The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Issue 10 | October 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Integrated Urban Land Use and Water Supply Management in Jamalpur City, Bihar

Diwakar Kumar

PhD. Scholar, Ram Manohar Lohia Avadh University (Ayodhya)

DOI : https://doi.org/10.5281/zenodo.17598757

ARTICLE DETAILS

Research Paper

Accepted: 17-10-2025

Published: 10-11-2025

Keywords:

Water Supply System, Land Use Pattern, Urban Water Management, Urban Land Use, Slum Upliftment & Rehabilitaion, Urban Sustainability.

ABSTRACT

This paper presents a detailed case study focusing on Jamalpur City located in Munger district of Bihar. The study tries to examine the challenges through which city currently dealing. Major one is city's water supply system and land use patterns. The main objective of this paper is to explore the relationship between land use, water supply and the distribution of slums within the Jamalpur municipality. The municipality's data highlight the difference between the water supply and production in city. A table showing projected water demand and production gaps illustrates the surplus and deficit in water availability as the city's population grows. The land use pattern of Jamalpur is like Hoyt's sector model. The city mainly consists of residential areas interspersed with commercial and agricultural zones. The administrative and commercial functions are concentrated at the city center, which corresponds to the Central Business District in the model. The paper also discusses the distribution of slums across different wards and their connection to water infrastructure. Finally, it outlines the key challenges faced by the city's water supply system and the existing plans and policies aimed at addressing these issues.

Introduction

As we listen to the phrase "Water is life" since childhood and its presence makes life possible on earth for all organisms. No Doubt, well maintained water supply is an essential tool to run the economy and social life of any cities or other country parts. Continuously, increasing trends of urban population,

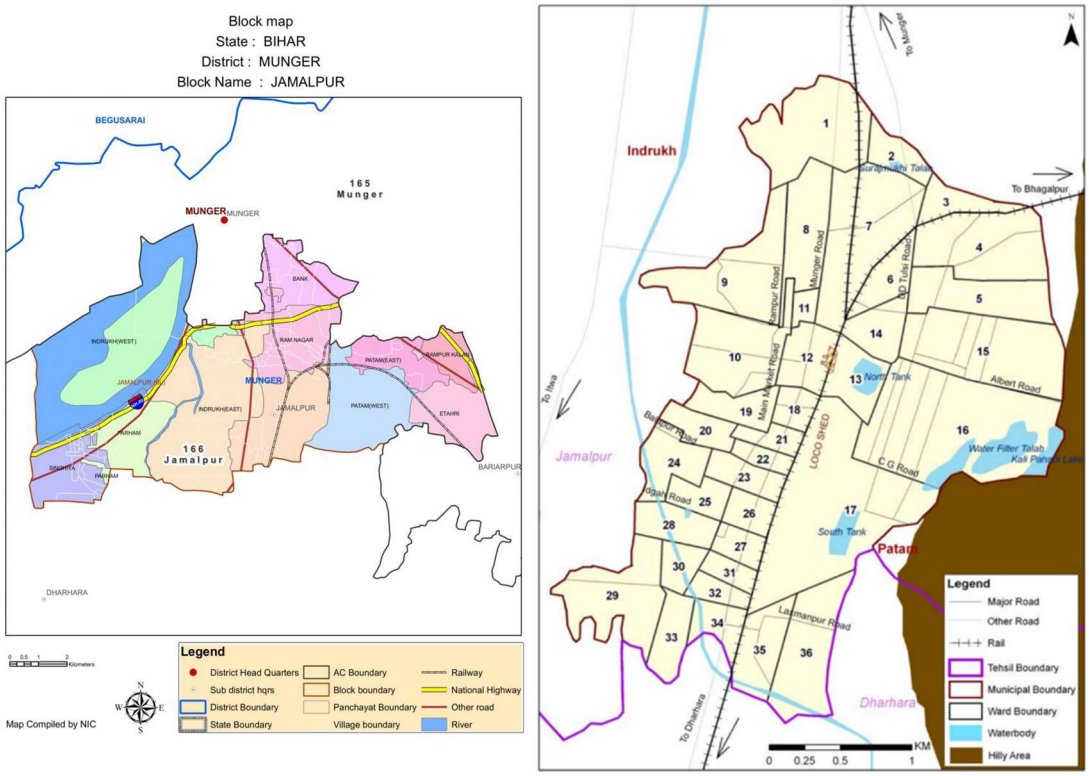
industrialization and growing water pollution continuously raising water demand in cities. As the world becomes more urbanized on the other hands, millions of people are forced to live in slums, and their life becomes full of difficulties. As a result, the situation for the urban poor is deteriorating. In India now, one out of every six urban residents are poor (Ratan 2016). There are basically four categories of land utility like commercial, industrial, residential and slum areas. Commercial activities are the predominant center place where most of the administrative work also occurs. Whereas southern and north-western wards are agrarians which fulfill city demand like milk, fruits and vegetables or other perishable goods. Moreover, the outskirts (wards) of Jamalpur City are predominantly slums populated. There are around fifteen different sites of slums within the city, and they lack even basic amenities like fresh water, sanitation and salter. Interestingly, according to 2011 municipal data, as well as the recent reports claims that there are no pipelines for water supply and people are completely dependent on hand pumps and wells. On the other hand, currently 3-4 tanks are built (near the bank of Ganga River and Railway station) for pipeline water supply in central commercial and industrial wards of the city. Residential areas near to the Railway station and central commercial wards have 3-4 hours water supply in a day. Whereas most of the residential wards are still dependent on hand pumps and wells for drinking and floating water. In Jamalpur Municipality, the per capita water demand for residential purposes is around 150 lpcd, while the per capita demand for the floating purposes is only 50 lpcd. The water demand is relatively higher near the CBD of the city, and the demand decreases as we go beyond the center. On the other hand, the water demand in the outskirt slum areas is higher due to densely populated and lack of pipelines supplies. As a result, municipality must arrange tractor-tank to supply water in those areas. Their supply is very irregular and pathetic due to municipality ignorance day by day.

