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Comparative study of Pipe Distribution Network and Canal Distribution network of Tembhu lift irrigation project

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Abstract : This study provides a comparative analysis of the pipe and canal distribution networks of the Tembhu Lift Irrigation Project with the objective to eliminate water scarcity and enhance agricultural yields in Maharashtra, India's drought-prone areas. The Tembhu Lift Irrigation Project, a significant initiative, provides an analysis of its pipe and canal distribution networks in this research. The effectiveness, cost effectiveness, environmental effect, and maintenance required of both distribution systems were evaluated under the investigation. The study analyzes these two networks with the aim of determining whether the approach for the Tembhu Lift Irrigation Project delivers improved sustainability and overall performance. The results indicate that although the pipe network is more efficient and provides advantages for water conservation, the canal system continues to be an excellent option due to its established use in the area and its economic viability. The recommendations in the paper's conclusion can be used to optimize the distribution network in order to save expenses, improve water use efficiency, and guarantee the irrigation project's long-term success.

Keywords: sustainability, economical, productivity, potential issues

I. INTRODUCTION

The majority of India's areas are susceptible to drought, making it impractical to provide water at higher elevations. Consequently, lift irrigation involves extracting water from a water resource with the use of pumps and other machinery. This approach increases agricultural productivity by supplying water to areas with greater elevations. Rivers also provide the water essential to industry, agriculture, and domestic use. They additionally create deltas as well as deposit fertile ground in the grasslands, stimulate inland fishing, and generate hydroelectricity. Chavan R. et al. (2014)

Rainfall is an essential component in the agricultural sector, and this is also essential in addressing the needs of the current population. The average yearly precipitation in a specific region influences the water conservation methods used within. The crops depend on the pattern of rainfall, with nearly every part of the state obtaining over 90–95% of it, which is extremely beneficial for agricultural output. Regeneration, the installation of carbon emission machines, a proliferation of nondegradable waste, and enterprises that generate or emit harmful pollutants into the environment are among the primary causes of changes in rainfall. Therefore, rainfall as well as temperature are the two key variables determining the agricultural sector. Agricultural activities rely mainly on the practices used for efficient crop growth. Waghmare T. et al. (2019)

II. LITERATURE REVIEW

Shah et al. (2007) have investigated that the use of groundwater likely provides the majority of the world's drinking water, and during the past 50 years, there has been an incredible, if mostly unnoticed, surge in the use of groundwater for agriculture, improving livelihoods and ensuring food security for billions of farmers and consumers. In both hydrologic and human systems, groundwater plays an important role, having its own impacts and being overlooked. It is demonstrated that research on the spatial and temporal aspects of groundwater use, as well as the variety of institutional and technological strategies used in attempts to regulate it, is reviewed in this article. It is concluded that, often, the most promising remedies may not be found in the groundwater industry itself but rather in a more comprehensive approach to resource systems.

Giordano et al. (2009) have presented that the use of groundwater has created many problems and also has a positive role in both hydraulic and environmental systems. It is also observed that the use of groundwater helps with agricultural purposes, industries, and commercial systems. In this article, it is presented that groundwater resources are difficult to manage, and many water management systems are established to control the usage of water.

Gebregziabher et al. (2009) have observed that the regional government of Tigray has implemented a number of irrigation techniques in an effort to reduce poverty. Their objectives are to comprehend the relationship between farm household income, poverty status, and small-scale irrigation. to identify strategies for alleviating Ethiopia's poverty and, lastly, to enlighten decision-makers. Using three-stage stratified sampling with probability proportional to size, a representative sample of 613 farm households (331 irrigators and 282 non-irrigators) was obtained. It is found that the average income of non-irrigating homes is about fifty percent less than that of irrigating households, and that the average yearly income gain per household as a result of having access to irrigation is between four thousand and four thousand Birr. Access to irrigation is adversely associated with money earned outside the farm.

Rao et al. (2011) emphasized the need for water user associations, which help in irrigation system management, especially in lift irrigation projects that augment water supplies in rainfall-prone areas. This study examined the effects of farmers' participation in these lift irrigation schemes on the management and use of water resources in the Amarachinta and Kanuparthy lift irrigation systems in Andhra Pradesh. In these two districts of Andhra Pradesh, India, field data was provided by farmers and government entities. In these two districts of Andhra Pradesh, India, field data was provided by farmers and government entities. The evaluation of the effects of farmer participation was contingent upon several aspects, including enhanced water usage efficiency, irrigation effectiveness, project water efficiency, fee collection, sustainability of the command area, finance management, and others. Irrigation efficiency increased from 46% to 81% as a result of beneficiary societies in the Kanuparthy LIS taking over management from the government. The two LISs have been used well.

Zende et al. (2012) have studied how state responsibilities have led to decentralization and delegation in irrigation management. It is observed that throughout India, especially Maharashtra, local farmer organizations have taken over approximately 30% and almost 50% of the country's public irrigation systems, respectively, since 2005. This study examined changes in agricultural, water use, environmental, and financial performance factors between 1984 and 2000 and 2001 and 2010 after the transfer, all within the context of the Takari Lift Irrigation Scheme. Over the next ten years, irrigation performance improved steadily, according to the data. The primary discovery was a notable increase in farming.

Singh et al. (2013) have evaluated the effectiveness of the Sirsa Manjholi Lift Irrigation Scheme's irrigation water management in the Solan region of the Shivalik Himalayas. A case study was created. The cropping pattern is not changed using this irrigation system. There are no permanent diversion headworks in the place so that the diverted water can be used. Because of the widespread mining of the riverbed material, the river's water level is decreasing daily. Farmers are not very involved in the scheme's water management, and the Krishak Vikas Sangh is non existent. The water charges are very low, and that too is not being collected.

Patil et al. (2014) have pointed out that water availability will drop from 1820 million m3/year in 2001 to as low as approximately 1140 million m3/year in 2050.By 2050, India's population is predicted to stabilize at roughly 1640 million. The growing concern over water scarcity is to provide water management systems for it. In India's drought-prone areas, solutions to the problem of water scarcity are frequently proposed, including roof-top rainwater harvesting systems that supply water for domestic use and micro-watershed development that guarantees the availability of water for domestic and agricultural use. The rooftop rainwater harvesting program in Renavi Village, Sangli District, Maharashtra, India, is the subject of this article's success story. According to the village's potential assessment, 1300 people's water needs will be met for at least 78 days by collecting about 20 lakh liters of water from rooftops. This estimate complies with the United Nations Standard, which states that each person in India needs 20 liters of water per day for domestic and cooking purposes.

