Innovative Groundwater Management: The Impact of the Shirpur Pattern in Dhule District, Maharashtra

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ABSTRACT:
Groundwater management is crucial for addressing water scarcity, particularly in regions susceptible to irregular rainfall and drought. This study focuses on the implementation of the Shirpur Pattern, an innovative watershed management approach, in Shirpur Taluka of Dhule District, Maharashtra. The Shirpur Pattern employs strategic water harvesting and conservation techniques tailored to the unique geological composition of the Deccan Plateau, which includes layers of black soil, sand, silt, and gravel. The research examines the principles behind the Shirpur Pattern and its application in groundwater management. Results indicate significant improvements in water availability and agricultural sustainability in the region. The Shirpur Pattern has proven effective in mitigating the adverse effects of climate change, such as alternating droughts and floods, by enhancing the resilience of local water resources. This paper highlights the transformative impact of the Shirpur Pattern on groundwater management, demonstrating its potential to serve as a model for other water-scarce regions facing similar challenges.

1. INTRODUCTION

The regions under consideration, namely Maharashtra's Khandesh, Marathwada, and Vidarbha, form a crucial focal point in the context of water scarcity and climate change challenges. These areas, known for their agricultural significance, face a heightened susceptibility to irregular monsoons, disrupting the traditional patterns of rainfall that are integral to their ecosystems. Khandesh, Marathwada, and Vidarbha are characterized by their dependence on the monsoon for sustenance, making them particularly vulnerable to the adverse impacts of climate change.

Irregular monsoons in these regions result in erratic rainfall distribution, leading to water shortages that significantly impact agriculture, daily life, and overall ecosystem health. The agricultural practices in these areas heavily rely on timely and adequate rainfall, and any deviations from the norm pose a direct threat to food security and livelihoods. Additionally, climate change exacerbates these challenges, creating a cyclical pattern of droughts and floods that further disrupts the delicate balance of the local environment.

Understanding the nuances of these regions is imperative for devising effective strategies to address water scarcity and climate change. By delving into the specifics of Khandesh, Marathwada, and Vidarbha, we gain insight into the unique challenges faced by each area, enabling the development of region-specific solutions and interventions to promote resilience in the face of environmental uncertainties.

1.1 Rain Fall

The distribution of rainfall in Shirpur taluka is notably erratic, with an annual normal rainfall of 617 mm spread over 36 days. about 75% of the total rainfall transpires during just 13 days, a critical factor contributing to water scarcity. Evapotranspiration, a key parameter for plant growth, is higher during the plant growth period, further limiting water availability for crops.

Surface water resources are rare in this taluka. Irrigation projects cover only a small portion of the taluka, primarily in the southeast, leading to a substantial increase in groundwater utilization for agricultural, drinking, and industrial purposes. The intensive development of groundwater has resulted in critical situations marked by declining groundwater levels and water supply shortages, necessitating comprehensive programs for groundwater resource augmentation and conservation throughout the taluka.

1.2 Climate

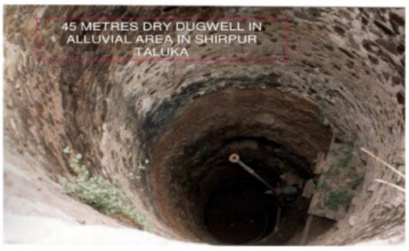
The climate in Shirpur taluka is predominantly dry, except during the southwest monsoon season, which lasts from June to September. The year is divided into four seasons: the cold season (December to February), the hot season (March to May), the southwest monsoon season, and the post-monsoon season (October and November). Shirpur taluka falls within the category of drought-prone areas, receiving rainfall between 750 to 1000 mm

2. GEOLOGICAL CHARACTERISTICS

Shirpur taluka encompasses an expansive geographical area of 837.39 sq.km, with a cultivable expanse of 653.77 sq.km (78.07%). The forest area covers approximately 101.09 sq.km, and non-cultivable land occupies 82.53 sq.km. Out of the cultivable land, only about 84.61 sq.km (12.94%) is under irrigation. The taluka, situated in the Tapi alluvial basin in Dhule district, primarily consists of alluvial formations and basaltic lava flows in the hilly tracts. While the basaltic lava flows are less conducive to groundwater development, they give rise to both perennial and seasonal springs. The alluvial deposits, including talus and scree deposits and alluvium with sand, clays, and gravel, play a crucial role in the overall hydrogeological composition.