Jamalpur's population is continuously increasing day by day where the city’s growth rate is falling but still around to which brought huge water crises in the city especially in Railways and industrial areas. Water crises preferred to be only of residential and industrial uses not for the slums. The LASA report estimates the water supply production gap of Jamalpur city seems maximum during the 2010s and the gaps seems to rise during 2020s and further minimum during the 2040s. Various strategies and initiatives have been taken by different Govt. & Non-govt. bodies to minimize the water supply demand gap in coming years. Some essential steps have also been taken to rehabilitate or to improve the slum's livelihood very soon, but their rate of action seems quite slow. Local bodies also trying to cope up with these problems but slums rapid growth from the irregular rural migrations becomes hurdle sometimes.

Study Area

Jamalpur is a city in the Munger district of Bihar. It lies on the southern bank of the River Ganga at about 25°19′ N latitude and 85°32′ E longitude. The city covers around 10.65 square kilometers and acts as both a block headquarters and a municipal council. Located nearly 7.2 kilometers south of Munger, the district headquarters, Jamalpur is well-connected by road and rail. Due to its historical importance in the railway sector, it is often called the "Rail Capital of Bihar." The city was established during British rule and became known for its railway workshop, which focused on manufacturing and repairing wagons, coaches, cranes, and jacks.

According to the 2011 Census of India, the Jamalpur Nagar Parishad (JNP) recorded a population of 105,434 people, with 56,072 males and 49,362 females. The 2021 JNP survey estimated the population at 130,530 residents across 25,218 households. Projections suggest it could rise to about 1.52 lakh by 2030. The City Development Plan (CDP) noted that Jamalpur previously had around fifteen slum settlements housing nearly five percent of the total population; however, there are no officially recognized slums now. The city's landscape shows a variety of landforms, including rocky uplands, pediplains, and alluvial plains, showing a shift from hilly areas to floodplains. Notably, Jamalpur's East Indian Railway Workshop was once a major industrial center, employing over 25,000 workers at its peak.



