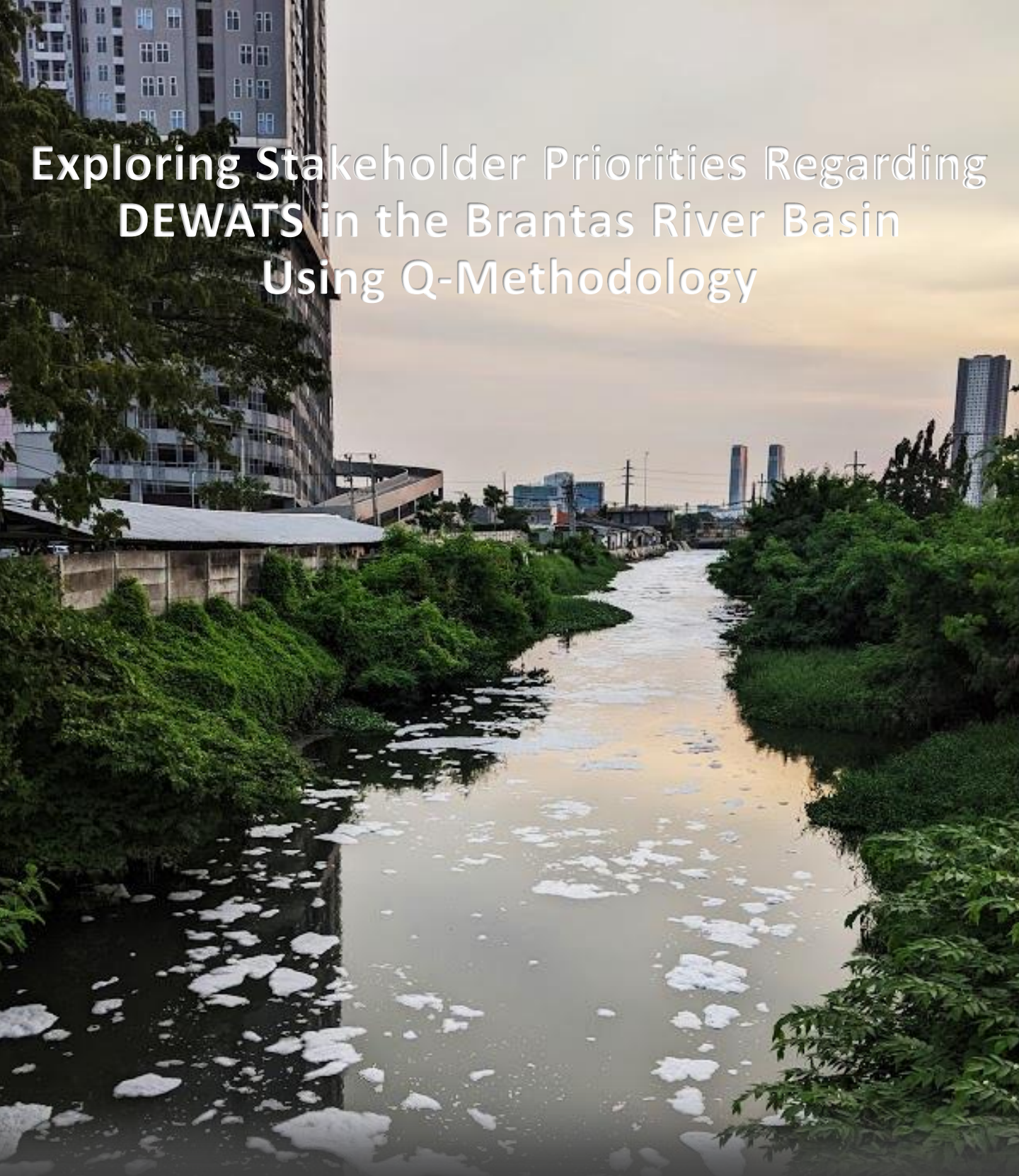
Exploring Stakeholder Priorities Regarding DEWATS in the Brantas River Basin Using Q-Methodology



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Abstract:

WASH interventions are essential to support human health, prosperity, and dignity, as they provide the base for an adequate standard of living. In many low- and middle- income countries, especially in rural and low-income areas, decentralized wastewater treatment systems (DEWATS) can offer a solution to convey, treat, and dispose of or reuse wastewater closer to the source and through smaller conveyance networks. In Indonesia, and as such in the Brantas basin in East Java, focus area of this study, the government has recognized DEWATS as their best available option for improving sanitation in dense low-income urban settings. Although the percentage of households with access to proper sanitation in the province of East Java has been increasing steadily, service coverage and the quality of sanitation systems still need to be increased to reach the desired coverage by 2024. Similar to other fields of application, within WASH and concerning DEWATS, stakeholder engagement is key to develop and strengthen integrated and sustainable approaches. Nonetheless, it is challenging to formulate targeted interventions in the watershed since they depend on the willing support of various stakeholders who may have different priorities (even within their own institutions), having diverse (and sometimes conflicting) viewpoints. This may result in stakeholders strongly contesting the appropriateness of various solutions. An exploration of stakeholder priorities is therefore needed to facilitate the application of wastewater treatment technologies. Due to its participatory approach and the type of interpretation that the method allows, Q-methodology was selected to explore this situation. Q-methodology is a set of techniques which allow for the study of 'subjectivity', combining statistics with the depth provided by qualitative data. It is composed of the data collection technique (called Q-sorting) and a data analysis step via correlation and factor analysis. In this research, the perspectives and priorities of various stakeholders regarding decentralized wastewater treatment solutions are explored to assess the applicability and acceptability of DEWATS in the Brantas river basin. This aims to identify context-based criteria and challenges to the implementation of DEWATS in the Brantas watershed. Although findings from Q-methodology cannot be generalized for a general population, the findings from this study show strong indication that Surabaya government workers tend to prioritize similar criteria, that Malang community members think more similarly than their Surabaya counterparts, and that if a respondent prioritizes the elements describing the 4-F1 perspective (*Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious*) then they are likely to be some type of specialist. Additionally, four distinctive perspectives were identified: a focus on long-term sustainability of the system, although with less defined stakeholder responsibilities; a pragmatic, need-based approach; a preference for community-led approaches with user-friendly systems and greater subsidy availability; and a collaborative, but still community-run, approach with a high feeling of ownership. Further research is needed nonetheless to identify how the levels of agreement and disagreement among the different groups for the various statements presented could be integrated into the design and decision-making process for DEWATS in the region.

Keywords:
Indonesia, DEWATS, Q-methodology, Technology implementation, Stakeholder involvement

Acknowledgements

When I started my academic journey at Virginia Tech, I had the luck to participate in internships and projects abroad that showed me the complexities, but most importantly the beauty, of working in the field of humanitarian engineering, low-resource contexts, and the importance of water and sanitation worldwide. It was at Virginia Tech that my half-joking, unofficial life motto of "travel at the expense of whatever university I'm in, whenever possible" emerged, but always inspired by an urge to chase incredible opportunities. Additionally, the university's motto "Ut Prosim", meaning 'That I May Serve', showed me how empathy and ethics could be integrated in a field like engineering, allowing me to merge my love for the environment, serving, and exploring.

Four years later, now pursuing a Master's degree at TU Delft, I started hearing about the MSc thesis possibilities that the students before me had chosen and completed. From the start, the ones related to engineering abroad attracted my attention, and I knew that whatever I decided to do would take me somewhere I had never been before. I looked at many options. Clay filters in Nicaragua; biofiltration in India; sanitation systems in Ghana; water reclamation in Mozambique… All incredible projects that I would still love to be a part of if possible! But it was the Brantas water quality footprint project that truly caught my eye. The last year was an incredible opportunity to dive into the many areas of research that play a role in project implementation and stakeholder involvement in sanitation and wastewater interventions. This thesis integrated my love for multidisciplinary approaches, allowing curiosity and creativity to take the driver's seat, and truly challenging my planning and networking abilities from the start. More than anything, it once again proved the reason why I love engineering projects abroad: not just for the amazing places you see along the way, but for the way that they can open your mind to alternative approaches, new challenges, and infinite opportunities to grow both professionally and personally along the way. This of course wouldn't have been possible if it hadn't been for the help and support of multiple people all over the world.

First and foremost, I would like to extend my deepest gratitude to my four amazing supervisors, Maurits, Mar, Schuyler, and Merle, for providing great academic, professional, and personal advice throughout this process. I couldn't have asked for a better committee, joining the social and technical worlds through open-mindedness and curiosity about how the research could evolve along the way. Thank you for giving me freedom to research about what I'm truly passionate about, allowing me to make a project that was 100% my own. Most importantly for trusting my capabilities, especially when I doubted them myself. Most importantly, thank you for trusting my capabilities, especially when I doubted them myself, and being patient and understanding in times when difficulties arose, caring above all for the wellbeing of your students.

To my family, thank you above anything for being proud of me every step of the way, for having faith that I can accomplish anything I put my mind to, and for supporting any wild idea or project that I've chosen to go after since I started my academic life. I can't promise that the projects will get less crazy as I advance in my career, but I can guarantee that I'll ultimately count with your excitement for me going after what makes me happy. To my friends in the Netherlands, thank you for helping me build a home away from home allowing me to pursue all my goals without having to worry about having an amazing circle around, and for keeping me sane(-ish) by playing the role of therapists more than once. I'm glad I got to have this experience with such an incredible, well-rounded, and fun group of people.

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Once again, thank you to everyone along the way.

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Nomenclature

Acronyms & Abbreviations

AHP	Analytic Hierarchy Process (AHP)
CSC	Community Sanitation Centres
STBM	"Sanitasi Total Berbasis Masyarakat" Community Based Total Sanitation
CFA	Centroid Factor Analysis
CR	Composite Reliability
DEWATS	Decentralized wastewater treatment systems
DsF	Design for Sustainability
EV	Eigenvalue
IPAL	"Instalasi Pengolahan Air Limba" Wastewater Treatment Plant
KADE	KenQ Analysis Desktop Edition
NGO	Non-Governmental Organization
OD	Open Defecation
PCA	Principal Component Analysis
PCC	Pearson Correlation Coefficient
PKK	"Pemberdayaan Kesejahteraan Keluarga" Family Welfare Empowerment Program
PUPR	"Pekerjaan Umum dan Perumahan Rakyat" Ministry of Public Works and Human Settlements
RPJMN 2020-2024	"Rencana Pembangunan Jangka Menengah Nasional" National Medium Term Development Plan
Q	Q-Methodology
SFL	Significant Factor Loading
SSS	Simplified Sewer Systems
SDGs	Sustainable Development Goals
WWTP	Wastewater Treatment Plant
3-F1	3-Factor solution, Factor 1

Useful Translations

"Eceng gondok"	Common water hyacinth
"Kampung"/ "Kelurahan"	Urban Villages
"Kota"	City
"Penghargaan Kampung ProKlim Tingkat Nasional"	National ProKlim Village Award

Table of contents

List of tables

List of figures

1. Introduction

1.1 Background

Water, sanitation, and hygiene (WASH) are essential to human health, prosperity, and dignity, as they provide the base for an adequate standard of living. Poor sanitation can represent both a public and environmental health hazard. Recognizing the importance of sanitation, the United Nations dedicated Sustainable Development Goal 6 to ensuring access to water and sanitation for all since, as of 2020, 673 million people remained without access to toilets and engaging in open defecation (OD). Additionally, 4.2 billion people (54% of the world's population) still used sanitation services that left excreta untreated (UNICEF & WHO, 2020). Moreover, goal 6.3 aims to halve the amount of untreated wastewater worldwide by 2030. However, as of 2020, 45% of household wastewater generated worldwide was still discharged without safe treatment. Hence, it is estimated that to achieve universal access to safely manage sanitation by the set year, the rates of progress would need to quadruple (WHO, 2022).

Additionally, in many low- and lower-middle income countries, stress is put on sanitation and service expansion interventions by rapid urbanization rates, migration from rural areas to urban centres, lack of funding, and low availability of technical human resources (especially in rural and low-income areas) to maintain interventions fully operational in the long run. In areas where sanitation services are not yet provided by local governments, or where traditional centralized wastewater treatment systems are not possible, decentralized wastewater treatment systems (DEWATS) can offer a solution to convey, treat, and dispose of or reuse wastewater closer to the source and through smaller conveyance networks. In Indonesia, the government has recognized DEWATS as their best available option for improving sanitation and handling OD in dense low-income urban settings. As of 2013, they were already implementing three types of DEWATS nationwide, mainly community sanitation centres (CSC) (77%), simplified sewer systems (SSS) (16%), or a combination of CSCs with the existing sewage network (6%) (Eales et al., 2013).

In the case of the Brantas river watershed in East Java, regardless of multiple decentralized domestic wastewater management systems constructed and served by the Ministry of Public Works and Human Settlements (PUPR), domestic wastewater remains as one of the main sources of pollution, contributing approximately 72% of the water pollution load in the river (Houser et al., 2022a). This pollution can be attributed, mainly in urban areas, to direct greywater discharge into nearby waterbodies, inadequate on-site treatment of blackwater, and insufficient septic tank management (Widyarani et al., 2021).

Brantas River Overview

The Brantas River (FIGURE 1) springs near Batu city atop of Mount Arjuno in the regency of Malang, and winds in a clockwise spiral passing through 16 regencies and six cities, ultimately emptying into the Madura strait in the North. The Brantas is the second largest river in the island of Java, with an approximate length of 320 km and a catchment area of over 14,000 km^2, which is roughly a quarter of East Java (PUPR, 20202; BBWS, 2022). Although more than half of the basin is agricultural land, the watershed is home to over 18 million people, which is nearly half of the population of the entire province.

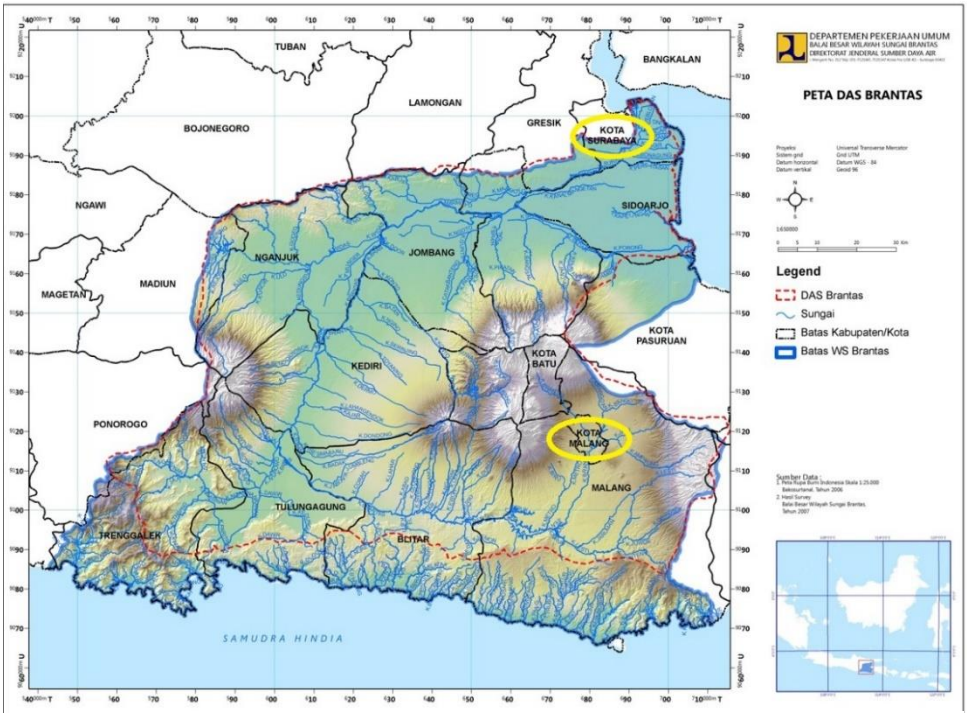
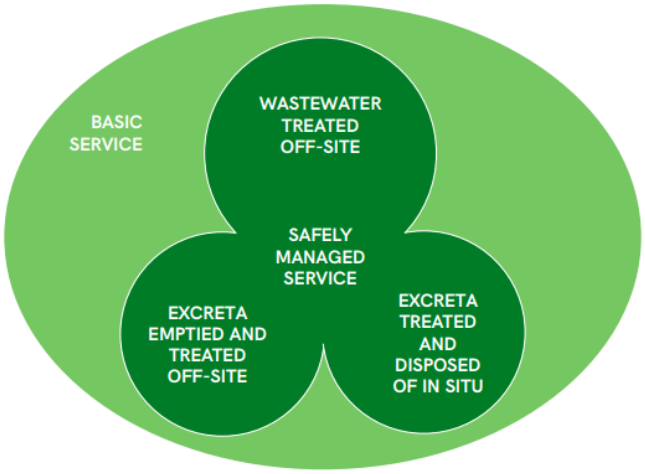


Figure 1. Map of the Brantas basin (DAS Brantas) showing the basin delineation (red), city/regency borders (black), and highlighting the cities of Surabaya and Malang (BBWS, 2022).

Approximately 15% of the Brantas watershed is made up of human settlements, the largest urban area being Surabaya, the capital of East Java and the second most populous city in Indonesia. Additionally, the Brantas is the most important fresh water source in the province, providing raw water for domestic, industrial, and agricultural use. With a water potential of 12 billion m^3 per year, the river is the main tap water supply for 40% of the population of East Java, for 143 industries in the watershed, and the main source of freshwater for irrigating 25% of Indonesia's rice crops (Houser et al., 2022a; Houser et al., 2022b). The Brantas Basin is therefore an area of great economic, industrial, and agricultural importance for the province, and for the country as a whole.

1.2 Problem Analysis

Similarly to the case of SDG 6.3, the rate of sanitation interventions in Indonesia needs to increase to reach the sanitation goals set by the National Medium Term Development Plan (RPJMN 2020-2024), which are to provide 90% of households with proper or improved sanitation, including 15% of them with safely managed sanitation facilities (PUPR, 2022). Improved sanitation systems must include either a septic tank or a pit latrine equipped with a gooseneck to break the contact between humans and their feces in a hygienic manner. These facilities can be either private, or shared among multiple households (PUPR, 2022; WHO & UNICEF, 2017). Safely managed systems, on the other hand, are not shared with other households and allow for treatment of the excreta to take place safely, either on- or offsite, as explained in Figure 2, to allow for safe disposal of the treated waste (WHO & UNICEF, 2017).



SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite
BASIC	Use of improved facilities that are not shared with other households
LIMITED	Use of improved facilities shared between two or more households
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
OPEN DEFECATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste

Note: *improved facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs.*

Figure 2. JMP ladder for sanitation services (WHO & UNICEF, 2017)

Although the percentage of households with access to proper sanitation in the province of East Java has been increasing steadily, surpassing 81% coverage in 2022 (PBS, 2023), service coverage and the quality of sanitation systems still need to be increased to reach the desired coverage by 2024. However, PUPR states that domestic wastewater effluent quality standards cannot be reached with the existing infrastructure and the limited application of technological innovation in the region. Moreover, they suggest that communities and the private sector should play a bigger role in sanitation to address the low social awareness with respect to the importance of sanitation (PUPR, 2022).

Aside from the arduous task of increasing general sanitation coverage, additional challenges exist with regards to the successful implementation of DEWATS in the basin and their ongoing maintenance. In many cases, the DEWATS systems, even if they remain operational, fail to achieve the desired effluent standards due to factor like a lack of proper and timely maintenance, or an exceedance in the treatment capacity of the system (Harahap et al., 2021). Nonetheless, failure due to non-technical factors are more prevalent when it comes to DEWATS project falling into disrepair. Community participation often decreases or stops after the implementation stages of DEWATS projects, setting up the communal-WWTP programs for a multitude of barriers for its success (Harahap et al., 2021), especially when

considering that DEWATS systems in Indonesia are usually managed by the communities themselves, even in cases where there is a lack of support for challenging maintenance tasks (Widyarani et al., 2021). Additionally, financing, which relies on fees paid by the users, tends to be insufficient to cover operation and maintenance costs (Eales et al., 2013; Harahap et al., 2021; Kerstens et al., 2012; Widyarani et al., 2021). There has therefore been an insufficient exploration of the impact of non-technical criteria and low consideration for socio-economic factors such as economic capacity of the community, as well as their capability and willingness to pay and maintain the system.

Furthermore, formulating locally appropriate, targeted interventions in the watershed is a challenge on its own since they depend on the willing support of various stakeholders who may have different priorities (even within their own institutions), having diverse (and sometimes conflicting) viewpoints. This may result in stakeholders strongly contesting the appropriateness of various solutions (PUPR, 2022; Houser et al., 2022b), even though Houser et al. (2022b) states that inputs from a variety of parties must be integrated to identify solutions that are both feasible and effective in the basin. An exploration of stakeholder priorities is therefore needed, but can this understanding facilitate the application of wastewater treatment technologies? It is certain however that the combination of the multiple existing criteria, the large range of existing sanitation technologies, and the often-conflicting preferences from stakeholders makes sanitation planning and decision-making a complex and multi-dimensional problem (Spuhler & Lüthi, 2020).

Considering the high level of influence that the non-technical factors can have in the successful and sustainable implementation of DEWATS in the basin, it is argued that a more human-centred approach, such as “design thinking” or “design for sustainability (DsF)” for example, could allow for a more holistic and flexible exploration of these existing conditions that may challenge or facilitate the implementation of wastewater treatment systems than a traditional engineering approach. Such a holistic exploration may prove even more valuable in cases where traditional approaches have been unsuccessful or in which greater innovation is needed, such as the case of DEWATS implementation in the Brantas (PUPR, 2022). Since design-thinking is both human-centric and user-specific, it relies on building empathy with the user that is affected by the problem in question in order to find a more impactful solution (Han, 2022). Similarly, DsF has evolved as a field to consider sustainability as a socio-technical challenge rather than having the traditional product-centric, technical focus, increasing the focus on the interaction between social issues and technological interventions (Ceschin & Gaziulusoy, 2016). Keeping in mind the possible benefits that a more human-centric approach can bring to the fields of technology implementation and engineering, and due to its participatory approach and the holistic interpretation that the method allows, Q-methodology was selected to explore the situation at hand. Q-methodology (hereby referred to as Q) is a set of techniques which allow for the study of ‘subjectivity’, combining statistics with the depth provided by qualitative data. It is composed of the data collection technique (called Q-sorting) and a data analysis step via correlation and factor analysis (Qmethod-Software, 2019).

Even though other qualitative data collection and analysis methods such as ethnography and open coding could be used alongside Q for a rich analysis and exploration of human behaviors, cultures, and viewpoints, Q manages to cover some of the great advantages from these types of methods. Just like ethnography, Q gives novel entries into stakeholder perspectives. However, Q also provides a rigidity (lacking in semi-structured interviews and ethnography) through a structured and systematic form of data collection and analysis which allows for comparison between the various gathered viewpoints and encountered perspectives (Wijngaarden, 2016). This structured and systemic approach also prevents the researcher from missing any important points for the interpretation of the factors, which can happen more easily with open coding for example (Khandkar, 2009). It still however maintains a flexible enough approach that allows for a wide range of interpretation by the researcher, doing justice to the complexity of human subjectivity, whilst still limiting the range of possible interpretations based on the statistical analysis performed. Nonetheless, these different methods could be used in conjunction to develop the concourse of possible statements for the data collection phase, as well as to enrichen the interpretation of the viewpoints identified (Wijngaarden, 2016; Pachecho-Vega, 2020).

