Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 8, No.2, August : 2025

"ASSESSMENT AND OPTIMIZATION OF LIFT IRRIGATION SYSTEMS: A CASE STUDY OF THE ALIS ABHANPUR C.G."

Abhay Singh Dahariya, M. Tech. Scholar Vishwavidyalaya Engineering College, Ambikapur, Chhattisgarh, India. Email id: adahariya127@gmail.com
Mr. Ankit Raj Nirala, Assistant Professor Vishwavidyalaya Engineering College, Ambikapur, Chhattisgarh, India.
Dr. R. N. Khare Principal Vishwavidyalaya Engineering College, Ambikapur, Chhattisgarh, India.

ABSTRACT:
Increasing population and urbanization leads to increase in water demand. Besides these agricultural activities in rural area also put a load on supply of water to meet its requirement. To fulfill such requirement various water supply systems have been developed. Out of those systems a lift irrigation system has been considered to supply sufficient water to people. The water source is a reservoir located about 100 km from the society. The present paper relates to the management of water to prevent it to go water without utilization. Previously this water has been utilized for agricultural activities. This system not only provides sufficient water but also prevents soil degradation and recharges ground water. Besides these there is a better management of remaining water. The system has been implemented at Abhanpur area at which urbanization has been developed recently. This has provided a better result and it has been extended for 30 years. This study explores strategies to balance water supply and demand in growing urban areas while minimizing environmental impacts. Key aspects include optimizing potable water distribution.

Keywords:
Canal irrigation, lift irrigation system, Head regulator, Head work, Diversion work, Reservoir.

INTRODUCTION
Due to urbanization near rural area, there is a need of proper water management so as to provide sufficient water to every people without wastage. For the purpose there is a need of water management system. Whenever an area is developed for residing purpose i.e. development of colonies on barren land that is not economically viable for agricultural purposes. The people residing in these colonies need water in sufficient amount to carry out their daily work. A water supply system has been installed to fulfill their demand. The primary purpose of the water supply system is to manage water on economic and environmental aspect. The environmental aspect is to prevent wastage of water, utilization of water, prevention of drought, recharging ground water. The economical aspect is to provide water at profit as the planning for the urbanization and hence water demand has been implemented for 30 years.
The residential colonies have been developed in the plateau areas where water supply by conventional methods like making smaller drains, pipeline system have been ineffective an inefficient. So, an innovative method Lift Irrigation System has been implemented in the area. A water reservoir is present to provide sufficient water to maintain the system. This system is mechanically operated and is easily supervised and maintainable.
In hilly areas, lift irrigation systems are commonly employed for irrigation purposes. Unlike gravity-fed canal systems where water flows naturally, lift irrigation involves transporting water using pumps or surge pools to elevate it from lower to higher levels. This method is essential for irrigating regions at higher elevations, where water scarcity remains an issue despite the construction of dams and canals that primarily benefit lower-lying areas.
This technique typically involves the use of pumps to draw water from rivers, wells, or reservoirs, which is then transported through a network of pipes or channels to irrigate fields. Lift irrigation not only enhances crop yields by providing reliable water supply but also allows for the cultivation of

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 8, No.2, August : 2025
crops in regions that would otherwise be unsuitable for farming. By effectively managing water resources.
This technique provides sufficient water for agriculture purposes. It means that it can provide sufficient water for domestic purposes as the requirement of domestic water is much less than that for agriculture purposes. As the water management system has been planned for 30 years, the system will be sufficient to maintain water supply in colonies.
The system has been installed near the reservoir and hence pump works in full efficient manner. There is a water reservoir named Ravishankar Reservoir having area 95 km^2 with capacity 910 MLD. This reservoir is sufficient for supply of water to colonies.
The system involves the flow of water from reservoir to canal and from canal water is drawing of water by pump. The pump lifts water to another canal that has been extended to the area where water must be supplied.
The water requirement is less than the present water supply. A calculation in this regard reveals that there will be sufficient surplus water remained which can be utilised for other purposes like proposed future industrial activities, institutional development, agricultural activities, recharging ground water etc. Thus, there may be fulfilling the economical as well as environmental aspects because of getting income by providing water and by recharging ground water the water scarcity in this area and nearby areas may also be eliminated.
So, the emphasis must be laid on the successful operation and time to time maintenance of the hydraulic lift system. This involves skilled personnels that there should be no any hindrance in water management.