Map: - Shows the Administrative Division of Munger District (Left) and Administrative Ward wise division (Base Map) of the Jamalpur City (Right). (Map Source- Dist. Handbook)

Database; -

Secondary data has been broadly used while making some senses out of this for general analysis. Ward wise data were collected from various sources as follows: -

- **Indian Census 2010 & Govt. Published Reports**
- **Municipal Data released by the City's Municipality**
- **District census handbook of Munger District**
- **City Development Plan published by the City's Municipality**

Methodology

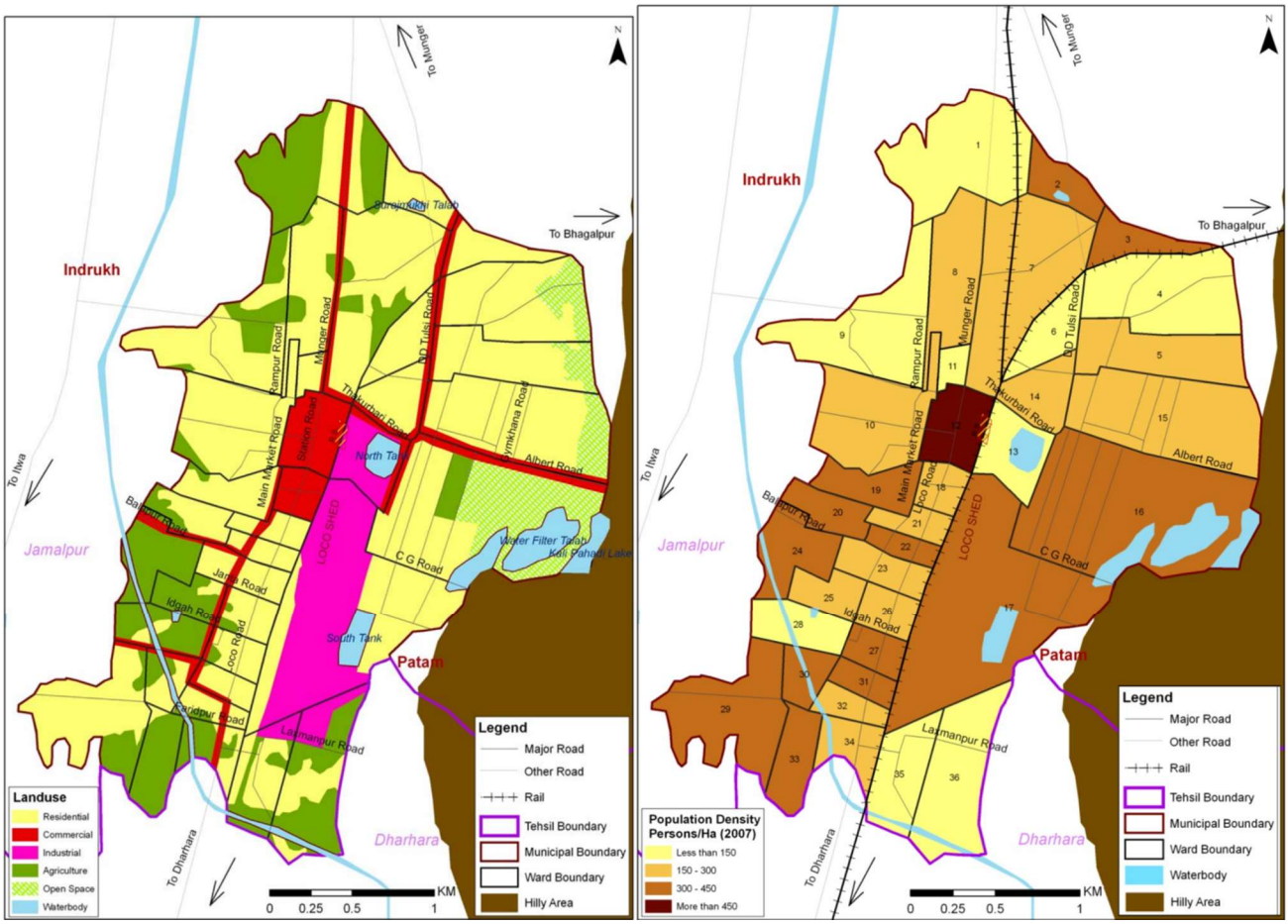
Simple statistical methods were used to process and interpret secondary data. Thematic maps were created with Geographic Information System (GIS) tools, using some base maps from the District Handbook. Ward-wise municipal and census data were added to the software's attribute table to create choropleth maps, classified by quartile distribution. Future projections were calculated using the arithmetic mean method. Relative values were used for comparative analysis across datasets, while absolute figures were avoided to keep the analysis consistent. Average mean values were preferred over absolute means for later interpretation and discussion. Graphical displays showing demographic trends and water demand gaps were created from municipal datasets and analyzed systematically using Microsoft Excel. Meanwhile, extensive literature review has been performed for further developing the understandings about Jamalpur city life and topography. Primary observation and small group discussion has been simultaneously performed to correlate the data with reality of the city. And Further slum's criticality has been carefully remarked and noticed before concluding our findings.