1.3 Scientific Relevance

Although the needs and challenges identified by the PUPR are known, characterizing DEWATS in Indonesia represents an additional challenge since existing studies are limited in terms of their reported parameters and the methodology they employ (Widyarani et al., 2021). Furthermore, some studies have been published exploring the relationship between community awareness, stakeholder preferences, and wastewater management in Malang and other

Indonesian cities (Zakiyya et al., 2017; Amala et al., 2017). These studies employed questionnaires and close-ended questions as data collection methods, analyzing the data via statistical analysis such as simple linear regression, Spearman Correlation, and Analytic Hierarchy Process (AHP). In their research, Zakiyya et al. observed a nonlinear relationship between domestic wastewater management and awareness with respect to municipal solid waste management, with a weak correlation coefficient indicating that another parameter outside of the one studied may have played a more significant role when affecting wastewater-related awareness levels. They therefore suggest that looking into other social or economic parameters may play a role in sanitation and wastewater treatment awareness.

On the other hand, the study by Amala et al. recognized that the points of view from the different stakeholder (which they classified as either "standard" or "interest groups") could indeed lead to different preferences which could create conflict based on the values from the different groups. The study mentioned that when addressing the challenge of increasing water and sanitation, "domestic wastewater" was the third priority of the stakeholders involved in the study (23%), with "supplying drinking water" (30%) and "solid waste" (25%) being the first and second priorities respectively, and "environmental drainage" occupying the fourth place (22%). The study did highlight that although domestic wastewater management and drainage was labeled as the third priority out of the four options presented to the group, it had the highest risk of affecting the environmental quality in the slum's surrounding, which can in turn have repercussion on the health of humans in the area. Although Zakiyya et al. did include wastewater treatment and stakeholder priorities, it explored priorities with respect to provision of both water and sanitation services in slums, not solely at the implementation of domestic wastewater treatment solutions. Therefore, the specificities of the stakeholders' points of view with respect to domestic wastewater management and treatment were not explored. Additionally, the characteristics of the study area are different from the type of site selected for this study, which does not focus on informal settlements. Lastly, the study does not do an in-depth study into how the priorities may or may not change amongst different types of stakeholders, which this research does aim to explore.

Neither of these studies, however, employ Q-methodology as their data collection and analysis method or investigate it as an alternative approach to explore stakeholder perspectives. Additionally, even though some studies were found using this method as a way of exploring technology implementation (van Dijk et al., 2022; Intriago Zambrano, 2022; Alexsander et al., 2018), none were found focused on implementation of sanitation systems, or wastewater treatment technologies. With all this in mind, this study will address both social and technical needs for sanitation interventions in the watershed by using Q-methodology as a different approach to explore the perspectives and priorities of various stakeholders regarding the implementation of DEWATS in the Brantas. This will hopefully lead to identifying key stakeholder-based criteria and challenges for the implementation of DEWATS up- and down-stream in the Brantas river basin.

1.4 Research Objective

The main objective of this research is to explore the perspectives and priorities of various stakeholders regarding decentralized wastewater treatment solutions to assess the applicability and acceptability of DEWATS in the Brantas river basin. This objective can be broken down into the following goals:

- Explore priorities of different stakeholders when it comes to domestic wastewater treatment and the implementation of DEWATS.
- Identify context-based criteria and challenges to the implementation of DEWATS in the Brantas watershed.

These objectives are in alignment with the need recognized by the PUPR to increase the role of community and private sector, as well as service coverage and quality of sanitation in the Brantas basin. They aim to explore whether looking at design or technology selection from a more "human" and "empathetic" approach could lead to more successful project development, by attempting to integrate stakeholder needs, wants, and beliefs into the design and decision-making process.

1.5 Research Question

The primary research question which will be answered in this thesis is:

What are the most important considerations for different stakeholders when implementing new DEWATS in the Brantas?

This overarching question is subsequently divided into the following sub-questions:

1. Do stakeholders with comparable affiliations hold similar points of view about the characteristics of an optimal solution?
2. What design criteria play the greatest roles in the implementation of new WWT systems in the Brantas?
3. What additional criteria and implementation challenges can be derived from the participatory approaches employed (interviewing)?
4. Could understanding the areas of convergence and divergence between stakeholder priorities facilitate implementation of DEWATS in the study area?

1.6 Scope and Site Selection

The study focuses on two small low-middle income communities classified as urban villages (or *kampungs*) located in the Brantas river basin. Following PUPR's service recipient priorities, the selected communities are low-/low-middle-income riverside kampungs, which ultimately discharge their wastewater effluent into the Brantas river (PUPR, 2022). Additionally, the selected communities have existing, well-established relationship with local academic contacts, which was preferred since this prior link to community leaders was vital in facilitating access to respondents for the community-focused Q-sorts. Based on personal communication with Dr. S. Houser, it was identified that the fieldwork could be performed in two cities located up-, and down-stream of the Brantas, these being Malang and Surabaya. Surabaya, located downstream, has a large population density, and is characterized by a heavily urbanized metropolitan area. This city also allowed for great local university support through Universitas Airlangga. On the other hand, Malang, located upstream, has a low population density compared to Surabaya, and is characterized by having numerous low-income neighbourhoods. Similarly to Surabaya, this city allowed for great local support from Universitas Brawijaya.

The study was conducted in two kampungs, namely Kampung Jambangan in Surabaya and Kampung Tlogomas in Malang. The kampungs were recommended by contacts from Universitas Airlangga and Universitas Brawiyaja respectively, since they had pre-existing connections with community leaders, both were densely populated, and were located along the Brantas river. Additionally, both had existing communal wastewater treatment plants (called "IPAL Komunal") in operation and some level of environmental awareness, which could allow for a wide selection of relevant respondents.

Figure 3. Greywater treatment system from the community dining hall in Kelurahan Jambangan, Surabaya.

Figure 4. IPAL Komunal in Kelurahan Tlogomas, Malang.

Kelurahan Jambangan is an urban village located in the Jambangan subdistrict in the Jambangan district of Southern Surabaya. Jambangan occupies an area of 7.8 hectares (0.078 km^2) and homes over 10,000 people, including 2476 households. The majority of the population is of productive age (18 – 59 years of age) and has an education level of junior or senior high school (Rohmawati, 2018). Kampung Jambangan is considered a "Smart Kampung" due to its

environmentally friendly practices which also provide income to community members through activities such as urban farming with reclaimed water, manufacturing of eco-textiles, and production of fertilizers from communal compost.

Kelurahan Tlogomas on the other hand covers an area of 1.86 km^2 located in the Lowokwaru subdistrict of Malang. Tlogomas has a population of over 16,000 people, including 4,976 households (Hasan et al., 2020; BPS Kota Malang, 2022). Tlogomas includes RW7, which installed an IPAL Komunal system in 1985 although community interest for the system was not yet widespread. After ten years, half of the houses were connected to the system and currently, all houses in the RW are connected to the IPAL, avoiding direct wastewater discharge into the Brantas river.

1.7 Reader's Guide

This thesis is made up of seven chapters. Chapter 1 introduces the background, objective, and scope of the research. Chapter 2 explains the methodology used for the research, looking at the literature study on design criteria performed that contributed to the development of the Q-set employed during the fieldwork. This chapter also takes a deep dive into the steps of Q-methodology. Chapter 3 gives an overview of the observations made during the fieldwork, as well as a detailed description of how the Q-sorts were administered in practice. Chapter 4 lists and explains the decisions made throughout the analysis process. Chapter 5 presents the results obtained from the analysis through KADE, as well as a better insight into the interpretation of each factor for both factor solutions. Chapter 6 tries to give answers to the questions guiding this research reflecting upon the findings and what implications they may have on the design process of DEWATS. Furthermore, it provides recommendations for future research. The thesis also includes an extensive appendix with supportive information. Additionally, the words "factor" and "group" will be found throughout this work and will be used interchangeably to identify the viewpoints extracted through the Q-sort analysis stage.

2. Methodology

Given the objective of the research, fieldwork was necessary in order to perform the Q-sorts, collect qualitative data, and perform on-site observations at the selected sites. The following methods were therefore selected for the different stages of the research:

- Literature review and document analysis
- On-site observations
- Q-methodology

The literature review and document analysis were performed prior to the fieldwork to formulate the set of statements for the Q-set, the selection of statements which will be sorted by the respondents. Field observations were gathered upon arrival to each city to provide additional background information for the selected sites, as well as to enrich the discussion surrounding the extracted factors. Lastly, Q-methodology was employed for data collection and analysis to ultimately provide an insight into what factors play a role when addressing wastewater treatment according to the multiple stakeholders. Lastly,

2.1 Literature and Document Analysis

Prior to the fieldwork, it was important to develop the set of statements that respondents would rank in the field during the Q-sorting exercise. This was done in two steps. First, a literature review was performed to identify some of the most important design criteria for decentralized wastewater treatment solution options. Second, specific statements that could identify the criteria were selected and formulated based on sets from existing Q-methodology studies.

By exploring criteria relevant to multiple existing systems and technologies, the concourse provided an extensive scope of criteria which could be useful to consider whether a solution is applicable and acceptable for the setting in question. The table below shows some of the search queries employed and the number of results for each in the platforms employed for the research:

Table 1. Main search queries employed for the gathering of literature-based design criteria.

Site	Search Queries	Results
SciFinder-n	(((Decentralized OR DEWATS Or “Decentralized wastewater treatment system” OR Localized) AND (Domestic) AND (Wastewater) AND (Treatment OR Management OR Engineering)))	19,242
	AND	
	((Design OR Implementation) NEAR/5 (Criteria OR Variable$ OR Requirement$))	4,279
	AND	
	(Urban OR Slum$ OR Informal settlement$ OR Periurban)	424
Scopus	(((Decentralized OR DEWATS OR “Decentralized wastewater treatment system” OR Localized) AND (Domestic) AND (Wastewater) AND (Treatment OR Management OR Engineering)))	7,438
	AND	
	((Design OR Implementation) NEAR/5 (Criteria OR Variable$ OR Requirement$))	316
	AND	
	(Urban OR Slum$ OR Informal settlement$ OR Periurban)	242
	("design" OR "implement*" AND "variable*" OR "criter*" AND "decentralized wastewater treatment system*" OR "dewats" AND "domestic" AND "wastewater" OR "sewage" OR "septate" OR "black water")	158

The articles encountered were filtered based on the information provided in their titles, abstracts, and keywords. Filtering was done based mainly on geographical and thematical relevance for the research. Preference was given to retain articles focused on:

- Domestic wastewater treatment systems
- Decentralized sanitation

- Study cases in low- and low-middle income countries, as determined by the World Bank's income-level country classification (The World Bank Group, n.d.).

The main papers used had the following keywords:

Table 2. Keywords for the main papers consulted while gathering design criteria.

General Theme	Keyword
Wastewater Management and Treatment	Wastewater Wastewater management Wastewater treatment plants Decentralized wastewater treatment systems (DEWATSs) Treatment efficiency Sewage Water reuse
Management Approaches and Models	Decentralized management Centralization level Decentralized approach Conceptual model Selection model Institutional capacity
Applicability and Analysis:	Applicability Economic analysis
Geographical Focus:	Developing countries Low and lower-middle income countries Tijuana River
Sustainability and Indicators:	SDG 6 (Sustainable Development Goal 6) Sustainability indicators
Additional Elements:	Urban green spaces (UGSs) Landscape irrigation

Although some of the papers in the set included keywords irrelevant to the research (e.g. "Tijuana River"), they were retained for the literature review since they contained additional relevant keywords, or targeted DEWATS projects in a country with the desire income-level, which provided valuable criteria to generate an extensive set. Upon reading the selected papers, a list of 148 design criteria were identified. Terms repeated or similar were clustered together in more generic terms in order to develop a more comprehensive list of the design criteria. Additionally, peers were consulted during this part of the process to complement the list with their findings and improve the terminology of the final criteria set, which included 39 design criteria. Additionally, each criterion was classified as either a Social, Environmental, Economic or Technical criterion. Each term was placed in their specific category according to the type that similar terms had been labeled as in literature. The best way to explore each criterion further was determined to identify what criteria could be explored best through Q-methodology, interviews, field observations, data analysis, or further literature study (see TABLE A2, APPENDIX 3). This was determined based on available Q-studies with similar technology implementation themes, considering possibilities and limitations within the fieldwork, and data availability.

According to Watts & Stenner (2012), a Q-set can be created by adapting items from existing questionnaires, Q studies, and interviews. This approach was taken to generate the Q-set for the study, and statements were identified from existing Q-methodological studies focused on technology adoption (van Dijk, 2020; Intriago Zambrano et al., 2022) and stakeholder viewpoints (Houser et al., 2022b; Shergill, 2021) which could be altered to refer or allude to the design criteria identified during the literature review. Statements that could be useful to answer the proposed "umbrella question" regarding topics such as ownership, funding, community participation, etc., were identified. Statements that were not appropriate for the selected ranking scale ("least important" to "most important") were removed from the list. Lastly, the remaining statements were edited to accommodate to the DEWATS topic, and statements were rephrased to address the specific design criteria from four categories: social, environmental, economic, and technical. All of the selected categories were used commonly in the literature consulted whenever the researchers decided to divide their criteria amongst different categories. The "social" category, however, was made to include criteria labelled

as “institutional” (Bernal, 2018; Cossio et al., 2020), “organizational”, “knowledge”, and “motivation” (Kaminsky et al., 2013), since these other categories included design criteria that overlapped between them, with the criteria listed plainly as “social” in other studies, or if the criterion depended upon people or the interactions between them.

Table 3. Example of criterion-based Q-set statements.

Category	Criterion	#	Statement
Social	Community Health	2	It should minimize our exposure to our domestic wastewater.
Environmental	Environmentally friendly; Wastewater produced; Toxicity of products	21	It should prevent untreated wastewater from **toilets** from reaching the river.
Economic	Availability of funding / subsidies	11	Subsidies should be available for the solution / technology.
Technical	Low maintenance	15	It should require little maintenance to operate.

The set of statements were once again revised with a fellow Environmental Engineering MSc student, who has been performing similar research focusing on participatory design for sanitation in the Philippines (Wingelaar, 2023), to make sure that it covered all the identified criteria. The set was also corrected for clarity, conciseness, and uniqueness of each statement by requesting feedback from both peers and professors. TABLE 3 above shows an example statement for each of the four categories. The complete, final set of statements used during the data collection can be seen in APPENDIX 4Appendix 5, along with the criterion or multiple criteria that each one alludes to. Lastly, the statements developed were translated into Bahasa Indonesia using Google Translate and DeepL Translator first, and then checked and corrected by a local contact. The translated statements that were presented to both specialists and community members can be seen in Appendix 5. Q-sort statementsAPPENDIX 5.

Additionally, a conscious effort was made during the literature review process to include articles addressing sanitation and domestic wastewater treatment in the area that this study focuses on (i.e. East Java and the Brantas river basin) from local academics. However, this proved to be challenging since numerous papers were in Bahasa Indonesia, so an additional search had to be performed using keywords in the local language whenever possible. At first, this was somewhat of an obstacle, but it was possible by using some basic terminology related to sanitation and wastewater treatment identified during the initial phase of the research. Nonetheless, this is a clear and obvious limitation when accessing local knowledge, since different sets of keywords and search queries unknown to the researcher may bring upon a goldmine of additional valuable studies and information.

For example, a search query used in Scopus including a few terms in Bahasa when looking for information regarding the common water hyacinth in Indonesia led to five possibly relevant papers. Alternatively, an identical query omitting Bahasa terms provided a single document in the same platform, as can be seen below:

Table 4. Example search queries in English and Bahasa Indonesia.

Language	Search Query Used	Number of Results
English Only	("common water hyacinth" OR "Pontederia crassipes") AND ("indonesia" OR "Brantas" OR "East Java" OR "Surabaya")	1
Including Bahasa Indonesia	("eceng gondok" OR " common water hyacinth" OR "Pontederia crassipes") AND ("indonesia" OR "Brantas" OR "East Java" OR "Jawa Timur" OR "Surabaya")	5

2.2 Introduction to Q-Methodology

General Overview of Q-Methodology

Q-methodology (hereafter referred to as Q) is a semi-quantitative research technique designed to study human subjectivity (views, opinion, beliefs, values, tastes, …) (Millar et al., 2022). Q assumes that subjective opinions, which tend to be unprovable, can be shown to have structure and form which can be made visible for observation and study (Brown, 1993) by combining the rigor of statistics with the depth of qualitative data.

Q consists of four stages: the research design, a data collection step called "Q-sorting", data analysis via "inverted factor analysis", and interpretation of results (see Figure 5).

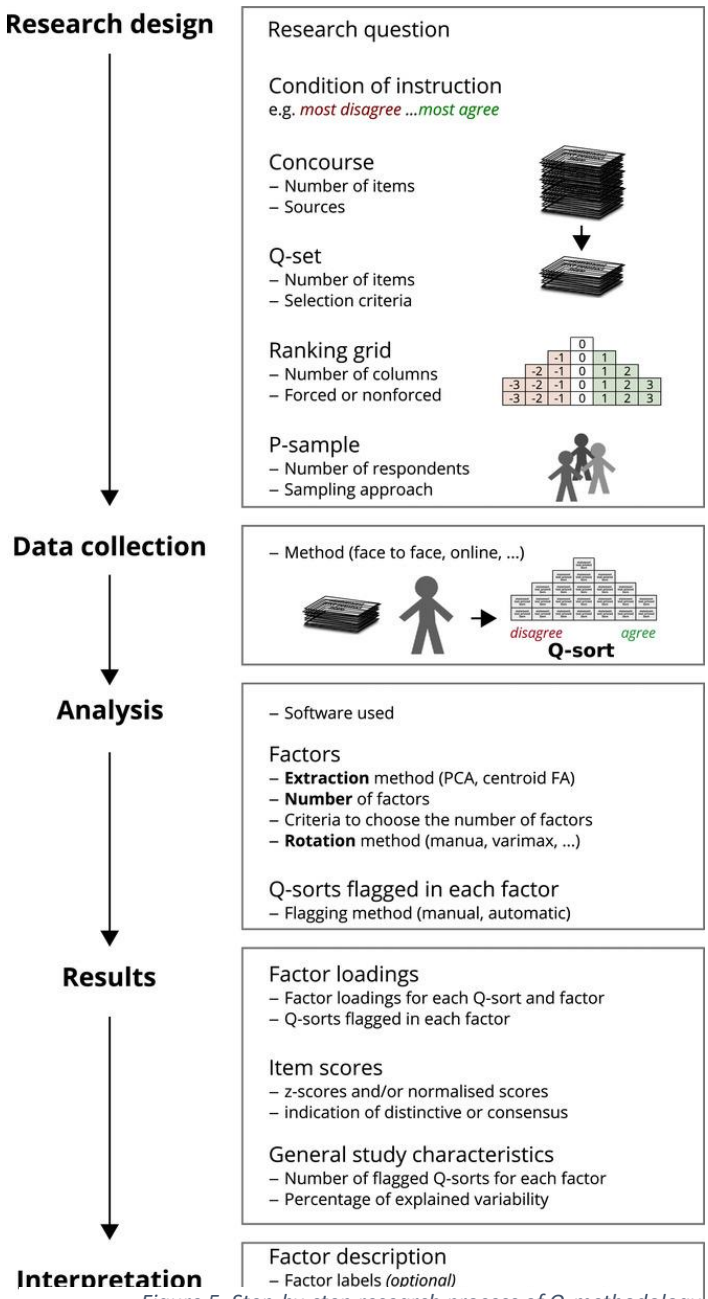


Figure 5. Step-by-step research process of Q-methodology (Zabala et al., 2018).

Stage 1: Research Design (P-set, Concourse, and Q-set Development)

During the first stage of Q, the topic that will encompass the scope of the study, and the "umbrella question" that respondents will be asked during the sorting exercise need to be determined. Then, a comprehensive set of statements or items that could provide a subjective opinion about the research topic needs to be gathered. This initial set, referred to as the "concourse" attempts to cover the full range of possible opinions about the topic in question. Statements could be gathered from a variety of written or spoken sources such as policy documents, scientific publications, interviews, among many other possible sources of opinion. Even visual sources could be used to select possible items for the set (Zabala et al., 2018). From the concourse, a representative sample of items, called a Q-set, can be drawn. It is up to the researcher to decide the best number of items to keep for the ranking exercise.

Since Q aims to explore the diversity of possible viewpoints related to the topic of study, the sample of respondents (P-sample) tends to be non-random and purposeful. Hence, the researcher needs to look for data rich respondents that can feel strongly and differently about the topic (Qmethod Software, 2023). Variation within the sample is therefore desired, and the number of respondents should be sufficient such that different perspectives can be identified and remain stable (meaning that adding more respondents would not alter the viewpoints uncovered). 40 to 60 respondents are usually plenty, but thorough studies can be performed with even less participants (Watts & Stenner, 2012). For the purposeful sampling, it is useful if the researcher has some familiarity with the stakeholders and their possible views, which can facilitate the selection of respondents. Prior knowledge of stakeholders can also lead to the use of convenience or snowball sampling. In this non-random technique of participant selection, respondents are sampled based on availability or referral by prior respondents. Sampling can also be driven by observable characteristics such as profession and academic level (Zabala et al., 2018).

Stage 2: Data Collection

In Q, data collection takes place via Q-sorting, a ranking exercise in which respondents are asked to organize the items of the Q-set into a grid following a simplified bell-shaped or quasi-normal distribution (see Figure 5, "Data Collection"

diagram). The proportion of the width and height of the sorting grid (known as "kurtosis") can vary between studies according to the number of statements in the Q-set, the complexity of the research topic, and the spread of knowledge levels expected from the respondents (Zabala et al., 2018; Intriago Zambrano et al., 2023).

A leptokurtic or steep grid (see Figure 6) provides room for greater neutrality, therefore reducing the number of decisions that the respondent needs to make during the sorting exercise. This distribution is more suitable for cases when the respondents may be less knowledgeable about the topic at hand. A flatter, platykurtic distribution expands the number of columns that the statements need to be distributed amongst, while giving less room for neutral statements. This means that respondents must be more thorough with respect to their decision-making while sorting, since the ranking scale becomes more extensive and the number of statements per column is reduced. This distribution is therefore more ideal for studies where the P-set is made of equally knowledgeable individuals about the topic (van Dijk et al., 2022; Intriago Zambrano et al., 2023). Most studies, however, employ a mesokurtic sorting grid, which provides both a wider ranking scale and a greater room for neutrality.

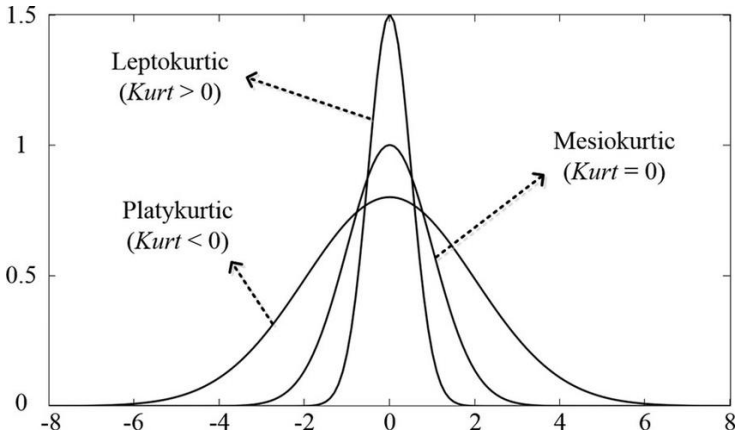


Figure 6. Possible curve kurtosis of the sorting grid (Zhong et al., 2016).