Here two distinct geological formations exists, one with Tapi Alluvium covering one-third of its total area and Deccan

Basalt covering the remaining two-thirds area . Both areas exhibit a multi aquifer system, characterized by alternate layers. In the Basalt region, weathered basalt and hard massive basalt layers are observed, while the Tapi Alluvium features alternate layers of yellow silt, sand, and boulders, with a sand bed effective porosity of approximately 30%.
The aquifer systems in both regions have been excessively exploited to meet the demands of irrigated agriculture, particularly cash crops like Banana and Sugar Cane. Unfortunately, this unregulated groundwater pumping has adversely affected the sustainability of groundwater, impacting rural drinking water schemes. The overexploitation of groundwater resources led to a drastic decline in groundwater levels, causing dug wells (Fig.1) in Tapi Alluvium to dry up in 1990, with even deeper tube wells becoming dry (Fig.2).



45 METRES DRY DUGWELLIN ALLUVAL AREA IN SHIRPUR TALUKA

Figure.1. Dry Dug Well

DISCHARGE OF WATER FROM 100M DEEP TUBEWELL HAVING 10 HP SUBMERCIBLE IN SHIRPUR AREA

Figure.2. Low Discharge of 10 Hp Pump on Tube Well

3. CLIMATE CHANGE AND WATER SCARCITY

Climate change has intricately woven a pattern of intensified droughts and floods, significantly amplifying water scarcity issues. Altered precipitation patterns, a hallmark of climate change, contribute to prolonged droughts by reducing rainfall and escalating evaporation. Concurrently, extreme weather events, such as storms, are on the rise, causing rapid and intense flooding in certain regions. These events disrupt normal hydrological cycles, with droughts leading to decreased water availability in rivers, lakes, and groundwater, while floods overwhelm drainage systems, causing rapid runoff and potential contamination. The impacts extend to water infrastructure, with droughts straining resources and floods damaging treatment facilities and distribution systems. Ecosystems suffer as well, with droughts leading to habitat loss and decreased biodiversity, while floods contribute to soil erosion and environmental degradation. Agriculture is profoundly affected, with droughts causing crop failures and reduced yields, while floods can submerge fields, washing away crops and causing agricultural losses. Human consequences include conflicts over scarce resources during droughts, migration from affected areas, and increased competition for water. In the face of these challenges, it becomes imperative to implement mitigation and adaptation strategies to enhance resilience and address the multifaceted impacts of climate change on water availability.

4. GROUND WATER

Alluvium, found in the central and southern parts of Shirpur Taluka, consists of alternating layers of clay, sand, gravels, and boulders. The thickness of alluvium exceeds 350 meters in some locations. Calcareous concretion hardpans, affecting vertical infiltration, are prevalent. Shallow-depth groundwater (up to 40 m below ground level) occurs under unconfined conditions, while deeper levels experience semi-confined to confined conditions. Similar to Bazada, dug wells and shallow tube wells in the alluvial areas are currently dry. Formerly, dug wells yielded 160-200 cubic meters/day with a 3 to 4 meter drawdown, and tube wells discharged between 2.8 to 3.0 cubic meters/hour.
The overall groundwater situation depicts a continuous decline, ranging from a few centimetres to 1.8 meters per year, with wells up to 50 meters deep experiencing dry conditions. Depths to water levels as profound as 50 meters below ground level have been recorded.