Van Le et al. (2014) have studied the recent development in Asian irrigation that has been described as a change from gravity to lift irrigation, but there is still an urgent need to gather data on the significance of surface water individual lift irrigation. During the spring crop season, surveys on field water application by farmers utilizing lift were conducted in three locations within the 44,600 ha River Son drainage and irrigation region. 82% of families were found to practice lift irrigation. The primary lift technology consisted of an electric and gasoline-powered mechanical pump, followed by swing and long-handle baskets. The primary means of lifting was through farm canals. While individual lift irrigation accounted for 25–52% of all irrigated areas, gravity irrigation maintained the most predominant field application method. Assuming larger values from the sites, individual lift contributed 29% to irrigation area and volume, while mechanical and manual lift contributed 17% and 12%, respectively. The use of mechanical pumps expanded dramatically with the distance of water supply from the main canal and was a response to locally high field elevations. Hydraulic pumping has a major and advantageous effect on flexibility and dependability. Farmers benefited from greater flexibility and dependability, as well as the capacity to use less water when using petrol-driven pumps, despite the comparatively high initial and operating expenses. In order to make up for the unpredictable availability of electric power, farmers who used electric pumps applied a lot more water, wasting energy in the process.

Chavan et al. (2014) pointed out that India is among the nations in the world with the greatest concentration of rivers and tributaries, which are beneficial to the nation's inland transportation network as well as the agriculture sector. In addition, rivers provide the water needed for agriculture, industry, and residential use. They also produce hydroelectricity, support inland fishing, deposit rich soil in the plains, and create deltas. Balsubramanian (2007) notes that certain river basins are also accountable for retaining natural gas and oil, which adds to the rivers' list of benefits. Rivers are important water sources that distribute nutrients and water throughout the earth. They serve as drainage pathways for surface water and are extremely important to the water cycle. Approximately 75% of Earth's land surface is drained by rivers.

Wagh and Katalakute et al. (2016) in this study they focussed and pointed out that India's agriculture sector plays a significant role in the country's economy and contributes significantly to its GDP. Nonetheless, erratic monsoons and shifting climate patterns throughout India have increased agricultural losses recently. A substantial portion of India's GDP comes from the prosperous and developed state of Maharashtra. This study examines the consequences of Maharashtra's droughts on the environment, agriculture, and social problems between 2011 and 2016. Rainfall deficits arise every five to six years, while severe droughts, which impact nearly half of the state, happen every eight to nine years. Between 2011 and 2015, Maharashtra had a decreasing amount of rainfall in comparison to average levels.

Kalle et al. (2016) has monitored that the Indian government has worked hard to create and sustain a variety of irrigation systems, but many of these efforts have not produced the expected outcomes, frequently because of structural issues that these programs are prone to. In the meantime, fresh ideas concerning solutions are being spurred by South Asia's increasing water constraints. This paper, which at first glance appears to have nothing to do with caste discrimination, evaluates the sustainability of lift irrigation systems (LIS) in Andhra Pradesh (AP) based on extensive fieldwork. It raises important concerns regarding the administration of these programs and discusses how new technologies affect rural development, making the case that the state must continue to be technologically astute in its involvement in the irrigation industry. Although it has been discovered that, aside from management-related concerns, greater use of solar energy could be extremely beneficial for bolstering economic viability and environmental sustainability, the study also uncovers additional socio-political reasons that could account for the withholding of state support for marginal farmers in the region under investigation.

Gaikwad et al. (2016) have reviewed that the degradation of water quality presented a difficult challenge to the scientific community. Regular monitoring of aquatic resources through assessment of their physical and chemical qualities is the only dependable approach to combating this terrible issue of water pollution. One of the holiest and second-biggest rivers in the Indian state of Maharashtra is the Krishna River, or Sangli. But now there is a serious contamination issue with the river. The current study was conducted to evaluate the water quality of the Krishna River in Sangli, Maharashtra, India, with consideration for the necessity of regular monitoring. To indicate the degree of contamination in the study region, various physicochemical characteristics were frequently examined during the evaluation period. The research region's Krishna River exhibits persistent pollution despite its improved water quality, as indicated by the notable diversity in its physicochemical parameters. The current analysis demonstrates the necessity of an urgent action plan to control pollution and preserve the river Krishna's higher water quality.

III. DESCRIPTION OF STUDY AREA

The study area, Tembhu Uplift irrigation project is in Satara District and located at 17°30' N and 74°24'E, It includes lifting of water from Krishna river in 5 stages to irrigate 80472 Ha area from Satara, Sangli and Solapur district of Maharashtra. The objective of the scheme is to extract water from the Krishna River and distribute it through a system of canals and pipes to irrigate about 98,000 hectares of farmland. The region has semi-arid surroundings with 500–700 mm of annual rainfall, the majority of which occurs during the monsoon season. Additionally, there are various soil types, which include lateritic, black cotton, and alluvial soils, and the landscape is undulating.

The Tembhu Lift Irrigation Project in Maharashtra's Satara district attempts to deliver an adequate and sustainable water supply for cultivation. The Krishna River provides the project's primary sources of water, which is then pumped up using large-capacity pumps and provided throughout a broad network of canals and pipes. The lift irrigation system is especially effective at navigating over obstacles caused by the region's varying geographical locations while simultaneously making sure the irrigation water reaches even more elevated peaks.

An enormous amount of water has been allocated to the project; each year, millions of cubic meters of water are lifted and relocated. The project's specific goal is to accumulate and disperse about 34 TMC (thousand million cubic feet) of water annually. This significant volume of water covers the irrigation requirements of an extensive quantity of agricultural land, facilitating the establishment of several crops and raising agricultural production.

The Tembhu Lift Irrigation Project's usage of water has been meticulously anticipated and analyzed in order to maximize effectiveness and minimize waste. Complex irrigation methods, such as sprinklers and drip systems, are used to ensure that water is used efficiently across areas. This emphasizes sustainable cultivation techniques while also contributing to the preservation of water. The design provides the construction of a barrage across the Krishna River near the village of Tembhu, measuring 285 meters in length and 16 meters in height. The "Link I A" network, which intends to connect the following villages - Tembhu, KambaleAnudh, Kadegao, Kadepur, Chikhali, Amarapur, Tondoli, Upale Mayani, Kherade wangi, Kherade Vita and Tupewadi, Renuswadi,Shivaji nagar, Kadegao MIDC - to a water source is part of the research area.The entire Kadegao network area is characterized by Zone I; the entire network is divided into three zones. The schematic diagram of the Kadegao WDN is shown in Fig. 3.