METHODOLOGY

STUDY AREA

New Raipur city which is come under the ALIS command area is our study area, which is the capital of Chhattisgarh State, the area of the Raipur capital region is situated 17 km to the South-East of the old urbanite in which the agricultural active is took place before the development of city and which is well irrigated by the Ravishankar reservoir irrigation system. Abhanpur Lift Irrigation Project is the major part of this irrigation system from which the irrigation of that new Raipur city land is irrigated. Abhanpur Lift Irrigation Project site coordinates are latitude -21°04’34” and longitude – 81°44’36”

SOURCE OF WATER REQUIREMENTS FOR LIFT IRRIGATION SYSTEM

The Gangrel dam, officially known as the pandit Ravishankar Sagar, is situated in Chhattisgarh, India, spanning the Mahanadi River. Located in the Dhamtari district, it is approximately 17 kilometres from Dhamtari and around 90 kilometres from Raipur. Recognized as the largest and longest dam in Chhattisgarh, it plays a crucial role in providing year-round irrigation, enabling farmers to cultivate two crops annually. Additionally, the dam serves as a key water source for the Bhilai steel plant and has a hydroelectric power generation capacity of 10 mw.

Reservoir

(Source -Ravishankar Sagar Project Gangrel- 2)

Creates	Ravishankar reservoir
Total capacity	910,500,000 m^3 (910.50 MLD)
Active capacity	766,890,000 m^3 (766.89 MLD)
Surface area	95 km^2 (95*10^6 SQUARE METRE)

CANAL DESIGN METHODS

Several methods can be employed for the design of the canal, depending on the region, water availability, and required level of detail. Below are some common methods:

1. Baker’s Method
2. Khosla’s Method
3. The Linear Theory of Flow

4. Parametric Method
5. Empirical Formulae: These are used to determine the slope, dimensions, and other parameters based on empirical data and research. These formulas are often used in small-scale canal designs. Calculating water flow in a canal system is Manning's Equation, which is expressed as:

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

EXISTING DESIGN OF CANAL SECTION

The design of a canal section involves several factors, primarily focusing on ensuring efficient water flow, stability, and cost-effectiveness. the bed width to depth ratio (b/d ratio) is a key parameter in designing the canal section, as it affects the hydraulic characteristics and the construction cost.

In your description, you mentioned the relationship between the discharge and the bed width to depth ratio (b/d ratio). this ratio is typically given in tables or charts based on the discharge rate, and is designed to balance factors such as water velocity, sediment transport, and erosion resistance.

Here is a general approach to designing the canal section:

1. Cumulative discharge

The cumulative discharge represents the total amount of water that needs to be conveyed by the canal. it is generally calculated by summing up the discharges from various sources or outlets along the canal system.

For each section of the canal, determine the design discharge based on the cumulative discharge from the cut-off statement or similar calculations.

2. Bed width to depth ratio (b/d ratio)

The b/d ratio is crucial for determining the geometry of the canal section. it ensures the water flows at a stable velocity and minimizes issues such as sedimentation or excessive erosion.

DESIGN STEPS

To design the canal section, follow these steps:

- determine the discharge: from the cumulative discharge data, identify the discharge for the section of the canal you are designing.
- select the b/d ratio: based on the discharge value, select an appropriate b/d ratio from the table above (or a locally recommended value).
- calculate bed width and depth:
- once you have the b/d ratio, you can calculate the bed width (b) and the depth (d) of the canal section.
- if the b/d ratio is given, use the formula:

$$b = (b/d \text{ ratio}) \times d$$

for instance, if the b/d ratio is 4 and you select a depth of 2 meters, the bed width would be:

$$b = 4 \times 2 = 8 \text{ meters}$$

Consider side slopes: the side slopes of the canal should be designed based on the material characteristics of the canal banks (e.g., clay, loam, or sandy soil). typical side slopes range from 1:1 (vertical: horizontal) to 2:1 for better stability.

