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RESEARCH ARTICLE

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Institutional arrangements for improving water and sanitation services in the rural villages of India: a systems thinking approach

Martin Kofi Kanyagui[1] | **S Rajendrakumar**[2] | **Pozhamkandath Karthiayani Viswanathan**[3]

[1]Amrita School for Sustainable Development, Amrita Vishwa Vidyapeetham, Amritapuri, India

[2]Department of Chemical Engineering and Materials Science, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India

[3]Amrita School of Business, Amrita Vishwa Vidyapeetham, Amritapuri, India

Correspondence
Martin Kofi Kanyagui, Amrita School for Sustainable Development, Amrita Vishwa Vidyapeetham, Amritapuri 690525, India.
Email: martinkanyagui@gmail.com

Abstract

This study examines the impact of institutional arrangements on water and sanitation (WATSAN) services in a village context in India. Data from households in Nagla Chandi village in Uttar Pradesh state were used to assess the situation. A systems thinking approach was employed to identify intervention points and improve access. The study identified under-resourced local institutions, a lack of village-level WATSAN rules and regulations, a lack of participation by both public institutions and communities, and trust issues as the critical barriers to accessing WATSAN services. It advocates for setting up a local WATSAN fund to ensure sustainable service delivery and a better understanding of the broader governance environment for sustainable WATSAN delivery in rural communities.

KEYWORDS

governance, India, institutional arrangement, Nagla Chandi, policy, rural, systems map, systems thinking, water and sanitation

1 | INTRODUCTION

The provision of water and sanitation (WATSAN) services requires efficient governance and institutional arrangements (IA) at both national and local levels. WATSAN is a critical component of sustainable development (SD), and it is apparent that countries develop the necessary mechanisms to achieve the targets as prescribed in Sustainable Development Goals 6 (SDG 6) (UN-Water, 2018). Without a proper IA, very good programs and initiatives are likely to fail (Walker et al., 2008).

The need to ensure proper IAs at the local level, particularly in developing countries with poor and weak IAs, is emphasized by SDG 16.B, which seeks to promote and enforce non-discriminatory laws and policies for SD (NITI Aayog, 2021). While the right to WATSAN has been recognized as a fundamental human right in many countries, including India (Koonan & Bhullar, 2012), its realization is lacking, particularly in small and impoverished rural communities (Gaude & Desai, 2019).

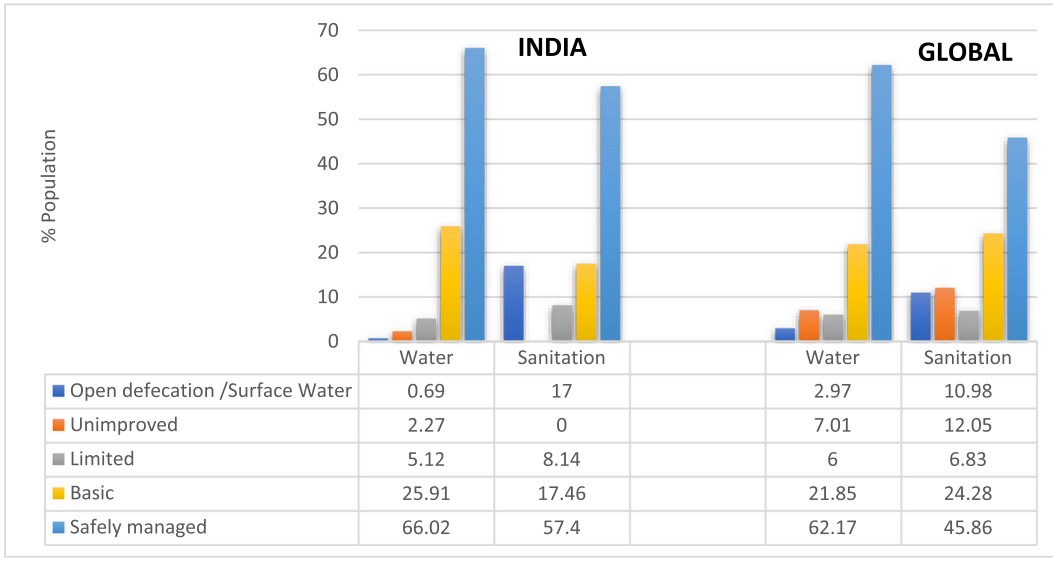
1.1 | IA

The term institution has been used in different fields and has several meanings based on the applicable context. In general, IAs refer to the policies, rules, norms, and values that countries have in place to legislate, plan, and manage the execution of development, the rule of law, the measurement of change, and other such functions of the state (ETF, 2014). IAs are a combination of formal regulations, informal rules, and associated enforcement mechanisms. They can also be classified as rules and public policies intended to achieve set objectives (Hodgson, 2006; Klijn & Koppenjan, 2006; North, 2010). The success of any set of defined objectives greatly depends on the IAs in place. Locussol and Van Ginneken (2010) note that the analysis of the IA of WATSAN delivery normally addresses several key issues, including the responsibilities of the WATSAN service providers, the operational and management schedule of the utilities, defined service standards, finance mechanisms, regulatory systems in place to protect resources and the environment, alternative sources available to consumers, and finally enforcement mechanisms for rules and standards.

1.2 | Rural WATSAN service provisioning

Globally, safe drinking water coverage has increased since 2015 from 69% to 73%, with 32 countries on track for universal access by 2030. However, 2.2 billion people still lack safe water, with 78 countries progressing too slowly and 16 countries experiencing decreasing coverage (WHO and UNICEF, 2020). To meet the SDG global target, progress needs to increase sixfold. In the case of sanitation, since 2015, sanitation coverage has increased from 49% to 57%, with rural and urban areas seeing improvements. However, no country is on track to achieve universal access by 2030, and progress needs to increase fivefold to achieve the set targets. In 2022, 3.5 billion people still lacked safely managed sanitation (WHO and UNICEF, 2020).

Rural access to WATSAN services remains a global challenge. With over 40% of the global population living in rural areas (World Bank Group, 2023), SDG 6 targets are at a risk of being missed. This global scenario holds true for rural India as well, as demonstrated in Figure 1, which presents the global and Indian rural access to WATSAN services.



	Water	Sanitation		Water	Sanitation
Open defecation /Surface Water	0.69	17		2.97	10.98
Unimproved	2.27	0		7.01	12.05
Limited	5.12	8.14		6	6.83
Basic	25.91	17.46		21.85	24.28
Safely managed	66.02	57.4		62.17	45.86

FIGURE 1 Rural access to water and sanitation (WATSAN) services. *Source*: https://washdata.org/data/household#!/dashboard/5371.

Figure 1 shows that 57.4% and 45.86% of Indian and global rural populations, respectively, have access to basic and safely managed sanitation. In terms of water, 66.02% and 62.17% of India and global rural populations, respectively, have access to basic and self-managed water delivery. To achieve SDG 6 targets of universal access to WATSAN services by 2030, policies and investment focusing on rural communities are required. The UN World Water Development Report 2019 (World Health Organization, 2019) highlights the need for government investment in water and sewage infrastructure in rural communities where extreme poverty breaks the principle of affordability.

According to the Department of Drinking Water and Sanitation's, 2011–2022 strategic plan for WATSAN delivery in India, the Government of India (GoI) and state governments had spent approximately Rs. 1,10,000 crores (USD 13271 million at current conversion rates) on rural drinking water since the first 5-year plan (1951–1956) as of 2011. During 2022–2023 alone, the Department had allocated Rs 67,221 crore (US$ 8110 million), which was 32% more than the revised estimates of 2021–2022. Despite these significant investments, the sector continues to face several challenges, including degraded groundwater sources, poor water quality impacts in many locations, and poor water system operation and maintenance. This situation has resulted from competing demands for limited water resources, poor institutional governance, insufficient support systems, and a lack of professional capacity at all levels (DDWS, 2011).

1.3 | IA for WATSAN delivery in India

In 1993, the Indian constitution (Wheare, 1951) and relevant state legislations were amended with the aim of decentralizing certain key responsibilities to subnational levels of governance like states and districts. Key among these was water supply and sanitation. Following the amendment, different states have adopted different approaches based on the local context

(Chaudhuri et al., 2020). The decentralized administrative set up for the delivery of WATSAN services in India have been illustrated in Figure 2.

As provided in Figure 2, a village WATSAN committee (VWSC) is expected to be established in each village to serve as the local institution that works with the Panchayat to ensure WATSAN services (Department of Drinking Water and sanitation, 2011; World Health Organization/United Nations, 2017). A well-trained and functional VWSC is crucial for sustainable WATSAN service delivery (Chaudhuri et al., 2020; RANCHI, 2013). The Controller and Auditor General of India (CAG) reports indicate that VWSCs were not formed in Bihar, Kerala, Rajasthan, and Tamil Nadu. In 10 selected Grama Panchayats (GPs), VWSC formation ranged between 29% and 96%. Audits observed shortcomings in VWSC functioning in 12 states, including non-involvement in planning and management, limited role in the sanitation sector, and non-representation of Scheduled Castes (SCs), Scheduled Tribes (STs), and poorer communities (CAG, 2018). Table 1 sets out the key issues affecting the operationalization of VWSCs.

Chaudhuri et al. (2020) assessed the operational performance of rural water supply services (RWSS) in India to understand challenges and opportunities. They observed that RWSS is marked by high spatial heterogeneity, inequality, and recurrent slip-backs, adversely affecting the National Rural Drinking Water Programme's (NRDWP) motto of "Har Ghar Jal (Water for All)." The study highlighted how water scheme failures compound the uncertainties associated to water and sanitation service delivery that adversely affect households. Table 2 shows states that have challenges with the functionality of VWSC and other institutional arrangement for WATSAN services in India.