Land Utilisation of Jamalpur City

The land use pattern of Jamalpur city is mainly residential, with a mix of commercial buildings. Other significant land uses include hilly areas, recreational spaces like parks and playgrounds, institutional zones with public and semi-public buildings, industrial areas featuring the railway workshop, and agricultural land. The city's main water bodies, Surj Mukhi Talab and Kali Pahadi Talab, are managed by the Jamalpur Municipal Council (JMC). However, these ponds have faced pollution and need ecological restoration. Several other water sources, such as the North Tank, South Tank, and Water Filter Talab, are

under the management of the railway authorities. The North Tank and Water Filter Talab currently serve as storage reservoirs for raw water taken from the River Ganga.

The River Ganga is the city's main water source for both domestic and industrial use, and it also supports agricultural irrigation in nearby rural areas. Spatial analysis shows that smaller ponds are crucial for meeting the city's basic water needs. Additionally, higher settlement densities are found in wards with better access to ponds or other nearby water sources, highlighting the connection between water availability and patterns of urban living.



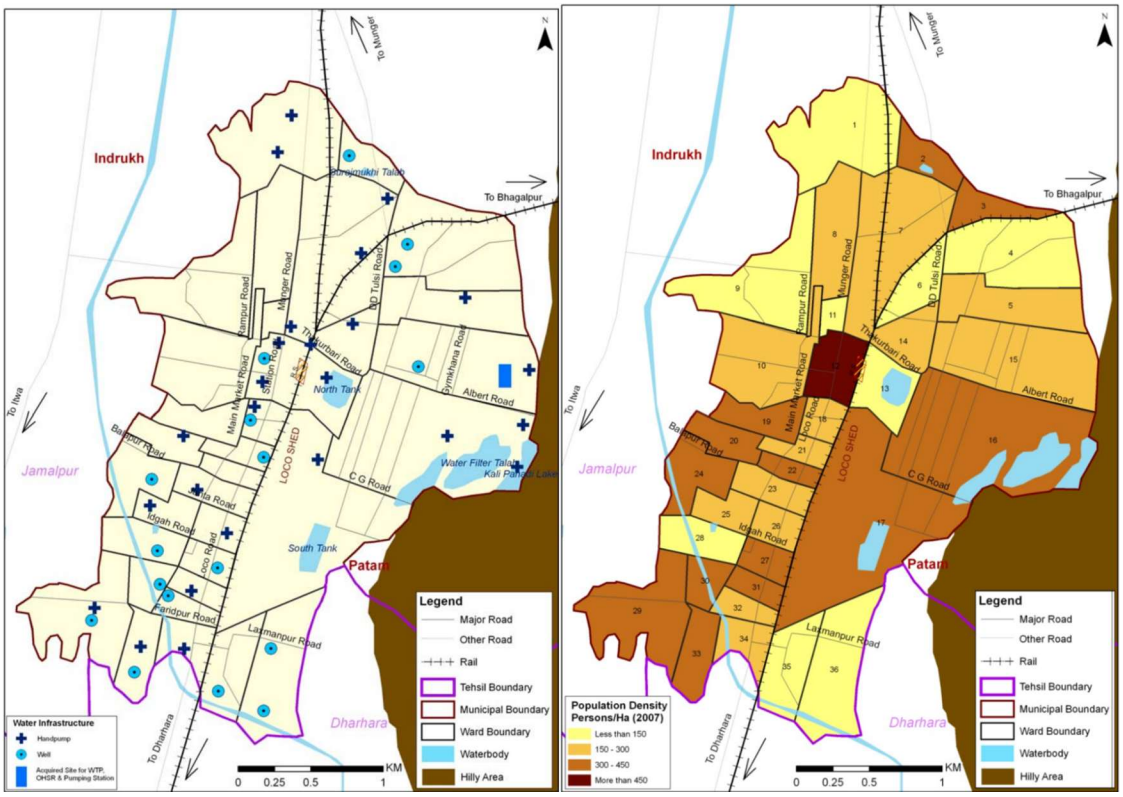
Map: Shows the land utilisation in Jamalpur (Right) and the ward wise distribution of population density (Left). (Map Source- Dist. Handbook)

The population distribution across the Jamalpur City shows a clear-cut imbalance. City situated in Bihar's Munger district and among that Jamalpur is the most densely populated tehsil, with an average population density of about 230 people per hectare. As we find in above maps, the highest concentration is found in Ward 12, which has around 780 people per hectare, mainly because it is close to central

administrative and commercial areas. Following this are Wards 16 and 20, with densities around 390 and 380 people per hectare, respectively. On the other hand, Ward 36 has the lowest population density, at only 31 people per hectare.

