

## **Innovation During COVID-19 Pandemic: Water, Sanitation, and Hygiene in Informal Settlements**

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### **ABSTRACT**

This paper explores informal settlements' innovations in the water, sanitation, and hygiene sector during the COVID-19 pandemic. Water, sanitation, and hygiene are important aspects that can reduce the spread of COVID-19. However, the water and sanitation conditions in densely populated informal settlements tend to be sub-standard, and residents must often rely on shared facilities. Previous research has generally explored innovation on a macro scale, whereas this research is local. This paper explores four elements of innovation: form, actor, conflict, and regulation, to study social innovations in six urban villages in Bandung City, Indonesia. This study found that innovations during the COVID-19 pandemic have generally been in the form of arrangements for using shared facilities and providing handwashing facilities. A mix of actors comprised the community, village/sub-district officers, the COVID-19 task force, and other community organizations, highlighting the importance of combining a bottom-up and top-down approach to social innovations. However, a lack of rules and the institutionalization of innovations, perceived getting better conditions, scheduling, and funding prevented the long-term success of the innovations. The paper develops policy recommendations for the water, sanitation, and hygiene sector based on these findings.

*Keywords:* COVID-19, hygiene, informal settlement, innovation, sanitation, water

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### **INTRODUCTION**

The spread of Novel Coronavirus Disease (COVID-19) closely relates to water, sanitation, and hygiene (WASH) (Donde et al., 2021). Nevertheless, WASH conditions are deteriorating during the COVID-19 pandemic, especially in informal settlements,

such to peoples' economic conditions and increasing demand for these services (Parikh et al., 2020). Therefore, there is an urgent need to identify water access as a public health priority during the COVID-19 pandemic (Renukappa et al., 2021) because of the important role of water in effective handwashing, sanitation, and overall public health (Donde et al., 2021; Warner et al., 2020).

In 2010, the United Nations General Assembly recognized safe drinking water and sanitation as human rights in Resolution 64/292 (United Nations, 2020). Thus, even a pandemic should not decrease access to clean water. However, in the Global South, access to water and sanitation is still an issue that is further exacerbated by rapid population growth (Behera et al., 2020). A quarter of the total world population is estimated to live in slum areas or informal settlements (Friesen et al., 2018). WASH conditions are generally worse in these informal settlements. These problems are related to the quality of life and economic conditions (Rahut et al., 2015) and can cause the spread of water-borne diseases (Reddy & Behera, 2006).

The COVID-19 pandemic leads to questions about contemporary approaches toward informal settlements (French et al., 2020). The infrastructure in these settlements is over-burdened, and it is not easy to carry out social distancing (Nyashanu et al., 2020). Adequacy and proximity are specific concerns during the COVID-19 pandemic. Informal areas are generally densely populated low-income areas. The clean water and sanitation infrastructure types

vary and include household connections and shared water infrastructure. The use of shared facilities hinders the application of physical distancing. Besides, reaching these shared facilities can be risky because the users have to pass through narrow alleys (Parikh et al., 2020). Such conditions are evident in informal settlements in various cities in Indonesia.

Some social innovations can be witnessed in informal settlements in Indonesia that address the various limitations in the WASH sector during the COVID-19 pandemic. These local-social innovations require further exploration to identify their status and their challenges. Sowby (2020) stated that the COVID-19 pandemic offers lessons about emergency preparedness in the water sector. Various interventions have emerged in the water sector (Antwi et al., 2021). Cases in Europe showed that these were generally short-term interventions to ensure a continuous water supply and make up for lost income by customers during the pandemic.

This study aims to identify the elements of social innovation in water and sanitation infrastructure and hygiene in informal settlements during the COVID-19 pandemic. Most studies on social innovations are on the macro scale, such as on the city or regional level (see, for example, Certoma, 2022; McFarlane et al., 2021; O'Byrne, 2014; von Schnurbein, 2021). However, studies on local-scale social innovations lack based on the authors' knowledge. Furthermore, studies related to innovation in the WASH sector during the COVID-19 pandemic are also limited.

We use six informal settlements in Bandung City in Indonesia as case studies. Bandung City is the third-largest city in Indonesia and is located on Java Island. Like other big cities in Indonesia, Bandung City has many informal settlements facing water and sanitation provisions problems. We assessed the condition of innovation in the cases using four elements of social innovation: a form of innovation, actor, conflict, and institutionalization. The study results can aid policy formulation in the WASH sector to address the spread of COVID-19. The remainder of this paper is structured as follows. The next section is a literature review of the elements of social innovation followed by the methodology. Then follows the result and discussion of innovations in the case studies and the conclusion.

## **LITERATURE REVIEW: THE ELEMENTS OF SOCIAL INNOVATION**

### **The Elements of Social Innovation**

Social innovation is the implementation of new ideas about how people organize activities or social interactions to fulfill one or more common goals (Christmann, 2020). Avelino et al. (2019) and Haxeltine et al. (2013) stated that social innovation is a change in social practices and relationships that involve new ways of doing, organizing, knowing, and forming a framework. In other words, how people decide, act, and behave individually or collectively (Franz et al., 2012). Social innovation can be in new products and services, processes, markets,

collaborative platforms, organizational forms, and business models (Foundation, 2012). Social innovation is different from other forms of innovation, such as business innovation and technical innovation, which generally use technology to convey innovation.