Check flow velocity: ensure that the canal section provides a flow velocity that is neither too high (to avoid erosion) nor too low (to avoid sediment deposition). the velocity can be estimated using the manning's equation for flow in open channels:

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

where:
V = velocity (m/s)
n = manning's roughness coefficient
R = hydraulic radius (m) = $\frac{A}{P}$ (where A = cross-sectional area, P = wetted perimeter)
S = slope of the canal bed (m/m)

LIFT IRRIGATION PROCESS

Lift irrigation is a method of supplying water to the crops by pumping water using power intensive synchronous level areas. A lift pump operates on the principle that air exerts pressure. It raises water to a distance machine to an upper altitude terrain or reservoir. The load on the pumping system is influenced by several factors, including the availability of water in the source (e.g., rivers, reservoirs, or canals). During the monsoon period. The basic principle of lift irrigation is to use external energy to pump water from a lower elevation to a higher elevation for irrigation.

In Lift irrigation water is lifted from lower level to higher level with the help of pumps and other equipment. The construction of dams and canals has significantly expanded the irrigated area, particularly in regions that are located below the level of the dam or water reservoir. These structures store and channel water to low-lying areas, ensuring that large tracts of land receive adequate irrigation. However, water scarcity remains a persistent challenge for areas situated above the dam level or at higher elevations, where natural water flow is not possible without external energy. This issue arises because water cannot flow uphill due to gravity, and atmospheric pressure alone is not sufficient to move water to significant heights. These pumps are mostly used in lift irrigation systems.

Pumping Unit

A pumping unit in a lift irrigation system is responsible for lifting water from one level to another. When using vertical turbine pumps, a circular pump house should be constructed to cover the pump and facilitate operation. Integral to this setup is the jack well, a circular civil engineering structure that plays a crucial role in collecting and directing water to the pumps. Alternatively, if the river water level is within the suction lift capacity of a centrifugal pump, a sump well is preferred over a jack well. This design consideration optimizes water intake and efficiency in the irrigation scheme, ensuring reliable water delivery to the fields.

Supply Pipeline

The size of the supply pipeline in a lift irrigation system is determined by several key factors, including the maximum water requirement, the types of crops to be grown, and the total area to be irrigated. Accurately sizing the pipeline is crucial to ensuring that sufficient water is delivered to meet the demands of the crops while minimizing losses due to friction and pressure drops. By taking these considerations into account, the design can effectively support optimal agricultural productivity and maintain efficient water management throughout the irrigation process.

Protection Valves

In a lift irrigation system, it is essential to install protection valves, such as air valves and non-return valves, in the correct sizes and at appropriate locations. Properly sized air valves help to release trapped air in the pipeline, preventing pressure buildup and potential damage to the system. Non-return valves, strategically placed, ensure that water flows in one direction, preventing backflow and protecting the pump from possible reverse flow that could cause operational issues. By carefully selecting and positioning these valves, the system's reliability and efficiency are significantly enhanced, contributing to effective water management.

Distribution Line

The distribution line in a lift irrigation system is meticulously designed to ensure that the entire field receives adequate irrigation. To maximize coverage and efficiency, delivery chambers are strategically placed at higher elevations, allowing gravity to facilitate water flow throughout the irrigation area.

Water Delivery

Water delivery in a lift irrigation system involves a systematic approach to ensure efficient irrigation across varied terrain. The area is first divided into blocks based on topography, allowing for a tailored assessment of water needs. The specific water requirement for each block is determined, and pipelines are designed accordingly to accommodate these needs.

Selection of Pumps:

The selection of pumps for a lift irrigation system (LIS) relies on collecting essential data from the civil engineering team, which reflects actual site conditions.

The Centrifugal Turbine Pump can indeed be used in applications where its specifications match the requirements. In this case, a pump with a head range of 33 meters and a discharge of 260 cubic meters per second (cumec) is suitable for lift irrigation system.