The three most populated wards together use over 1.7 million gallons of water each day. This shows a strong link between urban concentration and rising water demand in the central business district areas. A look at land use and population density maps shows that the southern (Wards 17, 18, and 28) and northern (Wards 1 and 9) edges of the city are mainly agricultural areas. These regions have relatively low populations, with fewer than 150 people per square kilometer. Moreover, large areas of open land remain in the eastern part of the city, especially in Ward 16. Here, over half of the total area consists of open spaces, despite a density of more than 500 people per hectare. This unusual situation is due to the extensive open lands, which reduce the effective built-up density. The city's growth is also limited by its physical features, with forested hills to the east and the Dakra Nala to the west serving as barriers to urban expansion.

Water Supply System



Map: Shows the Sources of Water Supply (Left) and the Ward wise Density Distribution of population of Jamalpur City (Right).

As we can see in the above maps, there are no pipelines for supplying water in the city. Because the city lacks a piped water delivery infrastructure whereas ground water is the primary source of water. The main sources of water are hand pumps and wells. The map on the left shows the land acquired for the proposed water supply system. It reveals where existing hand pumps, wells and ponds are located across Jamalpur Municipality. The estimated daily water supply for the city is around 20 lakh gallons, which is roughly 9 million liters per day. The major parts of the infrastructure include a reservoir in Ward 2, a Water Treatment Plant (WTP) in Ward 1, an Overhead Service Reservoir (OHSR) in Ward 8, and a distribution network about 6 kilometers long that serves the residential colonies.

By a report from the Jamalpur Municipal Council (JMC), around 75 public hand pumps were installed during 2009-10. The total number has since grown to 172. Of these, 170 are operational, serving over 90% of the city's population. The remaining 10% rely on limited pipeline connections. However, piped water supply mainly exists in the central and industrial (railway) zones. The primary water source is the Ganga River, which supplies water through a Jetty System that includes steamers with floating pumps. The municipal water supply lasts about 3 to 4 hours daily, except in the railway areas, which receive service for a longer time. Additionally, several open wells help meet the city's water needs. The Jamalpur Railway division itself requires about 26 lakh gallons of water each day. To fulfill this need, an intake pontoon is set up on the Ganga River at Munger.

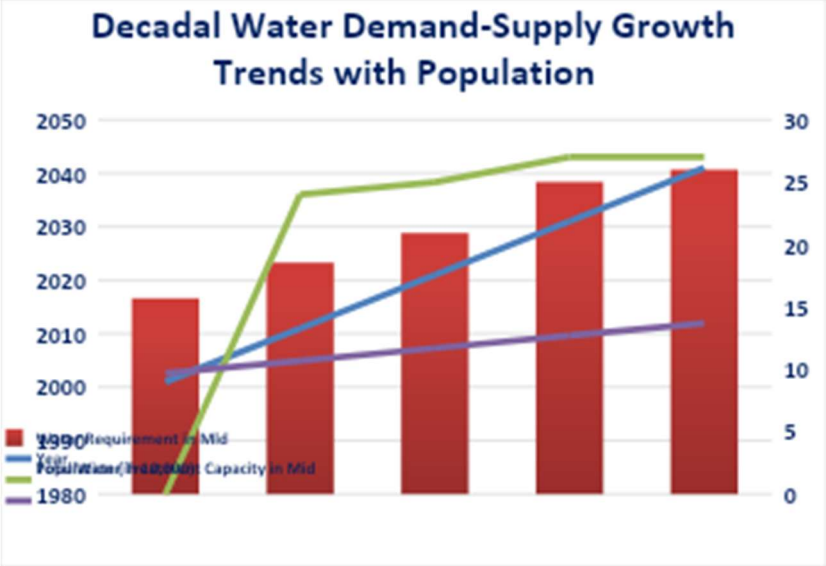
Water Supply and Demand Projection

Projected Water Demand and Production Gap						
Year		**Water Requirement in Mld**	**Total Water Treatment Capacity in Mid**	**Population (in 10,000)**	**Surplus (+) and Deficits (-)**	**Remark**
TRENDS	**2001**	15.68	0	9.69	-15.68	Piped Water supply Nil
	2011	18.6	24	10.71	5.45	Requirement for 24mld of water
	2016	19.78	24	-	4.22	Expected Production will remain surplus till the intermediate term

