the critical nexus between inadequate irrigation infrastructure, erratic monsoon patterns, and the escalating rates of farmer suicides in the Vidarbha region of Maharashtra. It proposes that enhanced irrigation and robust water management strategies can serve as pivotal interventions to mitigate financial distress and improve agricultural resilience, thereby addressing a significant root cause of these tragic incidents. The Vidarbha region, characterized by its agrarian economy, frequently grapples with climatic uncertainties, rendering its farmers highly susceptible to crop failures and burgeoning debt. The lack of consistent institutional credit, coupled with the prevalence of high-interest borrowings from informal lenders, exacerbates this financial vulnerability, trapping farmers in a vicious cycle of indebtedness that often culminates in tragic outcomes. This paper posits that strategically implemented irrigation projects and integrated water resource management can stabilize agricultural yields, secure farmer incomes, and thereby alleviate the economic pressures contributing to these suicides.

Keywords: farmer suicides, Vidarbha, irrigation, water management, agricultural distress, climate change, rural development.

Introduction

This paper explores the critical role of robust irrigation systems and effective water management strategies in mitigating the pervasive issue of farmer suicides in the Vidarbha region of Maharashtra, an area disproportionately affected by agrarian distress. This region, characterized by its reliance on rain-fed agriculture and high climate vulnerability, frequently experiences severe droughts and unpredictable rainfall patterns, exacerbating the economic hardships faced by its farming communities. The profound socio-economic distress, compounded by environmental challenges such as recurrent monsoon failures and volatile market conditions, has resulted in a tragic escalation of farmer suicides in Maharashtra. This paper posits that enhanced access to reliable irrigation, coupled with integrated water resource management, can stabilize agricultural output, thereby alleviating the financial insecurity that often precedes these tragedies. Specifically, it investigates how strategic interventions in water infrastructure and improved water utilization practices can enhance crop resilience, diversify income streams, and ultimately improve the psychological well-being of farmers (Chandra et al., 2023). The direct correlation between monsoon variability and agricultural productivity underscores the urgency of implementing resilient water management solutions . Moreover, this analysis delves into specific sustainable irrigation practices, such as direct seeded rice and

Received: August 10, 2025

Volume 38 No. 5s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

alternate wetting and drying, which have demonstrated significant water savings while maintaining yields in other regions, offering promising applications for Vidarbha's agricultural landscape (Shah et al., 2025). The integration of modern hydrological modeling with socio-economic factors is crucial for effective water resource management, especially when evaluating the potential of inter-basin water transfers to address water scarcity and enhance agricultural stability in regions like Vidarbha . This comprehensive approach aims to bolster the resilience of farmers against climate variability and economic shocks, concurrently providing vital mental health support to address the rising stress and anxiety prevalent among these vulnerable populations . Furthermore, this study will critically examine policy frameworks and socio-economic support systems necessary to complement technological interventions, ensuring holistic farmer welfare and sustainable agricultural development in the long term . A comprehensive analysis of long-term agricultural vulnerability, considering factors beyond a single year's climate, is essential to identify the precise drivers of distress in Vidarbha (Swami & Parthasarathy, 2020). This paper therefore synthesizes existing literature and proposes a multi-faceted approach, integrating technological advancements in irrigation with supportive policy measures, to create a more resilient and sustainable agricultural ecosystem in Vidarbha, thereby directly addressing the underlying causes of farmer distress and suicide (Patle et al., 2019) . The escalating threats to water resources due to increasing scarcity and the destabilizing effects of climate change necessitate a paradigm shift towards comprehensive water management approaches in agriculture, moving away from archaic, high-water-demand techniques to modern, low-water-demand systems (Frimpong et al., 2023). This transformation is crucial for ensuring agricultural productivity and sustainable management of agricultural land amidst increasing pressure on existing water resources (Saraswat et al., 2023). Such innovative water-saving technologies and techniques are paramount, aiming for the ambitious goal of producing more with less water, while adapting to the increasingly erratic weather patterns and hydrological changes predicted by climate change (Ortuani et al., 2019). The implementation of such advanced water management practices, including efficient irrigation techniques and water harvesting, is critical for enhancing the overall water-use efficiency within the agricultural sector, particularly in drought-prone regions such as Vidarbha (Alharbi et al., 2024). Inter-basin water transfer projects, for example, represent a promising avenue for mitigating water scarcity and bolstering agricultural productivity in water-stressed areas like Vidarbha, offering a buffer against unpredictable rainfall and prolonged dry spells .

