KEC Conference 2025

ISSN: 3021-940X (Print) DOI: https://doi.org/10.3126/injet.v2i2.78656

Assessment of Problem Associated with the Ilam Urban Water Supply System of Nepal

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Abstract

The Ilam urban water supply system in Nepal faces serious challenges that affect its efficiency and reliability. Many of the pipes and infrastructure are old and damaged, leading to frequent leaks and water wastage. Some areas do not get enough water, while others have too much, causing distribution problems. The Water Users' Committee (WUC) also struggles financially because it does not receive enough support from the municipality. Due to this, it cannot afford proper maintenance or pay staff well, making it harder to keep the system running smoothly. Additionally, the recent shift to a new management system has created further issues, as poor knowledge transfer and resistance to change have disrupted daily operations and led to financial losses. To fix these problems, a comprehensive plan is needed. First, the infrastructure must be improved by using better materials, fixing leaks regularly, and adopting modern leak detection technology. Strengthening financial planning, creating a formal water management board, and ensuring proper training for staff will also help improve management and reduce disruptions. Proper planning for water demand and supply, along with risk assessment, is necessary to keep the system stable in the long run. By taking these steps, the Ilam water supply system can become more reliable, ensuring a steady and efficient water supply for the growing community.

*Keywords***:** Urban Water Supply System, Water User Committee (WUC), Leakage, Demand, Supply, Knowledge Transfer

1. Introduction

Water, sanitation, and hygiene (WASH) are fundamental to human well-being, economic prosperity, and the health of ecosystems. Adequate water supplies, improved sanitation facilities, and proper hygiene practices are essential for survival. Enhancing global access to safe drinking water, sanitation, and hygiene is one of the most effective and economical ways to improve public health and save lives. Integrating these aspects is crucial for the healthy development of any community. Ensuring the provision of WASH in healthcare facilities is vital for preventing the spread and transmission of water-borne diseases, thus safeguarding public health. Effective implementation of WASH is a major determinant of health; however, it remains a challenge in developing countries like Nepal (Shrestha, 2023).

The climate in Nepal is significantly influenced by the Himalayan mountain range and the South Asian monsoon. Annual maximum temperatures have increased by 0.056 °C, and from 1975 to 2006, Nepal experienced a 1.8 °C rise in temperature (Synnott 2012). This rate surpasses the global average temperature increase of 0.8 to 1.2 °C (IPCC 2018). Trend analysis from 1971 to 2014 indicates a significant reduction in pre-monsoon rainfall in the high Himalayan regions, decreasing by 0.74 mm per year (DHM 2017). The changing monsoon patterns and decreasing rainfall have been widely observed across Nepal. There is a notable variation in climate within a north-south distance of 200 km in Nepal (Ahmad et al., 2018).

The Ilam Urban Water Supply and Sanitation system is a gravity-based water system that serves parts of wards 6, 7, 8 and 9 in Ilam Municipality. It is designed to meet the needs of a growing population, with a target of 38,172 people and an estimated water demand of 3.836 million liters per day (MLD) by 2039.The project includes a reliable water source, a treatment plant, and storage reservoirs with a total capacity of 1,392.5 cubic meters. It

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provides household water connections for 2,868 homes and includes additional facilities like 10 fire hydrants, office buildings, and valve chambers for efficient water distribution. The total pipeline network spans 109.8 kilometers, with 41.8 kilometers used for water transmission and bulk distribution. The water supply component costs NRs. 836.8 million, funded by 75% from the Government of Nepal (GON), 25% from a Town Development Fund (TDF) loan, and 5% from the Water Users and Sanitation Committee (WUSC). The sanitation part costs NRs. 11.1 million, with 85% covered by the government and 15% by local authorities and users. The total project cost is NRs. 847.9 million. The project has an Economic Rate of Return (EIRR) of 44.29% and a Financial Rate of Return (FIRR) of 7.91%. Since it falls under ADB Category B, only an Initial Environmental Examination (IEE) was required, which found no major negative environmental impact. Initially, the wusc was an operator of Ilam urban water supply system. However, after construction was completed, the Ilam Municipality created a Water Supply Board to take over its operation.

General objective: To assess the problems associated within the Ilam urban water supply system, Nepal.

Specific objectives:

- To analyze the leakage issues associated with pipe and fitting over time and its effectiveness.
- To analyze the strategies for ensuring a smooth transition for the Ilam urban water supply management team.
- To analyze the demand & supply dynamics for the Ilam urban water supply project.

2. Literature Review

2.1. Introduction of water supply system

About 70% of Earth is covered in water, but 98% is in the oceans. Only 2% is fresh water, with 1.6% locked in ice caps and glaciers. Groundwater makes up 0.36%, leaving just 0.036% in lakes and rivers for direct human use. This tiny amount supports domestic, industrial, agricultural, and public needs. (Gautam & Dahal, 2020).

2.2. Major problem and challenges with water supply system

About 71% of Earth's surface is water, but only 2.5% is freshwater. Most of it is in glaciers (68.7%) and underground (30.1%), leaving just 1.2% as accessible surface water. Of this, lakes hold 20.9%, rivers 0.49%, and ice/permafrost 69%. In 2017, 5.3 billion had safe drinking water, while 2.2 billion lacked access. Water scarcity, worsened by climate change, population growth, and urbanization, affects 4 billion people annually. SDG 6 aims for universal, equitable, and affordable safe drinking water by 2030. (Acharya, 2020).

i. Scarcity of Drinking water
ii. Climate -induced disaster in the water supply & Sanitation
iii. Population Growth and Urbanization