5. CHALLENGES AHEAD

Challenges Arise from Current Geological Conditions and Overexploitation

5.1 Deterioration of Dug Wells

The prevailing geological structure, with semi-permeable layers of silt offering minimal water transmission, has led to an increasingly critical situation. Notably, a well, positioned approximately 3 meters from the main canal and with a depth of around 50 meters, has remained dry for the past two decades, even after heavy rainfall. This indicates limited lateral and vertical percolation through the yellow silt.
According to Khanapurkar, the groundwater level is consistently decreasing, with declines ranging from a few centimetres to 1.8 meters per year. In certain locations, wells with depths of up to 50 meters are dry, and water levels as deep as 50 meters below ground level have been recorded.
In regions with basalt formations, the altered rainfall patterns (intense rainfall resulting in runoff with minimal percolation) have affected aquifers, which, despite effective porosity of 2.5 to 3%, struggle to fully saturate. Consequently, dug wells and bore wells in the Deccan Basalt region exhibit reduced water yield, particularly after December, causing severe shortages for both drinking water and irrigation. The increased reliance on groundwater, coupled with tapping deeper aquifers, has led to the depletion of deep wells. Dug wells in alluvial areas and many wells in the Deccan Basalt region have dried up, and even shallow bore wells and tube wells are now running dry, with diminishing yields in deep bore wells. This renders the significant investments made by individual farmers on dug wells, pump sets, and other development projects futile. Drinking water bore wells in elevated areas are particularly

affected, as proximity to newly drilled deep bore wells for irrigation has resulted in the drying up of drinking water sources in various parts of the taluka.

5.2 Escalation in Well Construction Costs

Excessive withdrawal from shallow aquifers has led to the depletion of shallow wells, prompting the tapping of deeper aquifers through the construction of deep bore wells. This shift has substantially increased the unit cost of bore well construction.

5.3 Rise in Energy Consumption

Modern groundwater extraction practices involve tapping deeper aquifers, necessitating the installation of high horsepower pumps to draw water from greater depths. Consequently, energy consumption has witnessed a notable increase.

5.4 Diminished Pump Efficiency

The installation of higher-capacity pumps in low-yielding wells has led to cavitation issues, resulting in a decline in pump efficiency.

5.5 Abandonment of Productive Land

Excessive withdrawal has caused the drying up of shallow wells and bore wells in many locations, impacting small and marginal farmers who cannot afford deeper bore wells. Consequently, once productive land has been left fallow due to the unavailability of water resources.

6. ACTION FOR ARTIFICIAL RECHARGE

The examination of the shifting characteristics of rainfall, aquifer attributes, and the presence of alternate layers of pervious and impervious strata in Deccan Basalt and Alluvium in Shirpur taluka has led to the acknowledgment that traditional methods of artificial recharge may not prove effective.
In the Basalt region, alterations in rainfall nature, characterized by heavy precipitation within a short duration, result in predominantly runoff with minimal percolation. Despite aquifers possessing effective porosity ranging from 2.5 to 3%, they seldom achieve full saturation. With the demand for water steadily increasing, the availability of water remains sufficient only until January, leading to water scarcity for drinking and irrigation thereafter.

6.1 Addressing this challenge requires consideration of three key aspects:

Ensuring 100% saturation of aquifers despite changes in rainfall patterns.
Sustaining a constant water supply to aquifers for maintaining water levels.
Implementing artificial removal of impervious layers, such as hard massive traps in Deccan Basalt and yellow impervious soil and silt in Alluvium.

6.2 Artificial Recharge Structures

To achieve the outlined objectives, the following actions have been plan for implementation:
Construction of series overflows check dams on every stream, regardless of stream size, without gates and waste weir. This follows the ridge-to-valley principle to augment water resources.
Deepening streams up to 15 to 20 meters and widening them up to 30 meters in both Deccan Basalt and Alluvium.
Artificially recharging deeper aquifers in the alluvial area of the Tapi Basin by utilizing surplus water from dams in the Deccan Basalt area. This involves directing water through dry dug wells with depths ranging from 40 to 50 meters.