Some states were found to lack the necessary local institutional arrangements due to a variety of issues, including a lack of functional committees, less competent or experienced membership of local organizations, infrequent committee meetings, staff shortages, and outdated operational systems. These limitations were identified as impediments to the functionality of local institutions that affect their ability to engage with communities (Chaudhuri et al., 2020). It was further observed that the knowledge and resources available to the VWSC members for water management were insufficient. Poor water and service system operation and maintenance were among the other issues found in the study. The survey also showed a lack of

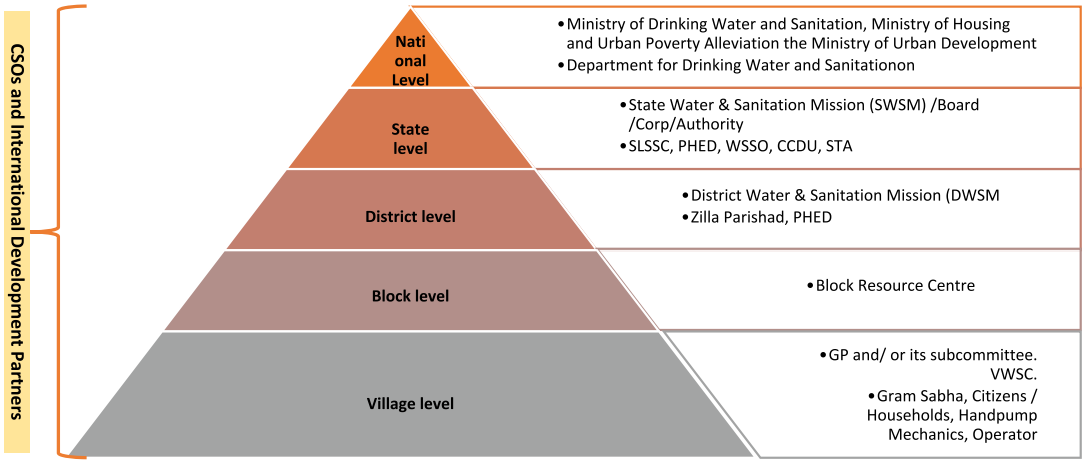


FIGURE 2 Institutional framework for water and sanitation delivery in India. *Source:* Government of India (2021).

TABLE 1 Prime concerns associated with village water and sanitation committee (VWSC).

Concerns related to effective VWSC	States
Committee not formed	Bihar, Kerala, Rajasthan, Tamil Nadu
Committee played a minor role in RWSS scheme development	Chhattisgarh, Jharkhand, Karnataka, Mizoram, Uttar Pradesh
Committee formed but non-functional	Jammu and Kashmir, Tripura
Committee only involved in sanitation sector	Assam
Committee did not ensure adequate community participation	Madhya Pradesh, Telangana, North Eastern Region

Source: CAG (2018).

TABLE 2 Village-level institutional features, functions, and states that completely lack them or have organizational/functional concerns.

Institutional features	Functions	States with functional concerns
Water & Sanitation Support Organization (WSSO)	Assisting Gram Panchayats in developing water security plans, conducting IEC/HRD activities, conducting impact assessment studies, and establishing IT support systems	Himachal Pradesh, Rajasthan, Goa, Telangana, Karnataka, Bihar, Assam, Arunachal Pradesh, Manipur, Meghalaya and Nagaland
Village Water and Sanitation Committee (VWSC)	Supervising RWSS planning, design, and implementation, as well as providing information to Gram Panchayats for the purpose of reviewing water and sanitation issues	Jammu and Kashmir, Uttarakhand, Rajasthan, Madhya Pradesh, Maharashtra, Telangana, Karnataka, Tamil Nadu, Kerala, Bihar, Jammu and Kashmir, Orissa and NER states Eastern Region

Source: Chaudhuri et al. (2020).

knowledge about the state's water systems (Ranchi India Institute of Management, 2013). According to Kanyagui and Viswanathan (2022), achieving SDG 6 targets requires effective collaboration between local state institutions and non-state actors providing WATSAN services to rural communities.

Even though research on IA has been replete and still on the rise, the implication of the effect on WATSAN service delivery at the village level has not been explored using a systems thinking approach. While most of the research in this context has focused on global (Rahman et al., 2011; World Health Organization, 2019), national (Dhoba, 2022), and community levels (Al'Afghani et al., 2019), our understanding as to how the IA translates into effective WATSAN delivery at the local level is grossly inadequate. To bridge this knowledge gap, we apply systems thinking as a tool to examine the effect of IA for WATSAN delivery within a village context.

Hence, the study seeks to achieve the following objectives:

1. To examine the status of WATSAN and the associated IA in place for its efficient delivery in rural India; and

2. Apply systems thinking as a tool to analyze the effect of IA on WATSAN delivery.The paper is structured into five sections. The first section is a review of existing literature on the subject as well as the study's objectives. The second section describes the methodology used,

underpinning theory, and the ethical consideration. The third section outlines the study's findings in terms of the status of WATSAN delivery. In the fourth section, we use systems mapping process to analyze the results and highlight the key issues and intervention points for sustainable WATSAN delivery in the community. The final section presents conclusions and the policy implications.

1.4 | Methodology

1.4.1 | Study area

The study area has a semiarid climate characterized by high temperature variation and low seasonal rainfall (monsoon season). The region's geology primarily composes of a single rock formation and does not exhibit any notable structural problems (Ahmed et al., 2018).

Nagla Chandi, also known as Nagla Purivia, is the study village and is situated 16 km (km) west of Mathura district in Uttar Pradesh, India (Kanyagui et al., 2023). It is part of the Ral Panchayat of the Agra Division as shown in Figure 3.

To gain a better understanding of the study's context in terms of the profile of the study village, we examined the socioeconomic profile by focusing on three key components: the economy, social, and environmental aspects of the village. Table 3 presents a summary of the socioeconomic and environmental profile of the village.

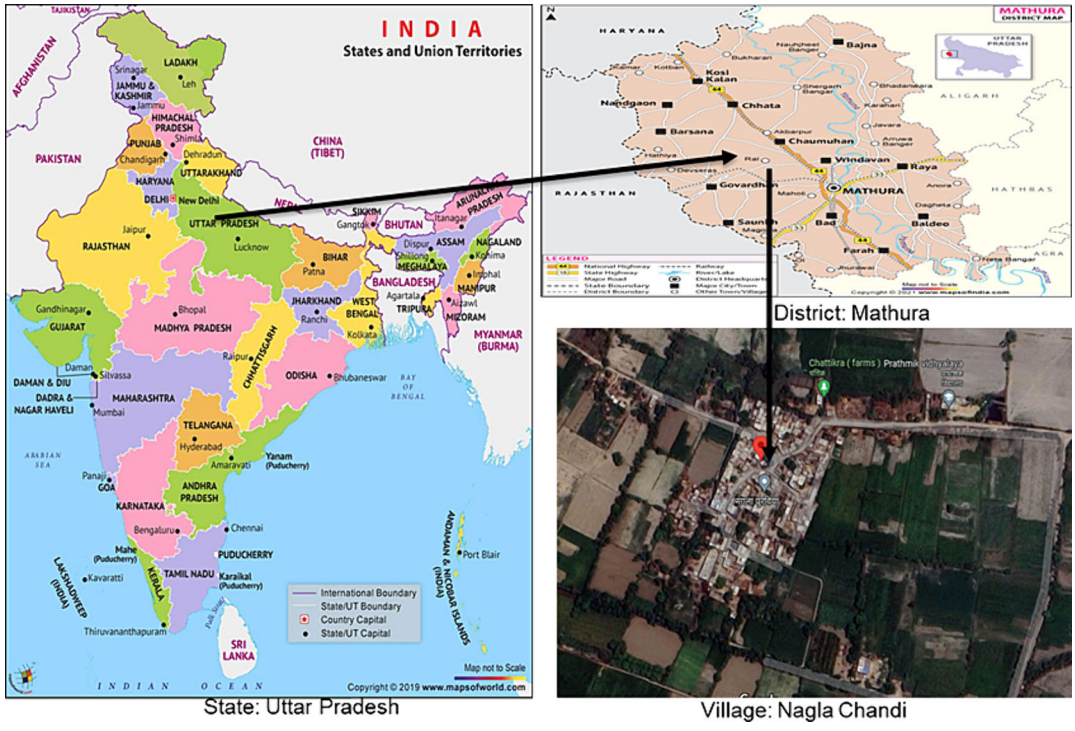


FIGURE 3 Map of India showing location of aerial view of study village, Mathura District and Uttar Pradesh in India. *Source*: Google map (https://images.app.goo.gl/4AAbp1sy7wdpxELE8, google map images).

TABLE 3 Socioeconomic and environmental profile.

Sector	Sub-sector	Findings		Source
Social	Population	- Total population is 350 (57% male and 43% female)		Household head survey
	Health	- Waterborne diseases are prevalent - Closest health facility is at Ral, which is about 5 km from the community - There is not transport service to carry the sick to the health facility during emergency		Focus group discussion with women
	Education	- There is a primary school in the village that has classes up to fifth standard with three permanent teachers and one principal number of students - 46% of household heads have never been to school, and 33% have basic education		Household head survey
	Cultural	- Rajput—patrilineal clan who traditionally believe they trace their ancestry to ancient warriors - 100% Hindu		Household head survey (Kanyagui et al., 2023)
Economic	Main occupation	- Main occupation is farming (66%)		Household head survey
	Types of crops grown	- Main crops grown are vegetables, wheat, and mustard. Number of farmers is also involved in horticulture		Observation
	Animal husbandry	- Buffaloes and cattle are owned by almost every household. They are milked for both domestic use and also for sale		Observation
	Resource flow	- Farm produce sold mainly at Ral and community members also buy hardware and other household essentials from both Ral and Mathura		Focus group discussion with youth
	Income for household heads	- INR 8000 based on data collected during the survey		Household head survey
	Income sources for women	Source	Average income (INR)	(Kanyagui et al., 2023)
		Sale of milk	2500/week	
		Sale of calf	3000	
		Work on the field	400/day	
Environmental	Source of energy	- 69% rely on dung and fuel wood - 28% rely on LPG gas even though this has recently reduced due to cost		Household head survey
	Deforestation	- Increasing cutting of trees for fuel wood		Observation

Source: First author's fieldwork (2023).