STUDY AREA

The present study has been extended to Abhanpur lift Irrigation project at Raipur, Chhattisgarh. The details have been given as:

INSTALLED PUMP & PIPES IN ABHANPUR LIFT IRRIGATION PROJECT

(Source - A.L.I.S. pump house Abhanpur lift irrigation plan scheme)

LENGTH – DISTANCE DILEVERY PIPE	- 33 METER
DOUBLE – DILIVERY PIPE	- 6 x 2 = 12
SINGLE – DILEVERY PIPE	- 8 NOS
PRESSURE – VALVE	- 20 NOS
NON-RETURN E – VALVE	- 20 NOS
200 H.P.V.T PUMP	- 20 NOS
200 H.P. AMPIER AUTOMATIC STARTER	- 20 NOS
400 AMPIER – A.C.B.	- 20 NOS
50 K.V.A CAPACITOR - PANEL	- 20 NOS
1250 AMPIER – A.C.B.	- 2 NOS
1250 AMPIER – O.C.B.	- 7 NOS
1000 K.V.A. TRANSFARMER	- 7 NOS

In a canal irrigation system, water is first lifted from a source, such as a river or reservoir, using pumps that transfer it into a storage tank. From this tank, the water flows through pipes into a network of canals designed for distribution. Once the water enters the canals, it is channelled to various agricultural fields, where farmers can access it for irrigation. This method ensures that the water is delivered efficiently and at the right volume to meet the needs of crops. After irrigation, any excess water can drain back into the canal system, helping to manage water levels and minimize wastage. This structured flow from pumps to tanks and then into canals is essential for optimizing water use and supporting sustainable agricultural practices.

MAHANADI RESERVOIR PROJECT RAIPUR ABHANPUR CANAL LIFT PROJECT ABHANPUR

(Source –Water Resources Department Division No. – 01 Raipur C.G.)

Scheme Details

Irrigation Area	2628 hectares
Maximum Irrigated Area	5100 hectares
Area of benefited village	54 grams
Beneficiary Development Block	Abhanpur / Arang
Number of Pumps Installed	20 Pumps (200 HP)
Maximum number of pumps operated	10 Pumps
Amount of water flow in the canal	260 cumecs
Length of the main canal	19.14 K.M.

Population Forecast

(Source - Punmia Dr. B.C., Jain Er. Ashok K., Jain Dr. Arun K. Water Supply Engineering, pp – 140 - 142)

Population forecasts are estimates or projections of future population growth or decline for a specific region or country based on various factors such as birth rates, death rates, migration, and historical trends. These forecasts are made using statistical models and demographic data, and they help

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 8, No.2, August : 2025

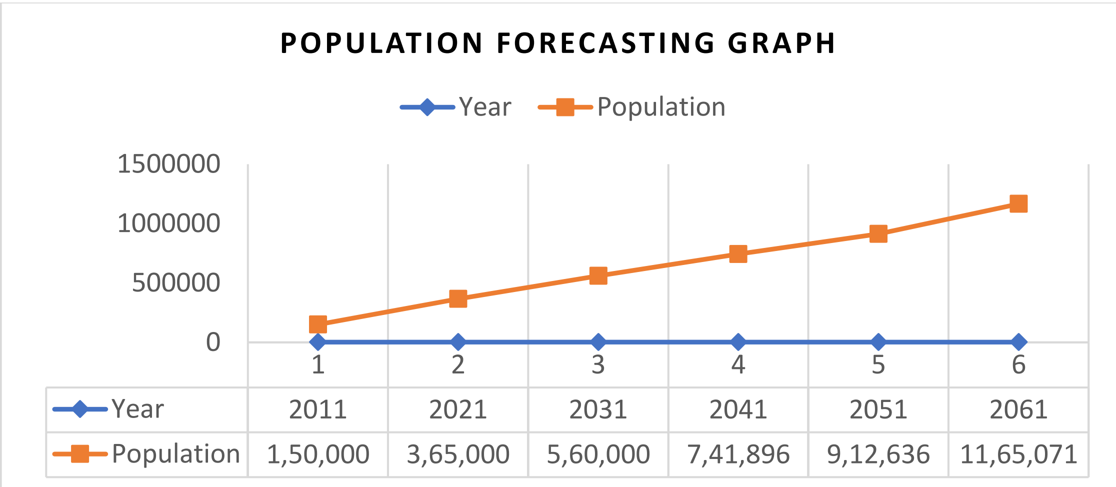
governments, organizations, and researchers plan for future social, economic, and environmental needs.