During the data collection phase, respondents are given a prompt for the ranking of the Q-set items (such as "most important to most unimportant"), along with an "umbrella question" that will guide their sorting. Items placed in the same column are given a similar ranking score. Researchers can decide (to some extent) the level of freedom that respondents can have during the sorting exercise by allowing either a forced or unforced distribution. During forced distribution, respondents must fit the items following the provided grid slots. In unforced sorting, participants can place more or less items in each column than the provided slots according to their preferences. Data collection is commonly performed in person, although online options exist as well, and includes a qualitative data collection phase in which respondents (during the exercise or directly afterwards) are asked to voice the reasoning for their ranking. This is mainly done by expanding upon the rationale behind the placing of the top- and bottom-ranked statements. This qualitative data plays a valuable role during the interpretation phase (Zabala et al., 2018). The completed Q-sort then represents the perspective of that specific individual with respect to the topic presented to them at the beginning of the exercise. It is important for respondents to be accompanied during the sorting in order to answer any questions, make sure instructions are followed, and to handle any unforeseen circumstances.

Stage 3: Factor Analysis

The third stage of Q-methodology handles the analysis of the collected Q-sorts and the production of viewpoints. A diagram showing the multiple steps of the factor analysis can be seen in APPENDIX 1. Although this process can be done manually, performing all required calculations by hand, dedicated software has been developed to make the process more efficient for Q-methodologists. Free Q analysis software is available online, such as KenQ Analysis Desktop Edition (KADE), PQMethod, and the qmethod package for R. This study makes use of KADE due to its ease of use and attractive visualization options.

The completed Q-sorts are compared and grouped by similarity through a by-person correlation and factor analytic procedure. The correlation matrix produced portrays the level of agreement between the collected, whole configurations (Q-sorts) produced by any two persons, not between individual items (Watts & Stenner, 2005). Correlations between configurations are calculated using the Pearson Correlation Coefficient (PCC), which measures the strength of the linear relationship between two variables. A value of +1 indicates a perfect positive correlation, while a value of -1 shows a perfect negative correlation (van Dijk, 2020). This correlation matrix is then subjected to factor extraction through a multi-variate data reduction technique such as Principal Component Analysis (PCA) or Centroid Factor Analysis (CFA).

Factor extraction is based on the common variance, which is the proportion of variability and meaning in a Q-sort that is shared by the group (Watts & Stenner, 2012). Different criteria can be used to determine the ideal number of criteria for a Q study. A more detailed explanation about the criteria to select the number of factors can be found in APPENDIX 10.3. Once the number of factors to extract, and the extraction method are decided, factor rotation takes place. Factor rotation changes the viewpoint from which the results are observed similarly to how changing a scale to logarithmic or changing its range can allow for a better fit or visualization of data (Zabala et al., 2018).

Each factor extracted can be represented by a composite Q-sort, which is an idealized representation of what a respondent with perfect correlation with that factor would have responded in their Q-sort. The software provides lists of each respondents' factor loadings, factor scores, and z-scores. A respondent's 'factor loading' is a correlation coefficient between +1 and -1 which indicates how closely an individual's Q-sort configuration is to the composite for that factor. Respondents with significant factor loadings are flagged to indicate what factor they load more strongly towards. In cases were respondents load significantly to more than one factor, they are said to be 'confounded', and they are omitted from the rest of the factor analysis. Factor scores and z-scores show the relationship between the items and factors. The z-scores are the weighted average of the scores that the flagged respondents gave to each item.

Both factor and z-scores show how a hypothetical representative of that factor would rank each item from the Q-set, but the z-score shows the ranking with greater precision. Z-scores are also used to determine consensus (similarly placed items) and distinguishing statements (significantly different z-scores in a factor compared to the other) for each factor (Zabala et al., 2018). Lastly, Q calculates the percentage of the variance that is explained by each factor, and attributes an eigenvalue (EV) to each one of them. A factor's EV is the sum of the square factor loading of all the Q-sorts in the factor. The EV and factor variance together can give some indication of the explanatory power of the factors extracted (Watts & Stenner, 2012).

Stage 4: Interpretation

After the different factors are determined, they are interpreted based on a combination of the factor scores obtained during the analysis phase, the qualitative data provided during the follow-up questions, and prior understanding of the researcher about the topic and the participants' views (Zabala et al., 2018). The interpretation should be done holistically and looking at the interrelationship of the multiple items within the factor array, not by focusing solely on the top and bottom ranking items set.

Interpretation can be done holistically and systemically by generating a "crib sheet" for each factor, as it allows researchers to engage with all items in the set while ensuring that nothing obvious is overlooked. Initially, the crib sheet includes items in four categories: highest ranked items in the factor, lowest ranked items in the factor, items ranked higher in that factor than in the others, and items ranked lower than in the other factors. This method of interpretation can give importance to items in the neutral section of the distribution, showing that their zero-score does not necessarily indicate neutrality or indifference (Watts & Stenner, 2012).

The narrative produced by interpreting the crib sheet is then complemented by the scores attributed to the remaining items, since analyzing other items can help understand how participants understood some of the statements. After the initial factor interpretation, the meaning of the factors can be complemented by looking at demographic information from the flagged respondents and enhanced by including pertinent qualitative comments made by them during the data collection step. These comments from participants help support the claims made during the interpretation of the factors (Millar et al., 2022). When presenting the interpretation of the factors, it can be useful for the reader to have an extensive, detailed version of the factor meaning as well as a summary with the key points of the viewpoint and occasionally a label distinguishing the factor. Relevant demographics and statistics about the factor are also presented. Additionally, discussion regarding the discrepancies and commonalities between the factors can follow, as some differences may be surprising or disagreements can be more subtle than the researcher expected (Zabala et al, 2018). Lastly, a follow-up discussion can be held with some of the participants of the Q-sorting exercise to receive feedback about the extracted factors and to what extent they feel represented by the factor that is said to describe their views (Millar et al., 2022).

Method Testing

In preparation for the fieldwork in Surabaya and Malang, a test was performed with a group of 10 students and peers from the Civil Engineering and Geosciences faculty. The test participants were selected based on convenience, but an effort was made to get a mix between area of studies (Water Management, Environmental Engineering, and Geosciences) and level of studies (MSc, PhD, PdEng, and Postdoc). Although this was not sought after, the participants were also of various nationalities (India, Mexico, Benin, Guatemala, Ireland, Colombia, Netherlands, and Italy). The participants were first given an estimate of how much time they should expect to spend on the exercise to allow them to say if they wanted to participate or not based on time constraints. Afterwards, they were given a brief explanation of the method itself, detailed instructions of what they were expected to do, and a suggestion for the presorting of the cards. However, they were free to follow this presorting advice or not according to their preference. In order to guide their sorting, participants were given an "umbrella question", as well as a context for the hypothetical community that they were instructed to keep in mind throughout the exercise. The question given was:

"What do you think people would find the most the important when a new decentralized wastewater treatment system is implemented in their community?"

***Context**: Dense, urban, low-middle income country, riverside community*

For the test, 34 statements were developed encompassing various themes relevant to the implementation of any kind of technology. Although it is acknowledged that this list cannot be a comprehensive account of all possible design criteria, the number of items was limited to 34 to avoid making the sorting exercise too strenuous or tedious for the participants (Houser et al, 2022). An effort was made such that the statements addressed a wide range of criteria as the one defined by the SHEETS criteria list: Safety, Health, Environmental, Economy, Technical, and Social. The SHEETS set was initially selected as it covered the basic criteria that should be identified and covered for innovation projects and their design (Harmsen et al., 2018). This resulted in a Q-set of 34 statements, distributed over the selected criteria categories as shown in TABLE A3, APPENDIX 4.

The sorting grid used followed a mesokurtic, inverted quasi-normal distribution (Watts & Stenner, 2012) (see FIGURE 7). This distribution was chosen since the participants were expected to have at least some level of understanding or first-hand experience, which would lead them to have some of type opinions, but they would not necessarily have the same levels of knowledge about the topic (Watts & Stenner, 2012; van Dijk et al., 2022). Furthermore, a nine-point -4 to +4 distribution was selected for the Q-sort, as suggested by Watts and Stenner for Q-sets of 40 statements or less.

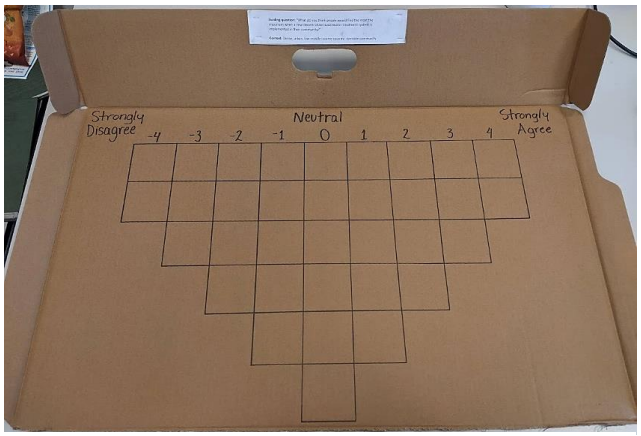


Figure 7. Q-sorting array used for the testing of the method.

Take-Aways from the Pre-Fieldwork Test

Even though the initial set of statements was not perfect, performing a test run of the method presented valuable insight about the procedure followed, including positive elements and possible improvements needed when implementing the methodology in the field. These findings were:

Positives:

- Response times ranged from 13 minutes to 45 minutes to complete the Q-sort, but the majority of respondents finished the exercise within the expected time (25-35 minutes). Considering that the whole exercise was estimated to take approximately one hour per participant, including the follow-up open question session, many respondents completed the exercise surprisingly quickly.

- Employing the method with a physical board and cards did involve some more time-consuming prior preparation than having an online version. Nonetheless, it proved to be more interactive for participants, and they remained engaged even if they took a longer time than initially planned. Additionally, some people

surprisingly volunteered to participate when they saw the card "game-like" board because they were curious, which facilitated obtaining subjects.

- People expressed to prefer this method rather than a regular rating system as found in common surveys.
- Valuable insights arose from the post-sorting interviews, regardless of them being short and concise, or more extensive and detailed. This showed the importance of truly engaging in conversation with participants to collect statements that could be useful in characterizing their points of view.

To Improve:

- The way in which the "umbrella question" was formulated ultimately generated some discrepancies regarding from what perspective the people were sorting the statements. While the question pretended to have participants put themselves in the shoes of community members from the described context, this proved to be difficult because:
    - They were not as familiar with the context described, so many statements would fall in the "neutral" category since they believed them to be greatly "context-specific".
    - Some participants would begin the sorting exercise adopting the instructed point of view ("what do you think ***they*** would find more important...?", but towards the end of the exercise they would be sorting based on what they considered to be more important themselves. Hence, it was already difficult to complete the exercise based on their own subjectivity, let alone when trying to take someone else's into consideration.
      Based on this confusion, it was determined that either the context offered should be more complete when asking the "experts" what they think so they can guide their sorting better, or it was better to have respondents sort the statements as themselves rather than having them respond what they think the people from the community would prioritize. Otherwise, participants ended up unconsciously sorting based on what they would prioritize themselves.
      This finding aligns with a recommendation presented in Watts & Stenner (2012) based on Curt (1994) which states that the question of a Q-study should focus either on the representation of a subject matter, the understanding of, or be conduct in relation to it. Asking the question in the format "what do ***you*** think is more important...?", focuses the question on the subjects *understanding* of the topic, implying a more personal focus to their responses. On the other hand, asking "what do you think ***they*** would find more important...?" turns the focus of the question into how the respondent perceives the *representation* of the topic, leading them to reflect about how the topic in question is understood by a specific group or setting. A study should avoid crossing these boundaries for the sake of clarity and integrity of the study, as they make sure that both the respondents and the items in the Q-set are answering the same type of question (Watts & Stenner, 2012).
- Statement 6 (addressing desludging) in particular, was said to be too technical or confusing by all participants without a water treatment background (6) and by one with that background. It was determined that similar statements should be rephrased or replaced to ensure that they are accessible to respondents from different backgrounds, affiliations, and education levels. This way, terminology could be accessible for a wider audience.
- Statements 27, 28, 30, and 31 are very similar, so it would be useful to bold the most important words in them and/or make them more concise.
- Statement 33 confused a participant because they felt that there were no other statements to directly make a comparison with, so it was like "the odd one out". This made the statement difficult to place within the relative ranking of the Q-sort. Therefore, all statements should be able to answer the "umbrella question", as well as be rated based on the provided range, for the comparisons to be possible.
- Statements with "would", "could" and "may" (conditionals) should be written as more of a "should" statement to be able to make less ambiguous decisions regarding how they are prioritized/ranked.

- Card mentioning “external organizations” should be either more explicit or there should be a sidenote or prior explanation to clarify what it means in this context or the survey.
- Some statements should be shorter or more concise. Since there are many statements to keep track of, fewer words make the exercise less overwhelming.
- After each person completes the sort, a photo should be taken, or the positions of the cards noted in a piece of paper with the Q-sort printed and the participant number. The results for each person should be recorded wherever data is being collected shortly after collection to facilitate data handling in the long run, especially since the fieldwork will involve significantly more respondents.

3. Performing the Fieldwork

3.1 On-site Observations

Field observations were conducted throughout the stays at Surabaya and Malang. This provided additional context for the research, as well as first-hand familiarization with the characteristics of the Brantas river in both cities. The most notable characteristics for each city were identified and documented photographically, as seen in Figure 8 and Figure 9. When it comes to the downstream city of Kota Surabaya, the city was heavily constructed and counted with a completely flat topography. This section of the Brantas is characterized by having a wide riverbed which, together with the geographic conditions of the city, translates to it having a low turbulence as well as a complete lack of flow in some of the gutters throughout the city. There was an abundance of common water hyacinth (*Pontederia crassipes*, known as "Eceng Gondok" in Indonesia), due to the favorable conditions generated by the high availability of nutrients in the water from agricultural activity upstream and the low turbulence of the river downstream (Mugidde & Wanda, 2002; Febriani & Hadiyanto, 2018). Furthermore, there was a high presence of solid waste (mainly plastic) in the river and its banks, since it did not get washed away by the current of the river as easily as upstream due to the low turbulence mentioned earlier. Additionally, the downstream part of the Brantas receives solid waste from the upstream areas, not just from its own inhabitants. Lastly, there was a notable presence of foam from the untreated discharge of detergents into the river which was the most visible when the greywater was discharged or when pumping stations were activated.

Figure 8. Field observation photographs from Surabaya showing: (a) Direct discharge of detergent-filled greywater into the river; (b) Close-up of foam from detergent discharge; (c) Presence of common water hyacinth in the Brantas; (d) Gutter with low flow and solid waste.

On the other hand, Kota Malang counted with a more varied topography with steep valleys that contributed to the river having a narrower riverbed and a higher turbulence than downstream. The river also appeared to have a greater presence of sediments, leading to a higher turbidity than in Surabaya. The communities located riverside appeared to be more densely constructed than in Surabaya, with steep and narrow pathways being prevalent within the kampungs. The riverside kampungs were therefore more easily accessible by foot. Some motorcycle traffic was still present, although much lower than the one observed in Surabaya riverside kampungs.

Figure 9. Field observation photographs from Malang showing: (a) Dense riverside housing in Kampung Tridi; (b) Close-up of direct greywater discharge into the Brantas river; (c) Steep, narrow entrance to Kampung Warna-Warni; (d) Steep entrance to Kelurahan Tlogomas.

3.2 Administering the Q-sorts

The respondents were first introduced to the research team, i.e. the researcher and accompanying translator(s), and given an explanation about the research and how their data and responses would be handled and presented. They were given an informed consent form (ICC) in accordance with the requirements from the TU Delft Human Research and Ethics Committee (HREC) requirements (see APPENDIX 6), and any remaining questions were answered before proceeding to the Q-sort exercise. They were also allowed to ask questions throughout the exercise and afterwards.

Participants

Upon arriving to East Java, several meetings were held with local academic and government contacts to gather valuable insight regarding sanitation and water management in the Province of East Java, and Indonesia as a whole. This provided a greater familiarization with the local context, as well as additional contacts for interviews and possible respondents. A few of the people contacted for the initial interviews were subsequently asked to participate in the Q-

sort as well. The decision of whether to include one of the specialists or not depended on their area of expertise and its relevance to the research question.

Table 5. Summary of Q-sort respondents.

City	Participant Type	Affiliation	Gender		Age				Total
			Female	Male	25 – 34	35 – 49	50 – 64	65+	
Surabaya	Specialist	Government	4	2	2	4	-	-	6
		Academic	1	1	-	1	1	-	2
		Business	-	2	-	2	-	-	2
	Community	-	6	4	3	4	3	-	10
Malang	Specialist	Government	2	3	1	3	1	-	5
		Academic	6	0	4	-	1	1	6
		Business	0	0	-	-	-	-	0
	Community	-	4	3	-	-	1	6	7
Total			23	15	10	14	7	7	38

The Q-sorting exercise was completed by 38 individuals divided between Kota Surabaya (20 respondents, 52.6%) and Kota Malang (18 respondents, 47.4%). Sampling was done both purposefully and by convenience, at times recurring to snowball sampling to facilitate access to relevant respondents. In these cases, the respondents were told what type of respondents were needed, and/or what institutions would like to be contacted to request the input of one of their workers. The combination of snowballing and purposeful sampling led to contact with workers from seven government agencies (from city, regency, and province level), academics from six universities, and one WWTS consultancy firm. TABLE 6 below shows an overview of what entities and communities were included in the study represented by one or more participants. In the case of the academics listed under "Malang", they were included because their research and expertise included relevant case studies in Malang, even if the academic institution itself was not in Malang.

Table 6. Entities and communities consulted for the Q-sort per type and location. For the government agencies, the text in parenthesis indicates the level of governance of the office visited.

Affiliation	Surabaya	Malang
Government	PUPR (Kota) Bappeda (Regency) Cipta Karya (Regency) DPKPCK (Regency)	Dinas Cipta Karya (Province) BPPW (Province) DLH (Province)
Academia	Universitas Airlangga (UNAIR) Institut Teknologi Sepuluh Nopember (ITS)	Universitas Negeri Malang Institut Teknologi Bandung (ITB) Radboud Universiteit Technische Universität Dresden (TU Dresden)
Business	WWTP Consultancy Firm	-
Community	Kelurahan Jambangan	Kelurahan Tlogomas

Although initially an even gender distribution was desired in the sample, in the end 60.5% of the total respondents were women, while 39.5% were male (see TABLE 5). The higher percentage in women in the sample could be attributed to two main reasons. First, when asking for access to respondents in the business and government organizations, the desired candidate was described. This explanation however focused on obtaining respondents with relevant experience and knowledge about the topics of DEWATS and their implementation, sanitation, and wastewater management in the region. Hence, it did not specify demographic characteristics. Similarly, the academics included as respondents were selected based on their areas of research, prioritizing their expertise in a field relevant or in-line with the research objectives. In this instance, the respondents facilitated were mainly women. On the other hand, since the community Q-sorts were performed during the day and mostly during weekdays, many men were unavailable to participate because they were at work. It was therefore easier for the leaders of the communities to contact a woman, or someone past the retirement age to participate in the exercise.

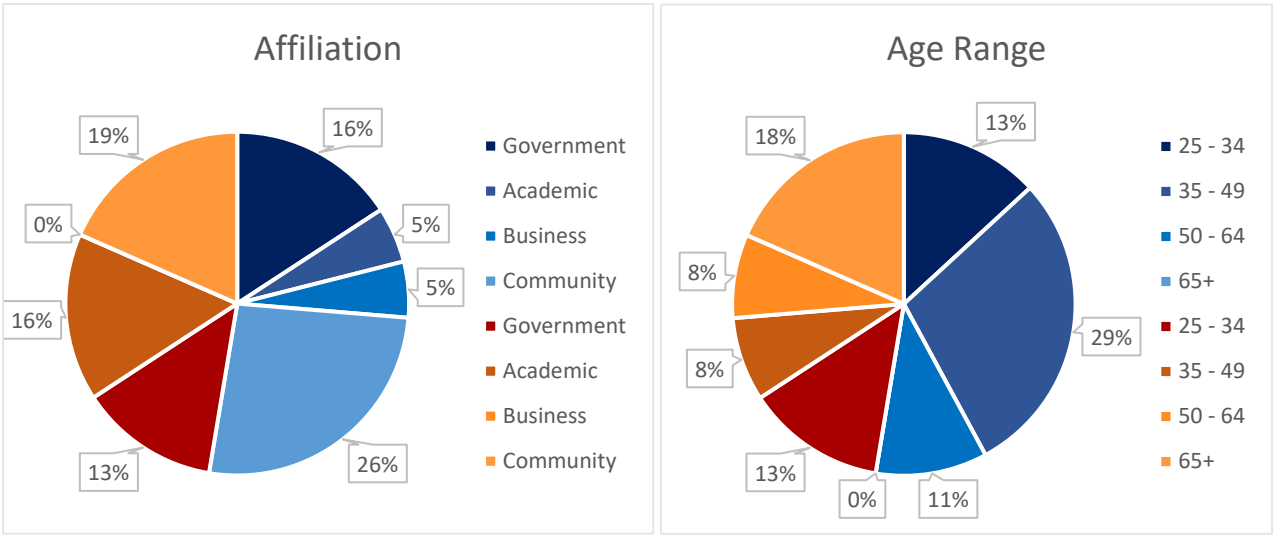


Figure 10. Participant affiliation (left) and age range (right) per type and location. Cool tones (right of pie chart) indicate association with Surabaya, while warm tones (left of pie chart) indicate association with Malang.

In-person Q-sorts

Three sets of cards and three sorting grids were prepared in advance (two in Bahasa and one in English), which allowed for two Q-sorts to be completed simultaneously whenever possible for the sake of time. The statements were presented as 6cm x 6cm cards made of cardboard with the statement on one side and their respective number in the reverse side. Statement numbers were placed on the back of the card in order to avoid any unconscious biased while sorting that may arise from the numbers associated with the statements. At the end of the exercise, the cards could be flipped to reveal their number for recording purposes. The grid slots were 6.5cm x 6.5cm, which gave some extra room for the cards and avoided the grid from appearing overcrowded, which could make the exercise feel overwhelming for the respondents. The sorting grid used followed a mesokurtic, inverted quasi-normal distribution (Watts & Stenner, 2012) (see Figure 6 from SECTION 2.2). This distribution was chosen since the participants were expected to have some level of understanding or first-hand experience with the topic presented, but they would not necessarily have the same levels of knowledge about the topic (Watts & Stenner, 2012; van Dijk et al., 2022). Furthermore, a nine-point -4 to +4 distribution was selected for the Q-sort, as suggested by Watts and Stenner for Q-sets of 40 or less statements.

Figure 11. Respondents from community in Malang (left) and government in Surabaya (right) completing individual Q-sorts.