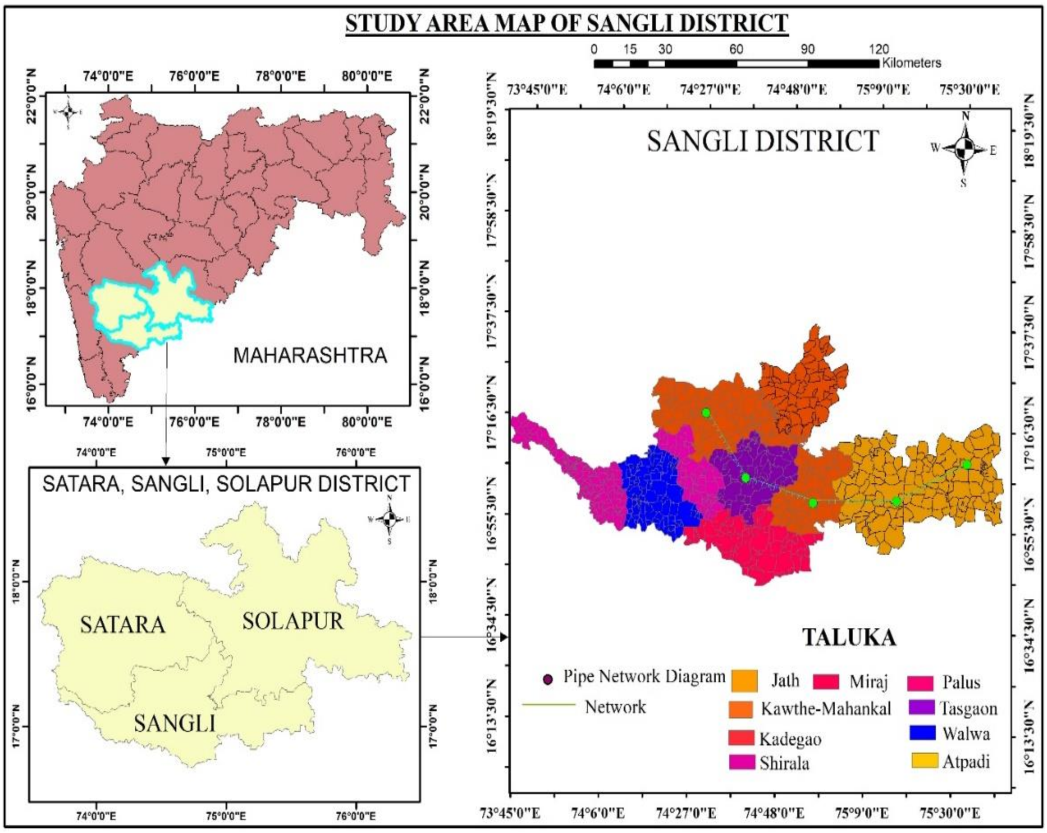

Figure 1 :- Study area map of Sangli district

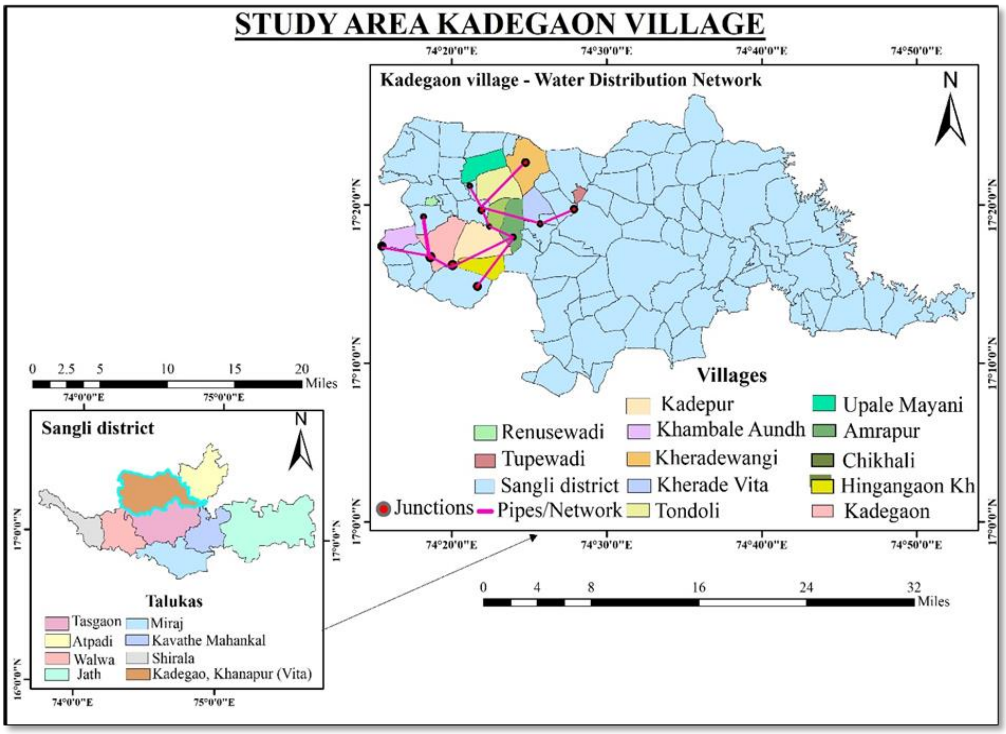

Figure 2 :- Study area map of Kadegaon District

There are 12 junction nodes, 1 clear water reservoir, 1 tank, 13 pipes, 1 pump, and 2 flow control valves (FCVs), particularly for the gravity cum pumping supply system. Nodal junctions from 1 to 5 are in Zone I, 6 to 8 are in Zone II, and 9 to 13 are in Zone III. Three tanks are situated in the Kadegao II area, receiving treated water supply from the water reservoir situated at the banks of the Krishna River. As of right now, Phases 1A, 1B, 2, 3A, and 3B of the Tembu project have been executed. Phase No. 4 at Vejegaon was completed in November 2018, and Phase No. 5 at Bhud was finalized in April 2019. For 7700 areas in Tasgaon Taluka, all phases of the Visapur Pundi Upsa Yojana have been executed.

The water distribution network of study area consists of 13 pipes, 12 nodes and one main over head tank. The pressure is computed using Darcy - Weishbach Approach. Pressure at all junctions are found to be adequate. The minimum diameter of pipe chosen was 1200 mm. There is fluctuation in the pressure head. The roughness coefficient of the pipe throughout the network is 100.

