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Water Distribution Management Using Pipe Distribution Networks: A Case Study Of The Tarandale Minor Irrigation Project

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Abstract: Efficient and fair water distribution is essential for sustainable farming, especially in areas with hilly terrain and unpredictable rainfall. This study focuses on the planning and practical use of a Pipe Distribution Network (PDN) developed under the Tarandale Minor Irrigation Project in Tarandale village, located in Kankavali Taluka of Sindhudurg district, Maharashtra. The system taps into a nearby stream (nalla) with a total storage of 10.084 million cubic meters. It compares the performance of the PDN with that of traditional open canal methods by looking at technical feasibility, costs, water efficiency, and community benefits. Results clearly show that the PDN reduces water loss, ensures better water access for all farmers, and supports a wider variety of crops—especially when paired with modern micro-irrigation techniques.

Index Terms **- Pipe Distribution Network (PDN), WaterGEMs, Water Supply, Sustainable Practices, etc.**

I. Introduction

For years, agriculture has depended on gravity-fed open canal systems to manage water. While these systems once served their purpose well, they now face growing issues like seepage, evaporation, and maintenance-related losses. These problems become even more severe in regions with uneven terrain and unpredictable weather. As a result, many areas are beginning to shift toward piped distribution networks for better efficiency. The Tarandale Minor Irrigation Project, located in a semi-hilly coastal area, provides a valuable case to explore this transition. The goal of the project is to upgrade existing irrigation infrastructure in a way that improves water delivery, reduces wastage, and ultimately boosts agricultural productivity. This study looks into how the PDN was designed and implemented, and examines its impact on irrigation performance and the broader development of rural communities.

Literature Analysis

Several studies emphasized the inefficiencies of traditional canal systems, particularly in areas with high infiltration rates and water scarcity. The Central Water Commission's 2018 guidelines advocate PDN for efficient on-farm water management. Case studies from Maharashtra and other Indian states validate the benefits of piped systems, including reduced water loss, better pressure control, and adaptability to micro-irrigation.

Aim

To evaluate the implementation of PDN for improved water management of Tarandale Minor Irrigation Project.

II. Study Area

The Tarandale Minor Irrigation Project is located in Kankavali Taluka of Sindhudurg District, Maharashtra. It is an earthen dam, situated at latitude 16°18’00”N and longitude 73°40’27”E, with a catchment area of 4.22 sq. km. The dam has a total length of 955 meters and a height of 48.60 meters at the main dam. It features a clear overfall-type ogee spillway, designed to handle a maximum flood discharge of 147.70 cumecs. The design discharge is 0.953 cumec, catering to an irrigation command area (ICA) of 550 hectares.