The sorting grids were placed on a surface large enough to accommodate the participants comfortably. Each person was instructed to perform the exercise individually, asking them to avoid discussing or making comments out loud to prevent them from influencing each other by accident or on purpose. The participants were given a card with the umbrella question, to allow them to keep it present throughout the duration of the exercise. The card was available in either English or Bahasa since some respondents did not speak English. In the case of the specialists, the card included a short description of the main characteristics of the communities that would be included in the research (see APPENDIX 5). The question provided as a guide for the sorting was:

"What do you think is most important when a decentralized domestic wastewater treatment system is implemented in your/a community?"

Context for specialists: *Dense, urban, low-middle income, riverside community*

Figure 12. Community participant from Malang pre-sorting the statements in Bahasa.

Then, they were told to sort the statements according to the Q-sort design pattern presented to them. This approach is referred to as "forced sorting" as it limits the freedom of their sorting slightly and forces them to prioritize some statements over others (Watts & Stenner, 2012), especially regarding the statements placed in the limited "most-" and "least important" ("paling-" and "paling tidak penting") positions. The participants were instructed to sort the statements from their "most important" pile first, followed by the "least important" pile, and finalizing with the "neutral" statements (see FIGURE 12). A note was made in each participant's score sheet after each category was sorted, noting with a bold line where each category ended and the next started. This can be useful during the interpretation step as it shows which point genuinely indicates the individual's disagreement (Watts & Stenner, 2012). Once the sorting was finished, respondents were given the opportunity to check their ranking, ask any questions remaining about statements that they found confusing, and make any last changes to their sort.

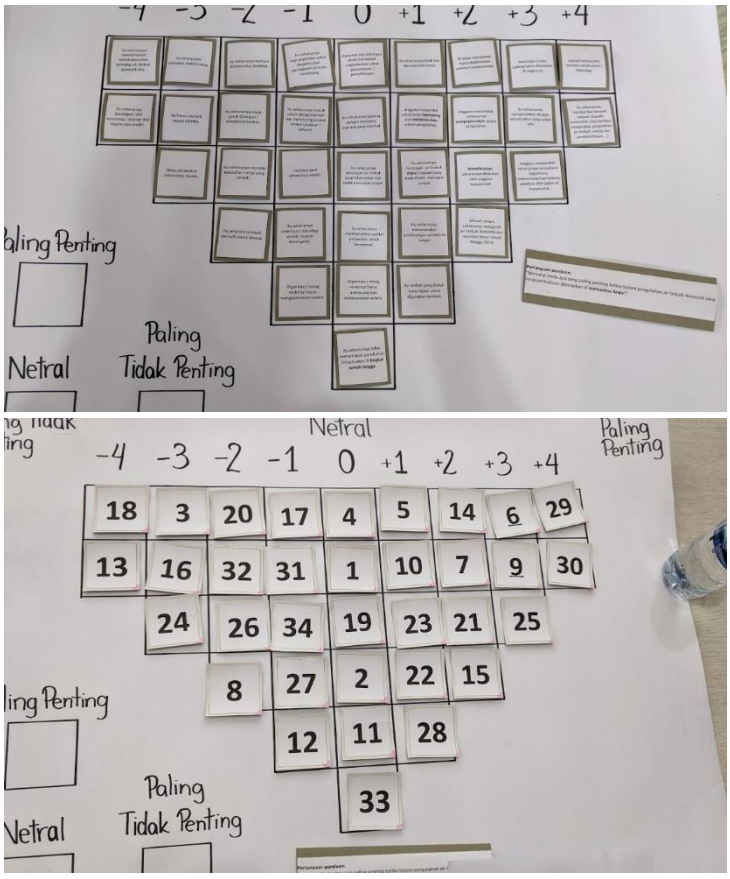


Figure 13. Example of a completed Q-sort exercise in Bahasa (top), and after turning the cards to show the statement number (bottom).

Once they were satisfied with their response, the cards were flipped over to the side showing each statement's number (see Figure 13), and the placement of their cards was recorded in individual score sheets. The respondents then filled in their demographic information and a short survey with questions about their relationship to the river and sanitation in their households (see Appendix 7). A short discussion followed to answer the follow-up questions (explained in SECTION 3.3), and any peculiarities observed during their sorting were discussed.

Online Q-sorts

Due to time constraints or distance limitation, four out of the 38 Q-sorts were performed online through a virtual setup of the sorting exercise in the Miro platform. The setup used during the online Q-sort sessions can be seen in APPENDIX 8. Miro was selected above existing virtual Q-sorting platforms due to its ease of use and the researcher's prior familiarity with the platform. Just like the physical version of the sorting grid, the grading scale was from -4 to +4, from "least important" to "most important. Additionally, the board included spaces for participants to perform the initial division of the statements in "most important", "least important" and "neutral" to facilitate the ranking exercise. The board also included a print-out of

the follow-up questions that the rest of the respondents were asked to complete, which they could fill-in themselves with either the “text” or “pen” functions that Miro offers.

The participants surveyed online included one community member from Surabaya who had to leave early from the meeting while in person, hence providing an incomplete response, but that was still eager to complete the exercise, and three academics that had completed sanitation research in Malang that were contacted but unfortunately not in the city at the time of the fieldwork. They were still enthusiastic to participate in the survey, even if it was online, and were quite interested in the methodology. In the case of the community member, instructions were given in person, while for three academics instructions were given via email when they were first contacted and asked to participate. All four online respondents were contacted individually via Zoom or Teams, depending on their preference. Then they were each sent their own Miro board, where they could move the cards for each statement, zoom in and out, and navigate around the board as they needed. The call started with an introduction, an explanation of the research and how their data would be managed, and with a more detailed overview of the instructions to follow to complete the exercise. At the end of the call, the cards were “flipped” to reveal the number corresponding to each statement, and their positions in the sorting grid were locked and recorded in the same form as the Q-sorts performed in person.

Performing the Q-sort online using a Miro board proved to be a great alternative to the in-person approach, as it gave flexibility regarding time and location for both the researcher and the respondents. Additionally, respondents expressed that they liked how they could see all cards simultaneously, even when doing the division in the three initial groups, which is to do in person unless you scatter them over a large surface. Similarly, as with the in-person approach, this online survey would have been harder to implement if language had been a barrier, although the four respondents were English speaking so there was no need for a translator. Nonetheless, if needed, the grid could have easily been edited to be in Bahasa, but a translator would still be necessary to facilitate the interactions with the respondent, explain the procedure, answer questions, and collect the answer for the follow-up interview.

3.3 Follow-up Questions & Interviews

When it comes to Q-methodology, a post-sorting interview is a great tool to collect supporting data for the interpretation process as it enriches the collected data and can provide further explanation to each individual’s decision-making (Gallagher & Porock, 2010; Watts & Stenner, 2012). For this study, the following questions were asked to complement the participants’ responses:

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0) *Were there any statements that were unclear or confusing?*
1) *Is there any other thing not represented in the Q-set that you would consider important? Where would you rank it?*
2) *Any additional comments about the domestic wastewater treatment situation in the city/in your community? In the Brantas? ("Overall view of the subject matter").*
3) *Any additional comments?*

Question 0 was asked after the respondents finalized their sorting in order to give them the opportunity to clarify any doubts about confusing statements in case that they would like to make any changes to their sort. Question 1 allowed participants to essentially “create a new item”, while simultaneously giving an assessment of the completeness of the set provided. Question 2 gave an insight into their overall view of the subject matter. Lastly, Question 3 aimed to get additional comments and recommendations from their end to improve the administration of Q-sorts with future respondents. For some respondents, this question led to a more general discussion about sanitation in the region, or the country as a whole.

4. Analysis

The "forced" sorts from participants were carefully recorded as hand-written notes using the score sheets showed in APPENDIX 7. Example survey score sheet The collected sorting data was then transcribed into the "Excel Type 1" format provided in the KADE GitHub user guide (Banasick, 2018), while the data collected from the follow-up questions was transcribed on a separate response matrix. The ID number for the different participants was changed to the format "X#YZ", where "X" was either "F" or "M" to indicate the sex of the participant; "#" was their age; "Y" showed their affiliation; and "Z" was either "S" for Surabaya or "M" for Malang. This change was made after the factors were extracted because it proved easier to make associations between respondents by having more distinct features as their participant-name rather than just their number.

For the data analysis step, the data from the 38 Q-sort participants was imported to explore the viewpoints from all participants regardless of their background and personal characteristics. After the data was checked for correct import into the KenQ Analysis Desktop Edition (KADE) software, the correlation table was produced using the Pearson Correlation Coefficient (PCC). Generating this person-by-person correlation matrix (see APPENDIX 10.1) allows to establish the degree of agreement or disagreement between the rankings generated by the different respondents, allowing a holistic, element-by-element comparison of their sets (Watts & Stenner, 2012).

Subsequently, **Centroid Factor Analysis (CFA)** was chosen for the factor extraction technique since it allows for a more in-depth exploration of the data, besides being the preferred method of factor extraction among experience Q-methodologists according to Watts and Stenner (2012). For CFA, KADE gives the option to extract the Centroid Factors using the method described in Brown (1980), which is more commonly used, or the Horst 5.5 method from 1965. The **Brown (1980) centroid factor** extraction method was chosen since with this method the composition of the factors does not depend on how many (additional) factors are extracted in the initial step of analysis (Schmolck, 2015). According to Brown (1980) a 'magic number 7' of factors is usually ideal for the centroid factor extraction, or one factor for every 6-8 participants (Watts & Stenner, 2012). This would indicate that 4 to 6 factors would be ideal for this case. The initial number of factors selected was therefore 7. This led to the results presented in TABLE A8, APPENDIX 10.2.

The factor matrix presented in APPENDIX 10.2 shows the initial or unrotated factor loading for each Q-sort, which is a measure that explains the extent to which each respondent's set is explained by the different factors. This association is characterized by the percent of the variance in each Q-sort that could be accounted for by each factor (Watts & Stenner, 2012). These values can give an initial understanding of how the Q-sorts can be grouped based on their points of view and give some insight for the number of factors that should ultimately be retained in the analysis. The seven factor, unrotated solution, accounted for 50% of the total variance of the study. As seen on TABLE 7Table 8, Factor 1 accounts for most of the variation in the study, explaining 22% of the variability in the data.

Table 7. Unrotated factors retrieved with KADE for data from 38 Q-sorts for the extraction of 7 factors with CFA, with their explained variance percentage and eigenvalues (EV).

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Eigenvalues	8.3327	2.8154	2.456	2.1398	1.62	0.3152	1.669
% explained variance	22	7	6	6	4	1	4
cumulative % explained variance	22	29	35	41	45	46	50

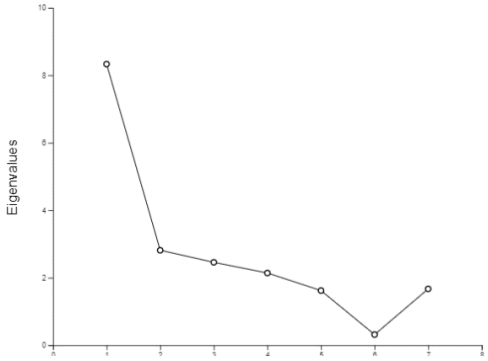


Figure 14. Scree plot generated from Brown CFA extraction.

Based on the Eigenvalues from each factor, their relevance was evaluated. Factors are said to be relevant if they have an EV greater than 1.0. Factor 6 was therefore dropped from further analysis based on this criterion. As observed in TABLE A12, APPENDIX 10.3, all factor solutions loaded more than 50% of the study respondents, therefore the representativeness criterion could not be used to discard any factors. However, the significant factor loading (SFL) criterion gave enough basis to drop the 5- and 7-Factor solutions since they did not count with the minimum of two Q-sorts loading significantly to every factor (see Table A11, APPENDIX 10.3).

The number of factors ultimately kept for rotation indicates how many factor solutions are going to be interpreted. Hence, for a 2-Factor solution two factors are kept for rotation, for 3-Factor solution three factors a kept, and so on. APPENDIX 10.3 details the process by which the number of factors to retain was determined. For this analysis it was decided to keep the 3- and 4-Factor solutions since they are the solutions with the smallest number of factors to have a high representativeness, while still having a high composite reliability (CR) value. A more detailed explanation of the criteria evaluated to decide the number of factors to retain can be found in APPENDIX 10.3. Furthermore, Factors 1 and 2 appear to remain stable when comparing the 3- and 4-Factor results, with their compositions and meaning being similar. The addition of the fourth factor, however, gives an extra dimension to the third viewpoint from the 3-Factor solution by providing more detailed information about the viewpoints of the flagged respondents. Moreover, the addition of a fourth factor approximately divides the third factor in the 3-Factor solution (3-F3) into two distinct groups in the 4-Factor solution (4-F3 and 4-F4) based on a few but noteworthy differences in these subgroups. These are discussed further in SECTIONS 5.1 and 5.2.

Once the desired number of factors to be extracted is specified, KADE gives the option to perform either a Varimax or a Judgmental rotation. **Varimax** rotation was applied to account for the maximum amount of variance explained by the factors that were extracted and retained (Houser et al., 2022b; Watts & Stenner, 2012). This method of factor rotation was selected above by-hand, or judgmental, rotation. This second method may be accompanied by an additional level of uncertainty and unreliability as it depends on the subjectivity and judgment of the researcher. By-hand rotation could however be interesting to apply to the actual data analysis if there are some respondents with particular power, influence, or belonging to a marginalized or minority community, that the study would like to focus on (Watts & Stenner, 2012). Since this is outside of the scope of the study, this is not the case with the participants in this test, and because this method requires much more Q-sort experience, by-hand rotation was not employed. Nonetheless, KADE does offer the option to apply this type of rotation within the software as well.

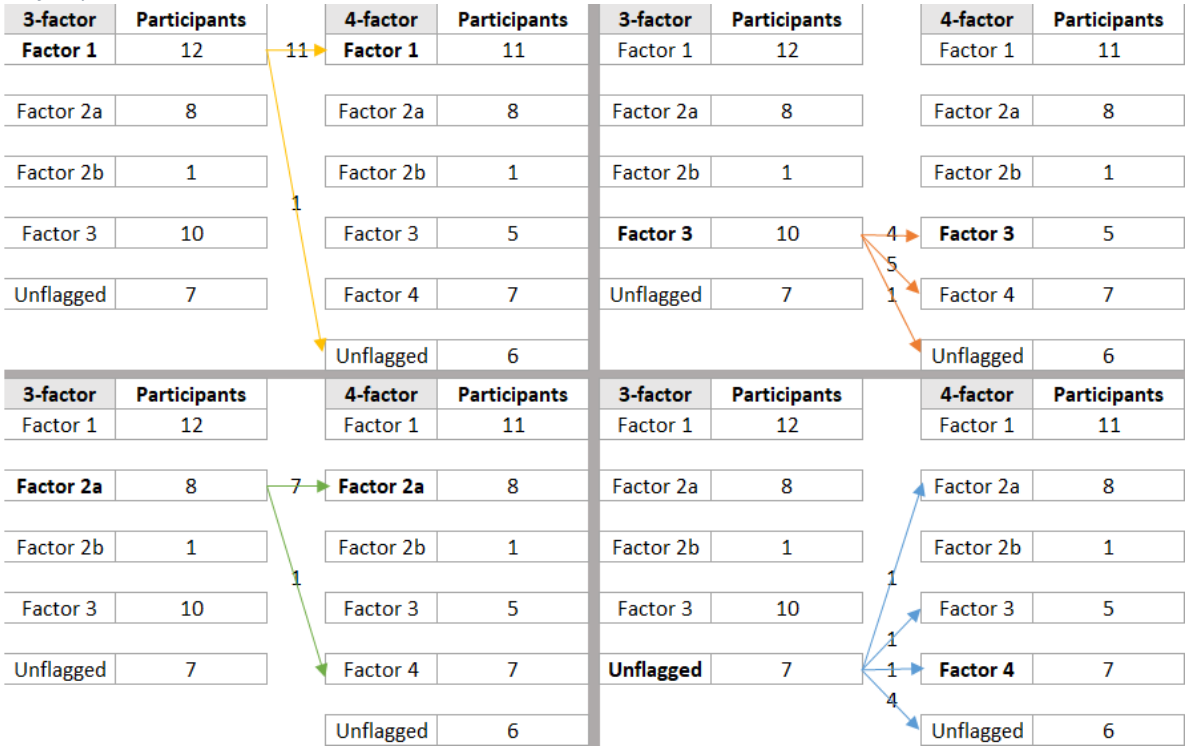
After selecting the number of factors to include in the analysis, a table showing factor groups (FG) and factor loadings per Q-sort was produced. The tables produced for both factor solutions are presented in APPENDIX 10.4 and APPENDIX 10.5. In the following step, the loading was performed through an auto-flag with a 5% significance level ($p < 0.05$), which is the default set by KADE, and requiring majority of common variance. With this auto-flagging process, the software distributes the Q-sorts over the selected number of factor solutions based on the significance of their respective factor loadings for each of the factors, assigning each Q-sort to whichever factor characterizes it the best. As explained in SECTION 2.2, the factor loadings indicate how much of the variability of that sort can be explained by each factor. Additionally, KADE omits any sorts that are confounded from the analysis. Although the non-significant Q-sorts are initially assigned to a factor, they are omitted from the analysis by remaining un-flagged for not having the minimum SFL.

For both the 3- and 4-Factor solutions, Factor 2 was split as a bipolar factor since it was characterized by both positively and negatively loaded sorts, even though only one of the sorts in the dataset was negatively loaded. This resulted in the solutions having technically 4 and 5 factors respectively: Factor 1, Factor 2a, Factor 2b, Factor 3, and Factor 4 (in the case of the 4-Factor solution). For both factor solutions, all factors were submitted for the final results except for Factor 2b. This factor was omitted from the final results because, although interpreting it could provide valuable insight into the bipolar nature of Factor 2, it was characterized by a single respondent (Q34, M70CM). Hence, Factor 2b in both factor solutions had a very low representativeness and CR value, meaning that it was not a reliable factor to retain. Lastly, the distinguishing statements ratios were set for $p < 0.01$ and $p < 0.05$ significance.

The data provided in the output is investigated further for the interpretation phase. The output of each factor solution includes general factor characteristics; a table showing the rank and z-score of each statement for each factor of the solution; information of the distinguishing statements for each factor; and composite factor visualizations.

Change from 3- to 4-Factor Solution

Table 8. Flow of respondents between the 3- and 4-Factor solution.



When changing from a 3- to a 4-Factor solution, the interpretation of most respondent's views appears to remain stable from one solution to the next. This can be determined since the composition of Factors 1 and 2 in the 3-Factor solution remained unaffected when adding an extra factor in the 4-Factor solution, with just two respondents becoming unflagged as can be seen in TABLE 8. Furthermore, because there is stability with the composition of the factors, adding the fourth group gives more detail to the viewpoints presented. This gives the chance to explore underlying points of view within factor 3-F3 when it gets divided into 4-F3 and 4-F4.

This stability in the solutions gives reassurance that the perspectives that emerged from the factor analysis are consistent even when adding new possible dimensions to the analysis, and that respondents are not being shuffled aimlessly between factors. Additionally, no change was observed between the 2b Factors from one solution to the next, indicating that Factor 2 retained its bipolar status in both solutions, with Factor 2b being characterized solely by Q34 (M70CM) in both cases. As there were no changes to portray, that factor was omitted from the diagram above.

Furthermore, the additional factor included when changing from a 3-Factor to a 4-Factor solution seems to provide a more fitting characterization for the participants that were initially grouped in Factor 3. As seen in TABLE 8 once again, the participants seem to be distributed almost in half between Factor 3 and 4 from the 4-Factor solution, with only one participant becoming unflagged. What is even more interesting, is that the addition of a fourth factor seems to generate space for the subjectivities of 3 of the previously unflagged participants to be embraced and described. However, what exactly these additional dimensions are, and understanding the changes that took place when making room for an extra factor, can only be determined by analysing and interpreting the two solutions.

5. Results

Following factor rotation and the initial assessment of the groupings with the 3- and 4-Factor solutions, it was decided to move forward with the interpretation of both solutions since, even though the 3-Factor solution could provide enough CR, explained variance, and distinguishing statements, the addition of a fourth factor could give more details about the initial grouping and give more depth to the third factor, as was explained in more detail in the previous section.

5.1 Factor Interpretation

The following section gives a detailed explanation about the meaning and composition of each factor for both factor solutions. The factors were interpreted in two steps. First, the output generated from the KADE statistical analysis was examined, looking into the sorting of statements with respect to one another within the factor itself, and then comparing the statements position in the ranking for the other factors. Therefore, it is important to oscillate between the meaning of the items' score by itself, and its relation to the rest of the sort, while interpreting the viewpoint presented in each factor (Watts & Stenner, 2012). This was done based on the information provided by TABLE 10 and TABLE 12, which show the factor arrays for the 3- and 4-Factor solutions respectively. Secondly, these initial interpretations were enrichened with the qualitative data collected from the follow-up interviews and any relevant information with respect to the demographics of the flagged respondents for that factor.

3-Factor Solution

For this solution, three factors were retained for the rotation step of analysis. These three factors accounted for 35% of the total variance in the data. 30 out of the 38 participants were *auto-flagged* to the factor that characterized their viewpoints the best, so the factors represent 79% of the sample. Seven of the unflagged participants were not flagged as they either did not have significant enough factor loadings for any of the factors, or they were confounded amongst various viewpoints (refer to SECTION 2.2, STAGE 3: FACTOR ANALYSIS for further explanation). As explained in CHAPTER 4, the remaining respondent was loaded to their own bipolar factor, but later this factor was removed from the output results. APPENDIX 10.4 includes a detailed narration explaining the factor meaning, factor matrix, crib sheet, and composite Q-sort for each of the factors. It also includes the factor array showing scores, ranks, and z-score values for each statement. The following section gives a broken-down explanation about the meaning and composition of each factor.

Table 9. 3-Factor solution summary.

	3-Factor Solution
Factor 1	*Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious* Simplicity (14:+4): Do not need large capacity or extra features (25:-3;10:-3; 23:-2) Cheap maintenance (9:+4); Little maintenance done by community (15:+3;30:+1) Low initial investment (8:+2) Minimal pollutant discharge (6:+2) Socialization before implementation (5:+3) so community can be self-reliant (29:0; 30:+1) Neighbouring success not important (18:-2) Installation and operation not just responsibility of one party (28:-3; 13:-4; 12:-4); collaboration (33:+1); need management plan (34:+2) Worry about river and human health (6:+2; 21:+3; 22:+2)
Factor 2a	*Benefit more users; User-friendliness; Community-led; Additional services; Function > Aesthetics* Large area (24:-4) for higher capacity (25:+1); households need infrastructure changes (31:-3) Subsidies should be available (11:+1), then initial cost will not be a concern (8:-2) Should give multiple services (10:+2) Community in charge of installation (13:-1) and operation (29:+3); simplicity is key (14:+2); less need for management plan (34:-3) Cheap maintenance (9:+4) done by community (30:+3). Need prior socialization (5:+3) Pests and smells expected (4:-2); aesthetics are not important (3:-3) Worry about river health (6:+4; 21:+2; 22:+1)
Factor 3	*Environment; User-friendliness; Fully community-led; External support; Ownership; Subsidized throughout project lifetime* River health, human health, and water reuse (6:+3; 22:+3; 4:+1; 21:+2; 23:+2) Prior socialization (5:+4) so community can install, operate, and maintain the system (28:+2; 29:+3; 30:+4) Waste product disposal (7:+2) should be easy to facilitate participation (16:-3) Large area (24:-3) to allow for desired treatment capacity and possible expansions (26:+1) Subsidies should be for more than just initial system (11:-2), then energy requirements are no problem (19:-1) External support is appreciated, even if from abroad (33:0; 1:-3), but not essential

Table 10. 3-Factor solution factor array.