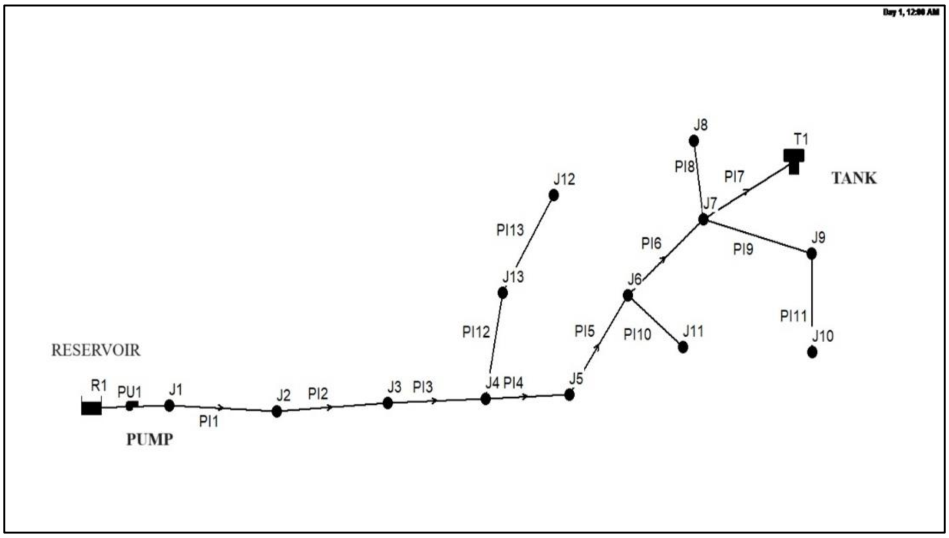

Figure 3 :- Schematic of Tembhu lift irrigation project – (LINK-1 Kadegaon region)

Given below table represents the various pipes and their required specification used in the above mentioned network.

Table 1 :- Pipe parameters

Pipe ID	Head Node	Tail Node	Length (m)	Diameter (mm)	Roughness	Pipe Material
P1	1	2	2350.0	2500	100	DI
P2	2	3	2426.54	1500	100	DI
P3	3	4	2140.96	2500	100	GI
P4	4	5	686.12	1500	100	DI
P5	5	6	2181.62	2500	100	DI
P6	6	7	520.43	2500	100	DI
P7	7	14	386.35	1200	100	GI
P8	7	8	1000.1	2500	100	DI
P9	7	9	1210.5	1500	100	GI
P10	6	11	1145.23	1800	100	DI
P11	9	10	1620.4	2500	100	DI
P12	4	13	1653.02	1800	100	DI
P13	12	13	1000.23	1300	100	DI

The pipe diameters varying from 2500 mm to 1500 mm are used to convey the water from the CWR to all junction nodes. They are made of ductile iron (DI) and galvanised iron (GI) having Hazen William's roughness coefficient of 100 for Cast iron (Unlined). The details of the pipe data are given in Table 1. The water demands of Zone I, Zone II and Zone III are 60, 30 and 20 L/s, respectively.

Advanced control equipment, including gates and valves, is installed at every junction to assist with regulating the water flow across different channels and sub-channels. Due to the region's uneven surfaces, this ensures that water reaches far-off fields even at different heights. The connecting elements also facilitate the integration of several lift points, which raise water with the help of powerful pumps and then separate it by gravity or additional transport stages. Additionally, these junctions are constructed to

dynamically track and change the distribution in accordance with the fluctuating demands of crop fields throughout the span of the year.
The study area map shown below is given in terms of pipes, pumps, tanks, reservoirs, and tanks specified by the place.

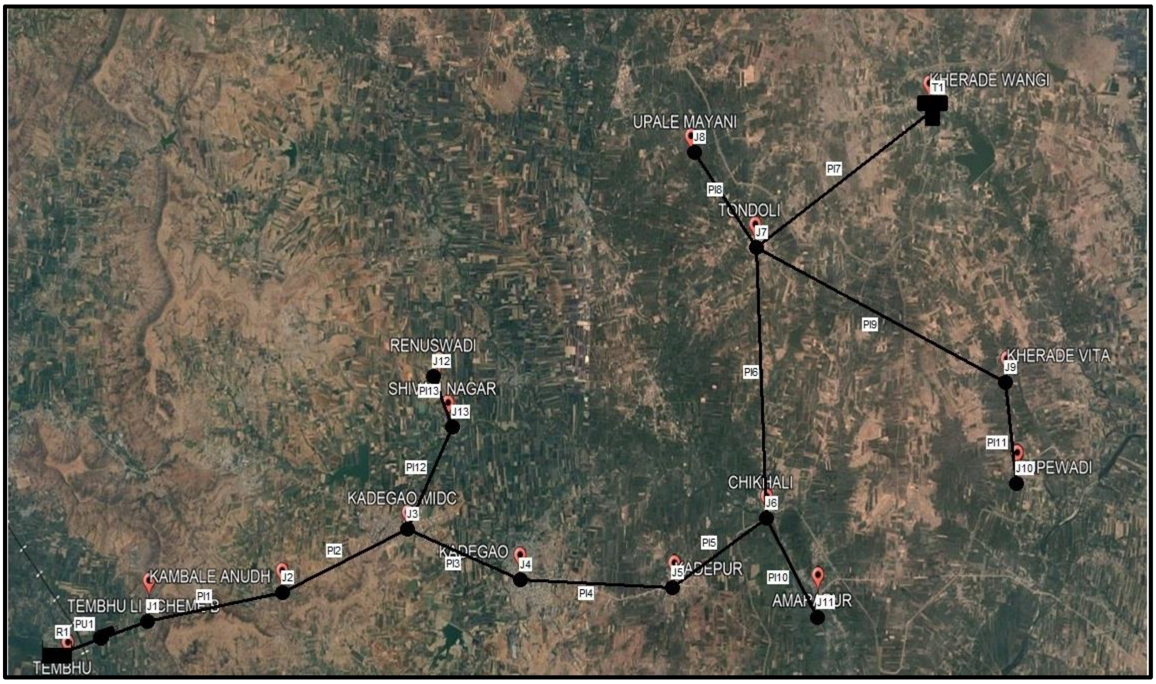

Figure 4 :- Water Distribution Network (Kadegaon)

The given below table classify the various nodes at different locations in the water distribution system .