2.3. Water supply system of Nepal

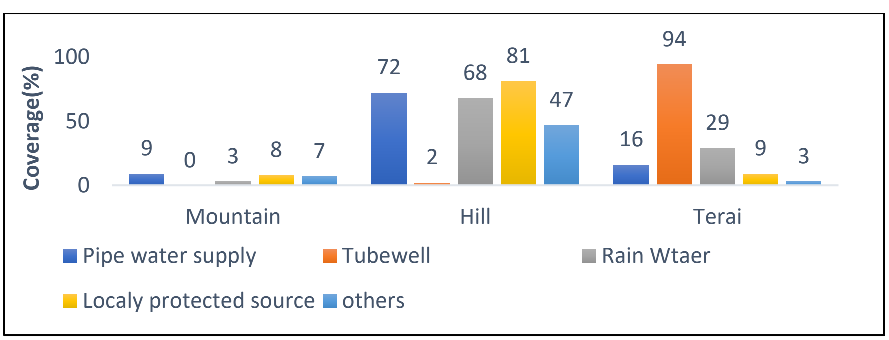


Figure 1. Water supply type on the basis of eco -regions (DWSSM, 2019)

In 2019, only 51.69% of Nepal's population had access to piped water, while 48.31% relied on un-piped, privately managed systems like tube wells. Despite meeting water supply-related MDGs, non-piped coverage rose from 36% in 2000 to 44% in 2017. Additionally, access to safely managed water sources declined from 24% to 18% over two decades (JMP 2021). These highlights ongoing challenges in water service quality and distribution.

Local governments manage daily water supply operations but must coordinate with provincial and federal bodies for large-scale projects, policies, and funding. The act decentralizes water management, granting local authorities' greater control over resources and services to enhance responsiveness and community involvement. It ensures local bodies play an active role in water resource management for public welfare. The Local Governance Act 2074 allows local governments to collect fees for water services, reinvesting in infrastructure with transparency and accountability. The act mandates sustainable water management, promoting conservation, pollution prevention, and efficient distribution. These measures secure water resources for future generations while meeting present needs (GoN, 2017)

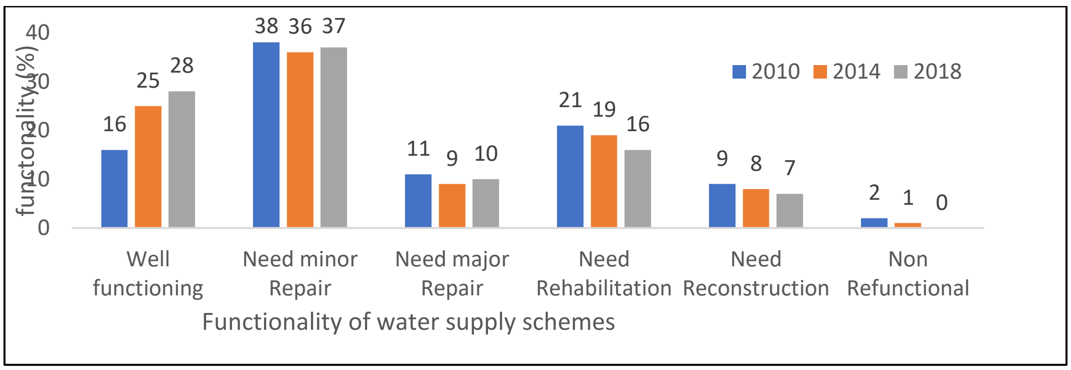


Figure 2. Compare status of the functioning of water supply schemes from 2010 to 2018. (DWSSM 2019)

2.4. Failure of PE pipes and Electrofusion joints

2.4.1. Failure of PE pipes

PE pipes can experience different failure modes due to their semi-crystalline nature, characterized by tie molecules that link the amorphous and lamellar crystal regions. These polymeric reinforcements undergo alterations under different stress levels and over time in service. The correlation between applied stress and failure time delineates three main failure types: ductile, quasi-brittle, and brittle failure, as depicted in the accompanying figure 6. (Shah et al., 2024).

2.4.2. Failure of electrofusion joint

Studies have identified four main failure modes in electrofusion joints: fusion interface failure, copper wire interface failure, fitting failure, and pipe failure.Fusion interface failure happens when weak bonding at the fusion point leads to cracks spreading outward (Shi et al., 2003).Copper wire interface failure occurs as the wire weakens shear strength, causing cracks along the wire interface (Tayefi et al., 2014).Fitting failure can be a ductile fracture with plastic deformation under high stress or crack propagation under low stress (Tayefi et al., 2018).Pipe failure differs by material—plastic pipes develop fractures, while Reinforced Thermoplastic Pipes (RTP) bulge due to interface debonding (Tayefi et al., 2014).

Polyethylene (PE) pipes, widely used in natural gas distribution, exhibit distinct failure mechanisms under operational loads and material degradation. The primary failure modes include ductile failure at high stress levels, characterized by plastic deformation; quasi-brittle failure due to slow crack growth (SCG), which is critical for long-term performance; and brittle failure caused by chemical or thermal aging, leading to stress-independent polymer degradation. Additionally, poorly fused joints, rapid crack propagation (RCP), and foundation settlement contribute to failures. These failure criteria underscore the need for robust lifetime prediction models, advanced inspection techniques, and effective repair solutions to ensure pipeline integrity (Wang & Shah,2024).

3. Methodology

3.1. Tools used

Field observation, in-depth interview, focus group discussion, and questionnaire survey are the major tools used during this study. The study was conducted during the period from August to November 2024.