1.4.2 | Research design and data

Explanatory research design approach (Igwenagu, 2016; Sileyew, 2019; Yin, 2003) is applied in this study and relies on both qualitative and quantitative data. With this approach, we seek to explain why and what sorts of IAs exist for WATSAN delivery within the study context. The approach involved a desk review, followed by an in-depth interview of the rural households within the context of the case study village.

Both primary and secondary data were used in this study. In the first instance, it reviewed various articles that were accessed from peer-reviewed journals. The search engines used for the literature mainly included Google Scholar and Scopus database. Search strings applied included words and phrases such as "WATSAN," "rural India," "Systems Thinking," and "Institutional Arrangement."

The primary data were collected using structured and semi-structured questionnaires for the socioeconomic and environmental profile of the study village, as well as the status of WATSAN/IAs for WATSAN delivery. Forty-nine household heads, representing 100% of the total households in the Nagla Chandi village, were interviewed. To examine the IA for WATSAN delivery in the village, a semi-structured questionnaire was used to interview the Village Contact for the Live-in-Labs® program. The program is a multidisciplinary experiential learning program exposing youth to rural India's problems, involving students and faculty, international students, and faculty to develop innovative solutions and collaborative problem-solving skills (Amrita Vishwa Vidyapeetham, 2019).

To determine the IA for managing WATSAN delivery within the Ral block, Pradhan, who is the head of the Panchayat, was additionally interviewed using an interview guide. Focus group discussion (FGD) consisting of six village women was also undertaken to infer the reasons for household water choices.

Data analysis

The study employs the systems thinking approach as an analytical tool. A system is a group of related parts that interact over time to form a whole with a purpose or function. It can be physical entities that can be observed and empirically examined, like a tree or a subway system, or abstract constructs used to understand our world, like a model of a cell or the solar system. It consists of various parts that interact with each other (Betley et al., 2021).

Application of systems methods. Systems thinking approaches have been applied in different contexts including rural development with success. It is useful in solving complex problems with different actors and interests (Arnold & Wade, 2015). It considers the synergies between elements that interact in a particular context or system, resulting in an expected goal or otherwise unwanted outcome called entropy. Polaine et al. (2022) used systems thinking to examine water security holistically, focusing on reductionist understanding of key processes and elements. Four case studies were used to show how this approach dissolves silos, change spatial scale, improve data acquisition, and integrate socio-ecological issues with traditional biophysical understandings. WATSAN services are a complex adaptive system involving various subsystems, requiring openness, multi-stakeholder partnerships, and unique characteristics to adapt to failures in one component (Casella et al., 2015).

Various systems thinking tools are applied by researchers and other practitioners including the iceberg model (Betley et al. (2021), systems map or causal loop diagrams (CLD) (Allen et al., 2018), quantitative modeling (Betley et al., 2021; Kim, 2000), stakeholder analysis (Allen

et al., 2018; Betley et al. (2021), and rich picture diagrams (qualitative) (Allen et al., 2018; Betley et al. (2021). This study applies systems mapping as the main analytical tool. The software we rely on is Kumu Livestream Community version 8.47.1 (https://kumu.io/).

Maps are essential for systems thinking, communication, and analysis of complex relationships. They represent realities and are perceived as power tools in the WASH sector, conveying WATSAN networks, value chains, causal relationships, and participatory methodologies (Saunders et al., 2016). By applying systems maps, we use causal loops to demonstrate how changing one part of a system can affect other parts or the WATSAN system's functioning. We then evaluate whether these links balance or reinforce a trend. CLD help visualize mental models by identifying key system components and how they interact.

Systems mapping. The first step of the process begins with the definition of the systems model, which includes the system elements, input, processing, outcome, entropy, interrelationships/synergies, boundaries, and, finally, the environment. The model gives a holistic view of the WATSAN delivery system within the study context. The next stages involved analyzing the study result through eight further steps as illustrated in Figure 4.

The definition of the various stages of the analytical process is provided in Section 2.4.

Ethical considerations. Free and informed consent of the participants or their legal representatives was obtained, and the study protocol was approved by the appropriate Committee for the Protection of Human Participants [Nagla Chandi Village] by the Institute of Medical Sciences Healthcare, Education & Research, Institutional Ethics Committee, Kochi, Kerala. Protocol No. IEC-AIMS.2O22. ASSD.255 on 05/10/2022.

2 | RESULTS

2.1 | Status of drinking WATSAN services

2.1.1 | Water

The primary source of water in the village includes covered hand-dug wells fitted with pumps installed in homes. The secondary source of drinking water is the Jivamritam water filtration system. Jivamritam is a community-based clean drinking water solution launched in 2017 with CSO support. The first phase aims to provide safe water to 10 million people in 5000 villages,

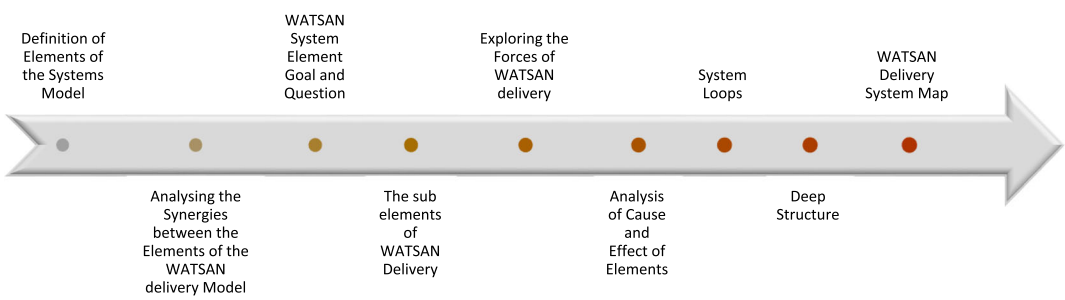


FIGURE 4 Systems mapping process. *Source*: Betley et al. (2021).

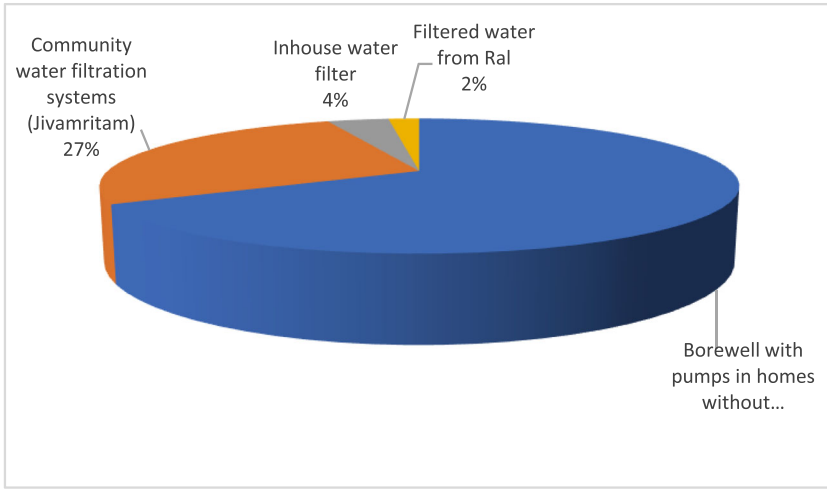


FIGURE 5 Percentage of household using alternative drinking. *Source*: First author's fieldwork (2023).

serving 2000 people daily (Ajith et al., 2022). A few households rely on treated water from the Jivamritam water system, which is sold at 10 rupees for a 20-L bottle. Two households have installed their own water filtration system at home. Details are provided in Figure 5.

Reasons for household choices of alternative water sources

The FGD with six women in the community and interaction with household heads was conducted. It was revealed that the main reasons why households prefer borewell water in their homes include cost of the treated water, which is 10 rupees for 20 L gallon; proximity of the system; and the fact that the system is not opened until evening when the waterman open it at 6–7 p.m. Most of them felt the water from the borewell is of good quality and taste better. One member of the group also mentioned that since the civil society organization (CSO) provided the water for free to the community, it should also be given for free to the community members since most of them could not afford it at the current price.

2.1.2 | Sanitation

Drainage system

It was observed that there is no proper drainage system in the village. Within the built-up areas, very shallow drains have been provided to channel liquid waste from homes to either farm sites or to a pool that is adjacent to the school located at the entrance of the village. Due to the shallowness of the pond, it occasionally overflows allowing some of the water to flow into the school compound. Its closeness with the school wall also compromises the integrity of the wall putting school children at risk. Currently, part of the school wall has collapsed as a result of the flooding issue.

Access to household toilets

Two types of toilet facilities exist. Majority are the "pour water" toilet, which the community refers to as the "Indian toilet," and the second is the flush toilet, which is commonly referred to

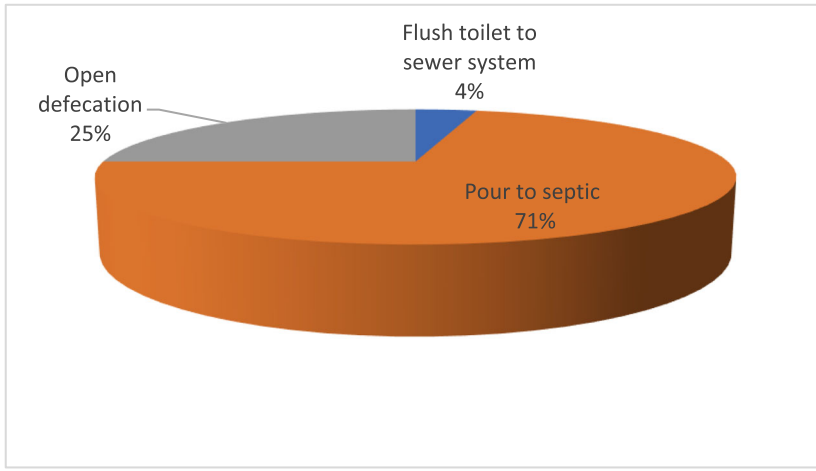


FIGURE 6 Household access to toilet facilities. *Source*: First author's fieldwork (2023).