	Statement	Factor Score			Z-score Variance
		3-F1	3-F2a	3-F3	
Social					
1	It should be provided by a person / association from my own country.	-2	-1*	-3	0.071
2	It should minimize our exposure to our domestic wastewater.	1**	-1	-1	0.31
3	It should be aesthetically appealing.	-1*	-3*	-2	0.153
4	It should not smell or attract pests.	1	-2**	1	0.407
5	Community members should understand how the system / solution works before it is put in the community.	3	3	4**	0.091
14	It should be simple (low-tech, easy to understand).	4**	2	1	0.219
16	It should work with minimal human intervention.	-1	-1	-3**	0.144
28	Members of the community should **install and commission** the treatment system.	-3**	0*	2*	0.717
29	Members of the community should **operate** the treatment system.	0**	3	3	0.151
30	**Maintenance** should be done by community members.	1**	3**	4**	0.379
33	There should be external support after implementation for monitoring / maintenance.	1	0	0	0.058
34	Management structure should be defined before implementation.	2	-3**	1	0.665
Environmental					
6	It should minimize discharge of pollutants into the river.	2**	4	3	0.13
7	It should be easy to collect and dispose of the waste products (solids / sludge).	0	0	2*	0.137
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3	2	2	0.034
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2	1*	3	0.151
23	Treated wastewater should be apt for reuse.	-2**	0**	2**	0.571
Economic					
8	The initial investment should be low.	2**	-2	-2	0.758
9	Maintenance should be cheap.	4**	4**	-1**	1.163
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	-3**	2**	-1**	0.603
11	Subsidies should be available for the solution / technology.	0*	1*	-2**	0.459
Technical					
12	An external organization / person should operate the treatment system.	-4	0**	-4	1.143
13	An external organization / person should **install and commission** the treatment system.	-4	-1**	-4	0.268
15	It should require little maintenance to operate.	3	2	0**	0.333
17	It should be quick to build / implement.	0	1	0	0.069
18	It should have been successful in nearby communities.	-2*	0	0	0.15
19	It should have low energy requirements.	1	1	-1**	0.184
20	Construction / replacement parts should be found in the country.	0	-4**	1	0.875
24	It should take up little space.	-1**	-4*	-3**	0.42
25	System should treat domestic wastewater from a large number of households (50+).	-3**	1**	0**	0.757
26	It should allow for future expansion or upgrades.	-2	-2	1**	0.419
27	It should be sturdy and hard to vandalize.	0**	-1	-2	0.206
31	It should not require changes in infrastructure at **household level**.	-1*	-3**	-1*	0.258
32	It should accommodate to existing infrastructure.	-1	-2	0**	0.187

For distinguishing statements: * = significance at $p < 0.05$; ** = significance at $p < 0.01$.

Consensus Statements

As can be observed in the previous section, only three out of the 34 statements provided show no strong distinguishment between the extracted factors. These statements show aspects that are valued similarly by the set of respondents. Only statement 21 (21:+3,+2,+2), however, shows commonality between the three factors and was identified by the KADE Software as a "consensus statement". This consensus statement is shaded blue in the factor visualizations for the 3-Factor solution (APPENDIX 10.4).

The high score given to this statement by all factors indicates that the respondents share an understanding of the importance of preventing blackwater from discharging into the river. Throughout the different factors, statements from respondents can be found in which they discuss the importance of having an open defecation-free society, and of having every household connected to a septic tank. This high level of overall awareness for the importance of improving sanitation could be attributed to the significant government efforts and the widespread implementation of the Open Defecation Free (ODF) Program that have taken place in the island of Java.

Another possible reason for the elevated importance given to the prevention of blackwater discharge into nearby water bodies is that Indonesia is a predominantly Islamic country, and many riverside communities still use nearby waterbodies for multiple activities. In Islamic law, feces are seen as "Najis", which is a term for filthy or impure. Mohd Salleh et al. (2020) states that treated wastewater can be considered pure again and be reused for different purposes, as long as this does not cause any harm, since the treatment process can remove the "Najis" elements. This however is still debated in the Muslim community and the acceptability of wastewater reuse may vary per country and per person, even among non-Muslim users. Religion, however, was only mentioned by one of the academics included in the study during a follow-up interview, so it is uncertain to what extent this may play a role in the perspectives of the respondents in the study.

Demographic Distribution

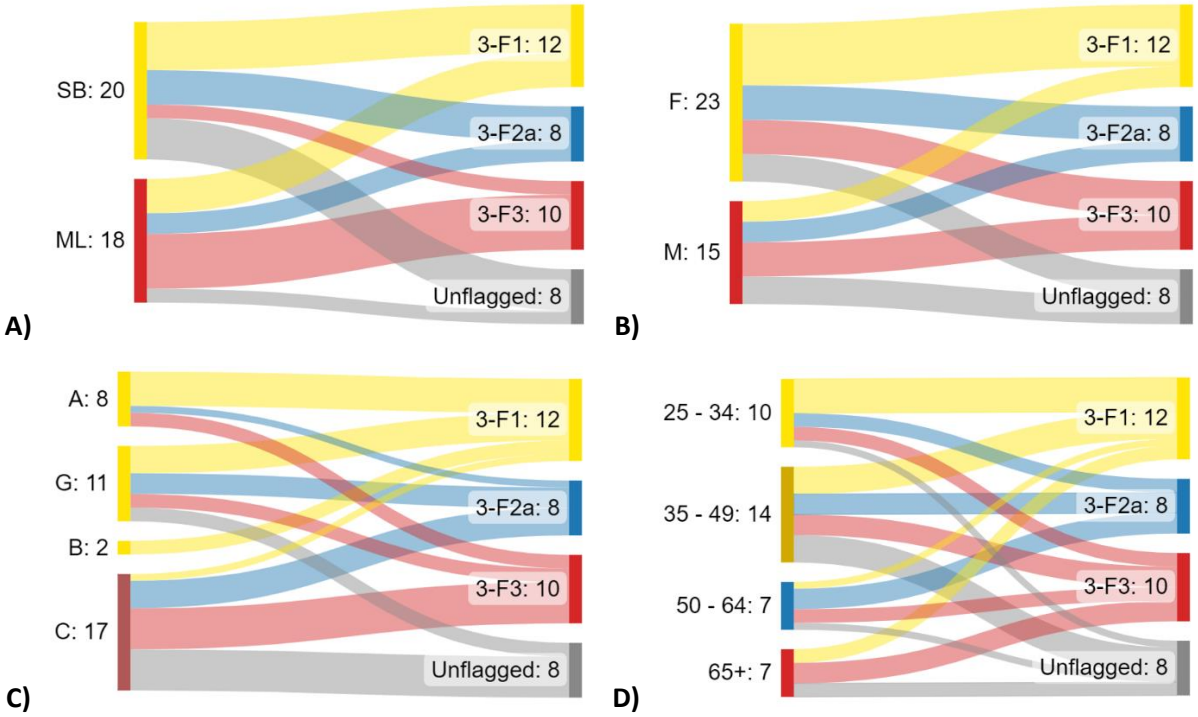


Figure 15. Noncumulative distribution of respondents across factors (F1, F2a, F3) with respect to (A) location (SB: Surabaya; ML: Malang); (B) gender (F: Female; M: Male); (D) affiliation (A: Academia; G: Government; B: Business; C: Community); and (D) age ranges for 3-Factor solution. The color from the starting node corresponds to the factor that includes the most participants from that group. The end node shows the groups formed by KADE. The numbers after each colon indicate the number of people in that category.

The figures above show the demographic compositions of the factors from the 3-Factor solution.

Location. As shown in FIGURE 15A, a larger proportion of participants from Malang appear to be characterized by the three factors generated than from Surabaya. Furthermore, 3-F3 appears to describe the point of view of Malang participants best. The other two factors seem to have evenly distributed participants from both cities, with a slightly higher representation from Surabaya participants which may be attributed to the fact that the sample size in that city was slightly higher.

Gender. FIGURE 15B on the other hand, shows the gender distribution of the factors. 3-F1 shows a clear majority of female respondents (75%), while the other groups (including the unflagged respondents) seem to have an even gender distribution.

Affiliation. When it comes to FIGURE 15C, portraying participant affiliation, the most notable aspect is the absence of community members flagged to 3-F1, and the greater representation of this group in 3-F3. Community members however seem to be the category with the greatest proportion of unflagged respondents (35%), followed only by government workers (18%). Group 3-F1 also includes both business category respondents.

Age. Lastly, with respect to age (shown in Figure 15D), 3-F1 seems to characterize mainly participants from the two lower age ranges. Meanwhile respondents belonging to the highest age bracket appear to not be described by 3-F2a, since none of them were flagged as significant for that group. 3-F3 on the other hand contains an even age distribution.

Combination. When examining the combination of these categories, some of the observations made above can be explained further. 3-F1 is made up mostly women (75%), is heavily loaded by specialists (92%), and is made up mainly of respondents belonging to the two bottom age ranges (75%). This connection can be attributed to most of the specialists consulted being women (refer to TABLE 5). Additionally, most of the specialists, regardless of gender, belong to the age range between 25 and 49 years of age. Furthermore, 3-F2a includes no respondents from the Malang community category, which explains the absence of the highest age range since this category includes most of the elderly respondents in the P-set. It also omits Malang academics, and Surabaya government employees. Lastly, 3-F3 represents Malang respondents heavily, and notably omits Surabaya specialists. Since the presence of the latter category leads to a much higher representation of the two lower age ranges, 3-F3 maintain the even age distribution described earlier.

Factor 3-F1

Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious

12 respondents load significantly in the first factor, which explains 13% of the variance in the study. As seen in FIGURE 15C above, this factor is characterized by an absence of community members when comparing it to the other group, as it includes 11 specialists and only one community member. The factor characterizes the viewpoints of both respondents from the business category, four government workers and one academic from Surabaya. Additionally, it includes four academics and one community member from Malang. Lastly, the people in this group are mainly women and young specialists.

The participants identifying with this viewpoint care mostly about the **long-term sustainability** of the system, prioritizing criteria such as **low complexity**. They believe the system should focus on **current needs** before considering criteria such as water reuse, resource recovery, and future expansions. This group also believes that a system servicing **fewer households** would be preferrable, as it would require a **lower initial investment** and be easier to run:

14	It should be simple (low-tech, easy to understand).	4
10	It should provide multiple services to my community	-3**
23	Treated wastewater should be apt for reuse.	-2**
26	It should allow for future expansion or upgrades.	-2
25	System should treat domestic wastewater from a large number of households (50+).	-3**
8	The initial investment should be low.	2**

Additionally, they give great importance to items related to **maintenance**. They believe strongly that maintenance should be **cheap** and **minimal**. They also believe that it should be up to the **community to take care of the system**, although statement 30 is not scored as high as in other factors:

9	Maintenance should be cheap.	4**
15	It should require little maintenance to operate.	3
30	**Maintenance** should be done by community members.	1**

When it comes to **installation** and **operation** of the system, this group thinks that this should **not be the responsibility of external entities** such as the government or NGOs. However, they indicate that the community should not be the ones in charge of the instalment and commissioning of the system either:

12	An external organization / person should operate the treatment system.	-4
13	An external organization / person should **install and commission** the treatment system.	-4
28	Members of the community should **install and commission** the treatment system.	-3**

They do indicate that community should be involved with the operation of the system. Nonetheless, they show a slight preference towards the system needing **little human intervention** to function, considering that the score given to statement 16 is relatively high if compared to the distinctively low score attributed to it in the third factor. This group seems to expect **less community participation** in the different stages of implementation than the other factors, as can be observed with the low score given to statements 28, 29, and 30 in comparison to the other factors:

29	Members of the community should **operate** the treatment system.	0**
16	It should work with minimal human intervention.	-1

The slightly higher score given to statement 33 however, indicates that they believe **collaboration** between community and external entities to be a better approach than the different responsibilities falling solely on a single group of the stakeholders. If collaboration is to take place, then a clear **management structure** should be defined before the system is implemented and prior **socialization** with the community should take place. Whether it has been successful in nearby communities or not is not important at all:

33	There should be external support after implementation for monitoring / maintenance.	1
34	Management structure should be defined before implementation.	2
5	Community members should understand how the system / solution works before it is put in the community.	3
18	It should have been successful in nearby communities.	-2*

Lastly, the factor gives great importance to items related to environmental benefits, showing that they give high importance to **environmentally friendly** solutions:

6	It should minimize discharge of pollutants into the river.	2**
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3
21	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2

In addition to the information collected from the statistical KADE analysis, the follow-up interviews with the respondents provided some additional insight into the underlying themes that guided their sorting. As explained above, this group places great importance on statements that they consider to be vital for the long-term sustainability and success of the system. **Low complexity** for example, was mentioned as an important criterion to facilitate community-led operation and maintenance to keep the system operational and up to standard (Q1, Q3, Q16, Q38). Justifications provided by nine out of the twelve respondents in this factor in the follow-up interviews ultimately associated the success of the system with **community participation**, which appears to be conflicting with this factor giving the lowest scores out of the three groups to statements 28, 29, and 30 (which address community participation in different stages of the system's lifetime) in comparison to the other two factors. It is also worth noting however that this is the factor with the least community representation.

Additionally, statements 12 and 13, addressing the extent of involvement of external entities, are ranked in the bottom of the set by six and two respondents respectively. Participants mentioned the additional **costs** associated with a third party operating the system (Q15, Q3), and referred to the importance of **community participation** to keep the system running. They also mention **external entities as a source of support** and facilitators of knowledge transfer, which gives additional importance to statement 33 (neutral, positive), and is represented by the high rank attributed to statement 5. Q16 for example, justified her high ranking for statement 5 using the phrase "tak kenal maka tak sayang", which translates to "don't know, don't love", indicating a connection between the level of **understanding** of the community and how much they care for it, i.e. keep it operational. This case shows the importance of follow-up interviews, as they shine a light on a participatory focus that could be missed based solely on the low ranks of some statements.

Furthermore, statements from three respondents give meaning to the position attributed to statement 16 (neutral, negative) and show how different respondents interpreted the statement regarding human intervention. Q33 mentioned that they do not believe low human intervention to be important, as they believe that human intervention would be needed regardless of the level of sophistication of the technology. Similarly, Q9 mentioned that a less-advanced, manual system (hence requiring greater human intervention) would be better due to the level of education

in the low-income, riverside communities, which may not accept a technology that is too advanced and complicated to keep in operation. They therefore linked **ease of use** and **complexity** of the system with the **expertise required** and the **availability of capable human resources** within the community. On the other hand, Q3 ranked statement 16 as one of the most important, arguing that a low-tech system requiring less human intervention would be better since less human intervention could lead to less human error. They justified this further by commenting on "people's lack of knowledge" on the matter of sanitation and wastewater treatment, which could lead to a greater occurrence of said human error. This respondent therefore connected **ease of use**, **complexity**, and **expertise required** (similarly as Q33 and Q9) but linked them to **awareness** as well.

As portrayed by the high scores given to economic statements such as 8 and 9 compared to other factors, **costs and funding availability** seem to be a great area of concern for participants in this group, even if statement 11 was given a neutral score. Funding and costs were mentioned by eight out of the eleven people that were loaded to this factor, associating budgetary concerns to statements 1, 8, 9, 10, 11, 12, 15, 20, 21, 23, and 25. Respondents mentioned low availability of funding, mainly for maintenance (Q15, Q33), as a challenge for the systems' success. Hence, they perceived a **lower CAPEX** as a better chance to receiving funding, and an opportunity to cater to more people with the technology if systems are more affordable. Respondents also associated costs to the **local availability of parts**, **complexity** of the system, **treatment capacity**, **removal efficiency**, and **expertise required**.

Lastly, the responses provided by the participants when discussing statements 6, 21, and 22 demonstrated a high level of **awareness** from their end with respect to the importance of sanitation and wastewater handling. Statement 21 was identified as a priority (scored +4) by four respondents covering both genders, both cities, the three groups of specialists, and from all age ranges except the youngest category (25 to 34 years old). One respondent (Q6) justified this statement as the most important by recognizing the reduction of OD in the region, but showing concern about the state of many septic tanks that contain the waste but "are not regularly desludged". He also mentioned the low **coverage of sewerage** throughout Indonesia as a reason to why wastewater from domestic toilets is of concern. Another respondent (Q37) also showed concern regarding the **low sewer coverage**, the conditions of new and existing septic systems, and even the possible **groundwater contamination** that could arise from leaking septic tanks in highly populated regions. Both described the sewerage coverage to be between 1 and 3% throughout the country. A third respondent (Q4) linked this statement to a need for additional **infrastructure** and **socialization** with respect to sanitation, especially in the many low- and low-middle income communities near the river, confirming the known need for **wastewater infrastructure** and **awareness** in the basin.

When it comes to statement 22, which addresses greywater handling and treatment, one of the respondents (Q2) suggested that the system should focus on treating greywater, which according to him represents approximately 60-70% of the wastewater produced in households, since blackwater is handled mostly through septic tanks throughout Indonesia. This claim is confirmed by literature as well, which states that 50 to 80% of domestic wastewater produced is greywater (Firdayati et al, 2015). Hence, he stated that the functioning of the tanks should be prioritized if this separation of the wastewater is to be maintained. Another respondent (Q37) agreed that most of the pollution in the Brantas comes from greywater, but also showed concern about what she referred to as a "lack of regulation addressing the collection, handling, and treatment of greywater", therefore linking this statement to the **policy alignment** criteria.

Factor 3-F2a

Benefit more users; User-friendliness; Community-led; Additional services; Function > Aesthetics

Factor 3-F2a has eight significantly-loading respondents and explains 10% of the variance in the study. The group is made up of four community members from Surabaya, three government workers from Malang, and one academic from Surabaya. As seen in FIGURE 15D above, this factor is characterized by an absence of respondents belonging to the highest age bracket (65 years old and over), as it includes no respondents from the Malang community. It also omits Malang academics, Surabaya government employees, and the business category since both respondents from that category were already flagged for 3-F1. Nonetheless, there seems to be no trend regarding gender distribution with respect to this factor. Lastly, the two lowest age ranges seem to be represented to a similar extent, while the second highest age range (50 to 64 years old) has a relatively higher presence in this group considering its lower representation within the overall sample.

This group puts great importance in utility and functionality. Therefore, they believe a **large area** should be destined for the system so it can treat the wastewater from more households. Furthermore, changes in household and community **infrastructure** should be accommodated if needed. They believe **aesthetics** are not important and, even more, that it is to be expected that the system will smell or attract pests (cause some level of **nuisance**):

24	It should take up little space.	-4*
25	System should treat domestic wastewater from a large number of households (50+).	1**
32	It should accommodate to existing infrastructure.	-2
31	It should not require changes in infrastructure at **household level**.	-3**
3	It should be aesthetically appealing.	-3*
4	It should not smell or attract pests.	-2**

Additionally, they believe the project should be **community-led,** having a greater role than external entities in the operation and maintenance phases mainly. Hence, **simplicity** is key. With simplicity, there's less need for such a detailed management plan. Prior **socialization** however remains very important:

28	Members of the community should **install and commission** the treatment system.	0*
13	An external organization / person should **install and commission** the treatment system.	-1**
14	It should be simple (low-tech, easy to understand).	2
34	Management structure should be defined before implementation.	-3**
5	Community members should understand how the system / solution works before it is put in the community.	3

Moreover, this group is the only one that does not indicate either statement 12 or 13 as the least important, indicating that some of the responsibilities for installation and operation should indeed **rely on external entities**. It is also the only factor that thinks it is important for the system to provide additional benefits to the community, such as **resource recovery**:

29	Members of the community should **operate** the treatment system.	3
12	An external organization / person should operate the treatment system.	0**
10	It should provide multiple services to my community.	2**

This group also believes strongly that it is important for maintenance to be done by the community. It is not as important for the initial investment to be low, since **funding** should be available for this, but it is still critical for the **maintenance to be cheap**. If this is the case, then importing materials and parts would not be an issue:

30	**Maintenance** should be done by community members.	3**
8	The initial investment should be low.	-2
11	Subsidies should be available for the solution / technology.	1*
9	Maintenance should be cheap.	4**
20	Construction / replacement parts should be found in the country.	-4**

Upon discussion with the respondents, they showed great concern for **functionality**, **simplicity**, and **costs** of the system. Their comments aligned with the low scores given to 3, 4, 24, 31, and 32. Three respondents (Q17, Q30, Q31) specifically stated that functionality was paramount when considering a system, so this group values criteria like **reliability** greatly and sees elements like the **aesthetics** of the system as either completely unimportant or as additional benefits. In this last case, such additional benefits should be considered after the system is operating properly and **fulfilling the existing needs** based on the existing situation (Q26, Q30). After all, what is the use of aesthetics if the system does not work (Q31)? Similarly, their comments regarding **infrastructure changes** and **land requirements or availability** (statements 24 and 32) showed how their label as unimportant was assigned from a pragmatic position. They stated, for example, that the area destined for the solution should depend on how much area is needed to implement a system that provides the desired benefits and coverage to the people. Hence, it is acceptable to "sacrifice some land" for a working system that will cover the needs of the community (Q26, Q30, Q31). These comments therefore linked **surface area** with desired **treatment capacity** and **centralization levels**, rather than to criteria such as geographic characteristics of the area or land availability for example. A similar sentiment existed with regards to communal **infrastructure changes** (statement 32), with Q23 for example stating that if the existing infrastructure does not work it should be replaced.

Five out of the eight respondents loaded to this factor mentioned costs when justifying their placings for statements 8, 9, 11, 15, 20, 27, and 31, which refer to the system's **CAPEX**, **OPEX/maintenance costs**, **funding** availability, **maintenance requirements**, **local availability of resources and parts**, **sturdiness**, and **household infrastructure** changes respectively. Furthermore, one respondent (Q12) mentioned costs as one of the main points that could alter the level of **support** received from the community to adopt a system, aggreging to use and pay for it, taking into consideration that the community is low-middle income. Additionally, two respondents linked costs to the selection process of the technology/system itself. Q5 for example, explained that technologies involving bioprocesses were the cheapest available options and were widely available in Indonesia, so importing materials and technologies would not be necessary. On the other hand, Q23 mentioned that if the **maintenance costs** are too high, a different system should be considered to find a better solution that would be a better investment.

Maintenance was also a recurring theme amongst the respondents in this group, being mentioned by six of the people flagged in this group including community members, academics, and government workers alike. **Maintenance costs** and **requirements** were connected to the system's **simplicity**, **energy** requirements, **funding** availability, **community responsibility**, **treatment efficiency**, and availability of **human resources**. Additionally, Q17 mentioned the importance of low overall costs since "funding available through the government does not extend to maintenance costs", which was also a challenge mentioned by Q15 in factor 3-F1.