3.2. Study area

The study area is situated in Ilam Bazar,which is located in Ilam Municipality, which is situated in Ilam district in the Koshi Province of the Country. The municipality is about 518 km from Kathmandu (Kathmandu-Khurkot Charali-Ilam)   Figure No: 3 Location Map of Ilam W.S.S. and 73 km north of Charali, Jhapa. It lies on the Mechi Highway on the way to Fidim, Panchthar district. The nearest operating airport is Bhadrapur in Jhapa district, about 90 km distant, where daily flights are available.Ilam is a hilly small town, which became a Municipality in 1958 AD (2015 BS). Geographically, it is located at 26º 54'N latitude and 83º 56' 25"E longitude. The terrain of the municipal area rises from an elevation of 401 m above mean sea level (amsl) at the riverbed to 1407 m amsl at the top of Ilam hill. The main Ilam Bazar lies at an altitude of 1228 m amsl. The service area of the proposed water supply project covers a complete area of wards 7 and part area of ward 6, 8 and 9. The following figure depicts the service area of the proposed project (UWSSP).

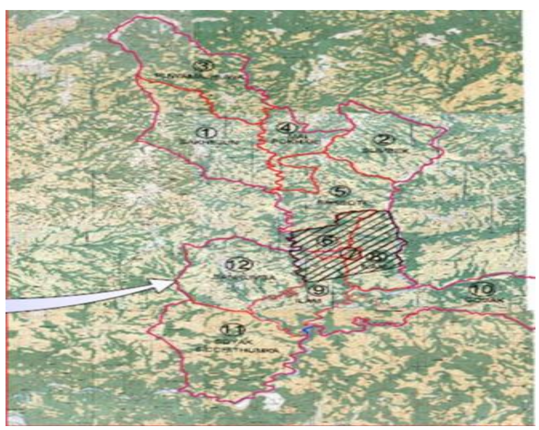


Figure 1. Study Area

3.3. Study population and sample size

In this study, the population means all the water users in the Ilam urban water supply Project. To achieve this, a purposive sampling method was thoughtfully chosen, aligning with the research's specific objectives to gather valuable insights from respondents.

3.4. Sample Size

The calculation of the required sample size followed Slovin's equation (i), where 'N' signifies the total population of the study area, set at 20000 for Ilam, for this context, and 'e' represents the acceptable margin of error, fixed at 8%. The calculation is illustrated below: Where, 'n' is sample size required, e' represents the acceptable margin of error, fixed at 8%. The calculation is illustrated below: Where, 'n' is sample size required,

$n = N/(1+Ne^2)$ (Equation 1)

$n = [20000/\{(1+20000(8/100)^2)\}]=155.038$,

So we take 156 sample size for the Ilam towns.

3.5. Relative Importance Index

Likert Scale is a survey tool with response options for measuring attitudes, while the Relative Importance Index (RII) is a statistical method that quantifies the significance of factors by assigning values to prioritize variables within a study. The RII values ranges from 0 to 1. 1-indicates very poor, 2-poor, 3, good, 4-very good and 5-excellent.

4. Results and discussion

4.1. Field observation

4.1.1. Network of Ilam Urban water supply project

A field observation was conducted from September 3 to 5, 2024, to assess the current status of the Ilam Urban Water Supply Project in Nepal. The system has four water intakes—Rate and Mewa (newly built under the project) and Gitang and Bhandi (existing ones).The water supply operates through a multi-reservoir system with nine reservoirs at six locations. Due to the scattered service area, stretching 15–20 km with an elevation difference of up to 1000 m, a Bulk Distribution System (BDS) is introduced to ensure equal water pressure for all households, including those at higher elevations and farthest points. Water from treatment plants will be distributed to all reservoirs, and the total length of the BDS is about 18.13 km.

Status of Water Quality

a) Physical ,Chemical & Microbiological Parameters

The all sources are free from microbiological contamination, ensuring safe drinking water in terms of pathogen presence as shown in Table 1. (Field survey, 2024).

Table 1. Summary of Water Quality Report (WUC, 2024).

Category	**Parameters**	**Observed data – Ilam urban water supply project**				**NDWQS, 2079 BS**
		2079/06	**2079/07**	**2080**	**2081**	
Physical	Turbidity (NTU)	1.3	0.84	1.2	0.4	3
	Temperature (°C)	25	25	25	25	-
	pH	7.2	7.1	7.3	7.6	6.5 - 8.5
	Electrical Conductivity (µS/cm)	97	98	98	36	1500
Chemical	Iron (mg/L)				0.2	0.3 (3)
	Ammonia (mg/L)	<0.2	<0.2	<0.5	<0.2	1.5
	Nitrate(mg/L)	0.8	0.8	0.8	0.8	50
	chloride(mg/L)	<5	<5	<5		250
	Total Hardness (mg/L as $CaCO_3$)	50	55	52	<10	500
	Calcium(mg/L)	30	30	30		
Microbiological	Faecal coliform (CFU/100 ml)	0	0	0	0	0
	Total coliform (CFU/100 ml)	0	0	0	0	0

4.2. Findings from the focus group discussion

Discussions at the WUC office and Aadarsh School (Sept 4-5, 2024) highlighted major challenges in the Ilam Urban Water Supply System. Poor infrastructure, including shallow and exposed pipelines, leads to frequent disruptions, high maintenance costs, and inefficient distribution—causing shortages in Pipalbote and wastage in Bajar and Tilkeni. Managerial inefficiencies and financial struggles further hinder operations, with the WUC unable to pay staff or maintain the system without municipal support. The absence of a water management board for two years has worsened governance issues, delaying repairs and reducing service reliability. Addressing these concerns requires infrastructure upgrades, financial aid, and improved management.