FIGURE 7 Two types of toilet facilities used in the village.

as the "English toilet." According to the household heads, most toilets in the village were built about 10 years ago under the government's Total Sanitation Campaign (TSC) initiative. Under this initiative, government funded 50% of the construction cost, and the rest was paid by households. Details have been provided in Figure 6.

Figure 6 shows that 25% of households do not own household toilets and therefore practice open defecation. The household heads mentioned that even though most households had access to toilets, a few people still prefer to practice open defecation mainly because their families did not have one of the toilets or the location of the toilet was on the farm sites and was difficult to access especially in the night. However, it was observed that the families who had the household toilet kept them always safe and secure even though most of them were sited very close to the household borewells. This has implication on the quality of the water from the well water. Figure 7 shows the two types of toilet facilities used in the village.

2.2 | IA for WATSAN delivery

2.2.1 | Assessment of IA components by Live-in-Labs village coordinator

To assess the IAs in the study village, we undertook a key informant interview with the village coordinator. The key parameters used to assess IA included rules and regulation, government policy, and finally the existence and involvement of local institutions in WATSAN delivery. As this study was with respect to issues that require specific knowledge on the subject matter, the village coordinators of a local CSO was the key informants interviewed using a structured questionnaire.

Results of a detailed discussion of each of the components based on key informant interviews with the village coordinator are presented in Table 4.

2.3 | Systems mapping

2.3.1 | WATSAN stakeholder mapping

The institutional map (Figure 8) shows the relevant stakeholders in the delivery of WATSAN services and a description of the relationships between the stakeholders and their expected roles in the WATSAN service delivery.

2.4 | Mapping of IAs

2.4.1 | Goal of WATSAN service delivery

The goal of the WATSAN delivery system is to improve quality of health by reducing incidence of waterborne diseases within the village through the provision of quality WATSAN services in the community.

2.4.2 | Elements of WATSAN service systems model

The elements are key components that interact to achieve its defined goal. For the purpose of this analysis, we focus on three main elements that are provided in Figure 9.

2.4.3 | Definition of elements of the WATSAN systems model

Elements of the systems model as shown in Figure 9 are defined in Table 5.

Analyzing the synergies between the elements of the WATSAN service delivery model

The element, namely, local institutions, and the rules and regulations have a direct relationship. Each can have a positive or negative impact on the other. However, there is no direct relationship between the elements: policies, rules, and regulation. The elements, namely, policies and

TABLE 4 Assessment of institutional arrangement component by village contact.

Indicator	IA (state)	Status quo of IA in study village
Rules and regulations	WATSAN byelaws as stipulated in the Indian constitution (Articles 243G, 243H, 243I, and 280), the relevant provision of the State Panchayat Acts on the responsibilities and powers of Village Panchayat on water supply, and the Jal Jeevan Mission (JJM) guidelines that clearly states the guidelines on how WATSAN is to be managed at the village level	- There are currently no local rules and regulations for WATSAN delivery - Treated water supplied by the Jivamritam is 10 rupees per 20-L bottle - Households follow family norms on how they keep their houses clean, but these are not applicable across the community - No local regulatory agency is responsible for ensuring WATSAN quality standards in the village. Villagers rely on their own traditional standards including watercolor, taste, observation of sediments in water, and smell to determine water quality
Institutions	Based on the national institutional framework arrangement, the highest level of authority at the village level is the Gram Panchayat based at Ral, the capital of the Block	- The is no VWSC in the village - The highest level of authority in the village is the household head - Gram Panchayat is not active in the village due to logistical constraints - No government agency is involved to ensure water quality and proper sanitation practices - The only CSO active in the community provided the Jivamritam water filtration system - There is a water man appointed by CSO in charge of the water system. The water man reports to CSO zonal coordinator and is not accountable to the community
Policies	Policy formulation is done at the national level and the Gram Panchayat ensure the implementation at the local level	- The India Government SBM policy led to the construction of the household toilet - Poor awareness of government policies regarding water and sanitation - Jal Jeevan policy implementation not implemented. Household pipe water connection is therefore not available

Source: First author's fieldwork (2023).

local institutions, have a positive relationship (Figure 10). Further discussion of the relationship can be found in the policy implications and conclusion section of the paper.

2.5 | Element goals and questions

Details of the elements' goals and questions are presented in Table 6.

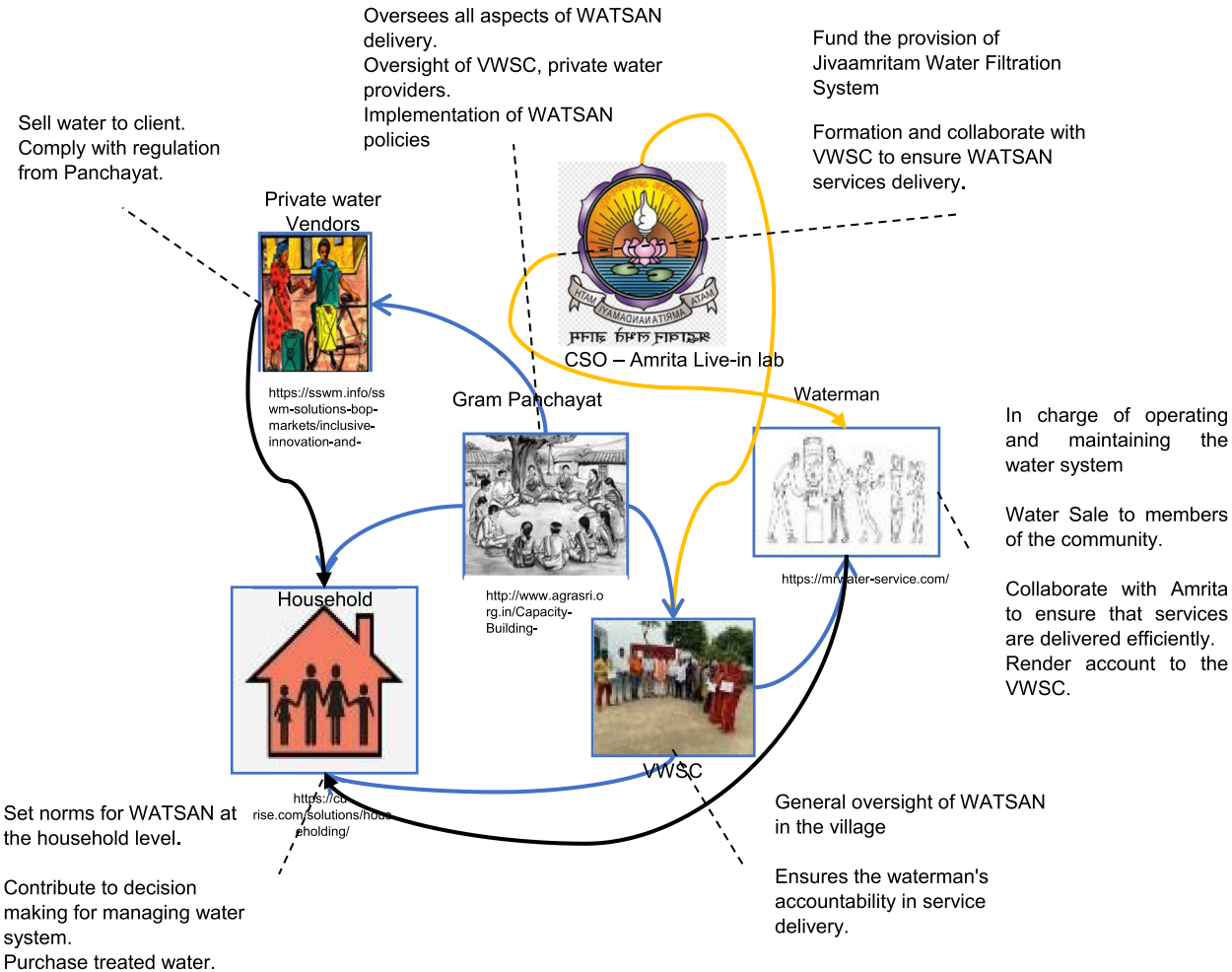


FIGURE 8 Stakeholder mapping. *Source*: First author's fieldwork (2023).