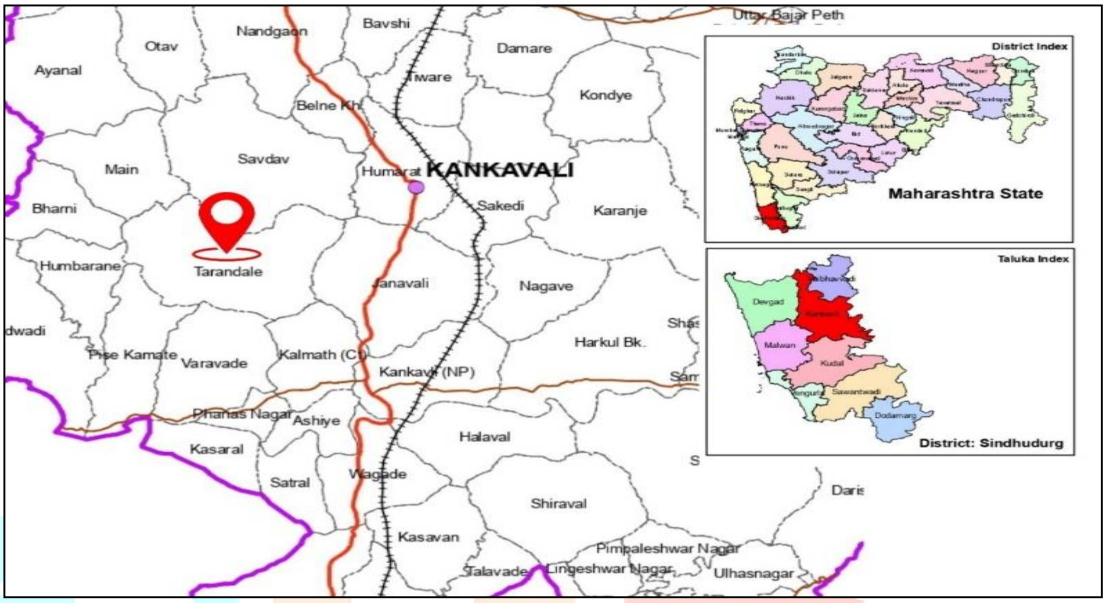

Fig.1 Location Map of Tarandale Dam

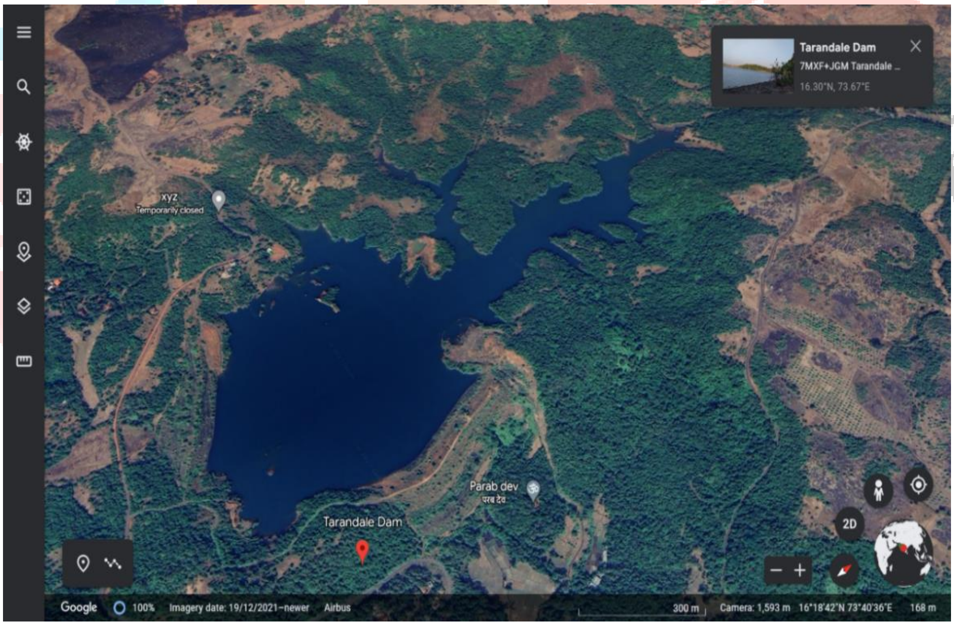

Fig.2 Satellite View of Tarandale Dam

III. Methodology

This research takes a blended approach, combining technical design evaluation, economic analysis, and feedback from local stakeholders. Data was gathered through project documents and on-site surveys. Both the traditional canal system and the new pipe distribution network (PDN) were studied in detail to assess their design features. A cost-benefit analysis was then carried out to compare the two systems, and input from community members was collected through discussions and surveys to understand their experiences and perspectives.

5.1 Economic Analysis

A cost comparison between open canal and PDN systems reveals:

Table -1: Cost Comparison

Sr. No.	Details	Open Canal	HDPE Pipe Line
1.	Construction Cost	Rs.132327546/-	Rs.134933123/-
2.	Land Acquisition Cost	Rs.31134819/-	Rs.4640086/-
	Total	Rs.163462365/-	Rs.139573209/-

Despite marginally higher capital costs, the PDN yields significant savings over time by reducing water losses and maintenance needs.

5.2 Hydraulic Model using WaterGEMs

To prepare hydraulic model of Pipe Distribution Network of Tarandale Minor Irrigation Project for improved water management following steps are carried out.