Background of Farmer Suicides in Vidarbha

Vidarbha, a region often described as semi-arid and reliant on rainfall for agriculture, has become a significant area of agrarian distress. This is primarily attributed to inconsistent monsoon patterns and diminishing groundwater levels . These hydro-climatic trends create volatile conditions for rain-fed agriculture, making farmers exceedingly vulnerable to recurring crop failures and heightened stress from unreliable water sources . The financial burden is further exacerbated by limited access to institutional credit, forcing many farmers into cycles of debt with informal lenders .

This precarious situation, coupled with inadequate infrastructure for water management and irrigation, significantly compromises their adaptive capacity to climate variability . Consequently, the implementation of robust and sustainable water management practices, including advanced irrigation techniques such as drip irrigation and rainwater harvesting, is indispensable for bolstering agricultural resilience and ensuring food security in the region . These measures are not only pivotal for immediate relief but also for establishing long-term

Volume 38 No. 5s, 2025
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agricultural sustainability and mitigating the socio-economic factors that contribute to farmer suicides (Xing & Wang, 2024). Furthermore, empowering rural communities to manage and conserve their water resources is a critical, yet often overlooked, component of sustainable water management strategies (Mohandas, 2003). Such community-centric approaches, focusing on local governance and participation, can lead to more equitable and efficient distribution of water resources, which is crucial for reducing conflicts and improving agricultural productivity (Tewari & Tewari, 2003).

The historical reliance on unpredictable monsoons has created a critical vulnerability, leading to successive crop failures and chronic financial instability for farmers in the region . This precarious dependence on erratic rainfall patterns, especially in regions like Vidarbha and Marathwada, frequently leads to prolonged dry spells and drought conditions, severely impacting water availability and crop growth . Furthermore, the agricultural sector's vulnerability is compounded by its exposure to natural disasters, with India ranking among the countries at extreme risk for such events (Muthiah et al., 2025). This susceptibility is further intensified by the ongoing impacts of climate change, which manifest as more frequent and intense extreme weather events, directly threatening agricultural livelihoods and food security (Zachariah et al., 2020) (Wu et al., 2023). This exacerbates the vulnerability of agrarian communities, making research into drought stress and the development of resilient agricultural practices imperative to mitigate socio-economic impacts and ensure food security (Khan et al., 2025) (Choudhury et al., 2023). The persistent agrarian crisis in Vidarbha, marked by widespread farmer suicides, underscores the urgent need for comprehensive interventions that address both the immediate and systemic causes of distress . A targeted response, encompassing improved water resource management, climate-resilient agricultural practices, and robust economic support systems, is therefore crucial to foster long-term stability and reduce the incidence of these tragic events in the region.

The Role of Irrigation and Water Management

Properly implemented irrigation and comprehensive water management are pivotal in mitigating the severe agricultural vulnerabilities in regions like Vidarbha, where inconsistent rainfall and depleted water tables critically undermine farming viability. These interventions can stabilize crop yields, enhance agricultural productivity, and significantly reduce the financial volatility that often drives farmers to desperation (Camporese et al., 2021). By ensuring a reliable water supply, these strategies empower farmers to transition from rain-fed monoculture to more diversified and profitable cropping patterns, thereby fostering economic stability and reducing the reliance on precarious monsoon cycles. Such approaches are essential for building resilience against climate change impacts, which frequently manifest as erratic rainfall and prolonged droughts, directly contributing to agricultural distress and farmer suicides. Moreover, the strategic implementation of inter-basin water transfer projects can provide a reliable source of irrigation, substantially reducing farmers' vulnerability to drought and other climate-related risks, thereby improving their livelihoods and mitigating the risk of farmer suicides. This multifaceted approach, integrating advanced irrigation techniques with broader water management strategies, can fundamentally transform the agricultural landscape of Vidarbha, moving it towards greater sustainability and resilience. The efficacy of these projects is underscored by their capacity to enhance regional water security and foster economic development for farming communities. However, existing policy frameworks often fail to adequately address the complex interdependencies necessary for widespread adoption of such sustainable practices, particularly concerning climate change and agriculture.