Geometrical Increase Method :- In this method, it is assumed that the percentage in population from decade to decade is constant. From population data of previous three or four decades, the percentage increase in population is found and its average is found. The population Pn after n decades, given an average percentage increase per decade Ig or n increase per decade expressed as a ratio Rg, is given by:

$$Pn = P\,(1 + Ig/100) \quad = P\,(1 + rg\,)^{n}$$

Table: Population Projection

Year	Population	Increment per decade	% increment per decade
2011	150,000		
2021	365,000	215,000	14.33
2031	560,000	195,000	53.42
2041	741,896		
2051	912,636		
2061	11,65,071		



Graph: Population Forecasting

Table: Proposed Water Demand for three decades

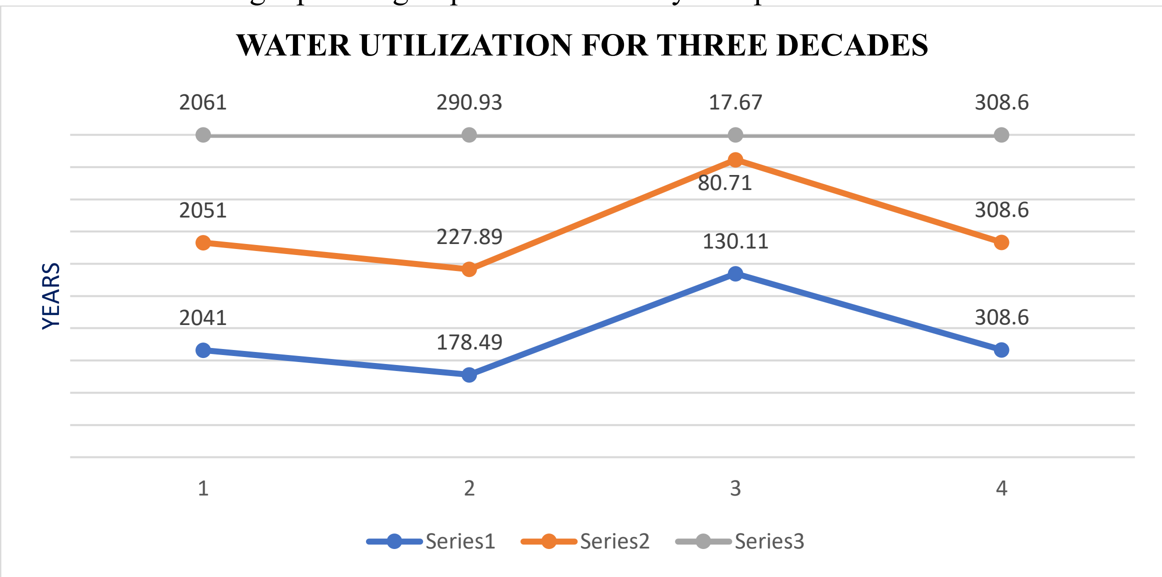
YEAR	TOTAL AVAILABLE WATER IN MLD	TOTAL DEMAND IN MLD	EXCESS WATER IN MLD
2041	308.60	178.49	130.11
2051	308.60	227.89	80.71
2061	308.60	290.93	17.67

RESULTS AND DISCUSSION

The canal lift irrigation system plays a crucial role in providing water to agricultural lands located at higher elevations where gravity-fed canal systems are ineffective. This system involves lifting water from a river, reservoir, or lower-level canal using pumps and distributing it through a network of primary, secondary, and tertiary canals. The study reveals that while lift irrigation significantly improves water.

The primary water source for the Abhanpur lift irrigation system is the Ravishankar Reservoir, from where water is transported through canals to the Abhanpur lift irrigation project. The canal water is then pumped through a pump house and lifted via pipelines to a height of 33 meters. This system is

designed to efficiently supply water for both rabi and kharif crops, covering a total irrigated area of 5100 hectares. The total water requirement for this agricultural area has been calculated based on seasonal variations and crop needs.
Additionally, a 30-year population forecasting study for Naya Raipur from 2041 to 2061 has been conducted. This study considers urban expansion, demographic trends, and migration patterns to estimate the highest projected population. Based on this high-population scenario, water demand calculations have been carried out to determine future requirements for residential, commercial, and industrial sectors. The findings contribute to urban planning and sustainable water resource management for Naya Raipur's development.
The study offers critical insights into the Abhanpur lift irrigation system's role in sustainable agriculture and the strategic planning required to meet Naya Raipur's future water needs.