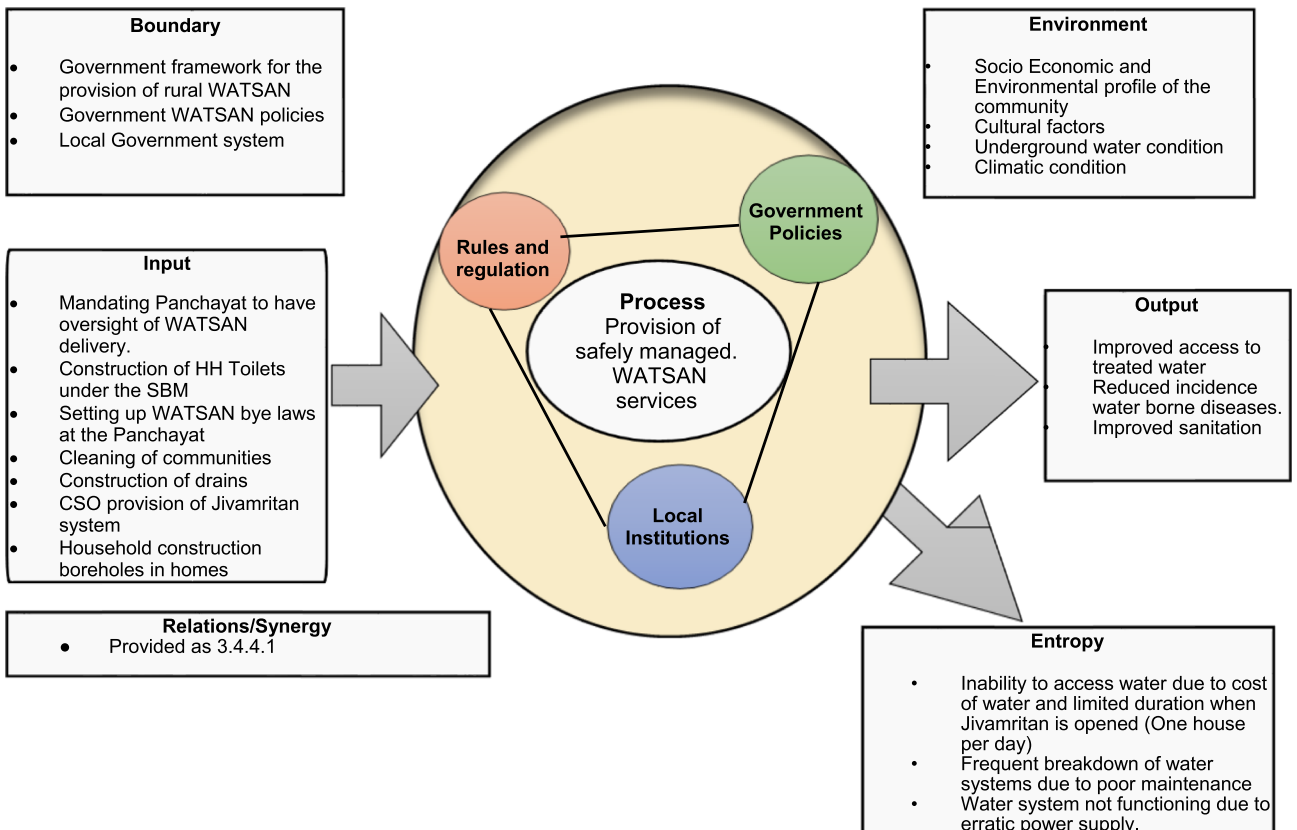


FIGURE 9 WATSAN delivery systems model. *Source*: First author's field work (2023).

TABLE 5 Definition of elements of the systems model.

Element	Definition
Rules and regulation	Set by local village committee or Panchayat to manage WATSAN delivery
Policies	Existing government rural WATSAN initiatives (Jal Jeevan and SBM)
Institutions	Local institutions/stakeholders involved in WATSAN delivery

Source: First author.

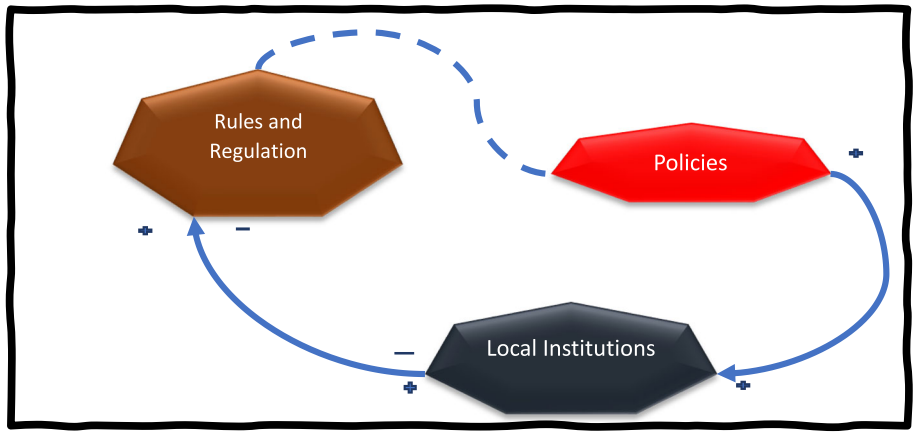


FIGURE 10 Analyzing the synergies between the elements in the WATSAN delivery model. *Source*: First author's fieldwork (2023).

TABLE 6 Institutional arrangement goals and objectives.

Theme	Local institutions	Rules and regulation	Policies
Element goal	Adopt an inclusive approach in the delivery of the WATSAN delivery to achieve equity and value for money	To ensure utilization of WATSAN resources and facilities	To ensure provision of WATSAN services
Element question	Why are local institutions (element) not contributing to improved access to WATSAN to achieve equity and VFM (system goal)?	How are households (element) adhering to rules and regulation to ensure better WATSAN delivery (system goal)?	What factors are contributing to poor water access (element) and its implication on improved health outcomes (system goal)?

Source: First author's fieldwork (2023).

2.5.1 | The sub-elements

The elements have their unique sub-elements that are listed with their respective role/purpose as in Figure 11.

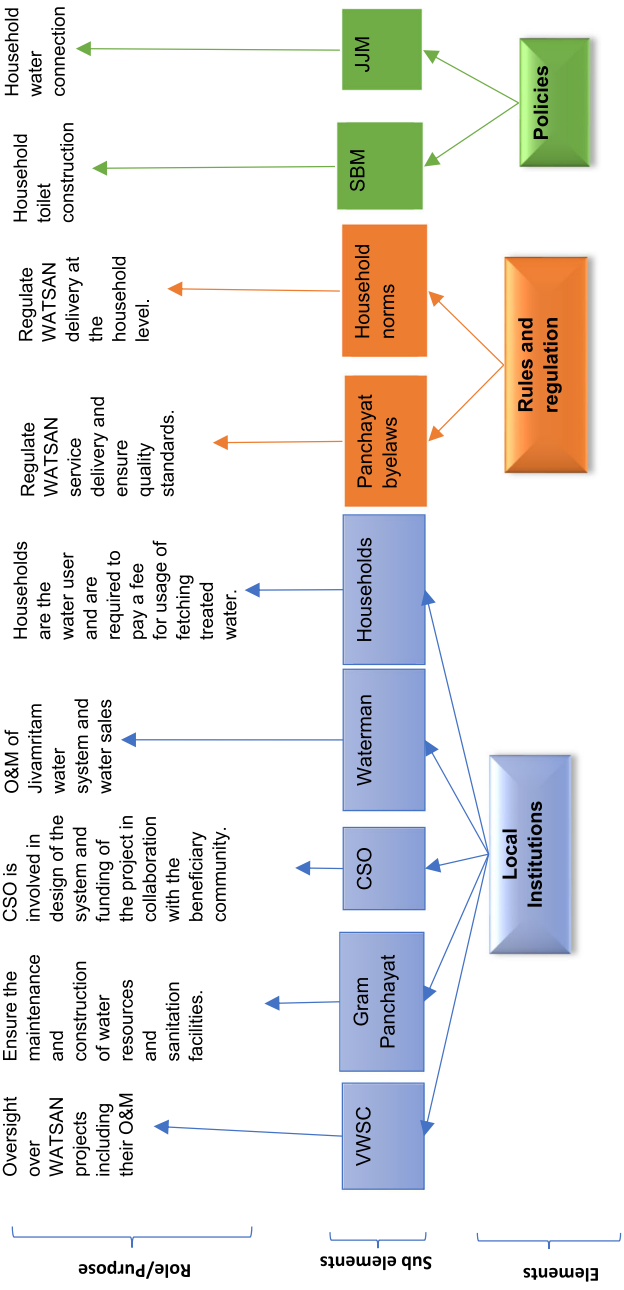


FIGURE 11 Sub-elements and role/purpose. *Source*: First author's fieldwork (2023).

2.5.2 | Exploring the forces of WATSAN delivery

The forces are the factors that either inhibit/constrain or enable/facilitate the defined elements of the systems in the process of achieving their goals.

- An enabler is a significant force in the system that supports, encourages, or increases the health and effectiveness of the system by its goal and purpose.
- An inhibitor is a significant force that undermines or prevents the system goal.

These have been indicated in Figure 12.

2.5.3 | Analysis of cause and effect of elements

We performed an analysis of the cause and effect of elements defined in Figure 12. To carry out this analysis, the two themes affecting WATSAN delivery in the village are analyzed in Table 7. These include lack of a functional VWSC (institutional) and lack of rules and regulation for WATSAN delivery.

- Upstream causes are factors that lead to the theme or that cause it to happen.
- Downstream effects are things that the theme causes to happen.

2.6 | System loops

System loop diagrams help in conceptually modeling dynamic systems comprehensively. It makes it possible to map how variables (i.e., factors, issues, processes) influence one another. The analysis helps to properly define the system's underlying feedback structures that makes it possible to define the intervention points in a system. Developing system loops also makes it

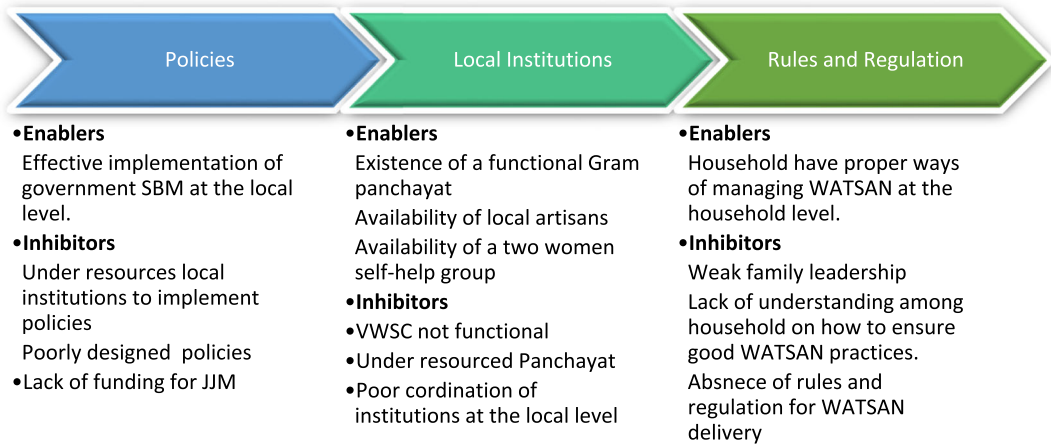


FIGURE 12 Exploring the forces of WATSAN delivery. *Source*: First author's fieldwork (2023).