Social innovation usually does not have to be something new, unlike other types of innovation. Rather, it is a novelty (Christmann, 2020). Social innovation can combine elements that already exist in a novel way. Old elements integrated into new situations, contexts, or spatial settings can also be categorized as social innovation. Another difference between social innovation and other innovations is the motivation of the main actors involved. The main motivations for business innovation are commercialization and competition. Conversely, the main motivations for social innovations are the social benefits and the public good of supporting the organization, community, and society (Dawson & Daniel, 2010). However, sometimes technical aspects and funding limitations remain a consideration even though social innovations aim to improve social conditions (Mumford et al., 2002).

Social innovation is a specific initiative that is implemented locally (Avelino et al., 2019; Domanski et al., 2019; Nilsson & Blomkvist, 2021). It refers to voluntary community involvement in developing and ensuring the sustainability of a new solution to address a social or environmental challenge (Davies & Simon, 2013). Voluntary community involvement in social

innovation is directed at collective actions to achieve common goals. It is done by sharing information and resources, identifying problems, resolving them together, and making joint decisions that affect decision-making and the government (Davies & Simon, 2013).

Social innovation is made up of four elements: (1) forms of social innovation, (2) actors, (3) conflict, and (4) institutionalization (Christmann, 2020). In this context, the novelty lies in the existence of authentic ways in which these elements are combined again (Füg & Ibert, 2019). Social innovation can take several forms: unconnected elements, the first link between elements, consolidation of elements and links, variation and adaptation, and mundane routine (Christmann, 2020).

Various actors are involved in social innovations (Christmann, 2020). Community involvement is a key element of social innovation (Esmailpoorarabi et al., 2020). It is important because interest groups and communities play a crucial role in promoting behavioral change. It is the case because, generally, people are more willing to change when they engage in collective initiatives with peers (Marchesi & Tweed, 2021). Social innovation has four community profiles: the 'citizen-sensor,' the 'sharing citizen,' the 'collaborative citizen,' and the 'entrepreneurial citizen' (Angelidou & Psaltoglou, 2017). Although community involvement is important in innovation, Harrison and Rubin (2018) suggest that a combination of top-down and bottom-up will yield better results.

Conflicts commonly play a role in processes of social innovation. Conflict in the form of friction and resistance commonly occurs in social innovation. However, these conflicts generally do not lead to failure. On the contrary, conflicts that constitute a constructive process support the progress of innovation. Various types of conflict can occur, such as avant-garde vs. establishment, dominant vs. average avant-garde, pragmatists vs. idealists, and fatigue (Christmann et al., 2020).

Institutionalization is the fourth element of social innovations (Christmann et al., 2020). Regulations are important in driving innovation (Bradshaw, 2017; Harrison & Rubin, 2018; Hodge & McCallum, 2017). Regulations are also a step toward institutionalizing social innovations. Efforts to institutionalize innovation include establishing concepts, rules and regulations, and differentiation of rules and regulations (Christmann et al., 2020). Institutionalization is an effort to change innovative practices into something more in the form of established orders (Howaldt & Schwarz, 2010).

### **Water, Sanitation, and Hygiene in Informal Settlement during Covid-19 Pandemic: Previous Studies**

Informal settlements show a high vulnerability to Covid-19 transmission. It is due to the high population density, narrow road network, and shared facilities, such as water points and public toilets (Parikh et al., 2020). The government policy to overcome the transmission of Covid-19 in

informal settlements includes lockdowns and mobility limitations. From the previous studies, it is known that India, Bangladesh, and Uganda implemented the lockdown policy (Akter et al., 2021; Bauza et al., 2021; Nuwematsiko, 2022; Parikh et al., 2020), while Indonesia implemented the limitation of mobility (Parikh et al., 2020). The form of innovation and adaptation that is carried out is very dependent on the implemented policy, lockdown, or limitation of mobility. In the case of a lockdown, innovation and adaptation are carried out top-down from the government or on a household and individual scale. In contrast, in the case of mobility limitation, innovation is also carried out on a neighborhood scale.

In informal settlements in India (Dharavi), it was found that there were initiatives related to WASH that were individual initiatives or direct interventions from the government. At the same time, in Indonesia, many community initiatives were spearheaded by the community leader (Parikh et al., 2020). The existence of communal-scale innovation in Indonesia is due to the limited WASH intervention from the government for informal settlement. However, Shermin and Rahaman (2021) stated that limited direct intervention, such as the provision of handwashing facilities, water supply availability, and overcrowded sanitation facilities, caused the situation to worsen.

Bauza et al. (2021) explained that there had been a change in community behavior in the WASH sector due to the Covid-19 Pandemic. This study, conducted in rural India, found changes in individual behavior

related to handwashing and water use. People are washing their hands more often with soap. People also filter and boil water before use. However, some individuals and families cannot implement the habit of washing their hands because of the problem of soap prices. At the same time, the Covid-19 pandemic has resulted in a decrease in income. Regarding water access, a few families no longer have access to water taps because, during a pandemic, water taps are not allowed. The study does not specifically mention informal settlements. However, the conditions in the case study have similarities with informal settlements in terms of water and sanitation infrastructure and the community's economic conditions.

Akter et al. (2021) explained the conditions of an informal settlement in Khulna, Bangladesh, related to the Covid-19 Pandemic. Some innovations made by the community are using ash as a substitute for soap to overcome the high price of soap. To overcome the problem related to the use of shared facilities, such as toilets, baths, and washes, a small portion of households made makeshift attached toilets. Funds for constructing this toilet were obtained by borrowing from relatives or friends. Families who cannot afford to make toilets lower water use to reduce trips to community toilets.