	2021	20.9	25	11.69	3.1	Expected Production will remain surplus till the intermediate term
	2026	23.9	27	-	3.15	Production will deficit after 2026: Requirement of additional 3.0 mld of water from the Ganga River
	2031	24.65	27	12.86	2.35	Expected Production will remain surplus till the horizon year.
PROJECTION	**2041**	26.6	29	13.53	2.41	Expected Production will remain surplus till the horizon year.

Table below describes the water demand up to 2041.

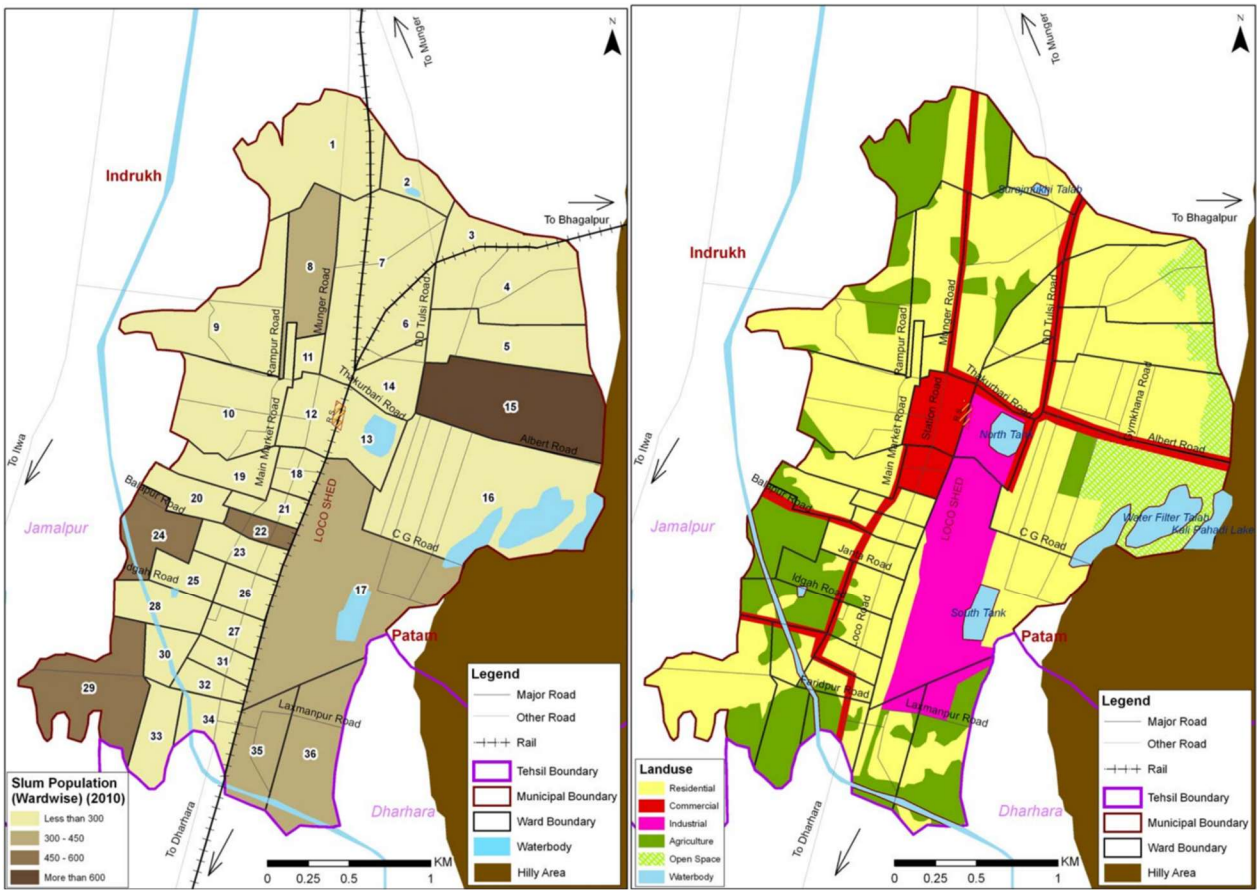
Jamalpur, the second largest urban center in the Munger district, is an important hub of population and economic activity after Munger city. An analysis of the average annual population growth rate from 1901 to 2011 shows that the city has grown slowly. Still, the ongoing population growth has caused a significant increase in water demand throughout the city. The Indian Railways, which runs large industrial facilities in Jamalpur, is a major water consumer, needing more than twenty lakh gallons daily. To meet this demand, a system of intake pontoons has been installed and floated on the Ganga River near Munger. This system includes several pumps at Pantun for extracting and moving water.