Graph: Surplus water is can be used for Naya Raipur Urbanization

CONCLUSION:
The assessment of the canal irrigation system in New Raipur, Chhattisgarh, highlights critical insights into the management and efficiency of water use in agriculture. The study demonstrated that irrigation applications vary significantly across seasons and years, influenced by fluctuations in rainfall and potential evapotranspiration (pet). These variations necessitate a more adaptive management approach to optimize water resources effectively.
In addition to addressing agricultural and urban water demands, this study underscores the necessity of integrating advanced water management technologies to enhance efficiency. The incorporation of smart water distribution systems and real-time monitoring can further optimize resource utilization and minimize wastage.
In conclusion, the canal irrigation system has been a catalyst for the overall development of New Raipur, fostering economic growth, agricultural sustainability, and social well-being. Its successful implementation can serve as a model for other regions seeking to enhance their water management systems for long-term prosperity, ultimately contributing to the broader development goals of Chhattisgarh.

REFERENCES

1. Srivastava, G. Addressing the issue of lift irrigation in canal system: Case of WUAs in DSC implementation area.
2. Kishore, A., Gupta, M., Dizon, F., & Kumar, P. (2023). An Assessment of Community-Led Lift Irrigation Systems in Jharkhand, India.

3. Shiyekar, S., & Patil, N. K. (2017). Design of Lift Irrigation System-Angar as A Case Study. International Research Journal of Engineering and Technology (IRJET), 4(1), 27-43.
4. Le, C. V., & Jensen, J. R. (2014). Individual lift irrigation: a case study in the Cau Son irrigation and drainage area, Red River Basin, Vietnam. Paddy and Water environment, 12, 223-238.
5. Dangwal, K. K., & Aggarwal, M. (2019). Irrigation in hilly areas by capillary lift. International Journal of Innovative Technology and Exploring Engineering, 8(12), 3227-3230.
6. HASAN, S. A., KHULE, V., & GORAKSHA, K. P. “LIFT IRRIGATION”-Civil Engineering Projects. JSPM’S, 29.
7. Kalle, J., & Kasi, E. (2016). Lift Irrigation Schemes in Andhra Pradesh: Technology as a Boon or a Bane?. South Asia Research, 36(3), 377-396.
8. Patra, S. P. (2016). A case study on pani panchayat of lift-irrigation point of khurda district with reference to theorissa agro industries corporation limited (Doctoral Dissertation, Central Library, OUAT).
9. Marothia, D. K. (2005). Institutional reforms in canal irrigation system: lessons from Chhattisgarh. Economic and Political Weekly, 3074-3084.
10. Viswanathan, P. K. (2016). Reengineering the Irrigation Systems of Kerala: The Case for Designing Lift Irrigation Schemes as Multiple-Use Systems. Review of Development and Change, 21(2), 35-65.
11. Thakur, N. K., Khalkho, D., Katre, P., Jamrey, P. K., & Mishra, R. K. (2020). Design of Irrigation Network of the IGKV Farm, Raipur, Chhattisgarh, India. Int. J. Curr. Microbial. App. Sci, 9(5), 1787-1795.
12. Saher, F. N., Nasly, M. A., Kadir, T. A. B. A., Yahaya, N. K. E., & Ishak, W. M. F. W. (2014). Harnessing floodwater of hill torrents for improved spate irrigation system using geo-informatics approach. Research Journal of Recent Sciences. ISSN, 2277, 2502.
13. Shende, K., Ganvir, S., Meshram, D., Bhagat, A., Pachdhare, K., (2022). STUDY OF CANAL SYSTEM FOR IRRIGATION PURPOSE – A REVIEW. International Research Journal of Modernization in Engineering Technology and Science.
14. Rao, I. B., Rao, K. V., Sahu, R. K., & Dange, A. R., (2012). Water utilisation and crop production under lift irrigation scheme in Andhra Pradesh. Indian Journal of Soil Conservation, 40(2), 115-121.
15. Sharmila, D., Roshini, R., Sowmya, S. D., Devi, V. P., Nikeshvasan, R., (2018). Automation in Canal Irrigation System. International Journal of Innovative Science and Research Technology.