Nuwematsiko et al. (2022) stated that slum dwellers in Kampala, Uganda, did not feel the impact of the Covid-19 Pandemic on access to WASH. The community and the government have invested in WASH to anticipate the spread of Covid-19 due to the poor WASH sector.

## MATERIALS AND METHOD

### Approach

This study uses six cases of informal settlement in Bandung City, namely Lebak Siliwangi, Tamansari, Cipaganti, Sukabungah, Pungkur, and Nyengseret (see Figure 1). Informal settlements are high-density settlements, with houses and infrastructure built independently by the community, not by developers or the government. With this condition, informal settlement tends to be a slum area. The selection of study sites was carried out based

on directions from KOTAKU (Indonesia’s slum upgrading program) Officer. The criteria used are high-density settlement and the existence of social innovation.

As is common in large cities in the Global South, Bandung City faces problems with informal settlements. In each case, the study identifies the condition of the elements of social innovation in water and sanitation provision related to the COVID-19 pandemic. The elements are: 1) form of innovation, 2) actor, 3) conflict, and 4) institutionalization and regulation. The elements are explained in Table 1.

Table 1  
*Elements of innovation*

Element of Innovation	Question
Form of Innovation ( <b>Christmann et al., 2020</b> )	What is the type of innovation?
Actor ( <b>Christmann et al., 2020</b> )	Who is the main actor of innovation?
Conflict ( <b>Christmann et al., 2020</b> )	Are there any conflicts in the implementation of innovation?
Institutionalization and Regulations ( <b>Bradshaw, 2017; Hodge &amp; McCallum, 2017</b> )	What kind of institutionalization is evident in the innovation?

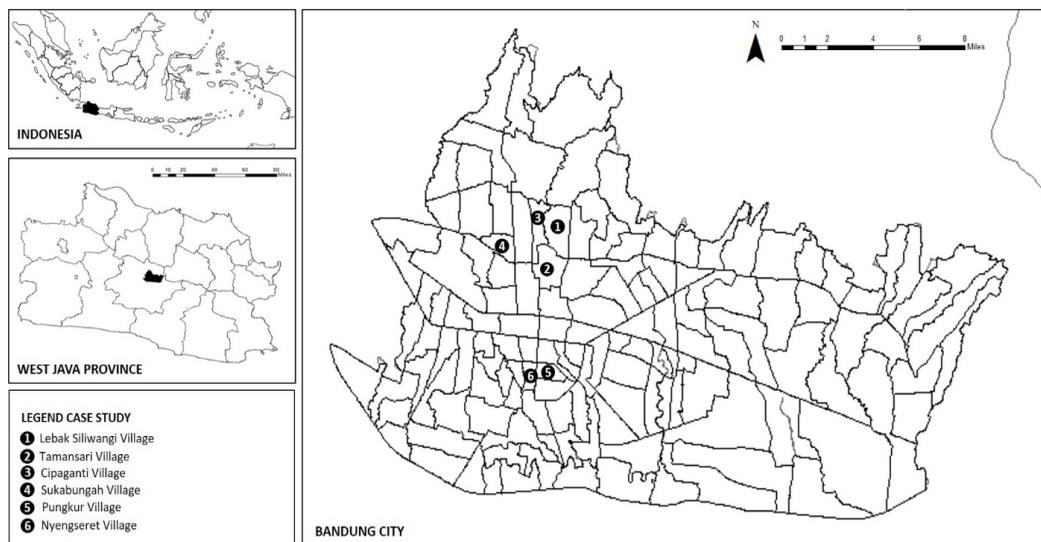


Figure 1. Case study location

### Data Collection and Analysis

This study uses two types of data: primary and secondary data. Primary data was obtained through online interviews with stakeholders consisting of representatives from KOTAKU, the Health Office, the Public Works and Spatial Planning Office of Bandung City, the Head of Pungkur Village, and the heads of neighborhood units (Community Leader) or residents for each case. The objective of the interviews was to explore the condition of the element of innovation in the six cases.

This study uses qualitative-descriptive analysis in the form of content analysis. The questions used for the analysis were the form of innovation, actors of innovation, conflict, and institutionalization and regulation (see Table 1). The coding system applied is a combination of the directed and traditional systems. The directed system starts from the relevant theory or research results. In this research, the main coding system is derived from the results of the previous study, namely the four elements in the social innovation system. Furthermore, the categories in the four elements developed according to the categories that emerged from the interview. The results of these interviews were transcribed and analyzed using the categorization system described above. One person carried out the content analysis. However, to ensure the credibility of the research, peer-checking was carried out by other research members, and member checking by returning to the respondents to confirm the results.

### RESULT

This section will describe the general condition of water, sanitation, and informal settlements in Bandung City, followed by a description of community innovations in infrastructure management during the COVID-19 pandemic.

#### Water, Sanitation, and Informal Settlements in Bandung City

The Public Water Supply Company (PDAM) and the Office of Housing and Settlement Areas, Land, and Landscaping of Bandung City (DPKP3) are responsible for providing water and sanitation services in Bandung City. DPKP3 is responsible for non-piping infrastructure, which serves 1.52% of the population in Bandung City. PDAM provides piped water services and serves about 75.75% of the city's population. The supply of decent water is 77.27% (Bandung City Development Planning Agency [BCDP], 2014), with average domestic water consumption of 15.32 m<sup>3</sup>/month (Ministry of Public Works and Housing [MPWH], 2018). Currently, the existing raw water production is 2,800 liters/second, with a non-revenue water rate in 2018 of 42%.