6.3 Transformative Water Conservation The Tech-Driven Initiative in Shirpur Since 2004

Since 2004, a technology-based water conservation project has been underway in Shirpur taluka, covering an area of approximately 100 square kilometers. The project encompasses the construction of 65 cement bunds along 14 small streams in a rained, non-command region. These bunds, devoid of gates and waste weir, have a storage capacity ranging from a minimum of 10 T.C.M. to a maximum of 150 T.C.M.

Innovative Cement Bund Construction: A Holistic Approach to Water Conservation and Rejuvenation
In the pursuit of innovative water conservation, a distinctive approach to cement bund construction has been implemented, involving a series of strategic steps:

- Strategic Placement: Cement check dams are strategically constructed at suitable locations.
- Upstream Planning: A few meters of space are intentionally left upstream of each check dam, facilitating bund formation. The process involves nalla winding and deepening, orchestrated with the assistance of JCB and Pocalain Machines, graciously provided through the collaborative efforts of MLA and Social worker Mr. Amarish Bhai Patel.
- Community Involvement: Farmers, using tractors provided by the initiative, engage in the free loading of excavated fertile silt/soft soil. A healthy competition among farmers ensues as they transport the soil to their farms for spreading and making their farm fertile.
- Road Infrastructure Development: The hard layer of excavated material finds purpose in the construction of new farm roads and the enhancement of existing ones.
- Multi-Purpose Bunds: Upstream of each check dam, imperious black soil is carefully filled, covered with hard soil to create a bund with dimensions of nearly 2 to 3 meters in top width and 2:1 side slope. The top is then fortified with stones up to the height of the check dam, transforming it into a versatile crossing bridge

roadway. The material excavated from the upper side of stream/nalla winding and deepening serves this dual purpose effectively.

- Leakage Mitigation: In response to previous issues of heavy leakages in old stone masonry check dams, a successful remedy involves the treatment outlined above.
- Aquifer Replenishment: Complementing the bund construction, artificial recharge projects have been adeptly implemented for 59 dry dug wells. To restore deeper aquifers in the alluvial area of the Tapi Basin, surplus water from dams is gravity-fed into the dry dug wells at a rate of 70,000 liters per hour.
- Stream Enhancement: A comprehensive effort extends to the widening and deepening of small streams, with targeted dimensions of 2 meters in width and 1.5 meters in depth. This multifaceted approach reflects a commitment to sustainable water management and environmental well-being.

6.4 Harvesting Hope: Transformative Gains from Innovative Water Conservation in Shirpur Taluka

The innovative approach to cement bund construction and water conservation outlined above has yielded several significant benefits:

- Enhanced Water Storage: The construction of cement check dams strategically placed at suitable locations has increased water storage capacity, allowing for better management of water resources.In the Basalt region, where water levels had previously plummeted by as much as 150 meters, an astonishing recovery has occurred, witnessing a resurgence of 140 meters. The current water level now hovers at approximately 10 meters below ground level. Dry borewells in the Basalt region have experienced a notable recovery, reaching water levels as shallow as 6 meters below ground level, while in the Alluvial areas, depths of 20 meters below ground level have been attained.Similarly, in the Alluvial area, where water levels had descended by up to 150 meters, a noteworthy rebound has taken place, with an increase of 110 meters. The current water level in this region stands at around 40 meters below ground level.
- Streams now retain water until March, a significant improvement compared to the previous scenario where they used to dry up by November.
- Erosion Prevention: The bunds formed upstream of each check dam, along with the widening and deepening of small streams, contribute to erosion prevention, safeguarding the surrounding landscape.
- Community Engagement: Involving farmers in the process by allowing them to take away excavated fertile silt/soft soil for their farms fosters community engagement and a sense of ownership in the conservation efforts.
- Road Infrastructure Improvement: The use of excavated material for constructing new farm roads and developing existing ones not only aids in water conservation but also improves local infrastructure and accessibility.
- Multi-Functional Bunds: The creation of bunds with imperious black soil and stone reinforcement serves multiple purposes, including water retention, roadway construction, and prevention of leakages.
- Leakage Mitigation: The remedy applied to address heavy leakages in stone masonry check dams has successfully mitigated water loss, ensuring the effectiveness and sustainability of the water conservation structures.
- Aquifer Replenishment: Artificial recharge projects have successfully replenished 59 dry dug wells, contributing to the restoration of deeper aquifers in the alluvial area of the Tapi Basin.
- Gravity-Fed Water Channeling: Surplus water from dams is channeled into dry dug wells by gravity, providing an efficient and sustainable method for aquifer replenishment.
- Environmental Sustainability: The comprehensive efforts, including stream widening and deepening, contribute to environmental sustainability by promoting balanced water ecosystems and preventing degradation.
- Long-Term Water Security: The holistic and multi-faceted approach to water conservation ensures long-term water security for the region, benefiting both agricultural and community needs.
- Sustainable Drinking Water Supply: The perennial drinking water problem has been effectively resolved, ensuring a lasting solution.
- Increased Irrigation Capacity: The irrigated area has expanded, enabling farmers to cultivate double crops in this rainfed and non-command region.
- Sustainable Drinking Water Supply: The perennial drinking water problem has been effectively resolved, ensuring a lasting solution.
- Increase in per capita Income: Average per capita income has witnessed a substantial increase, with at least one lakh Rs./Ha added to farmers' incomes.
- Energy Efficiency: Energy consumption has decreased due to a reduction in suction length. Low horsepower pumps have been installed to draw water efficiently.
- Diversification into Fisheries: Fisheries have been successfully introduced in many villages, contributing to a rise in the annual income of farmers. These results collectively underscore the positive and sustainable impact of the water conservation initiatives on the socio-economic and environmental aspects of the region.

These benefits collectively reflect the success of the innovative water conservation approach in Shirpur Taluka, showcasing the positive impact on the environment, agriculture, and the well-being of the local community.

7. CONCLUSION

The project has markedly alleviated the severe scarcity of drinking water and irrigation resources that Shirpur taluka faced before its initiation. The relentless depletion of water levels, prompting farmers to extend pipes into deeper aquifers, has been reversed. In a region where 85% of the area depends on rainfed and non-command water sources, the completion of the project's sixth year heralds a transformative outcome. Adequate water is now available for irrigation, drinking, and industrial use, even during the summer months. The demonstrated success and viability of this initiative suggest its potential for broader application.

The Water Conservation techniques as implemented in this project, holds promise for replication across all small streams within mini and micro watersheds throughout Maharashtra. The envisioned outcome is the elimination of tanker-dependent villages and the assurance of water availability for second crop cultivation in rainfed and non-command areas. Envisioning a comprehensive impact, the total eradication of both floods and water scarcity seems achievable within a decade. The success of this project serves as a testament to the effectiveness of strategic water conservation initiatives in addressing critical water challenges and fostering sustainable water management practices.

Figure.3. storage in Dahiwad cement bund

WIDENING AND DEEPENING OF SMALL STREAM OF HAVING DIMENTION 2 METRE WIDE AND 1.5 METRE DEEP

Figure.4. widening and deepening of small stream of having dimensions 2m wide & 1.5m deep

ARTIFICIAL RECHARGE THROUGH THE DRY DUG WELL IN ALLUVIAL AREA OF SHIRPUR TALUKA

Figure.5. Artificial recharge through the dry dug well in alluvial area of shirpur taluka

CASCADE TYPE CEMENT BUNDS

Figure.6. cascade type cement buds

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