4.3. Problem of Ilam urban water supply project

The weighted distribution of the existing problem of Ilam urban water supply project, Nepal. Respondents agreed with "Durability of Pipe Materials Used in the Project" is at top position with RII value 0.64 and "Frequency of pipe leaks over the years" has least RII value with 0.54 data are presented in fig.4

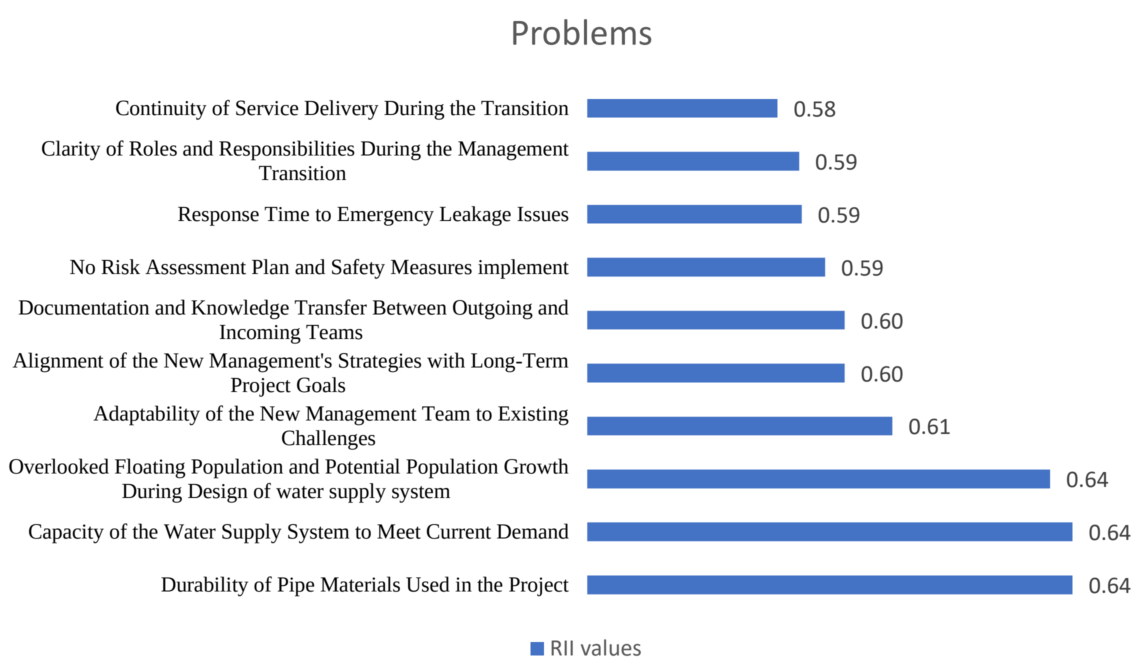


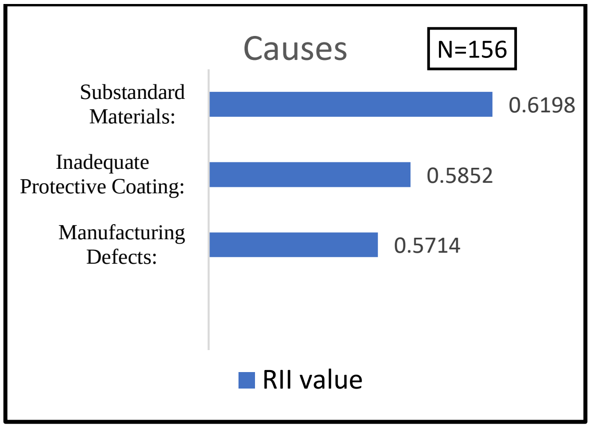
Figure 4. Problem of Ilam urban water supply system (Field Survey, 2024)

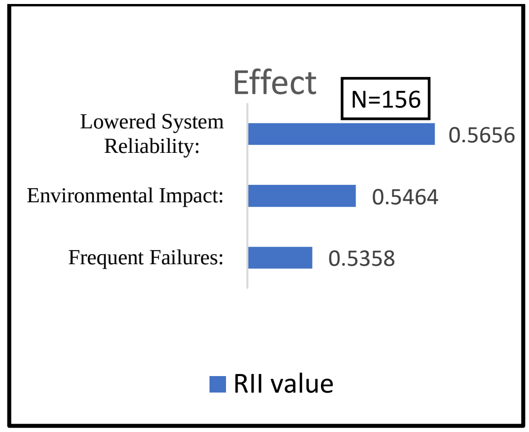
Causes and Effect of Problems

The Ilam Urban Water Supply Project faces pipeline leaks due to aging infrastructure (RII: 0.5470), poor materials (RII: 0.5954), and improper installation (RII: 0.5762), leading to water loss (RII: 0.5306) and high maintenance costs (RII: 0.5710). Substandard materials (RII: 0.6198) and inadequate coatings (RII: 0.5852) reduce pipe durability, causing frequent failures (RII: 0.5358). Cost-cutting (RII: 0.5852) and time constraints (RII: 0.5798) result in poor repairs (RII: 0.5556). Leak detection delays due to poor monitoring (RII: 0.5618) and terrain issues (RII: 0.6290) raise costs (RII: 0.5560). Emergency response is hampered by bureaucracy (RII: 0.5476) and resource shortages (RII: 0.5756), prolonging outages (RII: 0.5906). Management transition challenges, including unclear roles (RII: 0.5652), poor planning (RII: 0.5568), and weak communication (RII: 0.5702), cause inefficiency (RII: 0.5542) and delays (RII: 0.5512). Political interference (RII: 0.5276), staff turnover (RII:

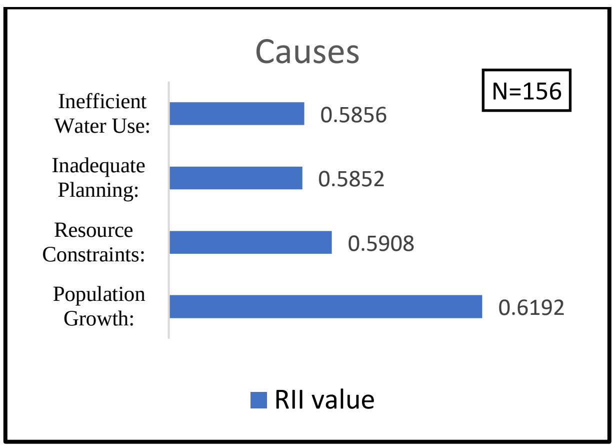
0.5462), and resource gaps (RII: 0.5704) disrupt service. The new management struggles with inexperience (RII: 0.5460) and resistance to change (RII: 0.5660), reducing efficiency (RII: 0.5512) the tabulated form is as below.