Lastly, and surprisingly contrasting with the findings from the follow-up interviews with respondents from factor 3-F1, only three out of the eight participants flagged in this group mentioned socialization, community involvement, and awareness when justifying their scores for items in the +4 and -4 positions, even though such statements received a higher score than in the first factor. Their comments referred to statements 5 and 29 only however, which address **socialization** with communities and the role of community members in the **operation** of the system. This differs from the case of 3-F1, where items addressing community involvement and awareness were ranked lower, but those themes were repeated multiple times by participants when explaining the importance of other items.

Factor 3-F3

Environment; User-friendliness; Fully community-led; External support; Ownership; Subsidized throughout project lifetime

Ten respondents load significantly to the last group in the 3-Factor solution. Factor 3-F3 explains 12% of the variance in the responses. As seen in FIGURE 15A above, 3-F3 describes the point of view of Malang participants better than the other groups. This third factor includes two academics and two government workers from Malang, while notably omitting any Surabaya specialists. This group also has the greatest representation of community members in the 3-Factor solution (see FIGURE 15C), including four community members from Malang and two from Surabaya. Age, however, seems to be evenly distributed within this group, as it contains individuals from all age ranges.

This group believes that it is of utmost importance for the implementation of the system to be **fully community-led**, being completely **independent** from interventions from external entities. They should therefore **know how it operates** before it is put in place or built, and tasks such as **waste disposal** should be easy for them to complete:

28	Members of the community should **install and commission** the treatment system.	2*
29	Members of the community should **operate** the treatment system.	3
30	**Maintenance** should be done by community members.	4**
12	An external organization / person should operate the treatment system.	-4
13	An external organization / person should **install and commission** the treatment system.	-4
5	Community members should understand how the system / solution works before it is put in the community.	4**
7	It should be easy to collect and dispose of the waste products (solids / sludge).	2*

Additionally, this group regards statements referring to environmental health such as 6, 21, and 22 as highly important,

6	It should minimize discharge of pollutants into the river.	3

which shows that these participants are **environmentally driven**. This is further confirmed by the importance they gave to solutions that allow for **water reuse**, in contrast with less of an interest in additional benefits:

21	It should prevent untreated wastewater from **toilets** from reaching the river.	2
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	3
23	Treated wastewater should be apt for reuse.	2**
10	It should provide multiple services to my community	-1**

Interestingly, this group holds a more neutral position (leaning towards less important) towards statement 2. The low importance given to the statement about community **exposure** to the wastewater (#2), compared with the high importance given to the other statements addressing **domestic discharge** (#6, 21, and 22), may indicate that they understood statement 2 differently than was intended. This is consistent with comments from some respondents, which were not sure of what was meant by the term "exposure" specifically. However, the contrasting position of this group towards statements 15 and 16 compared to the other factors, indicates a preference for a **hands-on solution** regardless of the amount of maintenance needed.

2	It should minimize our exposure to our domestic wastewater.	-1
15	It should require little maintenance to operate.	0**
16	It should work with minimal human intervention.	-3**

Lastly, this group presents a much different stance than the other factors by disregarding **cheap maintenance** as a top criterion and labelling a low **initial investment** as unimportant, while simultaneously ranking **subsidy availability** for the technology as less important than other statements. This is worth exploring further as it may seem illogical at first, considering that the community in question is low-income:

9	Maintenance should be cheap.	-1**
8	The initial investment should be low.	-2
11	Subsidies should be available for the solution / technology.	-2**

Although the statements 31 and 32 referring to infrastructure changes were scored as neutral/unimportant in this factor, this does not mean that respondents in this group had no opinion around it. Some respondents addressed infrastructure however from a perspective of **community involvement**, **socialization**, and proper **budget use**. Q13 and Q20 mentioned that a large amount of infrastructure has already been built, involving a large investment towards sanitation as was stated in prior sections. However, Q20 also mentioned the challenge that comes from maintaining all that infrastructure, exalting the importance of community involvement in maintenance tasks for the sanitation interventions to be sustainable in the long run. Q14 explained that since the community will ultimately be in charge of taking care of the system, their involvement throughout the process is paramount to avoid the systems and new infrastructure falling into disrepair since if they are not involved, they will not **care** for it. Lastly, Q13 stated that people are ultimately more important than the value (i.e. cost) of infrastructure, since if they are not involved it will not possibly remain operational, leading to **wasted monetary investments**.

This awareness for **cost**, **budgets** and **funding** availability was also reflected in the statements from four of the respondents in the group, including two community members and two government workers. A similar sentiment as that of Q20 was expressed by Q18 (both being government workers) who mentioned the need for communities to help with the operation and maintenance of the systems due to the existing budget limitations from the government. He therefore mentioned the importance of the community having a **sense of belonging** over the system but connected it to **reduction of costs**. The other government worker that mentioned funding (Q20) made an interesting remark about why he labelled statement 11 as unimportant. He labelled the statement as one of the least important in the set since he believed that subsidies from the government should not just be available for the technology, but that they should be available for the entirety of the project to be able to cover expenses before, during, and after implementation. This also shows how this statement can be interpreted differently by respondents and gives an explanation to why it was ranked so low in this group, especially when budgetary restrictions were mentioned by three of the respondents. Their remarks also link the importance of **locally available parts** for construction or repairs, a **lower involvement of external**

entities, and the importance of **thinking about future needs** for reducing costs and making a better investment in the long run (Q24, Q32). Lastly, seven of the respondents in this group justified their rankings by alluding to the more human side of the implementation process. This included addressing elements such as **awareness**, **mindset** and **behaviour** change, **care**, **skill strengthening** (to increase the availability and quality of human resources), communal **responsibility**, and **ownership** (Q13, Q14, Q18, Q20, Q21, Q27, Q36). Once again, these social elements were mentioned by community member, academics, and government workers alike, reflecting the high scores attributed by this factor to many of the social criteria represented in the set.

4-Factor Solution

For this solution, four factors were retained for the rotation step of analysis. These four factors accounted for 41% of the total variance in the data. 31 out of the 38 participants were *auto flagged* to the factor that characterized their viewpoints the best, so the factors represent 82% of the sample. Six of the unflagged participants were not flagged as they either did not have significant enough factor loadings for any of the factors, or they were confounded amongst various viewpoints (refer to SECTION 2.2, STAGE 3: FACTOR ANALYSIS for further explanation). Similarly, as with the 3-Factor solution, the remaining participant was loaded to their own bipolar factor, which was later removed from the output results. APPENDIX 10.5 includes a detailed narration explaining the factor meaning, factor matrix, crib sheet, composite Q-sort for each of the factors, factor array showing scores, ranks, and z-score values for each statement. The following section gives a broken-down explanation about the meaning and composition of each factor.

Table 11. 4-Factor solution summary.

	4-Factor Solution
Factor 1	*Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious* Simplicity (14:+4): Large capacity and extras not necessary (25:-3;10:-2; 23:-2) Cheap maintenance (9:+4); Little maintenance (15:+3); Done by community (30:+1) Low initial investment (8:+2) Neighbouring success not important (18:-1) Installation and operation not just responsibility of one party (28:-3; 13:-4; 12:-4); collaboration (33:+1); need management structure (34:+2) Minimal WW exposure (2:+1)
Factor 2a	*Benefit more people; User-friendliness; Community-led; Additional services; Function > Aesthetics* Worry about river health (6:+4; 21:+2; 22:+1) Community in charge of installation (13:-1) and operation (29:+3); simplicity is key (14:+2); less need for a management plan (34:-2) Should give multiple services (10:+2) Large area (24:-4) for higher capacity (25:+1); households need infrastructure changes (31:-3) Existing infrastructure needs to change (32:-2) Pests and smells expected (4:-1); aesthetics are not important (3:-3) Acceptable to import materials and parts (20:-4) if maintenance is cheap and infrequent (9:+4; 15:+3)
Factor 3	*User-friendliness; Community-led; Ownership; Familiarity; Subsidize throughout project lifetime; Water reuse* Neighbouring success important (18:+3) Avoid out of sight, out of mind (2;-3) Community led O&M (29:+4; 30:+4) with prior socialization (5:+2) and managerial planning (34:+2) Simple (14:+1), sturdy (27:+2) system with easy waste product disposal (7:+3) Subsidies should be for more than just initial system (11:-4) Small # households (25:-2) Water apt for reuse (23:+1)
Factor 4	*Community installed and maintained; Ownership; Widespread community and environmental health; Socialization and collaboration* Prior socialization (5:+4) so community can install and maintain system (28:+3; 29:+1; 30:+4) Vandalizing is not a concern (27:-4) if community takes care of it Operation should be done with external support (29:+1; 33:+2) Quickly service (17:+1) a large # households (25:+3), even if energy requirement (19:-3) and maintenance costs are higher (9:-1) Local materials and parts for repairs (20:+2) River and human health (6:+2; 22:+2; 21:+3)

Consensus Statements

As can be observed in TABLE 12, only nine out of the 34 statements provided show no strong distinguishment between the extracted factors. Out of these nine statements, KADE recognized statements 17 (17:0,+1,-1,+1) and 22 (22:+2,+1,+2,+2) as consensus statements. The factor scores for statement 17 suggest a shared feeling of neutrality regarding how quickly a new wastewater treatment system should be constructed in a community. On the other hand, the scores assigned to statement 22 suggest widespread consensus about the importance of preventing greywater from being discharged into the river, as it accounts for a larger volume than blackwater and it goes mostly untreated in the region (Firdayati et al, 2015; Widyarani et al., 2021). Consensus statements are shaded blue in the factor visualizations for the 4-Factor solution (APPENDIX 10.5).

Table 12. 4-Factor solution factor array.

		Factor Score				Z-score Variance
Statement		**4-F1**	**4-F2a**	**4-F3**	**4-F4**	
Social						
1	It should be provided by a person / association from my own country.	-3	-2	-3	-1	0.112
2	It should minimize our exposure to our domestic wastewater.	1**	-1	-3**	-1	0.491
3	It should be aesthetically appealing.	-1	-3*	-2	-2	0.117
4	It should not smell or attract pests.	1	-1*	1	0*	0.262
5	Community members should understand how the system / solution works before it is put in the community.	3	2	2	4*	0.091
14	It should be simple (low-tech, easy to understand).	4**	2	1	1	0.195
16	It should work with minimal human intervention.	0*	-1	-2	-2	0.499
28	Members of the community should **install and commission** the treatment system.	-3**	0*	1	3	0.733
29	Members of the community should **operate** the treatment system.	0	3	4	1	0.154
30	**Maintenance** should be done by community members.	1**	3	4	4**	0.465
33	There should be external support after implementation for monitoring / maintenance.	1	0	-1**	2	0.351
34	Management structure should be defined before implementation.	2	-2**	2	1	0.61
Environmental						
6	It should minimize discharge of pollutants into the river.	2	4**	1	2	0.161
7	It should be easy to collect and dispose of the waste products (solids / sludge).	-1	0*	3*	0	0.223
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3	2	0	3	0.124
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2	1	2	2	0.041
23	Treated wastewater should be apt for reuse.	-2**	0	1	0*	0.429
Economic						
8	The initial investment should be low.	2**	-3	-2	-1**	0.753
9	Maintenance should be cheap.	4**	4**	-1**	-1**	1.286
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	-2	2**	0**	-2	0.634
11	Subsidies should be available for the solution / technology.	0	1	-4**	0	0.892
Technical						
12	An external organization / person should operate the treatment system.	-4*	0**	-3	-3	0.668
13	An external organization / person should **install and commission** the treatment system.	-4	-1	-4	-2	0.418
15	It should require little maintenance to operate.	3	3	0	-1	0.499
17	It should be quick to build / implement.	0	1	-1	1	0.072
18	It should have been successful in nearby communities.	-1*	0	3**	0	0.492
19	It should have low energy requirements.	1	1	3	-3**	0.931
20	Construction / replacement parts should be found in the country.	0*	-4**	-1**	2*	0.794
24	It should take up little space.	-1	-4	-1	-4	0.625
25	System should treat domestic wastewater from a large number of households (50+).	-3*	1**	-2*	3**	1.132
26	It should allow for future expansion or upgrades.	-2	-2	0	1	0.563
27	It should be sturdy and hard to vandalize.	0*	-1**	2*	-4**	0.848
31	It should not require changes in infrastructure at **household level**.	-2	-3	0**	-3	0.292
32	It should accommodate to existing infrastructure.	-1*	-2*	0	0	0.265

For distinguishing statements: * = significance at $p < 0.05$; ** = significance at $p < 0.01$.

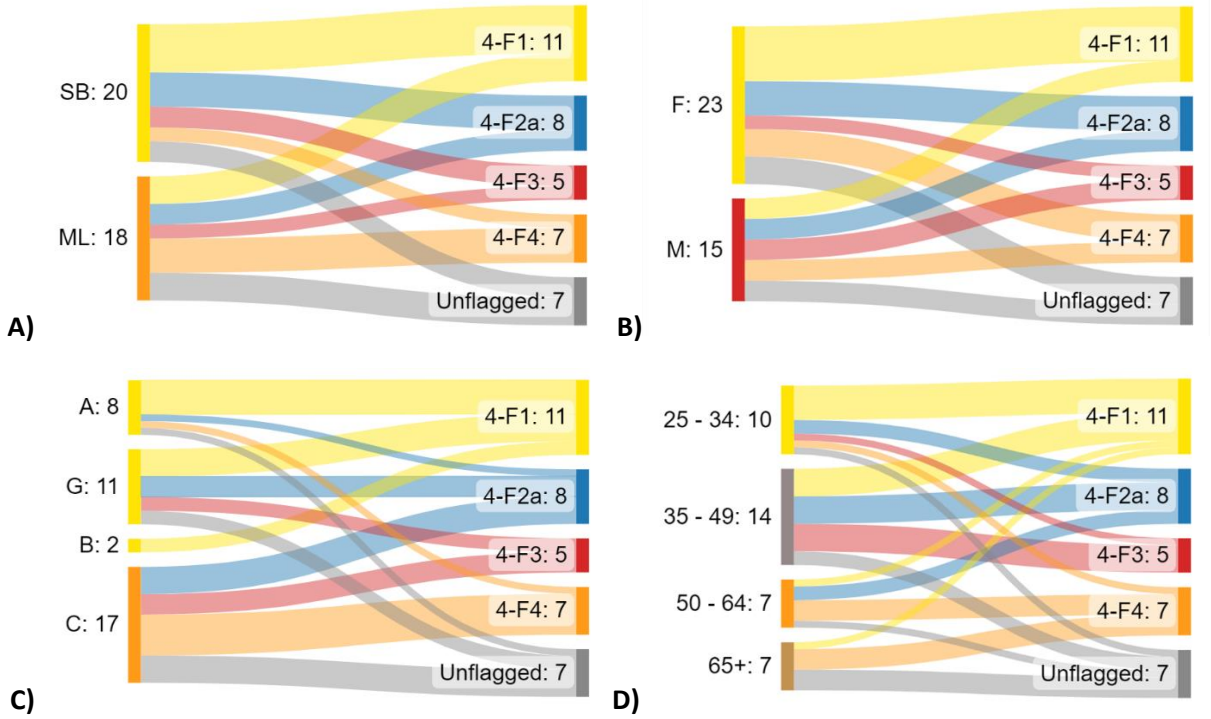


Figure 16. Noncumulative distribution of respondents across factors (F1, F2a, F3, F4) with respect to (A) location (SB: Surabaya; ML: Malang); (B) gender (F: Female; M: Male); (C) affiliation (A: Academia; G: Government; B: Business; C: Community); and (D) age ranges for 4-Factor solution. The color from the starting node corresponds to the factor that includes the most participants from that group. The end node shows the groups formed by KADE. The numbers after each colon indicate the number of people in that category.

The figures above show the demographic compositions of the factors from the 4-Factor solution.

Location. As shown in Figure 16A, the addition of 4-F4 halved the number of unflagged participants from Surabaya when compared to the 3-Factor solution but doubled those related to Malang. Furthermore, 4-F4 appears to describe mainly the point of view of Malang participants, while the other three appear to be more evenly distributed, with a slightly higher representation from Surabaya participants which may be attributed to the fact that the sample in that city was slightly higher.

Gender. Figure 16B on the other hand, shows the gender distribution of the factors. 4-F1 still shows a clear majority of female respondents (72%), while the other groups (including the unflagged respondents) seem to have a more even gender distribution.

Affiliation. When it comes to Figure 16C, portraying participant affiliation, the most notable aspect is the complete absence of community members flagged to 4-F1, and the high representation of this group in 4-F4. Although community members are the category with the greatest proportion of unflagged respondents once again (24%), this value was reduced from the 3-Factor solution. Group 4-F1 still includes both business category respondents.

Age. Lastly, FIGURE 16D shows how 4-F1 mainly characterizes participants from the two lower age ranges. Meanwhile respondents belonging to the highest age bracket appear to not be described by 4-F2a at all, since none of them were flagged as significant for that group. Lastly, the addition of a fourth factor divided 3-F3 into its younger and older flagged respondents almost perfectly among 4-F3 and 4-F4.

Combination. Upon examining the combination of these categories, some of the observations made above can be explained further. 4-F1 is made up mostly women, is heavily loaded by specialist, and is made up mainly of respondents belonging to the two bottom age ranges (75%). This connection can be attributed to most of the specialists consulted being women (refer to TABLE 5). Additionally, most of the specialists surveyed, regardless of gender, belong to the age range between 25 and 49 years of age. This first factor does not include respondents from the Malang community category, which explains the low representation of the highest age range since this category includes most of the elderly respondents in the P-set. Similarly, Group 4-F2a lacks any Malang community members and thus lacks the

higher age range as well. It also omits Malang academics, and Surabaya government employees. Likewise, 4-F3 includes no community members from Malang, so it only includes respondents from the two lower age ranges. It does not include specialists from Surabaya either, although their inclusion would not necessarily lead to a shift in the gender distribution of the group since the sample of Surabaya specialists is half female, half male. Lastly, 4-F4 is made up mainly of community members from the two highest age ranges (86%), primarily from Malang. The last respondent in this group is a young academic from Malang. This last factor omits Surabaya specialists similarly to 4-F3, showing that this trend did not change regardless of the addition of the fourth factor. Since the presence of this latter category leads to a much higher representation of the two lower age ranges, and all of the Malang community respondents were over 50 years-old, participants loaded to 4-F4 tend to lean towards the higher age ranges unlike those flagged unto 4-F3.

Factor 4-F1

Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious

11 respondents load significantly in the first factor, which explains 13% of the variance in the study (similarly to 3-F1). As seen in FIGURE 16C above, this group is characterized by a complete absence of community members, while including the eleven specialists that were flagged for 3-F1. However, the community member from Malang that was initially flagged for this first group (Q33) became unflagged with the addition of the fourth factor as it became confounded between 4-F1 and 4-F4 (refer to SECTION 2.2, STAGE 3: FACTOR ANALYSIS for further explanation). 4-F1 still shows a clear majority of female respondents and specialists belonging to the two lowest age ranges (25 to 49 years old). The factor characterizes the viewpoints of four Malang academics, both respondents from the business category, four government workers and one academic from Surabaya.

As with 3-F1, the participants identifying with this viewpoint care mostly about the **long-term sustainability** of the system, prioritizing criteria such as **low complexity**. They believe the system should focus on **current needs** before considering criteria such as **water reuse**, **resource recovery**, and future **expansions**. This group also believes that a system servicing **fewer households** would be preferrable, as it would require a **lower initial investment**:

14	It should be simple (low-tech, easy to understand).	4**
10	It should provide multiple services to my community	-2
23	Treated wastewater should be apt for reuse.	-2**
26	It should allow for future expansion or upgrades.	-2
25	System should treat domestic wastewater from a large number of households (50+).	-3*
8	The initial investment should be low.	2**

Additionally, they give great importance to items related to **maintenance**. They believe strongly that maintenance should be **cheap** and kept to a **minimum**. Although statement 30 is not scored as high as in other factors, the group still believes it is important for **maintenance to be done by community** members:

9	Maintenance should be cheap.	4**
15	It should require little maintenance to operate.	3
30	**Maintenance** should be done by community members.	1**

When it comes to installation and operation of the system, this group thinks that this should **not be the responsibility of external entities** such as the government or NGOs. However, they indicate that the community should not be the ones in charge of the instalment and commissioning of the system either:

12	An external organization / person should operate the treatment system.	-4*
13	An external organization / person should **install and commission** the treatment system.	-4
28	Members of the community should **install and commission** the treatment system.	-3**

They do indicate that community should be involved with the operation of the system, but this group seems to expect **less community involvement** in the different stages of implementation than the other factors. This can be observed from the low score given to statements 28, 29, and 30 in comparison to the other factors. Additionally, this factor believed it more important than the other three groups for the system to **need little human intervention** to function:

29	Members of the community should **operate** the treatment system.	0
16	It should work with minimal human intervention.	0*

The slightly higher score given to statement 33 however, indicates that they believe **collaboration** between community and external entities to be a better approach than the different responsibilities falling solely on a single group of the stakeholders. If collaboration is to take place, then a clear **management structure** should be defined before the system is implemented and prior **socialization** with the community should take place. Whether it has been **successful in nearby communities** or not however is irrelevant:

33	There should be external support after implementation for monitoring / maintenance.	1
34	Management structure should be defined before implementation.	2
5	Community members should understand how the system / solution works before it is put in the community.	3
18	It should have been successful in nearby communities.	-1*

In addition to the information collected from the statistical KADE analysis, the follow-up interviews with the respondents provided some additional insight into the underlying themes that guided their sorting. As explained above, this group places great importance on statements that they consider to be vital for the long-term sustainability and success of the system. **Low complexity** for example, was mentioned as an important criterion to facilitate community-led operation and maintenance to keep the system operational and up to standard (Q1, Q3, Q16, Q38). Justifications provided in the follow-up interviews by eight out of the eleven people in this group ultimately associated the success of the system with **community participation**, which appears to be conflicting with this factor giving the lowest scores out of the four groups to statements 28, 29, and 30 (which address community participation in different stages of the system's lifetime) in comparison to the other three factors. It is also worth noting however that this is the only factor with no community representation. This characteristic remains unchanged from 3-F1 in the 3-Factor solution.

Additionally, statements 12 and 13, addressing the extent of involvement of external entities, are ranked in the bottom of the set by six and two respondents respectively, similarly to the case of the 3-Factor solution. Participants mentioned the additional **costs** associated with a third party operating the system (Q15, Q3), and referred to the importance of **community participation** to keep the system running. They also mention **external entities as a source of support** and facilitators of knowledge transfer, which gives additional importance to statement 33 (neutral, positive), and is represented by the high rank attributed to statement 5. Q16 for example, justified her high ranking for statement 5 using the phrase "tak kenal maka tak sayang", which translates to "don't know, don't love", indicating a connection between the level of **understanding** of the community and how much they care for it, i.e. keep it operational. This case shows the importance of follow-up interviews, as they shine a light on a participatory focus that could be missed based solely on the low ranks of some statements.