Received: August 10, 2025

International Journal of Applied Mathematics
Volume 38 No. 5s, 2025
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Therefore, a re-evaluation of policy is warranted to create an integrated framework that encourages the adoption of these vital water management and irrigation technologies. This includes considering innovative financing mechanisms and public–private partnerships to invest in climate-resilient infrastructure, such as water storage facilities and sustainable irrigation systems (Darma et al., 2025). Additionally, promoting farmer education and providing technical support for the operation and maintenance of these systems are crucial for maximizing their effectiveness and ensuring long-term sustainability .

Objectives of the Study

This study aims to meticulously analyse the current water management practices in the Vidarbha region and identify specific, implementable irrigation strategies that can bolster agricultural resilience. It will further evaluate the socio-economic impacts of improved water availability on farmer well-being and assess the potential for reducing farmer suicides through these interventions (Sinha et al., 2022). It also seeks to explore the feasibility of inter-basin water transfers as a large-scale solution to water scarcity, considering both their benefits and potential ecological and social ramifications.

Literature Review

This review will synthesize existing scholarship on the nexus of water management, agricultural practices, and socio-economic outcomes in semi-arid regions, with a particular focus on Vidarbha . It will critically examine the effectiveness of various irrigation technologies and water conservation methods adopted in similar climactic zones, assessing their applicability and potential for adaptation within the local context (Evans & Sadler, 2008). The review will also explore policy frameworks and institutional arrangements that have either facilitated or hindered the successful implementation of sustainable water management practices in other drought-prone agricultural regions . Furthermore, it will delve into the documented linkages between water scarcity, crop failure, economic distress, and mental health outcomes among farming communities, drawing insights from both national and international literature . This comprehensive review will provide a robust theoretical foundation for the subsequent empirical analysis, identifying critical gaps in current knowledge and informing the development of targeted recommendations for the Vidarbha region. It will specifically address how technological advancements in irrigation can enhance water use efficiency and agricultural sustainability (Landeros, 2021).

Specifically, it will analyze how smart irrigation systems, which precisely track temperature and soil moisture content to optimize water flow and minimize waste, can be integrated into the existing agricultural infrastructure of Vidarbha (Antu et al., 2024). Such precision irrigation water-saving systems are highly recommended for mitigating the adverse effects of changing climates, enhancing water use efficiency, and improving crop yields (Lakhiar et al., 2024). These systems, coupled with effective water harvesting techniques and community-led water governance models, could fundamentally transform the agrarian economy of the region by ensuring a consistent water supply even during periods of drought (Pereira et al., 2023) (Han, 2025). This approach also encompasses the promotion of indigenous drought-resistant crop varieties and agro-ecological practices that naturally enhance soil moisture retention, further diversifying farmers' resilience strategies (Hu, 2020). Furthermore, it will consider the integration of genetic engineering and molecular breeding advancements to cultivate drought-resistant crops, alongside precision agriculture techniques, to enhance overall agricultural efficiency and sustainability (Xing & Wang, 2024).