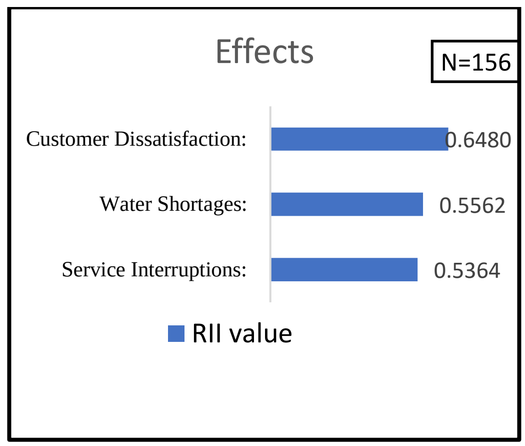
1. Durability of Pipe Materials Used in the Project



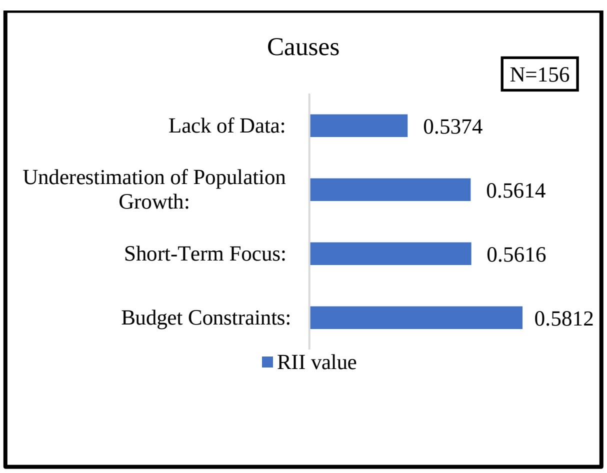


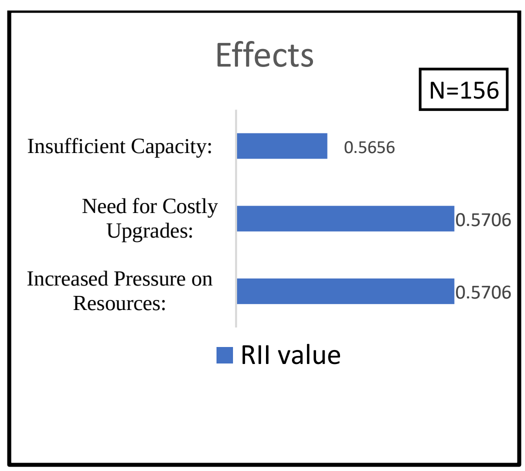
2. Capacity of the Water Supply System to Meet Current Demand



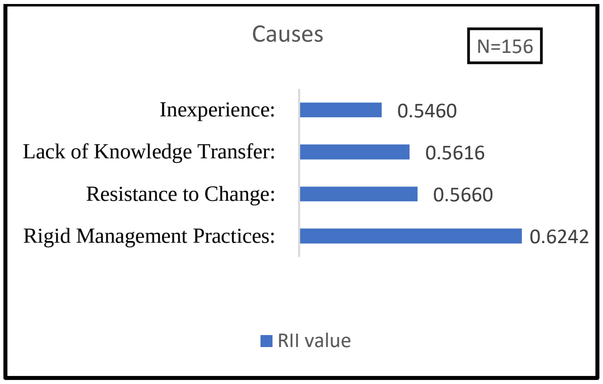


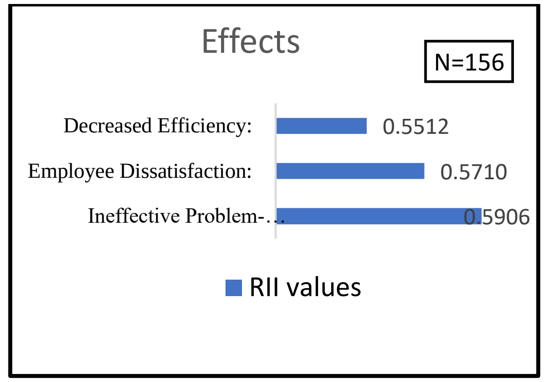
3. Overlooked Floating Population and Potential Population Growth During Design of water supply system



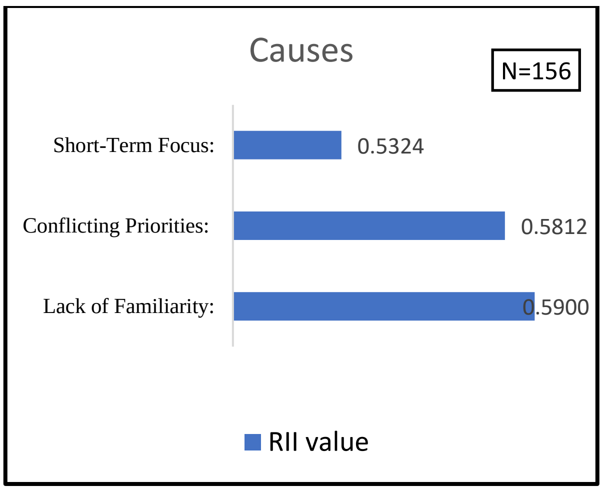


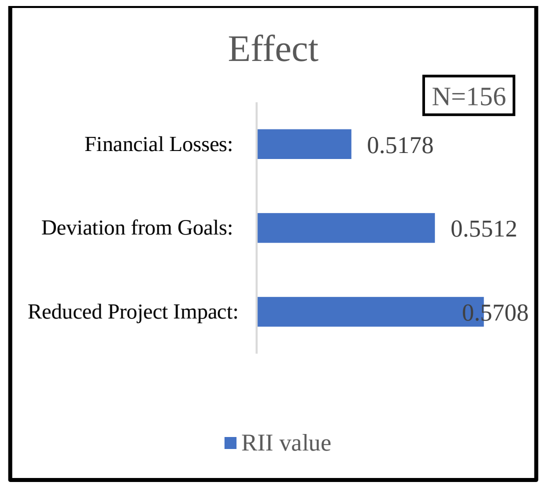
4. Adaptability of the New Management Team to Existing Challenges