TABLE 7 Analysis of the cause and effect of elements.

Theme 1 (rules and regulation): Lack of implementation of rules and regulations		Theme 2 (institutional): Dormant VWSC	
Upstream causes	**Downstream effect**	**Upstream causes**	**Downstream effect**
Structural Lack of capacity in Panchayat to establish and implement WATSAN byelaws	**Structural** VWSC does not have the capacity to formulate rules and regulation regarding WATSAN	**Structural** Lack of commitment by Panchayat to support VWSC Under-resourced Gram Panchayat to facilitate the operation of the VWSC	**Structural** Lack of community-level leadership to support the operation of the committee
Attitudinal Lack of commitment by Panchayat to ensuring community WATSAN standards are adhered to	**Attitudinal** Households are more interested in their own norms rather than any Block level or village level rules and regulation Because of the lack of leadership within the village, no one is responsible to ensure compliance to any form of rules and regulation	**Attitudinal** Disagreement among VWSC members on decision making	**Attitudinal** General community apathy toward VWSC Low commitment be members of VWSC
Transactional Water fee is set without community participation Water regulatory agencies do not carry out frequent testing of water quality due to lack of resources	**Transactional** Community members are unwilling to pay for water at the current rate due to poverty Households who are unable to raise counterpart funding to construct household toilet continue to practice open defecation	**Transactional** VWSC lacks funds to carry out activities such as awareness creations on proper sanitation practices. Lack of capacity of VWSC to perform their roles	**Transactional** VWSC members are not incentivized to commit to WATSAN activities

Source: First author's fieldwork (2023).

possible to define the limitations within the system (Betley et al., 2021; Jamshidi, 2008; Kim, 2000).

2.6.1 | Definitions of loops

- Vicious: System getting worse.
- Virtuous: System getting better.
- Stabilizing: Keep system from getting better.
- Stagnating: Keep the system from getting worse.

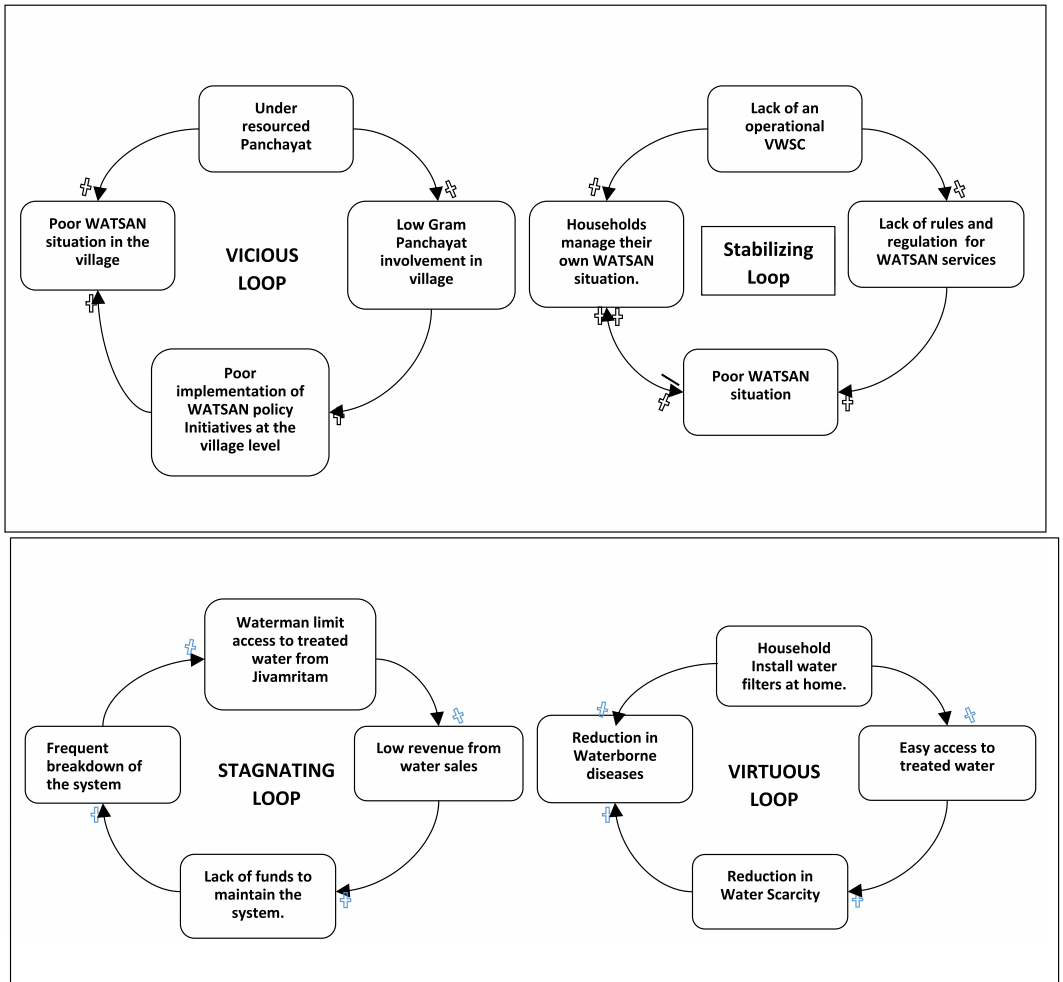


FIGURE 13 Institutional loops. *Source*: First author's fieldwork (2023).

2.6.2 | Local institutions' loops

The vicious loop in Figure 13 shows that the under-resourced Gram Panchayat has not made it possible for active engagement at the community level and this has led to poor implementation of National WATSAN policies and initiatives like SBM II. This has contributed to the poor WATSAN situation in the study village as well.

The stabilizing loop of Figure 13 shows a scenario whereby the dormant VWSC has led to the lack of formulation and implementation of WATSAN rules and regulations in the village. This will consequently lead to a poor WATSAN situation in the village. The absence of the VWSC in the village to provide leadership in managing WATSAN delivery will lead to household heads stepping into managing WATSAN at the household level to prevent the situation from worsening.

Virtuous - The installation of domestic water filtration system has enhanced access to treated water saving time and efforts as members of the household no longer travel to acquire potable water. This also improves the water quality and leads to a reduction of the incidence of waterborne diseases. The installation of water treatment system in homes also implies improved health outcomes as the households will no longer have to drink contaminated water, resulting in a decrease in the incidence of waterborne diseases.

Stagnating - The waterman opens the water for an hour in the morning and later in the evening. This results in low revenue from water sales as most households choose to access drinking water from borewells in their homes. This will result in insufficient revenue for system operation and maintenance, resulting in frequent water system breakdown.

2.6.3 | Rules and regulations

Figure 14 shows the four types of loops in relation to rules and regulations, which has been discussed below.

In the stabilizing loop scenario, the reliance on household norms to uphold good WATSAN has implied that the households do not concur on community-wide norms. It was noted during the FGD with the women SHG that this has frequently resulted in disagreement and quarrels in the community. Because of improper disposal of liquid and solid wastes, the situation has led to poor sanitation. Families who voluntarily keep their front yards and the area around their homes clean prevent the situation from getting worse.

Stagnating: Households find it challenging to purchase water due to the high cost of Jivamritam treated water. People continue to drink borewell water that has not been treated as a result. This ongoing reliance on well water has caused the water system to be underutilized, which has resulted in low revenue generation. The waterman continues to collect fees at the current high fee rate to cover the costs.

Virtuous: The waterman schedules an hour of opening and closing of water systems morning and evening. Because households are aware that the system is not operational throughout the day, they ensure that the water they purchase is not wasted. The controlled opening and closing of the water system prevents overuse of the system. This also reduces the frequency of system failure.