The slum baseline data from the KOTAKU (MPWH, 2021) shows that in Bandung City, 29% of residential buildings in slum settlements are not served by clean water/piped raw water or non-piped protected and proper water networks. Moreover, 17% of the community cannot acquire the minimum standard of 60 liters per person/day for showering, drinking, and

washing (Government of Indonesia [GoI], 2018). Furthermore, 10% of residential buildings in slum settlements do not have access to communal latrines/toilets, and 19% do not have gooseneck toilets connected to a septic tank. In addition, 69% of households dispose of their greywater into the settlement surface drainage. 52% of solid household waste in slum areas is transported to temporary or final disposal sites less than twice a week, 9% of slum areas are regularly inundated, and 35% of the drainage network in slum areas has an insufficient capacity (MPWH, 2021).

The local and national governments have various policies to provide water and sanitation facilities in informal settlements (see Table 2). This assistance is mainly in budget sharing between the government and the community. However, the implementation of projects and technical assistance from the government has halted during the COVID-19 pandemic because of the re-allocation of the government budget. Therefore, this budget is prioritized to address the direct impact of the COVID-19 pandemic.

### Description of the Cases

**Lebak Siliwangi Urban Village.** Lebak Siliwangi Urban Village is located in Coblong Sub-District. It has an area of 1 km<sup>2</sup> with 4,243 people and a population density of around 4,243 people/km<sup>2</sup>. Most residents of this village work in the service sector (Bandung City Statistics Office [BCSO], 2018). The clean water consumption of households in this village

is 40 liters/person/day. This number is below the water consumption standard in Indonesia, 60 liters/person/day (GoI, 2018). Approximately 85% of the population of this urban village can fulfill their clean water needs through various systems such as public clean water from public water supply companies, communal networks, and public wells (SAPPD, 2020). In addition, most households have access to sanitation facilities for black water, namely their latrines and final disposal of feces in the form of tanks/wastewater management installations. However, for greywater, more than 60% of households dispose of wastewater directly into rivers (SAPPD, 2020).

**Tamansari Urban Village.** Tamansari Urban Village is in Bandung Wetan Sub-District. It has a total area of 1.02 km<sup>2</sup> and is inhabited by 22,553 people. The population density of this urban village is 22,111 people/km<sup>2</sup>. Most people in this village work in the wholesale/retail trade and restaurant sectors (BCSO, 2018). An area of 10.74 hectares consisting of 40 building units in this urban village is categorized as a slum area. This slum section has 161 inhabitants from 51 households. Not all people living in slum areas have access to clean water and sanitation infrastructure. In this area, the percentage of people served by proper drinking water facilities is 77.5%, and access to family toilets/shared latrines is 82.5% (MPWH, 2021). However, none of these comply with technical requirements. The clean water consumption of the households

of Tamansari Urban Village ranges between 15 to 300 liters/day (SAPPD, 2020).

**Cipaganti Urban Village.** Cipaganti Urban Village is in Coblong Sub-District. It has an area of 0.34 km<sup>2</sup>, a population of 10,396, and a population density of around 30,575 people/km<sup>2</sup>. The residents of this village mostly work in the service sector (BCSO, 2018). Most residents use tap water with a meter (PDAM/PAM) for drinking and bathing/washing purposes. The family defecation facilities in this area are good because they comprise private latrines, and the final disposal of feces is through tanks/wastewater management installations.

**Sukabungah Urban Village.** Sukabungah Urban Village is part of the Sukajadi Sub-District. It has an area of 0.49 km<sup>2</sup>, a population of 25,388 people, and a population density of around 51,813 people/km<sup>2</sup>. Most residents of this village work in the service sector (BCSO, 2018). This village contains a slum area of 21,04 ha consisting of 102 building units. This slum area has a population of 537 people from 161 households. All residents have access to clean water and sanitation facilities, but not all these facilities comply with technical standards. A total of 98.04% of the population of this urban village has proper drinking water facilities. However, only 46.08% of the population can fulfill their needs for clean water. Access to family toilets/shared latrines is 97.06%, but only 20.59% of these facilities meet the technical requirements (MPWH, 2021).

**Pungkur Urban Village.** Pungkur Urban Village is in Regol Sub-District. It has an area of 0.3 km<sup>2</sup>, a population of 7,494, and a population density of around 24,980 people/km<sup>2</sup>. Most residents work in the wholesale/retail trade and restaurant sectors (BCSO, 2018). The urban village contains a slum area of 4.83 ha consisting of 220 building units. This slum area has a population of 1,154 from 299 households.

Not all residents have access to clean water and sanitation services. Specifically, 84.09% of the population is served with proper drinking water facilities, and 85% can fulfill their clean water needs. However, access to family toilets/shared latrines is 92.27%, but only 1.36% of these meet technical requirements (MPWH, 2021).