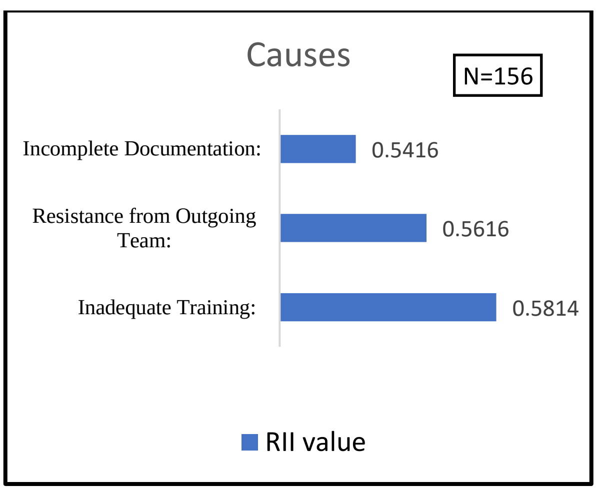


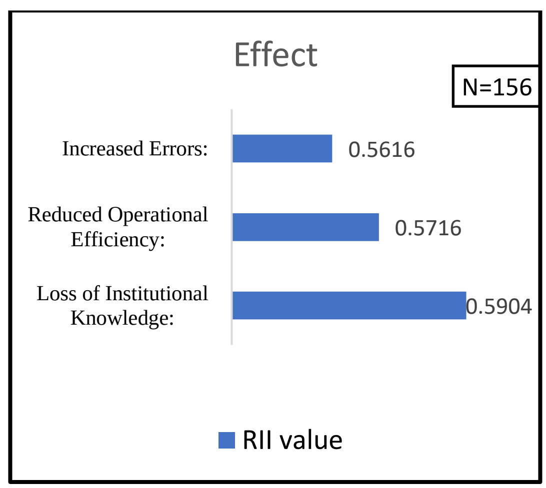
5. Alignment of the New Management's Strategies with Long-Term Project Goals



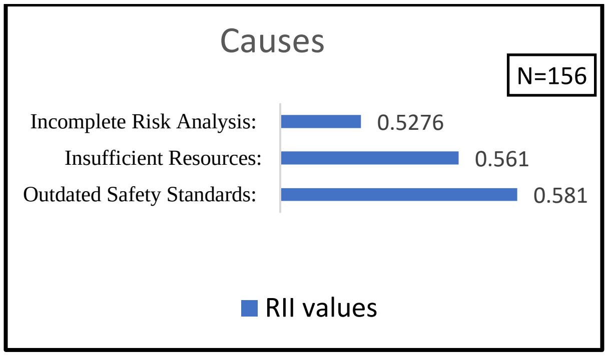


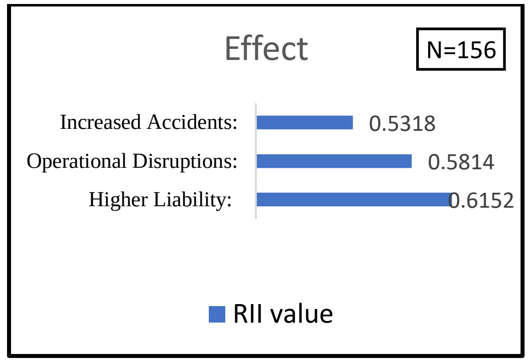
6. Documentation and Knowledge Transfer between Outgoing and Incoming Teams



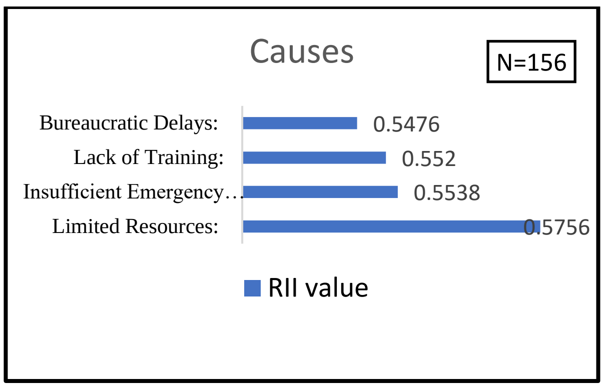


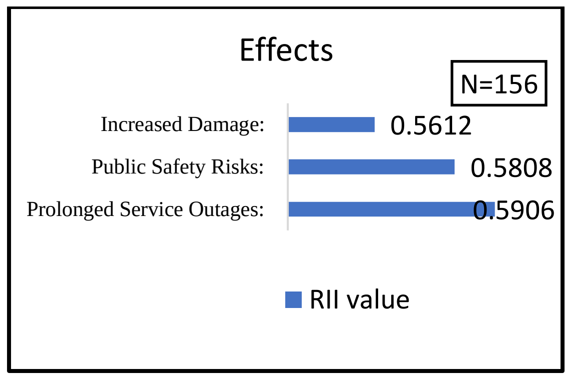
7. No Risk Assessment Plan and Safety Measures implement