Ganga River is an important natural resource and principal raw water source of Jamalpur City. It is situated approximately nine kilometres away from the Railway installations of Jamalpur. The river sustains the city's existing and future water demand. The gross water demand for 2010, 2025, and 2041 has been estimated at 18.6 MLD, 23.9 MLD, and 26.6 MLD, respectively. To address these requirements, the new Water Treatment Plant (WTP) will treat 3.5 MGD by 2025 and an additional 0.5 MGD by 2040. Four Overhead Service Reservoirs (OHSRs) of one lakh gallons capacity are being planned for Wards 6, 18, 26, and 31. The estimated overall lengths of the raw water pumping main, rising main, and distribution network are approximately 12,600 metres, 3,974 metres, and 54,789 metres, respectively, with a daily supply of 70 litres per capita. The overall estimated cost of the proposed water supply system is USD 63.87 million. The 2041 projection takes into account both the resident and floating populations, with the latter composing approximately 5% of the total.

The estimated resident and floating population water requirement per day is 135 litres for residents and 45 litres for the floating population. Projections for the short-term (2011–2016), medium-term (2016–2021), and long-term (2021–2041) indicate a strong correlation between population growth and water consumption. For instance, in the long-term period (2021–2031), the population will become around 1.27 lakh. This would demand 24.65 MLD of water supply and a rise in WTP capacity to 27 MLD, with a surplus of 2.3 MLD. The analysis of different growth curves indicates a remarkable increase in water demand as well as population growth. Jamalpur's status as a regional centre attracts individuals for trade, commerce, administration, medical care, banking, and other services, thus contributing to this demand. The floating population of the city, consisting of tourists and daily commuters, is approximately 5% of the entire population. Nonetheless, the rising dependence upon groundwater has led to a constant lowering of the water table. This condition has resulted in elevated fluoride and arsenic concentrations, above 1.5 mg/L and 0.05 mg/L, respectively, that are hazardous to public health and long-term water sustainability.

Water Supply in Slum Areas



Map: Shows ward wise distribution of slum population (Left) and Land Utility Map of Jamalpur City (Left).

As per the SPUR (2010) survey, nearly 22.7% of Jamalpur City's households, or a total of 6,905 households, are under the poverty line (BPL). Nearly 5% of the total urban households reside in slum settlements without any basic civic facilities. An estimate puts the number of people residing in these slum settlements at around 3% of the total population, or 874 households. Of the city's 36 municipal wards, 15 are identifiable with slum pockets. The principal clusters of slums are Choti Daulatpur, Naya Gaon, Badi Asikpur, Faridpur, Rampur, Naya Tola, Kabragah, Chhoti Kesopur, and Laxamanpur. Kabragah slum (Ward 15) has the densest population of slum dwellers, followed by Walipur Harijan Tola and Khalasji Muhalla in the second and third position, respectively. Slums in Jamalpur have a very poor availability of fresh water, which influences living conditions to a large extent.

The primary source of water in these slum pockets is the hand pumps, since none of them are tapped into the piped water supply of the city. Field investigations during the study revealed that there were 14 hand pumps and 5 open wells catering to these settlements. Therefore, people, including women and children, have to walk long distances and queue up for hours to fetch water. Moreover, none of the 15 slum

pockets possess functional drainage systems, as per the Jamalpur Municipal Council (JMC) slum survey. Without proper waste disposal, household waste is usually dumped on the streets, leading to unhygienic living conditions. The overall drain length in all slum zones is approximately 30.5 kilometers, which reflects poor sanitation and infrastructure neglect.