**Nyengseret Urban Village.** Nyengseret Urban Village is part of the Astanaanyar Sub-District. It has an area of 0.38 km<sup>2</sup> with a population of 12,235 and a population density of around 32,198 people/km<sup>2</sup>. Most residents work in the wholesale/retail trade and restaurant sectors (BCSP, 2018). This urban village contains a slum area of 10.8 ha consisting of 450 building units. This slum area has a population of 1,932 from 518 households. Access to clean water and sanitation services in this area is good. However, not all residents are served, and there are still facilities that do not comply with technical standards. The percentage of people who have access to proper drinking water facilities is 97.56%, and 99.33% of the population can fulfill their clean water needs. Access to family toilets/shared

Table 2  
Case study overview

Condition	Lebak Siliwangi	Tamansari	Cipaganti	Sukabungah	Pungkur	Nyengseret
Total population*	4,243	22,553	10,396	25,388	7,494	12,235
Population density (people/km <sup>2</sup> )*	4,243	22,111	30,575	51,813	24,980	32,198
Area (km <sup>2</sup> )*	1	1.02	0.34	0.49	0.3	0.38
Slum area (km <sup>2</sup> )*	NA	0.1074	NA	0.2104	0.0483	0.108
Slum buildings (units)**	NA	40	NA	102	220	450
Total residents in the slum areas (people)**	NA	161	NA	537	1,154	1,932
Total households in the slum areas**	NA	51	NA	161	299	518
Water and sanitation condition of slum area**	NA	<ul style="list-style-type: none"> <li>• 77.5% of the population has access to proper drinking water</li> <li>• 82.5% have access to family/ shared latrines</li> <li>• 100% of family/ shared latrines do not comply with technical requirements</li> </ul>	NA	<ul style="list-style-type: none"> <li>• 98.04% of the population has access to proper drinking water</li> <li>• 46.08% can fulfill their need for clean water</li> <li>• 97.06% have access to family/ shared latrines</li> <li>• 20.59% of family/ shared latrines do not comply with technical requirements</li> </ul>	<ul style="list-style-type: none"> <li>• 84.09% of the population has access to proper drinking water</li> <li>• 85% can fulfill their need for clean water</li> <li>• 92.27% have access to family/ shared latrines</li> <li>• 1.36% of family/ shared latrines do not comply with technical requirements</li> </ul>	<ul style="list-style-type: none"> <li>• 97.56% of the population has access to proper drinking water</li> <li>• 99.33% can fulfill their need for clean water</li> <li>• 94.44% have access to family/ shared latrines</li> <li>• 100% of family/ shared latrines comply with technical requirements</li> </ul>
Livelihoods**/**	Service sector	Wholesale/retail trade and restaurants sectors	Service sector	Service sector	Wholesale/ retail trade and restaurants sector	Wholesale/ retail trade and restaurants sector
Place/drain for wastewater from bathing/washing water**/**	River	River/sewers	Drainage (sewers/ gutters)	River	River	River

Table 2 (continue)

Condition	Lebak Siliwangi	Tamansari	Cipaganti	Sukabungah	Pungkur	Nyengseret
Source of water for drinking**/**	Tap water with meter (PDAM)	Refill water	Tap water with meter (PDAM)	Borehole or pump	Branded bottled water	Tap water with meter (PDAM)
Source of water for bathing/washing**/**	Tap water with meter (PDAM)	Tap water with meter (PDAM)	Tap water with meter (PDAM)	Borehole or pump	Borehole or pump	Tap water with meter (PDAM)
River water is polluted with waste**/**	Yes	Yes	Yes	NA	No	Yes
Occurrence of water pollution incidents**/**	Yes	Yes	Yes	No	No	Yes
Availability of community development related to sanitation and water infrastructure**/**	Yes	Yes	No	No	No	Yes

Source: \* = BCISO (2018), \*\*=SAPPD (2020), \*\*\*=MPWH (2021)

latrines is 94.44%, but none of these meet technical requirements (MPWH, 2021). Table 2 gives an overview of the case studies' population and water and sanitation conditions.

### **Community Innovations in Infrastructure Management during the COVID-19 Pandemic**

**Lebak Siliwangi Urban Village.** Clean water infrastructure in Lebak Siliwangi is very diverse, starting from piped water from the local water utility PDAM, communal piping systems, and shared public wells. During a pandemic, the location of the use of shared facilities can become problematic. Several community innovations emerged to prevent the spread of COVID-19. For example, a schedule for using the facilities has been enforced to avoid overcrowding. In addition, handwashing facilities are also provided in several places, especially on the entry route to the settlement. There have also been restrictions on entering the settlement area. However, these efforts have begun to decline.

The actors that implement these efforts include (1) the community together with the management of the neighborhood unit who provide handwashing facilities and enforce entry restrictions; (2) the COVID-19 task force, community, and neighborhood administrators help with disinfection of the neighborhood; (3) community protection units which monitor the implementation of health protocols; and (4) village officers, neighborhood officers, the community, the COVID-19

task force, and community organizations collaborating in controlling COVID-19 by establishing 3M health protocols (3M is the Indonesian abbreviation for using masks, washing hands, and maintaining distance) and promoting cleanliness activities to simultaneously support the 100% ODF (Open Defecation Free) program and Kang PisMan (Reduce, Separate, and Make Use) program through Gobar (Culvert and Cleanliness) officers. However, during the pandemic, a problem in this urban village was that many residents used shared facilities, making social distancing difficult to implement. In addition, innovations related to the prevention of COVID-19 were carried out well at first. Nevertheless, in the following months, these efforts began to decline.