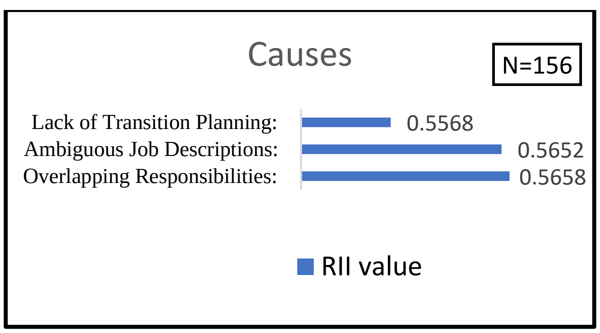


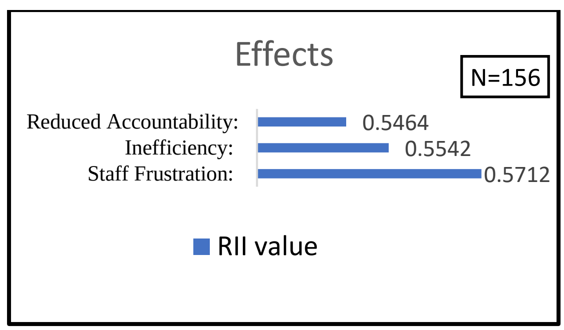
8. Response Time to Emergency Leakage Issues



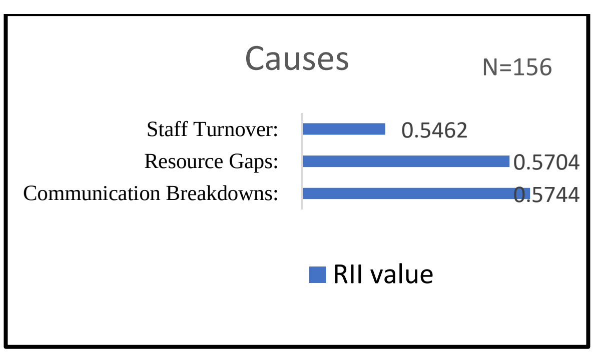


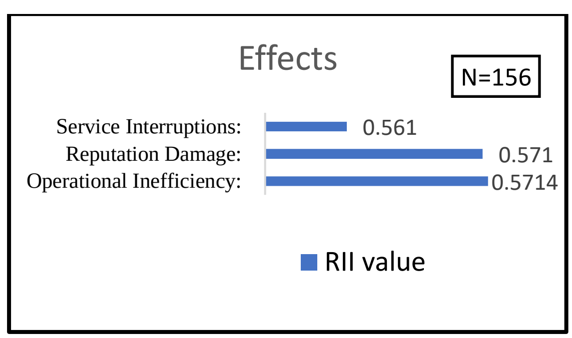
9. Clarity of Roles and Responsibilities During the Management Transition





10. Continuity of Service Delivery During the Transition





4.6. Demand and Supply of Ilam urban water supply project

4.6.1. Population analysis and projection

The population trend analysis from 1971 to 2011 shows growth in the service area, but the growth rate has declined since 1991. Based on this trend, the projected population for the project area in 2039 is 23,826. The assumed growth rate for this projection is 1.1%. This estimation helps determine the population to be served at the end of the design period.

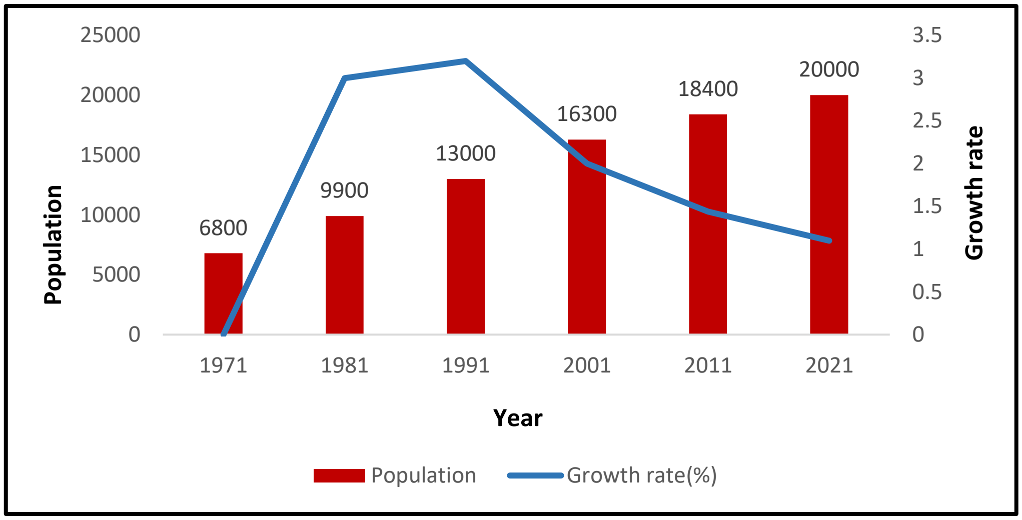


Figure 5. Trend analysis of population growth rate (Census, 2024)

4.6.2. Water demand Calculation

As per the above design criteria and population forecasting the water demand is shown in table 2.

Table 2. Water demand calculation

Types of demand	Units	Year 2021	Year 2025	Year 2030	Year 2035	Year 2039
Population	no.	20000.00	20895.00	21829.00	22806.00	23826.00
Domestic Demand	MLD	2.00	2.09	2.18	2.28	2.38
Non-Domestic Demand	MLD	0.20	0.21	0.22	0.23	0.24
Loss & Wastage	MLD	0.22	0.23	0.24	0.25	0.26
Total Demand	MLD	2.42	2.53	2.64	2.76	2.88
Total Avg. Demand	lps	28.01	29.26	30.57	31.94	33.37
Total peak demand	lps	84.03	87.79	91.71	95.82	100.10

4.6.3. Supply of water in Ilam urban water supply project

Water supply to the project area from the all four sources are collected at WTP, the SCADA system shows the inflow water date and time wise. From that data, the average water supply for the second week of September (4^{th} -10^{th} sept) is 44lps.