Furthermore, follow-up interviews from two respondents give meaning to the position attributed to statement 16 (neutral), which is a unit higher in rank than in 3-F1, and show how different respondents interpreted the statement regarding "human intervention". Q9 mentioned that a less-advanced, manual system (hence requiring greater human intervention) would be better due to the level of education in the low-income, riverside communities, which may not accept a technology that is too advanced and complicated to keep in operation. She therefore linked **ease of use** and **complexity** of the system with the level of **expertise required** and the **availability of capable human resources** within the community. On the other hand, Q3 ranked statement 16 as one of the most important in the set, arguing that a low-tech system requiring less human intervention would be better since less human intervention could lead to less human error. She justified this further by commenting on "people's lack of knowledge" on the matter of sanitation and wastewater treatment, which could lead to a greater occurrence of said human error. This respondent therefore made similar connections as Q9 between **ease of use**, **complexity**, and **expertise required**, even though Q3 and Q9 gave opposite ratings to the same statement. She did, however, make an additional explicit link to **awareness**.

As portrayed by the high scores given to economic statements such as 8 and 9 compared to other factors, **costs and funding availability** seem to be a great area of concern for participants in this group, even if statement 11 was given a neutral score. Funding and costs were mentioned by seven out of the ten people that were loaded to this factor, associating budgetary concerns to statements 1, 8, 9, 10, 11, 12, 15, 20, 21, 23, and 25. Q15 for example, mentioned the low availability of funding, mainly for maintenance, as a challenge for systems' success. Hence, she perceived a **lower CAPEX** as a better chance to receiving funding, and an opportunity to cater to more people with the technology

if systems are more affordable. Respondents also associated costs to the **local availability of parts**, the **complexity** of the system, **treatment capacity**, **removal efficiency**, and **expertise required**.

Lastly, the responses provided by the participants when discussing statements 6, 21, and 22 demonstrated a high level of **awareness** from their end with respect to the importance of sanitation and wastewater handling. Statement 21 was identified as a priority (scored +4) by four respondents covering both genders, both cities, the three groups of specialists, and from all age ranges except the youngest category (25 to 34 years old). One respondent (Q6) justified this statement as the most important by recognizing the reduction of OD in the region, but showing concern about the state of many septic tanks that contain the waste but "are not regularly desludged". He also mentioned the low **coverage of sewerage** throughout Indonesia as a reason to why wastewater from domestic toilets is of concern. Another respondent (Q37) also showed concern regarding the **low sewer coverage**, the conditions of new and existing septic systems, and even the possible **groundwater contamination** that could arise from leaking septic tanks in highly populated regions. Both described the sewerage coverage to be between 1 and 3% throughout the country. A third respondent (Q4) linked this statement to a need for additional **infrastructure** and **socialization** with respect to sanitation, especially in the many low- and low-middle income communities near the river, confirming the known need for **wastewater infrastructure** and **awareness** in the basin.

When it comes to statement 22, which addresses greywater handling and treatment, one of the respondents (Q2) suggested that the system should focus on treating greywater, which according to him represents approximately 60-70% of the wastewater produced in households, since blackwater is handled mostly through septic tanks throughout Indonesia. Hence, he stated that the functioning of the tanks should be prioritized if this separation of the wastewater is to be maintained. Another respondent (Q37) agreed that most of the pollution in the Brantas comes from greywater, but also showed concern about what she referred to as a "lack of regulation addressing the collection, handling, and treatment of greywater", therefore linking this statement to the **policy alignment** criteria.

Factor 4-F2a

Benefit more people; User-friendliness; Community-led; Additional services; Function > Aesthetics

Factor 4-F2a has eight significantly-loading respondents, seven of which remained unchanged from the 3-Factor solution, and explains 10% of the variance in the study. Similarly, as with 3-F2a, the group is made up of four community members from Surabaya, three government workers from Malang, and one academic from Surabaya. This factor's characteristics are therefore very similar to those of 3-F2a. The difference between the two factor solutions is that one of the male community members from Surabaya flagged in 3-F2a switched to 4-F4, while a respondent with similar characteristics, but from a lower age range, changed from being unflagged in the 3-Factor solution to being flagged for 4-F2a. As seen in FIGURE 16D above, this factor is characterized by an absence of respondents belonging to the highest age bracket (above 65 years old), which can be explained by the absence of Malang community members. It also omits Malang academics, Surabaya government employees, and the business category as both respondents flagged for 4-F1. Lastly, there seems to be no trend regarding gender distribution with respect to this factor.

This group puts great importance in utility and functionality. Therefore, they believe a **large area** should be destined for the system so it can treat the wastewater from **more households**. Furthermore, changes in household and community **infrastructure** should be accommodated if needed. They believe **aesthetics** are not important and, even more, that it is to be expected that the system will smell or attract pests to an extent (cause some level of **nuisance**):

24	It should take up little space.	-4
25	System should treat domestic wastewater from a large number of households (50+).	1**
32	It should accommodate to existing infrastructure.	-2*
31	It should not require changes in infrastructure at **household level**.	-3
3	It should be aesthetically appealing.	-3*
4	It should not smell or attract pests.	-1*

Additionally, they believe the project should be **community-led**, having a greater role than external entities in the operation and maintenance phases mainly. Hence, **simplicity** is key. With simplicity, there's less need for such a detailed **management plan**. **Prior socialization** however is still important:

28	Members of the community should **install and commission** the treatment system.	0*
13	An external organization / person should **install and commission** the treatment system.	-1
14	It should be simple (low-tech, easy to understand).	2
34	Management structure should be defined before implementation.	-2*
5	Community members should understand how the system / solution works before it is put in the community.	2

Moreover, this group is the only one that does not indicate statement 12 and 13 as one of the least important, indicating that some of the responsibilities for installation and operation should indeed rely on **external entities**. It is also the only factor that thinks it is important for the system to provide **additional benefits** to the community, such as **resource recovery**:

29	Members of the community should **operate** the treatment system.	3
12	An external organization / person should operate the treatment system.	0**
10	It should provide multiple services to my community.	2**

This group also believes strongly that it is important for **maintenance to be done by the community**. It is not important for the initial investment to be low, since **funding should be available** for this, but it is still critical for the **maintenance to be cheap.** If this is the case, then **importing materials** and parts would not be an issue:

30	**Maintenance** should be done by community members.	3
8	The initial investment should be low.	-3
11	Subsidies should be available for the solution / technology.	1
9	Maintenance should be cheap.	4**
20	Construction / replacement parts should be found in the country.	-4**

Upon discussion with the respondents, they showed great concern for **functionality**, **simplicity**, and **costs** of the system. Their comments aligned with the low scores given to 3, 4, 24, 31, and 32. Three respondents (Q17, Q25, Q31) specifically stated that functionality was paramount when considering a system, so this group values criteria like **reliability** greatly and sees elements like the **aesthetics** of the system either as completely unimportant or as additional benefits. In this last case, such additional benefits should be considered after the system is operating properly and **fulfilling the existing needs** based on the existing situation (Q26). After all, what is the use of aesthetics if the system does not work (Q31)? Similarly, their comments regarding **infrastructure changes** and **land requirements or availability** (statements 24 and 32) showed how their label as unimportant was assigned from a pragmatic position. They stated, for example, that the area destined for the solution should depend on how much area is needed to implement a system that provides the desired benefits and coverage to the people. Hence, it is acceptable to "sacrifice some land" for a working system that will cover the needs of the community (Q26, Q31). These comments therefore linked **surface area** with desired **treatment capacity** and **centralization levels**, rather than to criteria such as geographic characteristics of the area or land availability for example. A similar sentiment existed with regards to communal **infrastructure changes** (statement 32), with Q23 for example stating that if the existing infrastructure does not work it should be replaced.

Five out of the eight respondents loaded to this factor mentioned costs when justifying their placings for statements 8, 9, 11, 15, 20, 27, and 31, which refer to the system's **CAPEX**, **OPEX/maintenance costs**, **funding** availability, **maintenance requirements**, **local availability of resources and parts**, **sturdiness**, and **household infrastructure** changes respectively. Furthermore, one respondent (Q12) mentioned costs as one of the main points that could alter the level of **support** received from the community to adopt a system, aggreging to use it and pay for it, taking into consideration that the community is low-middle income. Additionally, two respondents linked costs to the selection process of the technology/system itself. Q5 for example, explained that technologies involving bioprocesses were the cheapest available options and were widely available in Indonesia, so importing materials and technologies would not be necessary. On the other hand, Q23 mentioned that if the **maintenance costs** are too high, a different system should be considered to find a better solution that would be a better investment.

Maintenance was also a recurring theme amongst the respondents in this group, being mentioned by six of the people flagged in this group including community members, academics, and government workers alike. **Maintenance costs** and **requirements** were connected to the system's **simplicity**, **energy** requirements, **funding** availability, **community responsibility**, **treatment efficiency**, and availability of **human resources**. Additionally, Q17 mentioned the importance of low overall costs since "funding available through the government does not extend to maintenance costs", which was also a challenge mentioned by Q15 in factor 4-F1.

Lastly, and contrasting with the findings from factor 4-F1 (similarly as with the 3-Factor solution), only three out of the eight participants flagged in this group mentioned **socialization**, **community involvement**, and **awareness** when justifying their scores for items in the +4 and -4 positions, even though such statements received a higher score than in the first factor. Their comments addressed to statements 5, 12, and 29 in this case, which address **socialization** with communities and the role of community members and external entities in the **operation** of the system. This differs from the case of 4-F1, where items addressing community involvement and awareness were ranked lower, but those themes were repeated multiple times by participants when explaining the importance of other items.

Factor 4-F3

User-friendliness; Community-led; Ownership; Familiarity; Subsidize throughout project lifetime; Water reuse

The third factor of the 4-Factor solution characterizes the viewpoints from five of the respondents and explains 8% of the variance in the responses. Four of them were flagged for the third factor in the 3-Factor solution, while the last respondent (a community member from Surabaya) became flagged onto 4-F3 after the fourth factor was introduced. The factor describes the viewpoint shared by three community members from Surabaya and two government officials from Malang. This group therefore does not include any of the academics surveyed during the fieldwork, Malang community members, or specialists from Surabaya (see FIGURE 16C). The group also includes four out of the five respondents from the two lower age ranges that were initially flagged for factor 3-F3, so it is loaded solely by respondents between 25 and 49 years of age, mainly from the second lowest age range (see FIGURE 16D).

Similarly to 3-F3, this factor gives great importance to **community involvement**, prioritizing their active participation in operation and maintenance:

29	Members of the community should **operate** the treatment system.	4
30	**Maintenance** should be done by community members.	4
28	Members of the community should **install and commission** the treatment system.	1

Moreover, **external support** is not valued as much, intervention from external entities is perceived to have the least level of importance, and external support is slightly unnecessary. This shows that that the group prioritizes **community involvement** with the system, and **independence** from external entities. It would therefore be valuable if tasks such as **waste disposal** were easy for them to complete:

12	An external organization / person should operate the treatment system.	-3
13	An external organization / person should **install and commission** the treatment system.	-4
33	There should be external support after implementation for monitoring / maintenance.	-1**
7	It should be easy to collect and dispose of the waste products (solids / sludge).	3*

Compared to other factors, this group gives great importance to **sturdiness** while having a more neutral stance towards statements 9, 15, and 20 than the other factors. This indicates that this group is more lenient with respect to the amount of **maintenance and costs** associated with the system, as long as the system is sturdy, since this can reduce the amount of maintenance needed. In this case, replacements would not be needed often, making whether parts and resources are local or not irrelevant:

27	It should be sturdy and hard to vandalize.	2*
9	Maintenance should be cheap.	-1**
15	It should require little maintenance to operate.	0
20	Construction / replacement parts should be found in the country.	-1**

Similarly to 3-F3, this group thinks minimizing **exposure** to domestic waste and for the system to operate with low **human intervention** are of low importance compared to the rest of the criteria. Considering their preference for a community-run system, this may indicate that they consider exposure and human intervention as opportunities for the community to be more involved and knowledgeable about the workings of the system. Like with 3-F3, this could mean that some respondents in this factor interpreted the term "exposure" differently from the other groups:

2	It should minimize our exposure to our domestic wastewater.	-3**
16	It should work with minimal human intervention.	-2

Unlike the other factors, 4-F3 gives major importance to prior **socialization**, prior definition of a **managerial plan**, and **neighbouring success.** Hence, they value elements such as accessibility and familiarity:

5	Community members should understand how the system / solution works before it is put in the community.	2
34	Management structure should be defined before implementation.	2
18	It should have been successful in nearby communities.	3**

Lastly, this group disregards **cheap maintenance** as a top criterion and labelled a **low initial investment** as unimportant, while simultaneously ranking **subsidy availability** for the technology as the least important among all statements. Just like in the case of 3-F3, this is worth exploring further as it may seem illogical at first, considering that the community in question is low-income:

9	Maintenance should be cheap.	-1**
8	The initial investment should be low.	-2
11	Subsidies should be available for the solution / technology.	-4**

Additionally, Q18, Q20, Q24, and Q27 provided comments that help explain the neutral/low score given to statement 33, which addresses **support from external entities**. When justifying the high scores attributed to statements 29 and 30 (about the community operating and maintaining the system) and the low score given to statement 13 (regarding external entities installing and commissioning the system), these respondents exalted the importance of community **participation** and **communal responsibility** as a way to lower **costs** and make interventions more sustainable. The comments from Q18 and Q20 went as far as stating that the government is the one that needs the support of the community in order to operate and maintain the new and existing infrastructure, rather than it being the other way around.

Similarly to the case in 3-F3, despite the low scores given to statements addressing economic criteria (i.e. 8, 9, and 11), three of the respondents in the group still mention **budget** and **costs** as a concern. They address it however by discussing how other areas of interest could lower costs or make the budget usage more effective, such as having the system be **sturdy** (requiring less maintenance and associated costs), having the **community operate and maintain** the system (avoiding the involvement of expensive salaries for external people), and improving **management practices** that would save them time, money, and resources (Q18, Q24). Additionally, the remark made by Q20 about why he labelled statement 11 as unimportant remains relevant for this factor to justify the low score for this item. As explained for 3-F3, he labelled the statement as one of the least important in the set since he believed that **subsidies** from the government should not just be available for the technology, but that they should be available for the entirety of the project to be able to cover expenses before, during, and after implementation.

Furthermore, Q24 was very adamant about the importance of **proper management** to have a more efficient budget usage and for it to be easier for the community to take charge. This reflects the high score given to statement 34 in this factor. Other elements mentioned that would be beneficial for this community-led approach included increasing the "sense of belonging" or **ownership** of the community towards the system (Q18), increasing the level of **awareness** with respect to the importance of proper waste handling (Q27), the **user-friendliness** of the system, and to consider **behaviors** that may facilitate or impede possible projects, such as a preference for familiar approaches (Q20, statement 18).

Factor 4-F4

Community installed and maintained; Ownership; Widespread community and environmental health; Socialization and collaboration

Seven respondents loaded significantly to the last group of the 4-Factor solution. Factor 4-F4 explains 10% of the variance in the study. This factor is heavily composed by community members (see FIGURE 16C), including four community respondents from Malang and two from Surabaya. Similarly to 4-F3, this group omits any specialist from Surabaya. Nonetheless, it does characterize the perspective of one of the Malang academics. Although all five of the Malang respondents in this factor were originally included in 3-F3, the two Surabaya individuals were initially in different groups. The first respondent became flagged by the addition of a fourth factor, while the second individual changed from 3-F2a in the 3-factor solution to 4-F4, as this new factor explains its viewpoint to a greater extent than 3-F2a. Lastly, this factor is made up mainly of community members from the two highest age ranges, as seen in FIGURE 16D, including four of the oldest respondents initially placed in 3-F3.

This group gives the utmost importance to **prior socialization** and for the system to be **community-maintained**. This group also believes that the system should be able to be operated and installed by them, although they believe less strongly about their responsibility with the latter:

5	Community members should understand how the system / solution works before it is put in the community.	4*
30	**Maintenance** should be done by community members.	4**
28	Members of the community should **install and commission** the treatment system.	3
29	Members of the community should **operate** the treatment system.	1

Similarly to 4-F1 and 4-F3, this group regards the **involvement of external** entities in phases such as installation and operation as unimportant. Nonetheless, it is the only group that labelled the **availability of external support** as one of the most important criteria from the set, showing that they find **collaboration** to be of great importance. On the other hand, this group is the only one that sees having a **vandalism-proof** system as unnecessary, probably because a higher sense of **responsibility** from the community can lead to greater **ownership** and more care towards it:

12	An external organization / person should operate the treatment system.	-3
13	An external organization / person should **install and commission** the treatment system.	-2
33	There should be external support after implementation for monitoring / maintenance.	2
27	It should be sturdy and hard to vandalize.	-4**

This group also gives great priority to providing a solution that can **benefit multiple households**, giving some importance to a **quick implementation**. On the other hand, it gives less importance to criteria such as **low energy and maintenance** requirements, indicates that it is not a problem if changes in **household infrastructure** are needed, and lists a low **land footprint** as least important. This shows that the group would be accepting or more flexible with respect to these criteria, which may make implementation and daily operation slightly more challenging, as long as the system can benefit a larger portion of the community. This is also the case with elements related to **costs and budget** availability, which evoke a more neutral response in comparison with the other items in the set:

25	System should treat domestic wastewater from a large number of households (50+).	3**
17	It should be quick to build / implement.	1
15	It should require little maintenance to operate.	-1
19	It should have low energy requirements.	-3**
31	It should not require changes in infrastructure at **household level**.	-3
24	It should take up little space.	-4
8	The initial investment should be low.	-1**
9	Maintenance should be cheap.	-1**
11	Subsidies should be available for the solution / technology.	0

Lastly, the factor gives great importance to items related to **environmental benefits**, showing that they value environmental health as well as widespread **community wellbeing**:

6	It should minimize discharge of pollutants into the river.	2
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2

When it comes to the arguments provided by the respondents assigned to this last factor, there seems to be a strong preference for practices that promote community empowerment and ownership over implemented systems. Their **involvement** throughout the whole project's lifetime is therefore seen as paramount for its success, so aspects such as prior **socialization** (Q5, Q14), and the implementation of **simple**, **community-friendly** technologies were mentioned in the follow-up interviews (Q32, Q36). Respondents also mentioned the importance of **awareness** and of promoting a **change of mindset** among the community to incentivize community support for the implementation and long-term successful maintenance of WWT projects (Q21). When it comes to the economic criteria, which received a more neutral score in this factor, three respondents did mention the importance of the government providing **funding**, and the selected solution being **budget friendly** due to this available budget being limited (Q22, Q32). Q11 did specify however that although monetary concerns are important, the success of a project cannot rely only on budget, mentioning the importance of **community empowerment** and **support for maintenance** when discussing her high score for statement 33 addressing the presence of external support after implementation.

5.2 Respondent Flow Between Solutions

As discussed in CHAPTER 4, the interpretation of most respondent's views appears to remain stable when changing from a 3- to a 4-Factor solution, with just a few changes taking place in the composition of each group. Although few, these changes help consolidate the viewpoints presented in the 3-Factor solution, since the respondents that were reassigned to a different group were either relocated to a factor that represented them better, or because they became confounded once a new perspective arose from the factor analysis stage (becoming unflagged). Because there was stability with the composition of the factors in the 3-Factor solution, adding the fourth group allowed to explore the third factor (3-F3) in more detail to find underlying points of view that may have guided the respondents' sorting. As seen in TABLE 8 once again, the participants seem to be distributed almost in half between Factor 3 and 4 from the 4-Factor solution, with only one participant becoming unflagged. What is even more interesting, is that the addition of a fourth factor seems to generate space for the subjectivities of 3 of the previously unflagged participants to be embraced and described.

When it comes to the change in composition for Factor 1 between the two solutions, 3-F1 remained unchanged except for Q33, which became confounded between 4-F1 and 4-F4, which shows indeed a higher representation of Malang community members (fitting this respondent's profile). With this change, 4-F1 became a specialist-only factor. The statement regarding the system being provided by a local (1:-2) lost one point in importance and switched positions with the provision of multiple services (10:-3). Ease of waste disposal (7:0) lost one point in importance and switched positions with minimal human intervention (16:-1). Lastly, needing household changes (31:-1) dropped one point and switched positions with neighbouring success (18:-2). These changes however did not alter the core characteristics of Factor 1.

In the case of the second factor, Q25 (previously unflagged) replaced Q30, a respondent with a similar profile but slightly older. This did not change the main demographic characteristic of this group, which was the absence of academics and community members from Malang. The statement regarding the system being provided by a local (1:-1) lost one point in importance and switched positions with not attracting pests (4:-2). Low initial investment (8:-2) lost one point in importance and switched positions with defining a management structure (34:-3). Lastly, prior community understanding (5:3) dropped one point and switched positions with low maintenance (15:2). These changes however did not alter the core characteristics of Factor 1. The increase in the scores from statement 15 reflects the preference for community-led, user-friendly solutions that was reflected by Factor 2a in the 3-Factor solution as well and strengthens this position.

Lastly, the addition of Factor 4-F4 made a clear division between the respondents originally attributed to 3-F3. The community members from Surabaya and the government workers from Malang all went to 4-F3. Additionally, Q29 (also a community member from Surabaya which was unflagged before), was grouped under 4-F3. On the other hand, all community members and academics from Malang, with the exception of Q13 (who became confounded and therefore unflagged in the 4-Factor solution), initially present in 3-F3 were regrouped into 4-F4. Interestingly however, Q30 (initially from 3-F2a) and Q11 (previously unflagged) were reassigned to 4-F4. Both respondents in this case are community members from Surabaya, but slightly older than those grouped in 4-F3.

6. Discussion & Conclusions

6.1 Stakeholder-Factor Alignment

Considering the stability observed in the 3-Factor solution, the small number of differences observed between the 3- and 4-Factor solutions, and the additional dimension that the addition of a fourth factor provides for the respondents in group 3-F3, it was chosen to proceed with the 4-Factor solution in the discussion. Furthermore, the small changes in the composition of the factors once the fourth group was added contributed to the groupings showing even better alignment between the characteristics of the respondents in each group. Although a few patterns can be observed between the age and gender distribution amongst the factors in both solutions, these can be explained by the characteristics of the sample. Therefore, these demographic variables do not provide an explanatory value to the formation of the groups.

On the other hand, location and affiliation of the respondents proved to have a much stronger relation to the grouping of the flagged respondents. In this respect, the results of the Q-sorting analysis do show some stakeholder alignment with the points of view encountered, namely that of specialists of both cities with the perspective exposed in Factor 1, complete absence of Surabaya specialists in groups 4-F3 and 4-F4, absence of academics in group 4-F3, and complete alignment of the flagged Malang community members with factor 4-F4. Surabaya community members appeared to have more varied points of view than their Malang counterparts, being present in all factors except 4-F1 (which was notably specialist-only in this factor solution). When it comes to the grouping of government workers from both cities, a similar phenomenon can be observed, but in the opposite way. While all Surabaya government workers that were flagged were grouped under 4-F1, the Malang government officials were distributed among 4-F2a and 4-F3, showing greater similarity in the perspectives of Surabaya government workers. The following table summarizes the presence of the different categories of respondents among the four factors:

Table 13. Summary of the distribution of respondents over the factors by type and location (S = Surabaya; M = Malang)

	Factor 1	**Factor 2a**	**Factor 3**	**Factor 4**
Government	S	M	M	-
Academia	SM	S	-	M
Business	S-	-	-	-
Community	-	S	S	SM

It is important nonetheless to acknowledge one of the main limitations of Q-methodology: it does not claim to explain the viewpoints of the larger population. Therefore, the factors found should not be generalized to the greater population. These findings however do show strong indication that Surabaya government workers tend to prioritize similar criteria, that Malang community members think more similarly than their Surabaya counterparts, and that if a respondent prioritizes the elements describing the 4-F1 perspective (*Basic current needs; Long-term sustainability; Socialization and collaboration; High awareness; Economically conscious*) then they are likely to be some type of specialist.