Table 2 :- Node Parameters

Node ID Junction	Elevation (m)	Base Demand (LPS)	Location
J1	1635	57.37	Tembhu scheme B
J2	1632	57.37	Kambale Anudh
J3	1638	32.88	Kadegao MIDC
J4	1700	22.8	Kadegao
J5	1754	30.27	Kadepur
J6	1765	29.4	Chikhali
J7	1785	53.24	Tondoli
J8	1820	35.14	Upale Mayani
J9	1685	25.52	Khearde vita
J10	1653	20.54	Tupewadi
J11	1705	25.36	Amarapur
J12	1753	55.68	Renuswadi
J13	1735	48.36	Shivaji nagar

IV. NECESSITY OF WORK

A comparative analysis of the pipe and canal distribution networks in the Tembhu Lift Irrigation Project is crucial to comprehension of the efficiency and constraints of each system in the context of modern irrigation demands. This study aims to evaluate the performance, cost-effectiveness, water conservation, and overall sustainability of the two distribution strategies. Pipes provide benefits such as reduced water loss through evaporation and seepage, along with the capability of greater precision water distribution, which could enhance agricultural productivity and resource management. However, they come with higher initial expenses along with upkeep issues. Traditional canal systems, on the contrary, are less expensive and easier to maintain; nevertheless, they periodically experience significant water losses and require a large amount of land, which can be an obstacle in highly populated or agriculturally intensive areas. This study aims to provide practical insights that can help officials and technicians determine the best irrigation method for the Tembhu Lift Irrigation Project, thereby optimizing water usage, lowering costs, and promoting sustainable agricultural practices. This study is not only crucial for the immediate geographical area, but it also has significant implications for equivalent irrigation projects internationally.

V. MATERIALS AND METHODS

In order to compile thorough information on both distribution systems, the study utilized references to engineering drawings, design documents, and complete project reports that were supplied by the project authorities. The distribution networks were mapped using Geographic Information System (GIS) technologies, which allowed for a geographical examination of the coverage and structure of the system. The hydraulic performance, efficiency, and dependability of both networks were simulated and contrasted using hydraulic modeling tools, such as EPANET for pipes. Cost-benefit analysis techniques were used in economic analysis to assess each system's original investment, ongoing operating and maintenance expenses, and maintenance requirements. In order to compare the ecological footprints of the pipe and canal networks, environmental impact assessments were carried out.

VI. OBJECTIVE OF THE STUDY

This study compares and contrasts the Tembhu Lift Irrigation Project's pipe and canal distribution networks in order to assess each system's effectiveness, affordability, and environmental impact. The purpose of this study is to evaluate each system's benefits and drawbacks with regard to sustainability, initial investment, maintenance needs, and water delivery efficiency. Through the analysis of these variables, the study aims to offer thorough recommendations for enhancing irrigation techniques, enhancing water management, and guaranteeing the Tembhu Lift Irrigation study's long-term sustainability. Supporting well-informed decision-making that maximizes agricultural productivity while preserving water supplies and reducing ecological disturbance is the ultimate objective.

VII. DESIGN PARAMETERS OF PDN AND CDN

Hydraulic Parameters - In PDN, the flow rate is minimum 57.31LPS and maximum flow rate in pipe network is 66.2 LPS. The flow rate and the necessity of minimizing friction losses are taken into account while determining the pipe diameter. Greater diameters cost an additional amount but also reduce friction. Primary pipelines in the Tembhu lift irrigation scheme have diameters between 1000 and 1800 mm, while secondary and tertiary pipelines have dimensions between 250 and 600 mm. In lift irrigation, the pressure head - the elevation to which water is raised - is crucial.

The Darcy-Weisbach or Hazen-Williams equations are applied for estimating friction losses, which have a consequence on the energy required to pump water. The length, roughness, and flow rate of the pipe significantly impact these losses. In the project, selecting smoother pipes and maximizing pipe diameters and lengths reduce overall energy costs by minimizing friction losses.For lift irrigation to overcome height inequalities, pumps are necessary. The project's energy consumption is directly impacted by pump efficiency, which is a measurement of the hydraulic performance of the pump. High-efficiency pumps with efficiencies between 70 and 85% are utilized to provide sustainable water distribution while decreasing energy consumption.

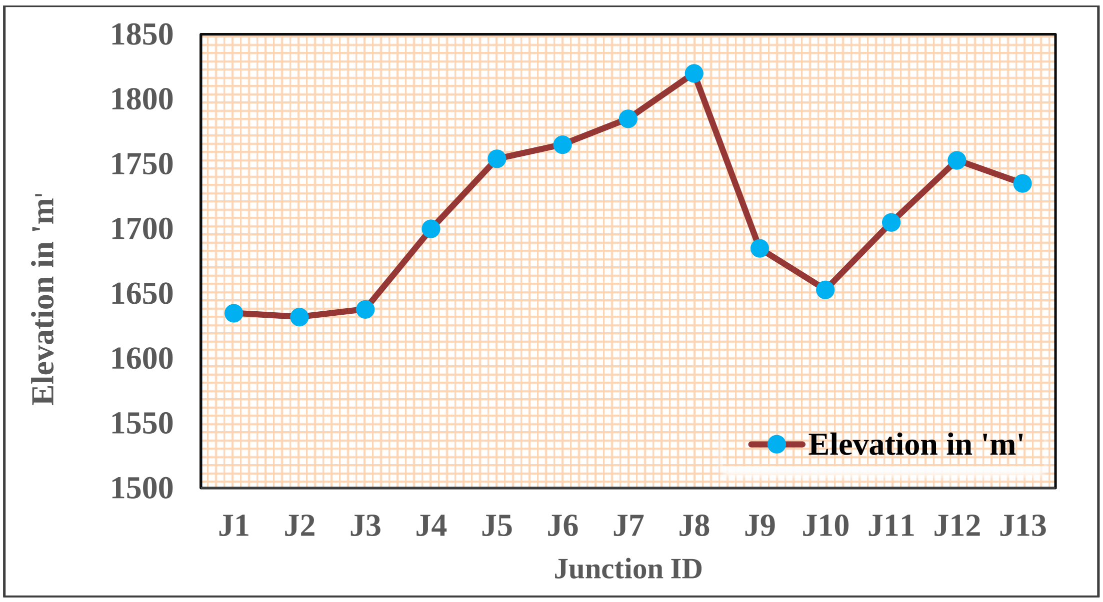

Figure 5 :- Elevation levels of various junctions graph

Material Selection - The selection of materials for the irrigation system's pipes and other parts has a significant impact on the project's effectiveness, longevity, and affordability. Steel, high-density polyethylene (HDPE), and polyvinyl chloride (PVC) are the main pipe materials used in this lift irrigation project. PVC pipes are used for small to medium-sized lift irrigation systems because of their lightweight, ease of installation, and resistance to corrosion. Due to their strength and flexibility, HDPE pipes are the best alternative for regions with steep terrain or for installing pipes along undulating paths. Steel pipes are used in high-pressure applications despite being more costly and heavyweight because of their durability and capacity to tolerate high internal and external pressures. PVC and HDPE pipes are used in combination for this project's distribution network. Because of the high pressure at this initial phase, the main lift station pumps water from the Krishna River into a large distribution pipeline constructed of steel. Subsequently, the water is transferred to secondary and tertiary pipelines, which are constructed of HDPE to effectively traverse the uneven terrain.