5.2.1 Data Collection – Collect geographical, topographical, and hydrological data of the command area. Gather soil data, crop patterns, and water requirements. Obtain the location and details of the water source

5.2.2 Chak Planning – Divide total command area into smaller zones known as chaks. Each chak should be of 8 to 12 Ha.

5.2.3 Layout of PDN - Draw a schematic layout of the main pipeline, sub-mains, and laterals based on field shape and slope. Choose pipe alignments to minimize energy losses and maximize gravity flow, if possible.

5.2.4 Material Selection – Select pipe material, valves based on working pressure, Soil conditions, Cost and durability and Availability.

5.2.5 Hydraulic Design - Design each pipe section using Modified Hazen-Williams formula to determine diameter and velocity.

5.2.6 Results – The hydraulic model provides optimal pipe diameters for each section of PDN, pressure head distribution at each node, flow velocity and discharge values.

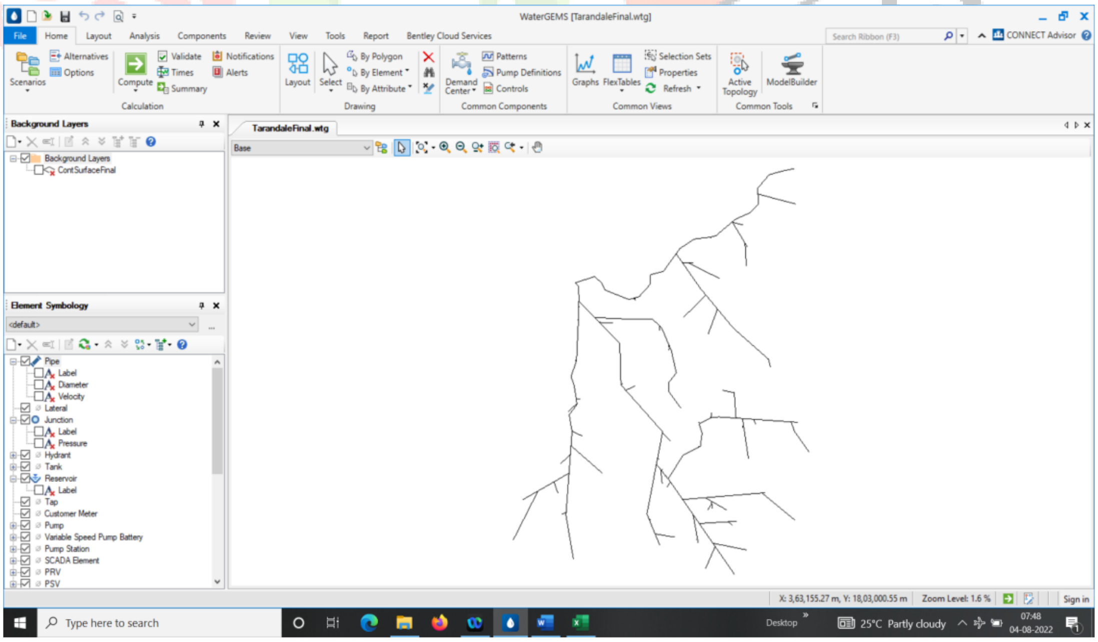

Fig.2 Schematic Network in Bentley's WaterGEMs

IV. Result and Discussion

Switching from the planned canal system to a Pipe Distribution Network (PDN) brought significant improvements. The Culturable Command Area (CCA) expanded from 550 to 744 hectares, boosting irrigation efficiency. While the canal system would have required around 29.19 hectares of land, the PDN functions effectively with just 4.35 hectares—cutting land needs by over 85%. This not only saved on land acquisition costs but also minimized environmental impact. The PDN delivers water more evenly across the area, especially reaching tail-end fields, and encourages the use of micro-irrigation techniques. Together, these benefits lead to better crop yields and more sustainable farming practices.