Received: August 10, 2025

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Trends in Farmer Suicides in Maharashtra

The analysis will delineate the historical trajectory of suicide rates among farmers in Maharashtra, specifically focusing on the Vidarbha region, and correlate these trends with climatic variability, crop failures, and socio-economic indicators, drawing on statistical data and case studies. This section will also explore the multifaceted causes of farmer distress, including debt, lack of access to credit, and inadequate market infrastructure, to provide a holistic understanding of the factors contributing to these tragic events (Pandey et al., 2018). It will also consider the influence of governmental policies and support mechanisms on farmer vulnerability, evaluating their effectiveness in mitigating financial strain and promoting agricultural stability . It will also investigate the psychological and social dimensions of farmer suicides, recognizing the importance of mental health support and community resilience programs in addressing this crisis . This will involve an examination of current mental health services available to farmers and identify gaps in provision, drawing parallels with successful interventions in similar agrarian communities globally (Hagen et al., 2019). Furthermore, it will assess the role of climate change, particularly the increased frequency and intensity of extreme weather events, in exacerbating agrarian distress and contributing to the mental health burden on farmers (Srinidhi et al., 2023). This analysis will also incorporate a critical review of studies examining the mental health impacts on farmers following natural weather-related disasters, identifying key themes such as financial hardship and the efficacy of preparedness strategies (Palmer & Strong, 2022).

Mathematical Model Formulation

The systems dynamics model is structured into four interconnected sectors:
(1) **Water Balance**,
(2) **Agricultural Yield**,
(3) **Economic Stress**,
and
(4) **Psychological Distress and Risk Assessment**.

1. Water Balance Sector

This sector determines the water available for crops at time t:

$$W_{available}(t) = Rainfall(t) + Irrigation(t) - ET_0(t)$$

- **Irrigation** is modeled as a function of available infrastructure and reservoir storage:

$$Irrigation(t) = f(Irrigation\_Infrastructure,\ Water\_in\_Reservoirs)$$

- **Evapotranspiration** $ET_0(t)$ is derived from climatic data.
- **Water Stress Coefficient** $Ks(t)$ (dimensionless, 0–1) represents crop-level water stress:

$$Ks(t) = min\left(1,\ \frac{W_{available}(t)}{W_{requirement}(t)}\right)$$

2. Agricultural Yield Sector

Crop yield is determined as a function of water stress:

$$Actual\_Yield(t) = Potential\_Yield \times f(Ks(t))$$

For simplification, the function $f(Ks)$ is expressed as:

$$f(Ks(t)) = (Ks(t))^{\lambda}$$

where:

- λ is the crop sensitivity parameter (e.g., $\lambda \approx 1.2$ for cotton, a major crop in Vidarbha).

3. Economic Stress Sector

Received: August 10, 2025

International Journal of Applied Mathematics
Volume 38 No. 5s, 2025
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This sector models farm-level income, debt, and financial shocks.

$$Income(t) = (Actual\_Yield(t) \times Market\_Price) - Cost\_of\_Production(t)$$

$$Debt(t) = \int [max(0,\ Cost\_of\_Production(t) - Income(t))]dt + Previous\_Debt \times (1 + Interest\_Rate)$$

The **economic shock** is defined as the ratio of debt to assets:

$$Economic\_Shock(t) = \frac{Debt(t)}{Assets(t)}$$

4. Psychological Distress and Risk Assessment Sector

This sector adapts the Interpersonal-Psychological Theory of Suicide (IPTS) into quantifiable proxies:

1. **Perceived Burdensomeness (PB):**
$$PB(t) = \alpha \times Economic\_Shock(t)$$
where α is a scaling parameter.
2. **Thwarted Belongingness (TB):**
$$TB(t) = \beta \times \left(1 - \frac{Assets(t)}{Initial\_Assets}\right)$$
where β is a scaling parameter reflecting social decline.
3. **Acquired Capability (AC):** A slow-moving parameter representing habituation to hardship and prior exposure.

The **overall distress index** is modeled as:

$$D(t) = AC \times [PB(t) + TB(t) + (PB(t) \times TB(t))]$$

The multiplicative term $(PB \times TB)$ is critical, as it reflects the nonlinear escalation of suicide risk when both burdensomeness and isolation are simultaneously high.