Pressure Distribution - The main steel pipeline from any pressure surges, pressure distribution has been carefully monitored via a sequence of pressure relief valves. Additionally, to verify that the pressure reduces to levels compatible with agricultural usage, pressure-reducing valves are strategically placed at certain critical locations in the secondary HDPE pipelines. Alternatively, air release valves are employed to prevent airlocks from being created and to ensure that water circulates freely throughout the network. Hydraulic simulations are carried out throughout the design phase to verify even pressure distribution and optimize water supply systems. With the use of these simulations, engineers managed to identify significant pressure drop locations while designing the necessary modifications, such as surge pumps and additional valves that are used. A key factor that impacts the efficiency and consistency of water delivery to fields is the pressure distribution throughout the pipe network. In order to prevent both under- and over-irrigation, proper pressure management helps ensure that all of the irrigated land receives enough water. Determining the hydraulic gradient and ensuring that the pressure at the network's distant point is within acceptable limits are two steps in the design process. To achieve this goal, highly accurate hydraulic modelling is required, along with pressure-regulating tools including air release, pressure-reducing, and pressure-relief valves.

Canal alignment and layout :- The main canal in the Tembhu lift irrigation Project on the Narmada River in India, which requires the benefits of natural slopes and allows water flow by gravity. This method of construction decreases dependence on pumps after initial lift from the river, thus reducing energy and operating costs. The main canal, branch canals, distributaries, and field channels are constructed in an ordered sequence within the canal network. Water flows from the source to various locations within the administrative region by the main canal, which is frequently a major part of the network. Branch canals move from the main canal to service the administrative geographical region's subregions. Assuring that water flows adequately to places with higher demand, these branch canals are thoroughly constructed around the slopes and depressions observed in the surroundings. From branch canals, distributaries extend downward, separating the flow to reach particular crop fields. The topography of the land and the watering demands of regional vegetation influence where these distributaries are positioned. During stability, to minimize conveyance losses and maintain timely water supply, the distributaries of the project have been placed so that only a part of the area of operation is more than a short distance from a water source. The network's decreased drainage systems, referred to as field channels, are designed to supply water to the crops directly. These channels are designed to circulate water evenly throughout the fields, and they are typically positioned across agricultural boundaries. Field canals are carefully constructed in order to ensure that water reaches all areas of the land, increasing agricultural yields and enhancing water use efficiency. For controlling and regulating the water flow, structural elements like division boxes, gates, and regulators are positioned consciously throughout the network of canals. These structures are crucial in regulating the distribution of water as their functions maintain that, along with demand, the appropriate amount of water is distributed to each component of the network.

Cross - drainage and sediment control structures:- Canal cross-drainage and sediment control structures are necessary for effective transportation of water and system durability in lift irrigation projects. For the canals to provide constant flow, prevent causing harm to the canal, and regulate natural watercourses that intersect the canal network, cross-drainage structures are required. Aqueducts, siphons, major channels, and level crossings are some examples of these constructions. Where the canal is to cross a naturally existing stream, an aqueduct is utilized to efficiently convey the canal water across the stream without creating any blending together. On the contrary, a siphon creates an imbalance in pressure that forces the water through the siphon pipe, allowing the canal to flow beneath an obstruction like a road or river.

VIII. CONSTRUCTION GUIDELINES OF PDN AND CDN

i) Excavation and Trenching:- Digging trenches for pipelines according on the width and depth determined by the design. To contribute to facilitate water flow, ensuring that the trenches are oriented and sloped adequately. The trench required to be at least 300 mm (12 inches) wider than the pipe diameter for pipes up to 150 mm (6 inches) in diameter. It provides backfilling and compaction substantial area. The trench width should be the pipe diameter and 450 mm (18 inches) for pipes bigger than 150 mm in diameter. For protection of the pipe from surface hazards the minimum cover, the space between the pipe's head and the ground should be at least 600 mm, or 24 inches. The covering level to at least 900 mm (36 inches) in areas with heavy use or load-bearing surfaces.

ii) Pipe Laying and Jointing:- Laying pipes in the trenches that are being excavated, ensuring that they are supported and oriented accurately. Making use of the appropriate jointing techniques (such as butt fusion for HDPE pipes and solvent welding for PVC pipes). Monitoring for leaks in joints ahead of backfilling.

iii) Backfilling and Compaction:- Using the appropriate material to backfill trenches, ensuring to compact the material thoroughly to prevent settlement subsequently on. For repair reasons, leave traces or signs indicating wherever buried pipes are placed. To support the pipe, a bedding layer of sand or other granular material at least 100 mm (4 inches) deep is placed at the bottom of the trench. Ensuring that the bedding has been distributed evenly and is under pressure. Pipes have to deliver equal support within their entire width against the covering layer. Avoiding sharp stones or other debris in the bedding material that might damage the pipe. Backfilling the area enclosing the pipe with the specified fill material (sand or fine granular material) up to at least 150 mm (6 inches) above the pipe's top. To ensure stability, compacting the initial backfill into layers of 100 mm (4 inches). For the last backfill, utilizing excavated material that is cleared of large stones or other debris and subsequently compacting the backfill into 150-mm (6-inch) layers.

iv) Installation of Valves and Meters:- For regulating water flow, implement control valves at desired points throughout the network. Installing water meters in significant locations to maintain track on employ to identify leakage.