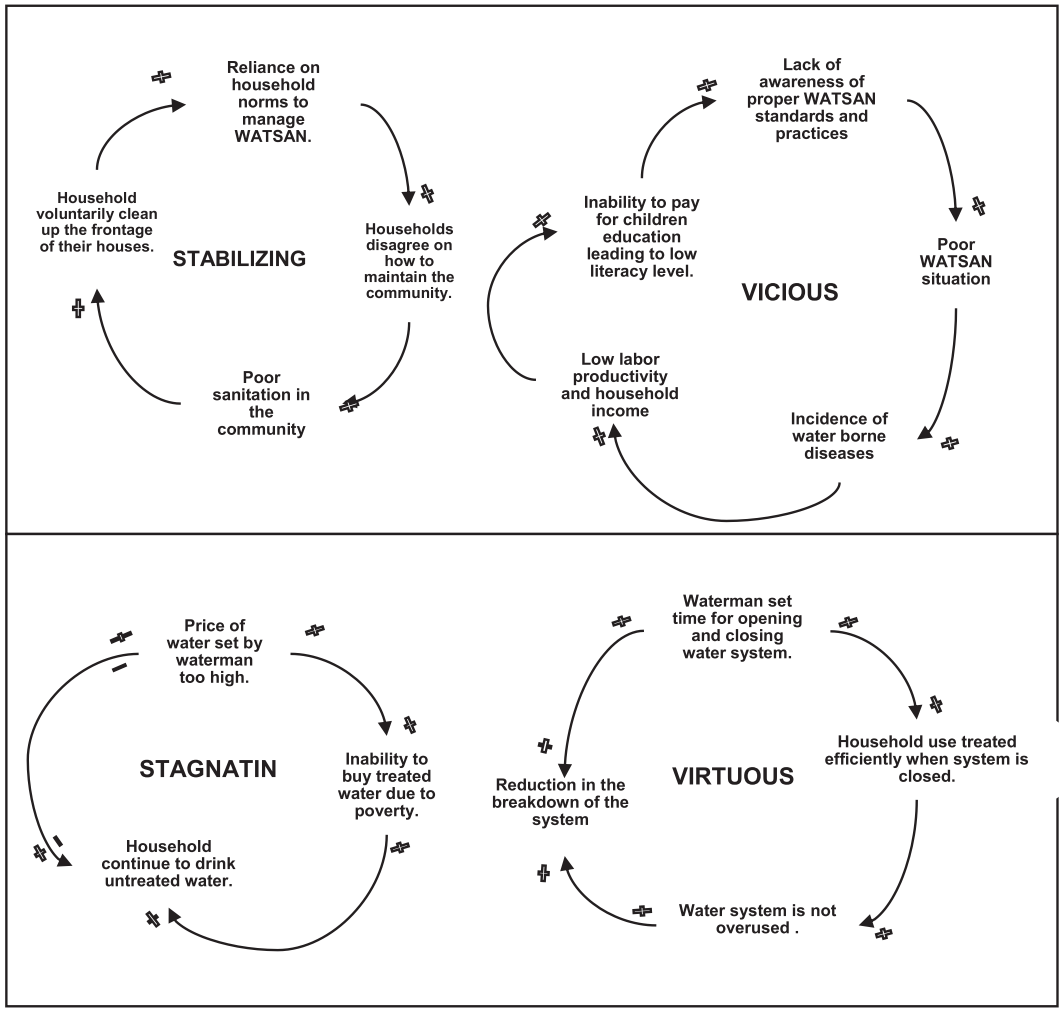


FIGURE 14 Rules' and regulations' loops. *Source*: First author's fieldwork (2023).

2.7 | Deep structure

Deep structure refers to the anchor for the identified primary causal loops that have been previously established under the IA and social service delivery loops. This is illustrated in Figure 15.

Figure 15 shows that the lack of financial capacity of the Panchayat due to under-resources has resulted in their inability to provide the necessary support to the VWSC in the village. Household heads therefore continue to take leadership in managing the WATSAN needs of their household. This has led to the poor WATSAN situation as individual households do not have the capacity to manage WATSAN needs at the community level. This situation has contributed to the high incidence of waterborne diseases. The under-resourced Panchayat (Rao & Rao, 2008) and the continuous incidence of waterborne diseases have implied that the CSO must continue to support the community so the situation does not get worse.

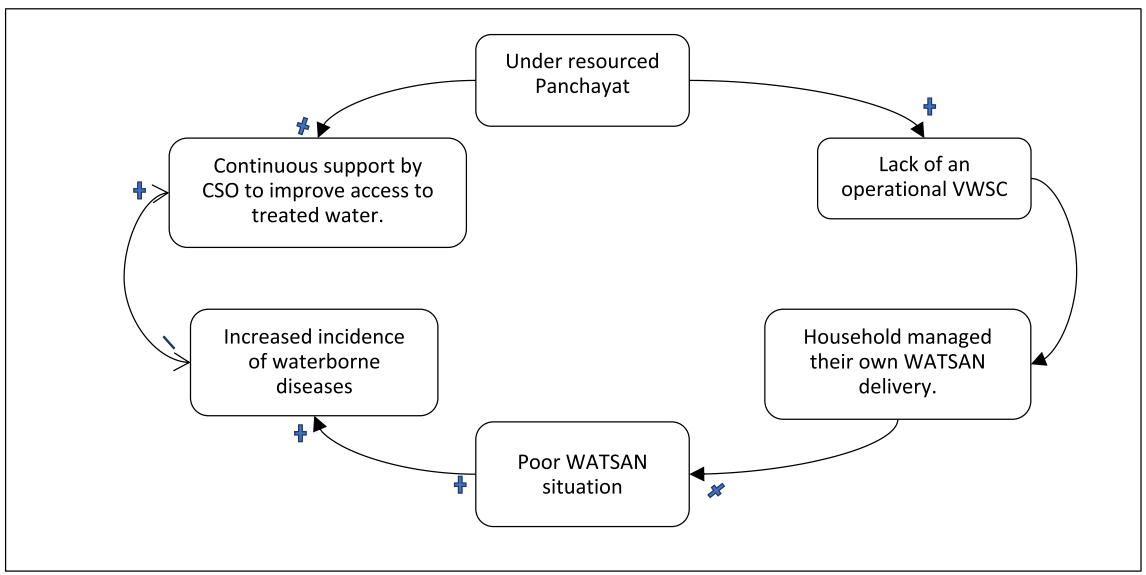


FIGURE 15 WATSAN delivery deep structure. *Source*: First author's fieldwork (2023).

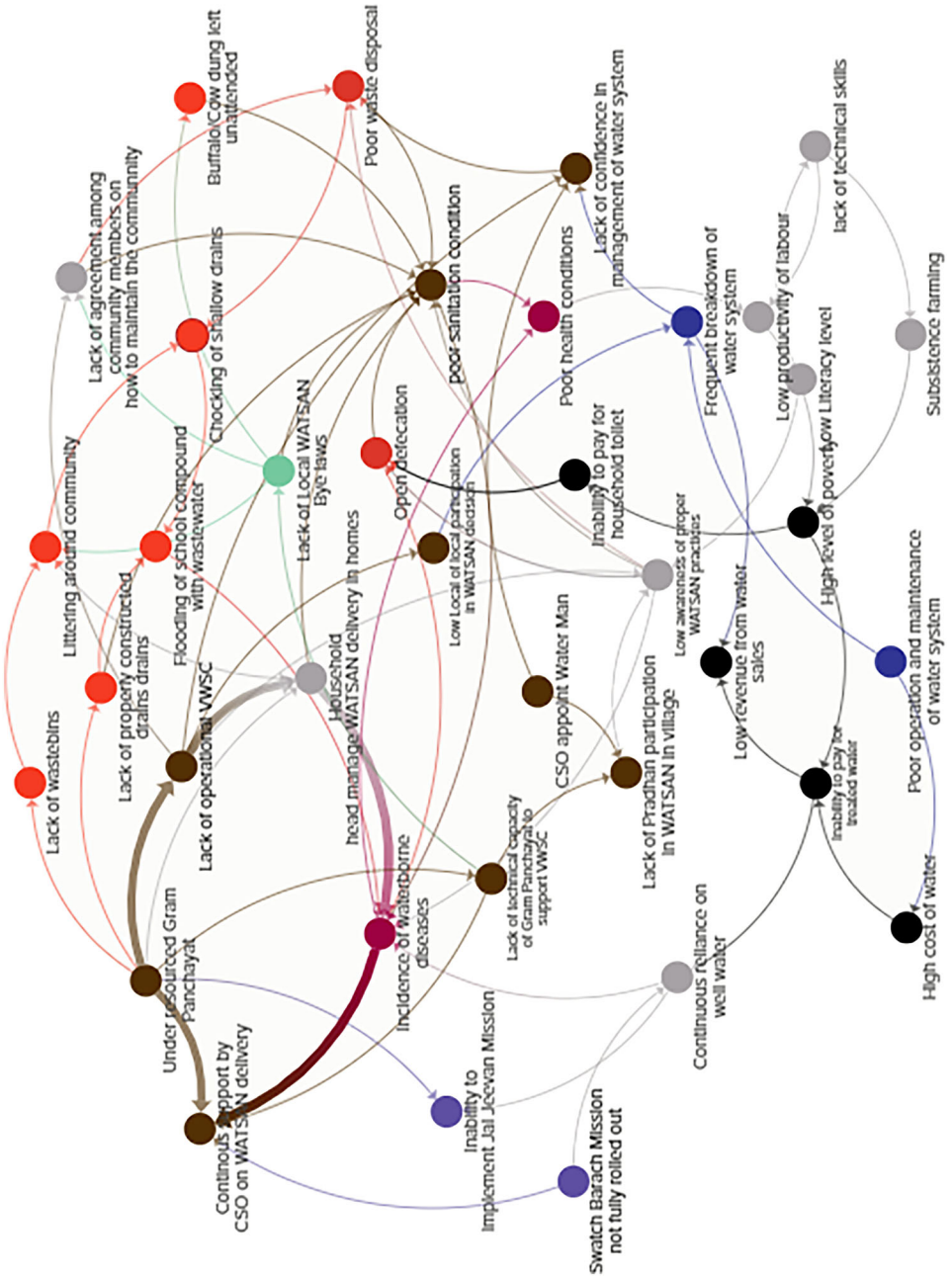


FIGURE 16 WATSAN institutional arrangement systems map. *Source*: https://embed.kumu.io/2eea9979a951691a6ee382d85e666bea.

2.8 | WATSAN delivery systems map

The systems map establishes the causal relationship between the different factors or forces of social and institutional factors. This helps clarify how the different components and roles are interconnected through causal relationships, highlighting the values they exchange in terms of positive and negative causalities (Betley et al., 2021; Jamshidi, 2008; Kim, 2000). The systems map is built around the deep structure that was derived from the various loops developed for the two delivery systems. The map is illustrated in Figure 16.