4.6.4. Comparison of demand and supply of water

The study says that the avg. water supply is 44.8lps whereas the demand of water for the year 2021is 28.01lps, 2025 is 29.26lps, 2030 is 30.57lps and 2039 is 33.37lps. It shows that the supply of water is enough as per demand.

4.7. Mitigation Measures

The water shortage in Pipalbote and the wastage in Bajar and Tilkeni can be solved by properly managing the gate valve installed in the BDS system. The mitigating measures are presented in the figure (figure 6)

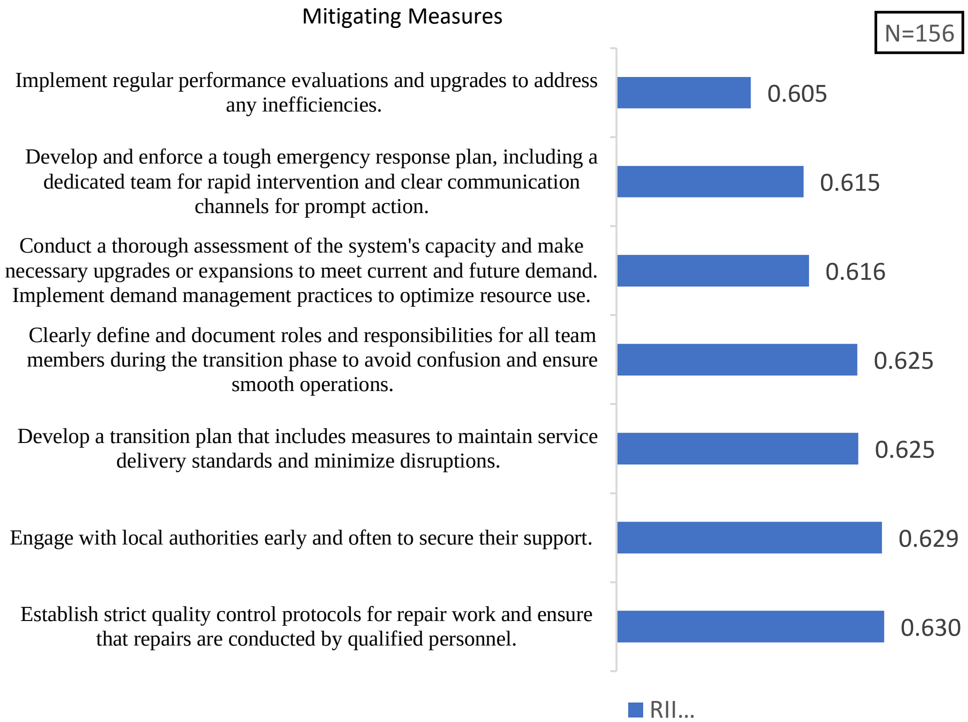


Figure 6. Mitigating measures

4.8. Discussion

Urban and rural water supply systems in Nepal face numerous challenges, particularly in urban areas where service delivery remains inadequate due to poor coverage, low water pressure, intermittent supply, and high levels of non-revenue water (Gautam & Dahal, 2020). The Ilam Urban Water Supply Project, in particular, struggles with critical infrastructure, financial, and operational inefficiencies. This has led to an uneven distribution of water, with areas like Pipalbote experiencing shortages while others, such as Bajar and Tilkeni, face overflow and wastage. Additionally, climate change is exacerbating these problems by influencing precipitation patterns and increasing the frequency of extreme weather events, further straining the water supply system.

Beyond financial and infrastructure challenges, broader water management issues persist, including deteriorating water quality and increasing demand due to urbanization and population growth. Pollution, rising salinity, and climate change-induced displacement further complicate water security, necessitating a multi-sectoral approach involving government, private sectors, and local communities. Sustainable water management strategies should focus on efficiency improvements, alternative water sources such as wastewater reuse and rainwater harvesting, and stricter policies to protect water resources. Drawing from successful international models, such as Australia's national water management design guidelines, Nepal could develop a more comprehensive framework to address these challenges effectively and ensure long-term water security.

5. Conclusions

The Ilam urban water supply system faces several problems with its infrastructure and management. Poorly installed pipes, exposed transmission lines, and unresolved leaks are weakening the system and making water distribution inefficient. Additionally, the Water Users' Committee (WUC) is struggling financially due to a lack of support from the municipality, making it hard to carry out maintenance or pay staff on time. The delay between project design and construction has caused an imbalance between water demand and supply, leading to shortages in some areas and overflows in others.

Another issue is the failure to set up a proper water management board, leaving the WUC with poor oversight. The uneven water distribution and growing dissatisfaction among community members show the need for more community involvement and better financial planning. For the system to improve, the WUC, municipality, and local residents must work together to fix infrastructure issues, ensure financial stability, and increase community participation in managing the water supply.

Finally, the new management team is struggling to deal with the existing challenges, partly due to inexperience and resistance to change. The lack of proper knowledge transfer between the old and new teams has caused operational problems and financial losses. To address this, future projects must focus on better documentation, smoother transitions between teams, and stronger management strategies to ensure the water supply system runs reliably and meets the needs of the community.

The study would like to suggest that the execution of regular inspections and maintenance to identify and fix water leaks, it's important to do regular checks and maintenance, use high-quality materials, and train staff to use modern leak-detection tools. Old pipes should be replaced with stronger ones, and better installation methods and coatings should be used. Management should have clear roles, avoid political interference, and keep good records. Operations should improve valve management and create risk plans. Finally, storing water for high-demand times will help handle population growth and climate changes in the long run.

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