Aspect	Pipe distribution network (PDN)	Canal Distribution Network(CDN)
Definition	Main pipeline system that carries water from the source to the main locations for distribution	Water circulates across fields by a network of canals from initial delivery regions.
Material Selection	HDPE, ductile iron pipes (DIP), and reinforced concrete pipes (RCP)	Brick-lined, unlined earthen, and concrete-lined canals
Design Capacity	Large amounts throughout the entire area of command	Reduced quantities for regional distribution
Pressure Considerations	High pressure, requires strong materials	Gravity flow, lower pressure, depends on canal slope and design
Alignment and Layout	Minimize elevation changes, avoid populated and sensitive areas	Follow topography, use gravity flow, network of primary, secondary, and tertiary canals
Valves and Controls	Main control valves, air release valves, isolation valves, SCADA systems	Gates, sluices, weirs for flow control
Distribution Points	Main delivery points with outlets for secondary networks	Division structures, field channels, farm turnouts

Table 3:- Comparative study of PDN and CDN

IX. WORKING PRINCIPLES OF PDN AND CDN:-

Projects using lift irrigation involve the mechanical lifting of water from lower elevations to higher levels. These projects are essential in areas where topography prevents irrigation by gravity flow. The pipe distribution network, which ensures the effective and efficient transmission of water to agricultural fields, is one of the key components of lift irrigation. In a lift irrigation project, a pipe distribution network is working at various stages:

i) Water Collection and Pumping:- Collecting water from the source is an initial step in this process. Water is filtered and delivered into a sump or directly to the pumping station by the intake structure. The water rises in elevation by the pumps from the source elevation. The selection of a pump is vital, considering it's necessary to have a significant flow rate and head (elevation gain). Pumps frequently consist of motors and control systems, which enable them to adjust the flow and performance depending on demand.

ii) Water transmission through the Rising Main:- The rising main is then used to carry the increased flow. These pipes require valves that eliminate any trapped air and maintain pressure because they are made for handling high pressure. Pressure relief valves prevent overpressure bursting of the pipes, and air release valves reduce air locks.

iii) Water Distribution to Agricultural Fields:- Water flows into the main distribution network through the rising main. Every region of the command area receives equal pressure and flow due to the main distribution pipes that cross over it. Sub-mains and mains, which supply water to specific fields, separate from the main pipelines. Every section of the control region will receive adequate water delivery according to the design.

iv) Control and Monitoring:- Lift irrigation projects used at present employ sophisticated control and monitoring technologies. These systems maximize water distribution with automated controls and sensors. At multiple locations across the network, sensors maintain track of the pressure and flow rates. A central control unit transmits this information. The control unit may adjust the operation of pumps and valves to guarantee optimal performance, depending on the information provided.

X. EFFECTIVE MAINTENANCE STRATEGIES USED FOR PDN AND CDN:-

The durability, effectiveness, and reliability of a lift irrigation project's water distribution network depend significantly on effective maintenance techniques. An organized network assures a consistent flow of water to the agricultural fields, minimizes water loss, and lowers operational costs. The following are some comprehensive techniques for preserving such a network to the maximum extent possible.

i) Regular Inspection and Monitoring:- For detection of any potential issues when they develop into significant, routine inspections are necessary performed periodically. This includes examining the pipes for leaks, wear-and-tear measurements, and any physical damage. Real-time monitoring of networks might be enhanced by implementing modern equipment like drones, sensors, and Supervisory Control and Data Acquisition (SCADA) systems. Through analyzing pressure variations, flow rates, and leaks, these systems provide data necessary for timely repairs. Testing the water quality on a regular basis aids in determining upcoming issues regarding the pipes, which include microbial growth, corrosion, and debris deposition. With the goal for maintaining high water quality, suitable techniques for treatment and filtration must remain in position.

ii) Preventive Maintenance:- Periodic pipe cleaning and draining helps in the removal of silt, biofilm, and other material that can block pipes and lower system efficiency. Air scouring, water flushing, or hydraulic scrapers are among the tools used for this. Cathodic protection is required to stop corrosion in metallic pipelines. To avoid electrochemical reactions that cause rust and degradation in the pipes, sacrificial anodes or impressed current devices are used. Keeping smooth functioning and preventing wear and tear can be accomplished by routine lubrication of moving elements, such as pumps and valves. It is necessary to maintain these parts after complying with the manufacturer's manuals.

iii) Water User’s Association (WUA):- These pipeline distribution schemes were constructed for small and marginal farmers. To permit beneficiaries to decide on crops depending on their needs and financial resources and to strengthen farmer participation, the schemes will be assigned to beneficiaries through the formation of Water Users Associations, and these will then be liable for the scheme's maintenance and administration. The primary advantage anticipated from this structure is that farmers are going to grow a sense of obligation and resemblance for the pipeline distribution schemes, preventing misuse and damage, reducing government intervention, and ensuring full compliance with the rotational water supply.

iv) Training and Capacity Building:- Improving technicians skills with the most recent techniques and tools will enhance their abilities while also making it easier for them to do their respective duties with greater proficiency. Ensuring the transmission network's long-term sustainability involves creating an efficient population of employees.

XI. HYDRAULIC ANALYSIS USING EPANET 2.0 SOFTWARE

The water flow in every pipe, the pressure at every node, the water level in every tank, and the concentration of different chemical species across the network are modeled using EPANET. When comparing the distribution networks of pipes and canals in lift irrigation projects, it is especially helpful. The effectiveness, dependability, and performance of the two kinds of distribution networks may be examined and contrasted using EPANET.

The water distribution network of study area consists of 13 pipes, 07 nodes and one main over head tank. The pressure is computed using Darcy - Weishbach Approach. Pressure at all junctions are found to be adequate. The minimum diameter of pipe chosen was 1200 mm. There is fluctuation in the pressure head. The roughness coefficient of the pipe throughout the network is 100.