3 | DISCUSSION

The systems map depicts the synergies that exist between the identified WATSAN IA system elements. The map's focus includes the key elements that comprise the core structure around which the entire map evolves. The elements with the most linkages stand out as intervention points that can produce the best results in terms of the systems goal.

The key elements that drive the system includes local institutional weaknesses in the form of under-resourced Panchayats, non-operational VWSC, and poor water system management, and general poverty, which makes it difficult for households to meet their household WATSAN needs. The result of the underlying factors is poor sanitation in the community and continued reliance on untreated borewell water, which leads to an increase in the incidence of waterborne diseases. The discussion that follows provides further details of the key outcomes of the system analysis.

3.1 | Institutional issues

3.1.1 | Effect of Local Laws in ensuring WATSAN delivery

According to Balogun and Redina (2019), the absence of effective management and regulation in water delivery systems has implications for reliable water supply. In India, the Constitution provides for WATSAN byelaws and assigns the responsibilities and powers governing WATSAN at the local level to the Village Panchayat (Ahmed & Araral, 2019). However, most Panchayats lack the expertise to formulate byelaws for the areas under their jurisdiction. Where byelaws do exist, public awareness of them is poor. Residents in the study village are unaware of such byelaws within the Ral Panchayat as indicated by Figure 8 and Table 4.

The Ral Gram Panchayat, which oversees eight villages with a total population of 12,826 and total household of 2092 based on the 2011 census, is inadequately resourced as in the case of many rural communities in India (Rao & Rao, 2008) and consequently has less impact on the communities within its jurisdiction. As a result, the community is reliant on household values and village standards, with household heads serving as the primary agents for assuring WATSAN delivery. Village WATSAN delivery has been insufficient due to a lack of knowledge and technological know-how of the household heads.

3.1.2 | Effect of local institutions/agencies on WATSAN delivery

The sustainability of water infrastructure has also been impacted by the lack of suitable IAs in rural communities (Cronk & Bartram, 2018; Iyer, 2018; Noemdoe et al., 2006). Most public institutions are concentrated in cities. Local institutions established because of decentralization are under-resourced to carry out their tasks. Nongovernmental organizations have primarily supplemented the functions of the government in rural communities (Niti Aayog, 2019). The Swajaldhara and externally funded projects in the rural water supply sector demonstrates that CSOs have had a significant impact on community mobilization and aided the community in the planning and management of water supply schemes (Government of India, 2013). While local CSOs play an important role in providing WATSAN and other social services in many rural communities around the world, the lack or ineffectiveness of community-based institutions to administer such CSO efforts has rendered such interventions unsustainable.

The lack of support by Panchayat to the VWSC to ensure sustainable WATSAN service delivery has rendered them dormant in the community. Following the setting up of the VWSC by the CSO, the Panchayat has not taken any initiative to collaborate or build their capacity. Furthermore, the absence of legal backing and resources for household heads for WATSAN delivery at the household level has exacerbated the community's inadequate sanitation and poor access to treated water.

The dormant VWSC which is at its early stages of establishment has also adversely affected the operation and maintenance of the Jivaamritan filtration system installed by the CSO, as community members are less interested in water system management. The dormant VWSC has also meant that the activities of the waterman appointed by the CSO is not monitored by any locally appointed entity. The water system's poor management has led in recurrent breakdowns of the system. Community residents have thus relied on hand-dug wells equipped with pumps in their homes, which they believe are of good quality and more reliable. The lack of an effective VWSC to oversee WATSAN delivery in the community has further contributed to the prevalence of open defecation and a lack of good hygiene practices. This contributes significantly to the high frequency of waterborne infections in the village, as well as the poor health outcomes.

3.1.3 | Community ownership of the water system

Furthermore, the failure to properly transfer WATSAN infrastructure and support services to communities has had a negative impact. The Live-in-Labs, for example, provided a water filtration system at Nagla Chandi, which is managed by a waterman appointed by the agency. Because the recently formed VWSC is not operational to oversee the system's operation, the waterman has alone established how the community can access the treated water. Furthermore, because the waterman is not paid for his services, he only operates the system for 1 h per day because he must work elsewhere to support his family. Community members left the impression that the system belongs to the CSO (as it installed the system in the village) and therefore expect them to repair the system anytime it is not functional.

3.1.4 | Impact of local and national-level policy initiatives on WATSAN delivery

There is increasing focus on provision of water than sanitation in most countries (Obani & Gupta, 2015). Globally, access to safely managed water is about 85% and 60% in urban and rural areas as compared to less than 60% and 50% in urban and rural areas in the case of sanitation (UN-Water, 2021). India has made significant progress by formulating and implementing WATSAN initiatives like the JJM and SBM(G), which target local communities (Sarkar & Bharat, 2021). For instance, through the SBM, more than 75% of Nagla Chandi has access to household toilets, and open defecation has drastically reduced. However, the Jal Jeevan (Lal & Sahoo, 2021), which aims to ensure household water connection in all rural communities by 2024, is lagging due to funding issues.

3.2 | Social issues (WATSAN service delivery)

Being an agrarian community involved in subsistence farming, the income level of the community is low. The vegetables, flowers, cereals, and milk produced by the farmers are not processed and are sold at low prices in Ral Market while the rest is kept for domestic consumption. The low-income levels have been a constraining factor as it is challenging for households to buy filtered water sold at the filtration system at 10 rupees per liter. On an average, each household of approximately seven members require about 20 L per day, which sums up to 100 rupees. This is far beyond their financial strength, and hence, most prefer drinking water from the wells at home that are not only free but easily accessible. The inability to pay for treated water results in low-income generation from water sales, which impact the operation and maintenance of the water system.

Furthermore, the lack of agreement among households on how to keep the community clean has further worsened the sanitation situation and contributes to the apathy toward WATSAN issues in the village.

The poor health outcomes also affect productivity of labor contributing to the low-income levels as well. The general poverty levels in rural communities that have similar challenges

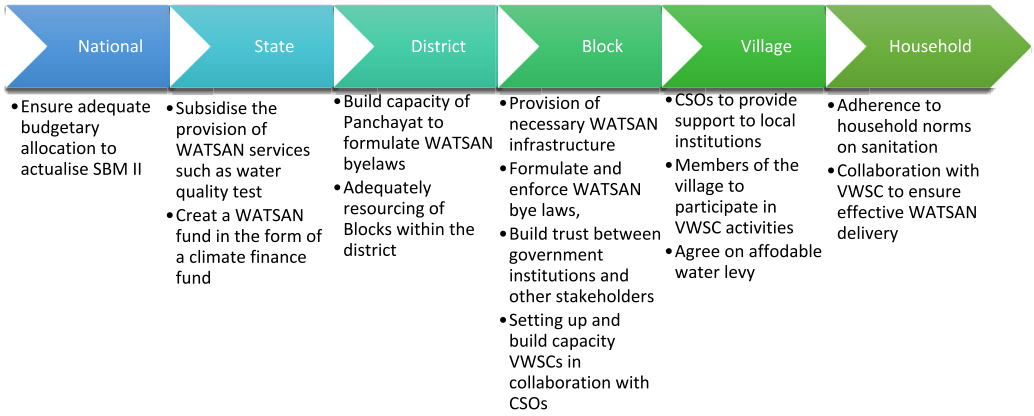


FIGURE 17 Suggested IA initiatives at various levels of governance. *Source*: First author's fieldwork (2023).

contribute to the government's inability to mobilize taxes to support the provision of social services like health centers and treated water in homes and schools in all villages in India.

3.3 | Conclusions and policy implications

Figure 17 outlines initiatives aimed at improving IAs for WATSAN delivery from the national to the household level. While the list is not exhaustive, the chart sets out initiatives that can be considered by various stakeholders working to ensure sustainable WATSAN delivery.

The 2030 SDG agenda places an emphasis on pragmatic approaches to achieving set goals, particularly considering the global economic crisis and pandemic. Sustainable WATSAN services are critical for livelihoods, and proper IAs in rural areas are critical for meeting set targets. It is critical for the state and local institutions to provide adequate funding and technical assistance to improve access to WATSAN services at the village level.

Thus, there is an urgent need to strengthen Panchayat finances by creating a WATSAN fund in the form of a climate finance fund. Many government and nongovernmental initiatives fail in this front because local communities are unwilling to bear the cost of operation and maintenance. As a result, new approaches to managing and maintaining public utility services are required.

To address the issue of treated water costs, the VWSC can facilitate community discussions for members to agree on an affordable monthly fixed levy for treated water. To ensure accountability, a bank account where money from water sales can be kept must be established. The savings can be used for water system maintenance and future WATSAN investments such as household connections, in line with the JJM initiative, which aims to ensure that all rural households have water connections.

Many rural initiatives by NGOs and CSOs have not been embedded into the local context through the building of trust between the local communities, the new institutions (agencies), and the existing state institutions, if any, which is one of the institutional weaknesses in many Indian rural communities. To effectively deliver and maintain WATSAN services, a culture of trust must be nurtured at the local level among various institutions and stakeholders, including the communities.

The effective implementation of the Government JJM and SBM policies will enable the Ral Gram Panchayat to carry out their local initiatives toward effective WATSAN delivery. Beyond the technical aspects of the WATSAN sector, it is necessary to understand the broader governance environment for sustainable WATSAN delivery, particularly in rural communities, to strengthen institutions and improve efficiency.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest to declare by any of the authors.

ETHICS STATEMENT

Free and informed consent of the participants or their legal representatives was obtained, and the study protocol was approved by the appropriate Committee for the Protection of Human

Participants [Nagla Chandi Village] by the Institute of Medical Sciences Healthcare, Education & Research, Institutional Ethics Committee, Kochi, Kerala. Protocol No. IEC-AIMS.2O22. ASSD.255 on 05/10/2022.

ORCID

Martin Kofi Kanyagui https://orcid.org/0000-0002-6107-8878

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