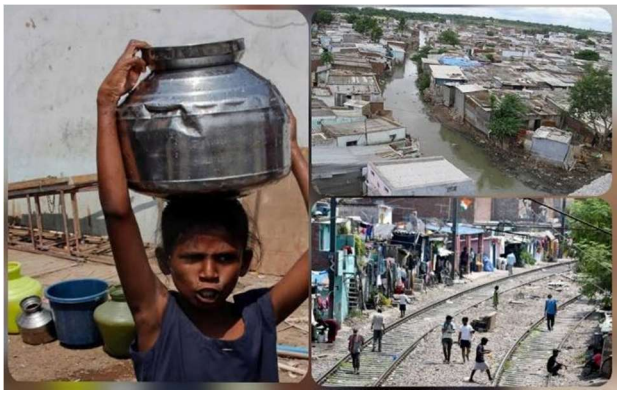


Fig: These pictures show the major slum areas and speak slum's livelihood at Jamalpur City (Munger, Bihar).

This picture speaks a lot about the slum's livelihood in Jamalpur city. In Picture, Slums are densely population and linearly settled besides the Dakra Nala which drain through ward number 14. Here we find 500 slums (Census data, 2011) which probably increased upto 1500 in 2021 have only one well reported for water supply. Slums over dependencies on one well compel to use even Sewage water for doing other activities except cooking and drinking. In other picture, These slums have settled both sides of railway lines over the government lands. They are mostly low wages labourers who work either in rail factories or near the CBD. Their status is relatively better than the city's other slums because they get work very easily for livelihood. City as being a massive East Indian Railway workshop, which employed over 25,000 people at one time where low wages labourers were mostly slums. For water they have easy access to rail supply water.

Initiatives to Strengthen Water Supply System in Jamalpur

In 2009, the Public Health Engineering Department (PHED) developed a water supply plan for Jamalpur City. The plan had divided the city into two primary water supply areas in accordance with the local topography in order to enhance distribution. Zone, I comprise sections of Ward 7 and Wards 8, 9, 11, 18 to 20, and 21 to 36. Zone II comprises Wards 3 to 7 and Wards 13 to 15. Railway colonies, comprising Wards 1, 2, 10, 12, 16, and 17, were excluded as they have an existing railway water supply system. The planning also considered the projected population of seven nearby villages to ensure they have enough service in the future. Four Overhead Service Reservoirs (OHSRs), each 100,000 gallons capacity, are proposed for Wards 6, 18, 26, and 31. The approximate lengths of the raw water pumping main, rising main, and distribution network are 12,500 meters, 3,975 meters, and 53,788 meters, respectively, with an estimated supply of 70 liters per person per day. The cost of the project works out to approximately ₹61.76 crore. The scheme has been formally approved. The JMC has given the PHED an initial capital of

₹1 crore. A 3-acre plot of land in Ward 15 has been purchased for the project at a cost of ₹15.95 lakh. Tenders for Jamalpur Water Supply System construction have been floated, initiating the implementation process under the technical supervision of PHED, Munger. The project location and the locations of existing wells and hand pumps in the city are indicated in the map.

Conclusion

We saw how the water supply system decides the landuse pattern of Jamalpur City. Higher the households or residential wards with denser population indicate the better the water supplies in that ward in comparison to lesser populated wards. Where higher the number of slum population indicates the poorer the supply of basic amenities like water and sanitation. From the study, we noticed that the primary difficulties with the city's water supply system are (a) Delays in implementing water delivery schemes (b) Overexploitation of groundwater due to a lack of pipeline supply. (c) Higher concentration of fluoride and arsenic levels in groundwater (greater than 1.5 mg/litre and 0.05 mg/litre, respectively) and (d) Water bodies on the surface are not well maintained. Even with these difficulties, the municipality and government together stepped out and have been continuously working to improve the water supply system of Jamalpur City. To overcome these difficulties, feasible plans and strategies have been built to meet the water demand curve before 2041. As we saw, the slum's livelihood is literally worse; there are continuing state-level programmes and CDP for poverty reduction, slum upgradation and slum rehabilitation, that are also being implemented in SMC. Slum upgradation and rehabilitation are going on, but its rate is extremely slow, which requires immediate boosting of attention. These are as important factors for city growth and development as others. Obviously, we see Jamalpur City as our dream hometown in the coming years.

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