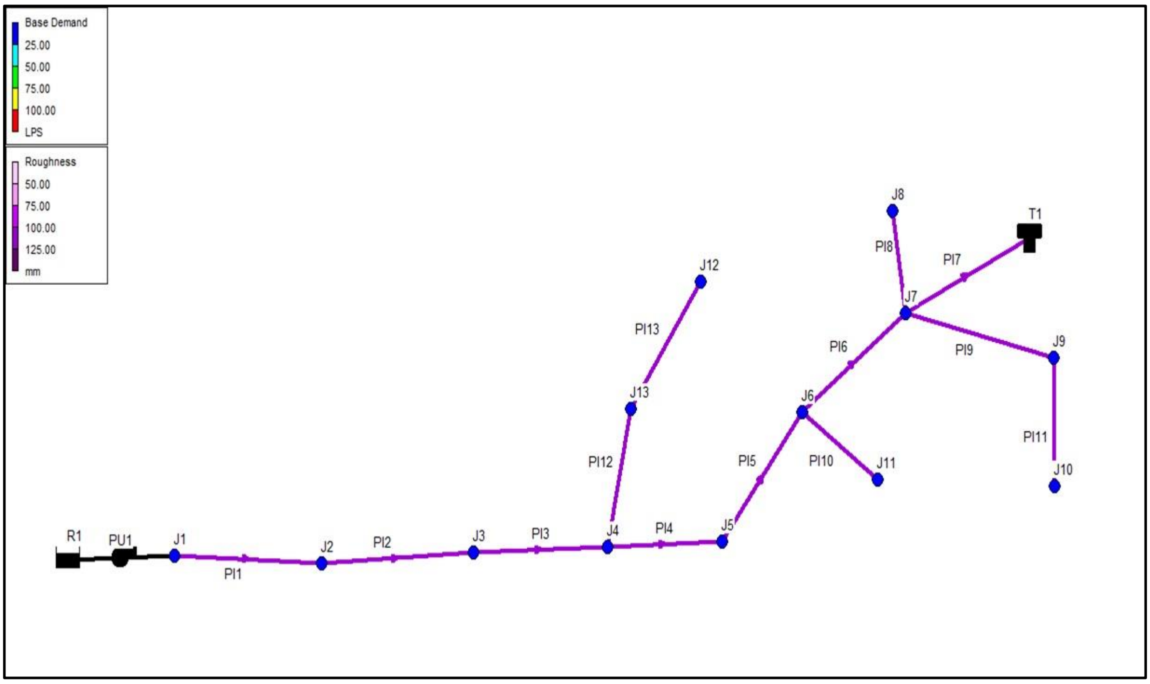

Figure -6 : Base demand and Roughness distribution

Length of the pipe is taken as the road length. The diameter of the pipe is considered based on the purpose served by the pipe, such as main, sub main, branch pipes. Pipe roughness coefficient is taken 100, since Galvanized Iron pipes are used.

Initially draw a network representation of distribution system from the extracted map . Then edit the properties of the objects that make up the system. The input parameters for each nodes and pipes are to be properly assigned. Describe how the system is operated. Then select a set of analysis options. Finally run a hydraulic/water quality analysis. The last step is to view the results of the analysis.

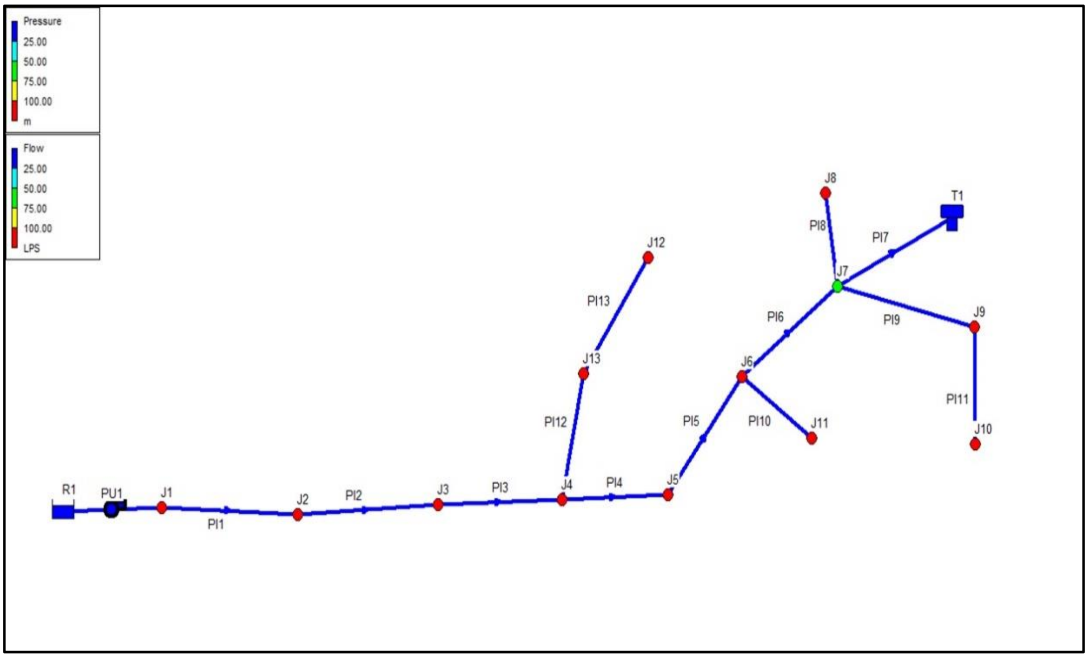

Figure - 7 : Pressure and Flow distribution

X. NEW TECHNIQUES AND ADVANCEMENTS IN THE PROJECT

The ability to map and analyze irrigation networks with greater accuracy was made feasible by the integration of Geographic Information Systems (GIS) with hydraulic modeling programs like EPANET. Appropriate topography data collection and canal condition monitoring are also being accomplished through the use of drone surveys and innovative remote sensing technologies. Irrigation management is becoming more flexible and efficient with the creation of Internet of Things (IoT) devices and sensors for real-time monitoring and control of water distribution systems

XI. FUTURE SCOPE

The integrated topographic analysis and hydraulic modeling program EPANET 2.0 has great potential to improve methods of managing water resources, encourage sustainable development, and address the issues of water shortages and climate change resistance in agricultural areas. Persistent research, innovation, and collaboration amongst teams with diverse backgrounds will be necessary for the successful implementation of integrated systems for water administration as well as the realization of their potential benefits.
The integrated framework's usage of artificial intelligence and machine learning algorithms may enable the use of predictive modeling competencies, enabling adaptive risk assessment and decision-making. By utilizing current data and environmental factors, these methods have the potential to increase operational performance, optimize infrastructure design, and project future water demand.

XII. CONCLUSION

The Tembhu Lift Irrigation Project's pipe and canal distribution networks are compared with the goal of illustrating the specific advantages and drawbacks of each design. Pipes serve as a more effective means of transporting water with lower losses from evaporation and seepage, which is especially useful in areas where water is scarce. Furthermore, they provide greater influence over the distribution of water, ensuring equal availability in all areas within the project's coverage. Additionally, using pipes will open up additional space for cultivation by minimizing the amount of land required for irrigation infrastructure.
While canals canal being more traditional and typically less expensive to install, they suffer from significant water losses and require additional maintenance for the management of issues like siltation and weed creation. Larger areas of land, which can potentially be used for cultivation, are also taken up by irrigation canals.

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