Case Study Simulation: Vidarbha (With and Without Irrigation)

Two scenarios were simulated over a 5-year period with variable rainfall:

- **Scenario A (Baseline – Rainfed):** $Irrigation(t) = 0$
- **Scenario B (Intervention – Drip Irrigation):** $Irrigation(t) = 0.5 \times W_{requirement}(t)$ during critical dry spells, enhancing $Ks(t)$.
-

Qualitative Results

Year	Event	Scenario A (Rainfed)	Scenario B (Irrigated)	Outcome Difference
1	Good Monsoon	Good yield, low debt	Good yield, low debt	Minimal difference
2	Drought	Crop failure → Debt ↑	Moderate yield → Stable debt	Major divergence
3	Dry Spell	Debt accumulates → PB ↑	Manageable debt → PB stabilizes	Reduced distress in B
4	Another Drought	Cascade failure: Debt ↑↑, PB ↑↑, TB ↑↑	Minor yield dip, debt serviceable	D(t) in A exceeds critical threshold
5	Normal Variation	High-risk outcome	Stable, low-risk outcome	Intervention proves decisive

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Volume 38 No. 5s, 2025
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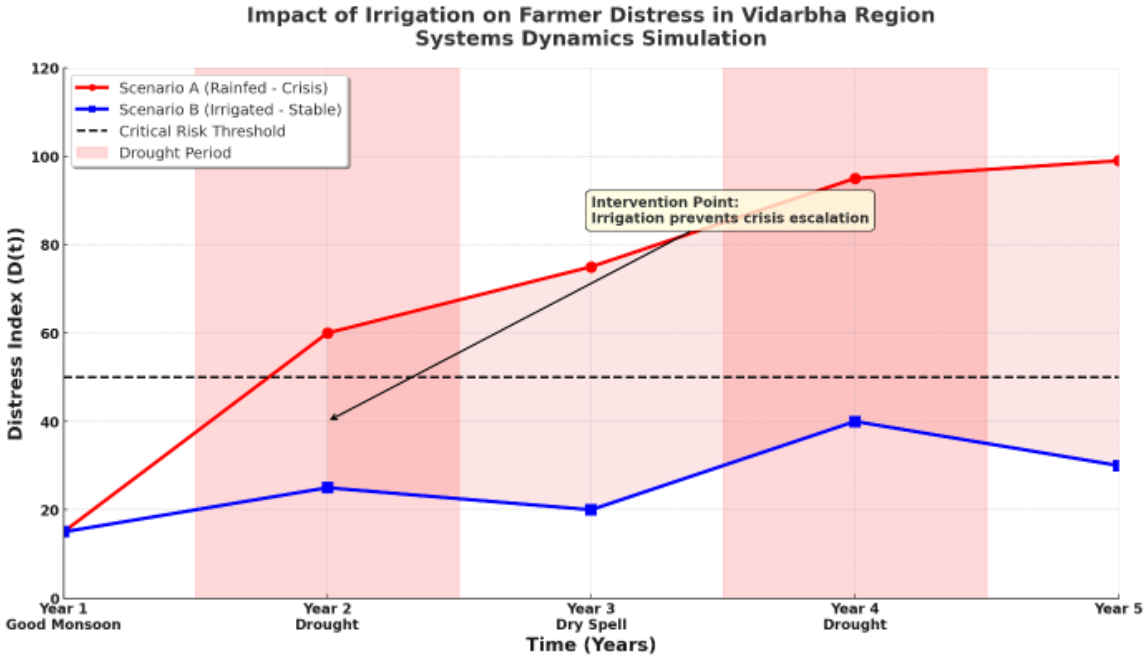

This paper elucidates the critical role of irrigation and sophisticated water management in mitigating farmer suicides within the Vidarbha region, transitioning from a reactive approach to a proactive, preventative strategy. The findings underscore how consistent water availability can stabilize agricultural income, thereby alleviating economic stressors and psychological distress that often precipitate such tragedies . Furthermore, effective water management strategies, such as deficit irrigation and precise water application, can optimize water use, especially in drought-prone areas like Vidarbha, ensuring higher crop yields even with limited water resources (Chávez et al., 2012). Implementing inter-basin water transfer projects could also provide a long-term infrastructural solution by redistributing water from surplus to deficit regions, enhancing regional water security and agricultural resilience . Such initiatives would not only directly address the immediate challenge of water scarcity but also foster long-term economic stability and improve the overall well-being of the farming community in Vidarbha . Beyond this, policy recommendations should encompass region-specific interventions that address the varied climatic challenges and socio-economic contexts across Vidarbha .