**Tamansari Urban Village.** Most residents of the slum area of Tamansari Urban Village have access to the PDAM (public water supply), so there are not many community activities related to communal infrastructure. During the COVID-19 pandemic, the absence of budget assistance related to infrastructure from the KOTAKU program led to community innovations at the beginning of the pandemic by providing a sink at the end of alleys and hand sanitizers in the mosque. However, these efforts have been discontinued because the residents have become increasingly slack. As a result, the impact of the COVID-19 pandemic on clean water and sanitation infrastructure is felt less by the community. Initially, the water supply from PDAM was problematic,

but water flow became smoother during the pandemic because of a decline in population after boarding students returned to their hometowns. Drainage conditions also improved because of the population decline. It is linked to the habit of many people disposing of their domestic waste in the drainage system.

The actors in this village showed various efforts to halt the spread of COVID-19. For example, (1) the community, together with neighborhood administrators, provided sinks and hand sanitizers at the end of the alleys and the mosque; (2) the community protection team monitored the implementation of health protocols; (3) the COVID-19 task force, community, and neighborhood officials disinfected the neighborhood; and (4) the Family Empowerment and Welfare (PKK) provided necessities for vulnerable populations. Furthermore, this urban village followed the 3M regulations set out by the state of using masks, washing hands, and maintaining distance. In addition, the Citarum Harum Program and the KOTAKU Program are strategic programs for maintaining sanitation and hygiene and providing proper water facilities.

**Cipaganti Urban Village.** Most of the residents of Cipaganti Urban Village are served by PDAM through a grant program for drinking water (*hibah air minum*). The rest uses shared facilities, which are generally in the mosques. There are two shared facilities currently being used by the community. During the pandemic, there is a queue of users of the shared facilities.

However, there are no written rules for using these facilities. Therefore, related to general COVID-19 protocols, people have become slack in queuing orderly and keeping their distance. In addition, hand washing facilities and soap used to be provided independently, but these have been discontinued. Moreover, in the early days of the pandemic, entry to residential areas was restricted, but this is not the case anymore.

To prevent the spread of COVID-19, the actors involved in this village include (1) village/sub-district officers who plan and implement strategies for preventing COVID-19, (2) the community protection team that monitors the implementation of health protocols, (3) the COVID-19 task force and the community who provide independent handwashing facilities with soap, and (4) the Family Empowerment and Welfare (PKK) team which provided necessities for vulnerable groups. Furthermore, this neighborhood follows the 3M regulations set out by the state, namely, using masks, washing hands, and maintaining distance. In addition, the urban village implements a 100% ODF (Open Defecation Free) program, which is a strategy for maintaining cleanliness and proper sanitation.

**Sukabungah Urban Village.** All residents of Sukabungah Urban Village are served by the local water utility PDAM, so no one uses shared facilities. The form of innovations in preventing COVID-19 is public facilities and stalls for washing hands with soap, for example, in shops. Entry restrictions to

residential areas were implemented only at the pandemic's start. Efforts to prevent COVID-19, such as restricting entry to settlements, did not continue because most of the population uses private facilities.

The actors involved in efforts to prevent the spread of COVID-19 in this urban village include (1) village/sub-district officers who plan and implement strategies for preventing COVID-19, (2) the community protection team which monitors the implementation of health protocols and entry restrictions in residential areas, (3) the COVID-19 task force and the community, who provide independent hand washing and soap facilities. The regulations applied in this village follow 3M regulations set out by the state of using masks, washing hands, and maintaining distance. In addition, the KOTAKU Program is a strategy for maintaining sanitation and hygiene and providing proper water facilities, especially in slum areas.

**Pungkur Urban Village.** In Pungkur Urban Village, 75% of the community is served by the piped water network from the local water utility PDAM. The rest of the residents use individual wells, shared wells, and communal piping network facilities. The lack of available land hinders the addition of clean water facilities in this neighborhood. The form of innovations for preventing the spread of COVID-19 in the shared facilities here relate to their management, specifically scheduling and bringing water to each other's homes and using the toilet at home. In addition, handwashing stations and soap are provided at alley entrances. At

the pandemic's beginning, Pungkur Urban Village restricted access to non-residents. At the entrances of the neighborhood, facilities for washing hands with soap were installed. However, later these efforts began to decline.

The actors involved in preventing the spread of COVID-19 and their efforts in this urban village include the following: (1) the community and village administrators plan, realize, and monitor the implementations of strategies in preventing COVID-19, (2) the COVID-19 task force and the community who independently provide hand washing and soap facilities, and (3) KOTAKU facilitators facilitate water and sanitation infrastructure provision, especially in slum areas. The regulations applied in this urban village follow the national 3M regulations of using masks, washing hands, and maintaining distance. In addition, there is the Citarum Harum Program and the KOTAKU Program, like in Tamansari Urban Village, which is a strategy for maintaining sanitation and hygiene and providing proper water facilities.

**Nyengseret Urban Village.** Most families in Nyengseret Urban Village use the clean water facility from the local water utility PDAM for drinking and their daily necessities such as bathing and washing. However, water continuity is a problem in this village. Especially during the dry season, it is not easy to obtain water, and residents regularly need to ask for water or buy it from neighbors. With the increase in COVID-19 cases, the innovations in this village are like the other case areas.

Namely, security personnel and residents often spray disinfectants on all corners of the neighborhood. Furthermore, hand washing tools, hand sanitizers, and masks were also actively distributed.