Table -2: Sample of Modelling in Bentley's WaterGEMs and H.G.L. Statement

Start Node	Stop Node	Pipe Label	Length Scaled (Mts)	Flow in (Lps)	Internal Diameter (mm)	External Diameter (mm)	Elevation at start (meter)	Elevation at end (meter)	Start Pipe Top Elevation (meter)	End Pipe Top Elevation (meter)	Elevation Difference (meter)	Head Loss (Mts)	Hydraulic Grade Start (M)	Hydraulic Grade Stop (M)	Pressure Start (m H_2O)	Pressure Stop (m H_2O)	Velocity (M/Sec)	Pipe Material
R-1	J-1	P-1	9.803	561.40	664.5	710	79.00	78.31	77.500	76.81	-0.69	0.03	80.00	79.97	1.00	1.66	1.71	HDPE PE100 710/4
J-1	J-2	P-2	188.005	551.90	664.5	710	78.31	60.95	78.310	60.95	-17.36	0.51	79.97	79.47	1.66	18.52	1.68	HDPE PE100 710/4
J-2	J-3	P-3	52.841	157.72	468	500	60.95	69.15	60.950	69.15	8.20	0.08	79.47	79.39	18.52	10.24	0.97	HDPE PE100 500/4
J-3	J-4	P-4	123.601	149.05	468	500	69.15	72.51	69.150	72.51	3.36	0.17	79.39	79.22	10.24	6.71	0.91	HDPE PE100 500/4
J-4	J-5	P-5	389.953	136.83	468	500	72.51	75.04	72.510	75.04	2.53	0.45	79.22	78.76	6.71	3.72	0.84	HDPE PE100 500/4
J-5	J-6	P-6	426.102	124.45	421.1	450	75.04	76.80	75.040	76.80	1.76	0.69	78.76	78.07	3.72	1.27	0.94	HDPE PE100 450/4
J-6	J-7	P-7	40.762	110.24	332.2	355	76.80	75.92	76.800	75.92	-0.88	0.17	78.07	77.90	1.27	1.98	1.34	HDPE PE100 355/4
J-7	J-8	P-8	303.522	100.56	294.7	315	75.92	69.85	75.920	69.85	-6.07	1.87	77.90	76.03	1.98	6.18	1.55	HDPE PE100 315/4
J-8	J-9	P-9	147.642	87.58	262	280	69.85	62.58	69.850	62.58	-7.27	1.25	76.03	74.78	6.18	12.20	1.71	HDPE PE100 280/4
J-9	J-10	P-10	86.070	75.65	262	280	62.58	58.92	62.580	58.92	-3.66	0.56	74.78	74.22	12.20	15.30	1.48	HDPE PE100 280/4
J-10	J-11	P-11	187.705	59.17	233.9	250	58.92	54.98	58.920	54.98	-3.94	1.35	74.22	72.87	15.30	17.89	1.45	HDPE PE100 250/4

The PDN system is built using HDPE PE100 pipes of different sizes, allowing it to handle water flows ranging from 561.40 to 59.17 liters per second across a 1,985-meter stretch (as observed in sample data). Flow speeds stay within an optimal range of 0.84 to 1.71 meters per second, which helps keep energy losses low. Even with changes in elevation along the route, the system maintains consistent hydraulic pressure—from 1.00 to 17.89 meters—ensuring smooth, gravity-based water delivery. This results in reliable and fair water distribution, making the setup especially well-suited for micro-irrigation. Overall, the design works efficiently even on uneven terrain, offering a sustainable solution for agricultural irrigation.

V. Conclusion

Replacing the proposed canal system with a Pipe Distribution Network (PDN) has brought a major boost in irrigation efficiency and long-term sustainability. The Culturable Command Area (CCA) increased from 550 to 744 hectares, while land needed for the project dropped sharply—from 29.19 hectares to just 4.35 hectares. This more than 85% reduction in land use also translated into significant cost savings. The PDN provides a steady and even water supply, reaching even the tail-end fields more effectively, and encourages farmers to adopt micro-irrigation methods, which help improve crop yields.

The network uses HDPE PE100 pipes of various diameters and manages water flow efficiently—from 561.40 to 59.17 liters per second—across a 1,985-meter stretch (as per sample data). Flow speeds remain in an ideal range of 0.84 to 1.71 meters per second, and the system maintains stable hydraulic pressure between 1.00 and 17.89 meters with minimal head loss. This makes it highly suitable for uneven terrain and positions the PDN as a reliable, scalable solution for modern, climate-resilient farming.

VI. Acknowledgment

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