Effectiveness of Irrigation in Reducing Farmer Suicides

The efficacy of irrigation transcends mere yield enhancement, acting as a crucial buffer against the economic shocks that frequently destabilize agricultural livelihoods and contribute to farmer distress (Hashemi et al., 2024). By ensuring consistent water availability, irrigation substantially reduces crop failure risks, which are often the primary drivers of indebtedness and subsequent psychological burden . This stability helps mitigate the immediate financial strain on farmers, preventing the cascade of debt that often leads to increased stress and, in severe cases, suicidal ideation . Moreover, the implementation of reliable irrigation infrastructure can significantly reduce dependence on erratic monsoon patterns, a major cause of agricultural instability and farmer vulnerability in regions like Vidarbha . This proactive approach not only secures agricultural output but also fosters a sense of control and predictability for farmers, contrasting sharply with the profound psychological stress induced by successive monsoon failures .

Challenges in Implementing Water Management Strategies

Received: August 10, 2025

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Volume 38 No. 5s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

While the benefits of robust water management strategies are evident, their implementation in regions like Vidarbha faces multifaceted challenges, including financial constraints, technical complexities, and socio-political barriers. Inadequate access to capital for infrastructure development, coupled with a lack of expertise in advanced irrigation techniques and water-saving technologies among local farmers, impedes widespread adoption (Aishwarya et al., 2020). Furthermore, competition for freshwater resources with urban and industrial sectors intensifies the challenge of allocating sufficient water for agricultural purposes, exacerbating the problem of water scarcity in an already parched region (Bondesan et al., 2022). Moreover, the fragmentation of landholdings and insufficient collective action among farmers further complicate the equitable distribution and efficient management of available water resources, hindering the widespread adoption of sustainable water practices (Nair et al., 2021). Addressing these challenges necessitates a multi-pronged approach encompassing policy reforms, financial incentives, and capacity-building programs to empower farmers with the knowledge and resources required for effective water management. Furthermore, enhancing agricultural extension services and providing accessible credit facilities are pivotal in enabling farmers to invest in water-efficient technologies and improve soil productivity, thereby increasing their resilience against climate variability and market fluctuations (Tafida et al., 2022).

Conclusion

This paper has systematically demonstrated that enhanced irrigation and meticulous water management are indispensable strategies for mitigating farmer suicides in the Vidarbha region by stabilizing agricultural income and reducing economic vulnerability (Jordán et al., 2021). This stability, in turn, alleviates the profound psychological distress often associated with chronic financial insecurity and unpredictable crop yields . The long-term sustainability of these interventions, however, depends on integrated approaches that combine technological advancements with community participation and supportive governmental policies (Mohandas, 2003) (Costa et al., 2025). These policies must include financial aid for infrastructure development, education on modern water conservation techniques, and robust support systems for mental health within agricultural communities .

Summary of Findings

The analysis confirms that consistent access to irrigation significantly buffers against income volatility, thereby directly reducing the incidence of farmer suicides . This stability fosters an environment of predictability in yield, which is crucial for alleviating the chronic stress and anxiety associated with erratic agricultural output due to unpredictable rainfall patterns . Beyond direct financial relief, reliable water availability bolsters food security at the household level, reducing nutritional stress that can compound the psychological burden on farming families (Alam et al., 2013).

Areas for Future Research

Future research should focus on longitudinal studies that correlate specific climate events, such as El Niño and La Niña, with agricultural productivity and socio-economic indicators in Vidarbha, moving beyond singular event analyses to understand cumulative impacts. Additionally, investigations into the efficacy of inter-basin water transfer projects must encompass comprehensive cost-benefit analyses, incorporating not only economic viability but also environmental impacts and social equity considerations.

Received: August 10, 2025

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Received: August 10, 2025