The actors involved in preventing the spread of COVID-19 in this village include (1) village/sub-district officers who plan and implement strategies for preventing COVID-19, (2) the community who helps maintain cleanliness, and (3) the COVID-19 task force. The urban village follows the 3M set out by the state of using masks, washing hands, and maintaining distance. In addition, the KOTAKU Program seeks to maintain sanitation cleanliness and provide proper water facilities, especially in slum areas.

The management of clean water infrastructure carried out by the community generally provides a place for washing hands at the access to housing or public places. It is done independently by the community. The urban village implemented schedules for queueing and using shared facilities. In addition, people collect water and carry out their activities at home rather than in public facilities in some places. It is not a problem for piped network users because they have access to water in their houses. During the pandemic, various places saw a 5-10% increase in water use. Table 3 shows the comparison of elements of case study innovation.

## DISCUSSION

The forms of innovation related to water and sanitation during the COVID-19 pandemic have generally been arrangements

for using shared facilities and providing handwashing facilities. Other forms of innovation unrelated to water and sanitation are restrictions on entering the settlement for non-residents, spraying disinfectants, social distancing, and using masks. These innovations are not something new, but these activities can be categorized as innovation because there is a difference in doing something.

The innovations in each informal settlement are relatively similar, although the communities in the different settlements have not coordinated these efforts. The type of innovation in informal settlements in India, Bangladesh, and Uganda is similar (Akter et al., 2021; Bauza et al., 2021; Nuwematsiko et al., 2022). The difference is only in the use of shared facilities, which is found in the case in Indonesia. There is no intervention in terms of technology in the communities. This result is following Wehn et al. (2021) and Nuwematsiko et al. (2022). The areas with adequate access to piped water supply have implemented no specific arrangement for the use of water infrastructure. This result supports Parikh et al. (2020) statement that piped water infrastructure is better for serving the city in the long term.

The actors involved in the innovations consist of the community, village/sub-district officers, the COVID-19 task force, and other community organizations. Both community and the village-scale government came up with innovative ideas. Thus, as Harrison & Rubin (2018) stated, a combination of bottom-up and top-down approaches is important in social innovation.

Table 3  
*Comparison of elements of case study innovation*

Location	Element of Innovation	Form of Innovation	Actors	Conflicts	Institutionalization / Regulation
Lebak Siliwangi	<ul style="list-style-type: none"> <li>Rules for using shared facilities</li> <li>Provision of handwashing facilities at the entrance to settlements</li> <li>Restriction to entering residential areas</li> </ul>	<ul style="list-style-type: none"> <li>Rules for using shared facilities</li> <li>Provision of handwashing facilities at the entrance to settlements</li> <li>Restriction to entering residential areas</li> </ul>	<ul style="list-style-type: none"> <li>Community and neighborhood unit/village administrators</li> <li>COVID-19 task force</li> <li>Community protection units</li> </ul>	<p>Shared facilities are still heavily used, which makes social distancing difficult. At first, innovations related to the prevention of COVID-19 were carried out well, but in the following months, these efforts began to decline.</p>	<ul style="list-style-type: none"> <li>3M health protocol (using masks, washing hands, and maintaining distance)</li> <li>Rules for using shared facilities</li> </ul>
Tamansari	<ul style="list-style-type: none"> <li>Provision of a sink and hand sanitizer at the end of the main alley.</li> <li>Road closures</li> </ul>	<ul style="list-style-type: none"> <li>Community and neighborhood management</li> <li>Community protection team</li> <li>COVID-19 task force</li> <li>Family Empowerment and Welfare Team</li> </ul>	<p>Over time, the innovations to provide sinks and sanitizers at the end of the main alley did not continue because the public did not care anymore.</p>	<ul style="list-style-type: none"> <li>3M health protocol (using masks, washing hands, and maintaining distance)</li> </ul>	
Cipaganti	<ul style="list-style-type: none"> <li>Application of queueing for using shared water and sanitation facilities.</li> <li>Hand washing and soap facilities are provided independently.</li> </ul>	<ul style="list-style-type: none"> <li>Village/sub-district officers</li> <li>Community protection team</li> <li>COVID-19 task force.</li> <li>Family Empowerment and Welfare Team</li> </ul>	<p>Queuing rules were poorly followed because there were no written rules, so this effort did not continue during the pandemic.</p>	<ul style="list-style-type: none"> <li>3M health protocol (using masks, washing hands, and maintaining distance)</li> </ul>	
Sukabungah	<ul style="list-style-type: none"> <li>Each shop owner provides hand washing facilities.</li> <li>Restrictions on entry to residential areas.</li> </ul>	<ul style="list-style-type: none"> <li>Village/sub-district officers</li> <li>Community protection team</li> <li>COVID-19 task force</li> </ul>	<p>Efforts to prevent the spread of COVID-19, such as restrictions on entry to settlements, were discontinued because most residents use private facilities.</p>	<ul style="list-style-type: none"> <li>3M health protocol (using masks, washing hands, and maintaining distance)</li> </ul>	

Table 3 (continue)

Location	Element of Innovation	Form of Innovation	Actors	Conflicts	Institutionalization / Regulation
Pungkur		<ul style="list-style-type: none"> <li>Scheduling the use of shared water and sanitation facilities.</li> <li>Enforcement of restrictions to entering settlements for non-local residents.</li> <li>Provision of handwashing facilities.</li> </ul>	<ul style="list-style-type: none"> <li>Community and neighborhood unit/village administrators.</li> <li>COVID-19 task force</li> <li>KOTAKU Facilitators</li> </ul>	<p>The availability of land constrained the efforts to provide clean water facilities. Therefore, scheduling was implemented for using shared facilities. However, over time, these efforts began to decline.</p>	<p>3M health protocol (using masks, washing hands, and maintaining distance)</p>
Nyengseret		<ul style="list-style-type: none"> <li>Providing facilities for washing hands and masks.</li> <li>Spraying of disinfectants.</li> </ul>	<ul style="list-style-type: none"> <li>Village/sub-district officers</li> <li>Community</li> <li>COVID-19 task force</li> </ul>	<p>Water continuity is problematic because people face difficulties obtaining water during the dry season.</p>	<p>3M health protocol (using masks, washing hands, and maintaining distance)</p>

The actors involved in innovation in this study are different from those stated by Akter et al. (2021), Bauza et al. (2021), and Nuwematsiko et al. (2022). In these studies, the actors involved are individual households, the government, and NGOs, while in this study, the actors involved are mostly neighborhood-scale actors and the community. In addition, the actors involved depend on the policies implemented to deal with the transmission of COVID-19. For example, lockdown policy involves more actors on an individual and government scale on a top-down basis, while the limitation of mobility policy involves neighborhood-scale actors.

This study finds a fairly important role for community leaders regarding actors. The contribution given is not in the form of a large financial contribution but in directives to innovate, make regulations and set sanctions, and raise funds. Besides community leaders, there is also an important role of village-scale government. Besides the directive to innovate, the village-scale government connects the community with outside parties or higher-level government parties who will assist.

Efforts to implement the innovation that community leaders and village-scale government have directed are supported by a fairly large role from the community. It was stated by Respondent 1, from Tamansari Urban Village,

“The limited community meeting was conducted to discuss the form of innovation. The form of innovation is adjusted to the needs of the residents” (Respondent 1)

The cases impose no rules, sanctions for violating the rules, or specific types of organizations to implement rules, except in Lebak Siliwangi. The community, community leader, and village-scale government in the rest urban village have not realized the importance of rules and sanctions in the sustainability of an innovation. In Lebak Siliwangi urban village, the use of shared facilities is scheduled, as stated by Respondent 2 in Lebak Siliwangi Urban Village,

“There are rules set out in the use of shared facilities, and social sanctions, such as frowning, verbal assaults, which are applied for violations of the rules. The users of shared facilities are the controllers of the implementation of the rules”. (Respondent 2)

However, the existence of rules and sanctions for violating the rules does not guarantee the continuity of this innovation. Innovations made by the community are driven by conditions that can threaten health and safety. After conditions are felt better, innovation discontinues even though there are rules and sanctions. Respondent 3 in Lebak Siliwangi Urban Village stated,

“The implementation of rules and sanctions do not continue, because we feel that the conditions of Covid-19 get better”. (Respondent 3)

Besides the perceived better condition, the scheduling factor is also an obstacle to the sustainability of the implementation of

innovation, as stated by Respondent 2 in Lebak Siliwangi,

“...so far activities that use shared facilities are carried out in the morning before other activities. Timing the use of shared facilities causes users to adjust the overall schedule. This is not an easy thing”. (Respondent 2)

Christmann et al. (2020) and Howaldt and Schwarz (2010) stated that rules and regulations are very important in establishing innovations as long-term practices. Nevertheless, this study finds that rules and regulations do not fully guarantee continuity of innovation. Factors that encourage innovation and the difficulty in implementing the innovation also determine the sustainability of innovation.

Besides rules or regulations, this study also found that funding availability influences the implementation of innovation. This finding is consistent with the study of Akter et al. (2021) and Bauza et al. (2021) for cases in India and Bangladesh. People living in informal settlements are mostly low-income people. In a pandemic situation, most people experience a decrease in income. The provision of soap for handwashing is not an urgent matter for the people. Respondent 4 in Cipaganti Urban Village, said that

“...the provision of soap for communal handwashing has been stopped because of funding problems”. (Respondent 4)

In the case of Indonesia, the provision of soap is carried out communally with shared funds, but funding problems remain an obstacle. The monetary reason is one of the reasons for the discontinuation of providing common facilities in the case study areas. This finding is also consistent with the study from Mumford et al. (2002), that funding limitations are an important consideration in social innovation processes.

In some locations near universities, such as Lebak Siliwangi, Tamansari, and Cipaganti, the pandemic led to a better quantity of water. Many households rent out their house or room to students from nearby universities. During the pandemic, the students return to their hometowns because the teaching and learning process is online, which causes a decrease in population—consequently, the discharge of water sources that can be utilized increases.

## **CONCLUSION AND RECOMMENDATIONS**

The community has implemented several efforts or innovations in terms of WASH, which is especially important during the COVID-19 pandemic. Even before the pandemic, the high population density and economic condition of informal settlements have been sources of WASH problems. During the pandemic, the problem is even worse. The community, the village/sub-district officers, and community organizations implemented some innovations to overcome these WASH problems. Nevertheless, these have not been long-lasting actions because of a lack of regulations and sanctions, better

conditions, scheduling, and funding. This study also found that settlements with good water supply through a pipeline network have fewer problems than those with shared facilities. Another finding is that the number of populations impacts the quality of the water supply.

Based on the findings, the study proposed (1) institutionalizing or regulating innovations in order to sustain the action, (2) educating people related to WASH and public health, and (3) prioritizing the household connection as a means of water supply in informal areas, (4) controlling population to avoid overburdening the capacity of water and sanitation facilities.

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