6.2 Factors and Prominent Criteria

Major themes were identified while engaging with most of the respondents, regardless of their demographic characteristics, based on the justifications they provided for their sorts. These were therefore also reflected on the extracted factors, as presented in the FACTOR INTERPRETATION SECTION. These were mainly concerned with the **participatory aspect** of the wastewater treatment projects, elements relevant to the **maintenance** of the systems after implementation, and criteria related to the **financing** of the system. These aspects were of concern for different reasons but were perceived as vital for the long-term sustainability of a system. This comes to no surprise, considering that they were some of the main causes for WWTP failure in Indonesia (Eales et al., 2013; Harahap et al., 2021; Kerstens et al., 2012; Widyarani et al., 2021), as explained in SECTION1.2.

Although all factors discuss the role of community, 4-F1 looked at it from a more practical perspective focused on facilitating logistics by to reducing the overall costs of the project and lending a hand to government agencies. All other factors, which are made up of over 50% community members each, address the role of community based more on the

education, empowerment, and ownership value that it brings to the community. In this sense, although 4-F1 has a different motivation than the rest, all groups seem to agree on the importance of this criterion. It is important to note however, that 4-F1 was the only statement that ranked statements related to this topic as items of low importance, even though respondent interviews showed differently. This could very well be linked to a divergence in understanding regarding the concept of "community involvement". The different factor scores for statements covering the roles of community and external entities also showcase this discrepancy in the expected level of participation and distribution of responsibilities.

Table 14. Summary of the expected level of community responsibilities explained by each factor for different system lifecycle stages (C= high responsibility; c = low responsibility; ~ = moderate position).

	Factor 1	Factor 2a	Factor 3	Factor 4
Installation	c	c	c	C
Operation	c	c	C	c
Maintenance	c	c	C	C
Ext. Support	~		~	Yes

Maintenance proved to be of concern mainly due to the availability (or lack thereof) of funding and budget for maintenance purposes, proving the OPEX of the system to be of great importance as well for all. The element of a low availability of capacitated human resource however was not mentioned by that many respondents, even though it is a challenge recognized by the PUPR (2022) and Harahap et al. (2021).

Lastly, as shown on TABLE A23, statements addressing economic criteria show some of the highest levels of disagreement among the four factors. This was surprising considering the income levels of the selected communities. Nonetheless, the scores and reflections provided by the respondents with regards to the "funding availability statement" (#11) also demonstrates the different meanings that respondents can attribute to the provided items and shows the importance of thorough follow-up conversations to clarify such confusions.

Such differences observed shine a light on some questions that may be asked when engaging with the communities and planning a sanitation intervention, addressing topics such as willingness to build the required infrastructure; willingness to operate and maintain the system; views on roles of government and community with respect to sanitation and wastewater treatment responsibilities; users' willingness to pay for interventions.

6.3 Implications for Design

Upon observing Table A23 it can be observed that a greater level of disagreement exists among respondents for statements related to economic and technical criteria, while social and environmental elements appear to have a greater level of commonality among respondents. The greatest discrepancy appears to be with respect to statement #9 ("Maintenance should be cheap."), with factors 4-F1 and 4-F2a (both with a significant representation of specialists) giving it the utmost importance (+4) and factors 4-F3 and 4-F4 (with higher community representation) having a more neutral position (-1). The treatment capacity of the system (#25) seems to also be an area of dispute, showing a difference in scoring form -3 by the specialist-heavy factor 4-F1 (wanting to focus on a smaller number of households), and +3 from 4-F4 (mostly Malang community). Statements with a high consensus level do not mean that there is agreement about them being important however, so it is important to note the score that the groups attributed to the item. Statement #22 (addressing greywater handling) for example, had the greatest level of consensus and showed a shared view for its importance (scores between (+1 and +2). Statement #17 (quick implementation) on the other hand, was the technical statement with the greatest level of agreement but shows consensus around a feeling of neutrality. Statement #5 (prior socialization) was the social item with greatest level of agreement, having a high level of importance (+2 to +4).

These associations between the levels of consensus or disagreement, and the neutrality, positive, or negative positions presented by the provided scores could probably be used in conjunction to decide what elements need further research due to the conflict among stakeholders that the scores may show, what items show a level of overall importance independently of the factor, and which are not viewed as important by the different groups. Nonetheless,

although some associations can be made in this manner between levels of importance attributed in the scores and level of agreement amongst groups, this does not indicate that this relationship can be explained fully based on the knowledge gained from this research. It would be valuable to explore this further to see how that information could be used in the design and implementation process, and if this understanding could indeed lead to save time, money, and/or resources in DEWATS projects.

Lastly, it is important to recognize another limitation from Q: the comprehensiveness of the results depend on the completeness of the concourse in order to develop an all-inclusive Q-set. There is great complexity and multi-dimensionality that should be addressed to construct a list of criteria that covers all bases of what should be a sustainable sanitation solution (Spuhler & Lüthi, 2020). Although the Q-set attempts to cover as wide a range of criteria as possible, it is impossible for it to be truly comprehensive. This is why additional question number 1 in the follow-up questionnaire is of great importance to keep contributing to the concourse and expanding it. Through Q-methodology and the interviews performed, the additional criteria "Stakeholder attitude/disposition" and "Gender Dynamics" were found. “Gender dynamics” were mentioned by two academics (respondents 6 and 5) belonging to factors 4-F1 and 4-F2a respectively. "Stakeholder attitude/disposition" on the other hand, was mentioned by six respondents from groups 4-F1 (#6), 4-F2a (#19), and most notably 4-F3 (#18, 20 and 24). Three out of these respondents are also Malang government workers (#18, 19 and 20). These two additional items were not in the reduced set of criteria used for the research, but them arising from various subject responses shows the importance of including them in the design and decision-making process. The "attitude and disposition" additional criterion was concluded from statements by respondents given while justifying their Q-sort rankings. It includes aspects like behaviour, mindset, habits, interest, and commitment to the system. This element can be very individualistic, but may present a significant challenge to broad acceptance, adoption and sustained use of a new system. On the other hand, including “gender dynamics” within the criteria was particularly important in bringing a voice to women who are typically more involved with household sanitation and child health, but historically lacking representation in decision-making processes.

6.4 Recommendations

As with any research, areas of improvement and follow-up questions arose throughout the process. This section thus offers recommendations aimed at refining the application of Q in studies of similar nature, as well as outlining potential paths for future research stemming from this investigation.

Method Improvement

Upon completion of the fieldwork, a few but important areas of possible improvement arose that would benefit both the application of Q-methodology for this type of investigation and the outcomes of the research as a whole. These are:

- The set was first used by some of the specialists, who stated that the translation was slightly hard to understand and that they should be simplified further for community members. Nonetheless, when talking to community members, most seemed to have no problem with the statements and, if they did, it could be resolved with a simple mid-exercise explanation. It could be useful to get feedback for the set, and from the translated version, from people with different backgrounds who speak both English and Bahasa to make sure that the meaning of the statements is not lost in translation and that they can be understood by people from multiple educational level, field of work, and ages.
- Considering the importance of respondents providing their own opinion in this methodology, it would be beneficial to perform the Q-sorts in private whenever possible or with few other people present in order to give privacy to respondents to express their points of view without external pressures or influences.
- While all respondents were enthusiastic to participate in the survey, in a few cases this excitement led to the participant being eager to respond based on *what they thought that the researcher wanted to hear* in their responses, or in trying to *say the right thing*. It is important to identify this behavior during the exercise, and make sure that participants know and understand that the exercise is to look at what **they** consider important. Therefore, it is worthwhile to mention while explaining the exercise that there are no such things as right or wrong responses in Q-methodology, as long as the sorting is done consciously and thoughtfully.

- Accessibility proved to be of great importance, since reading the cards was challenging for some respondents. This was mostly the case with more elderly respondents, who expressed that it would be better if the font size was bigger. This obstacle was overcome by having one of the translators assist any respondents struggling with reading the cards, helping them read statements if they found it difficult. This proved the importance of having an additional translator or research assistant to help with unforeseen circumstances during the Q-sort exercise, especially when doing the Q-sort with two respondents at once.
- Statements including a negative, as is the case with statements 4 and 31, should be omitted or ideally rephrased to avoid confusion among respondents and facilitate interpretation, since they would lead to a double negative when given a negative score.
- Items including an "or" or "and", like statements 4 and 27, should be avoided or reconsidered as they give room for ambiguity in the interpretation from both the respondent's and the researcher's sides. Ideally, such statements could be rephrased or divided in as many additional items as needed so each targets a single element. These statements, however, gave room for interesting discussions depending on which element from the card the respondents chose to focus on. Nonetheless, this does not imply that statements without "and/or" don't give room to multiple interpretations of a single phrase or word, since many responses in this study showed that similar terms may have different meanings for different individuals.
- If the method is to be used for the selection of designs and a more thorough ranking of design criteria, it would be worthwhile to use a more extensive set of statements in order to provide one statement per criterion and be able to make a direct translation between the two dimensions. Alternatively, the criteria themselves could take the place of the items in the Q-set, allowing the respondents to make a direct comparison between them. This, however, brings two important challenges. First, the design criteria are likely to include terminology that may be too technical for the desired audience, unless the P-set is composed solely of experts in the field. In that case additional documentation would be required providing an explanation of each term and maybe even examples for the respondents from the general public to allow for a more conscious sort. A constant need for explanation of the terminology could be detrimental to the development of the exercise though, as it would become lengthier (therefore requiring a greater availability from both the respondents and the researchers, and hence would become a more tedious experience for the sorter. Second, this approach would increase the number of items in the exercise substantially, making the exercise both more tedious and complex for respondents. Therefore, such an approach should be tested in advance in order to identify useful surveying techniques (e.g. further pre-sorting steps or completion throughout multiple sessions) that would allow respondents to complete the exercise mindfully and successfully.

Future Research

Considering the limitations and scope of this study, as well as additional questions that arose from the fieldwork activities, numerous themes are worth exploring in greater depth through future research. Below are several potential routes for further research that could extend from this investigation.

- The communities in which the Q-sorts were conducted are both recipients of the National ProKlim Village Award (Penghargaan Kampung ProKlim Tingkat Nasional). Hence, they both count with a significantly higher level of awareness and understanding with respect to sanitation, environmental protection, and community health than the average neighbourhood, due to their explicit commitment to becoming more environmentally friendly and turning their community into a "model kampung" for sustainable neighbourhoods.
  This however is not the norm in every neighbourhood in Surabaya, Malang, or Indonesia in general. It can therefore be safely assumed that the overall level of environmental and WASH awareness is significantly lower in low-income communities which are not engaged with these initiatives or with climate resilience programs. Therefore, it would be worthwhile to perform a similar study, but including community members from communities which are in greater need for sanitation solutions, have a lower level of knowledge about wastewater treatment, and/or lack interest in implementing solutions. Such a study would not only be more inclusive of the possible views of average low-income riverside communities, but it would also allow for comparison between the findings in both cases and identifications of common themes or key differences between what different communities believe to be of importance.

The PUPR has identified some neighbourhoods of concern in which sanitation and wastewater treatment is necessary, so these areas of interest could be a place to start to select and approach a possible community. Nonetheless, interest from the PUPR does not guarantee access to respondents from the desired kampung, so it is important to establish communication with community leaders in a timely manner. It is vital to obtain their permission to perform the research in their community, as this can facilitate access to respondents and lead to a more amicable and transparent interaction between the researchers and the respondents.

- An analogous study, centred on stakeholders' perspectives regarding the allocation of responsibilities throughout the lifespan of wastewater treatment systems, could offer valuable insight into stakeholder dynamics in sanitation interventions. This is prompted by the observed discrepancy in the expected level of involvement that stakeholders expected from each other during the different phases of a DEWATS lifecycle.
- Since Q-methodology does not pretend to create generalizations of the points of view uncovered, it could be fascinating to perform a widespread survey to determine to what extent the points of view found characterize what stakeholders along the Brantas think. This could start at a smaller scale, surveying members of the communities where the Q-sorts were first collected, to get a first idea of the generalizability of the findings.
- Considering that design specifications and in-depth study of existing interventions were beyond the scope of the research, specific implications for design implementation or design modifications should be explored further upon making a more direct link between the points of view discovered and the criteria gathered (maybe through one of the changes proposed in the METHOD IMPROVEMENT section above). This way, the integration of the social and technical aspects of DEWATS using this methodology could be explored beyond just the "need identification" and "ideation" phases of the design process (Liedtka, 2015), allowing for a deeper, less-speculative investigation about the utility of Q-methodology in the field of DEWATS design.
- It would be worthwhile to explore the economic impact of investing in sanitation and wastewater treatment infrastructure, education, and policy development in the region. Such study could showcase how valuable sanitation and proper domestic wastewater management is for regions undergoing development and rapid growth, which could promote further government interventions and increase budget allocation towards sanitation. Such a study could delve into aspects such as:
    - The disease burden of improper wastewater management
    - Effects of river pollution from domestic wastewater on community and environmental health
    - Increase in the cost of water supply costs from high contamination from domestic wastewater into main water sources (Firdayati et al., 2015) (such as the lower Brantas in the case of Kota Surabaya)
    - Link to the production of solid waste (mainly single use plastics like water bottles), and its cost of collection, handling, and processing due to tap water not reaching drinking water standards in many Indonesian cities

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Appendices

Appendix 1. Standard analytical process in Q-methodology

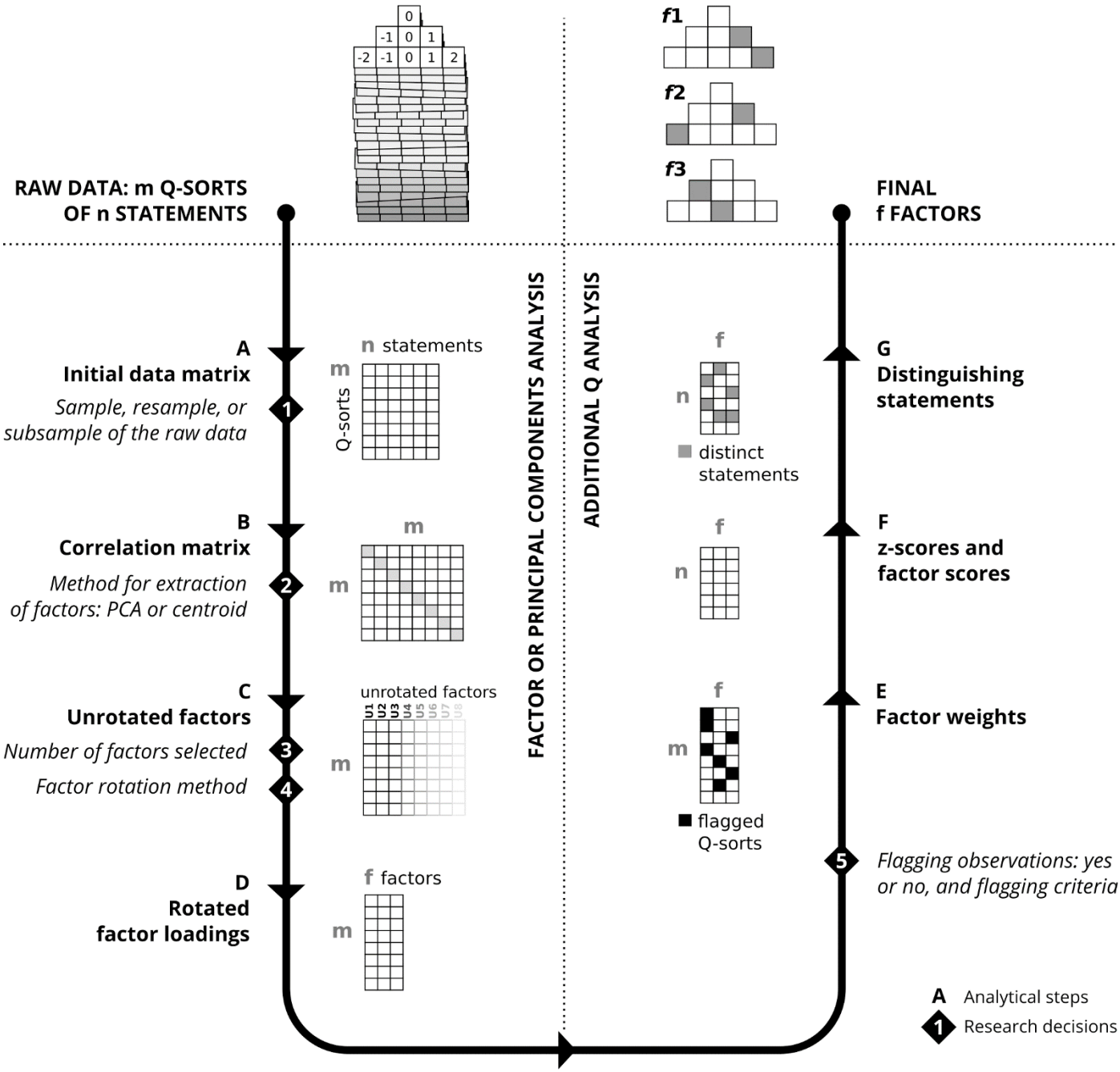


Figure A1. Q-methodology step-by-step analytical process (Zabala & Pascual, 2016).

Appendix 2. Q-set used for the method testing

Table A1. Initial Q-set statements divided according to SHEET criteria.

Criteria Type	Stat. #	Statement
Safety	1	I want a technology that has been successful in nearby communities
	2	There should be external support after implementation
	3	I find it important that the system is hard to vandalize or steal
Health	4	I am happy with how domestic wastewater is currently handled and treated in my community.
	5	I want a technology that minimizes the exposure we have to our domestic wastewater
Environmental	6	Desludging does not impact my capacity to use my preferred/available sanitation facility.
	7	I want to protect the environment
	8	The solution should have a low footprint
	9	I want minimal discharge of pollutants into the river.
Economy	10	I prefer to pay more to have additional technical assistance for the operation and maintenance from external organizations or persons.
	11	I prefer to pay less and have the community handle the operation and maintenance of the treatment system.
	12	I wouldn't want to invest if I needed to do infrastructure changes in my own household.
	13	I want it to be cheap to maintain the technology.
	14	I don't mind contributing financially to pay the electricity/fuel to keep the technology working.
	15	I want overall affordable costs.
	16	I would prefer a subsidized solution/technology
Technical	17	I prefer a solution that works with little to no human intervention.
	18	I'm interested in understanding how the technology/system works before it is put in my community
	19	I prefer a simple technology (low-tech, easy to understand)
	20	I prefer a technology that can treat domestic wastewater from a large number of households (50+).
	21	I prefer a more expensive technology but that treats the wastewater to higher quality standards before discharging it.
	22	I prefer a solution that only focuses on treating the wastewater.
	23	I prefer a solution that provides multiple benefits to my community (community sanitation + treatment, energy production...)
	24	The system should be quick to build/implement
	25	I want a technology that provides the possibility of water reuse from wastewater.
	26	Replacement parts should be found in the country
Social	27	An external organization or person must be in charge of installing and commissioning of the treatment system.
	28	Some members of the community could have job positions by being involved in the installation and commissioning of the treatment system.
	29	The system/solution should be aesthetically appealing.
	30	An external organization or person must be in charge of operating the treatment system.
	31	Some members of the community could have job positions by being involved in the operation of the treatment system.
	32	I would prefer a person/association from my own country to provide my community with the wastewater treatment system.
	33	We have other more urgent issues to address in the community before the treatment of our domestic wastewater.
	34	There should be a clear management structure defined before implementation.

Appendix 3. Reduced list of identified criteria

Table A2. Reduced list of design criteria identified through the literature review along with the method by which they could be explored further during the research.

Category	Criterion	Method					Reference
		Q	Interview	Field Observation	Literature	Data	
Social / Institutional	Cultural Alignment	X	X	X	X		Akhoundi & Nazif, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2018 Kaminsky et al, 2013
	Community Health	X	X		X	X	Akhoundi & Nazif, 2018
	Nuisance	X	X	X	X		Akhoundi & Nazif, 2018 Bernal, 2018 Cossio et al., 2020 Massoud et al., 2009 Salamirad et al., 2021
	Ease of Use	X			X		Garrido-Baserba et al., 2018 Kaminsky et al., 2013 Massoud et al., 2009
	Job creation	X			X		Akhoundi & Nazif, 2018 Cossio et al., 2020
	Policy alignment		X	X	X		Bernal, 2018 Garcia et al., 2022 Garrido-Baserba et al., 2014 Kaminsky et al., 2013 Salamirad et al., 2021 W&B, n.d.
	Collaboration	X	X		X		Bernal, 2018 Cossio et al., 2020 Garcia et al., 2022 Kaminsky et al., 2013
	Institutional capacity / Management structure	X	X				Cossio et al., 2020
	Reuse potential / acceptance	X	X		X		Akhoundi & Nazif, 2018 Bernal, 2018 Cossio et al., 2020 Garcia et al., 2022 Garrido-Baserba et al., 2018
	Community participation	X	X		X		Bernal, 2018 Cossio et al., 2020 Kaminsky et al., 2013 Massoud et al., 2009
	Public awareness	X	X	X			Cossio et al., 2020 Kaminsky et al., 2013 Massoud et al., 2009
Environmental	Environmentally friendly	X			X	X	Akhoundi & Nazif, 2018 Bảo et al., 2012 Salamirad et al., 2021
	Toxicity of products		X	X	X	X	Akhoundi & Nazif, 2018 Bảo et al., 2012 Bernal, 2018 Garrido-Baserba et al., 2014

							Kaminsky et al., 2013 Salamirad et al., 2021
	Wastewater produced			X	X	X	Akhoundi & Nazif, 2018 Bảo et al., 2012 Garrido-Baserba et al., 2014 Massoud et al., 2009 Salamirad et al., 2021
	Geographical limitations		X	X	X		Bernal, 2018 Garrido-Baserba et al., 2014 Kaminsky et al., 2013 Massoud et al., 2009 Salamirad et al., 2021 W&B, n.d.
	Product disposal	X	X	X	X		Akhoundi & Nazif, 2018 Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2014 Massoud et al., 2009 Salamirad et al., 2021 W&B, n.d.
	Water use				X		Bảo et al., 2012 Garrido-Baserba et al., 2018
Economic	Capital expenditure (CAPEX)	X			X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2014 Garrido-Baserba et al., 2018 Kaminsky et al., 2013 Massoud et al., 2009 Salamirad et al., 2021
	Operational expenditure (OPEX)	X			X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2018 Kaminsky et al., 2013 Massoud et al., 2009 Salamirad et al., 2021
	Income potential / Cost effectiveness	X			X		Cossio et al., 2020 Garrido-Baserba et al., 2018 Massoud et al., 2009
	Availability of funding / subsidies	X			X	X	Cossio et al., 2020 Kaminsky et al., 2013 Massoud et al., 2009
Technical	Expertise required	X			X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Cossio et al., 2020 Kaminsky et al., 2013 Massoud et al., 2009 Salamirad et al., 2021 W&B, n.d.
	Sewerage coverage	X	X	X	X	X	Bernal, 2018 Garrido-Baserba et al., 2018

	Complexity	X	X	X	X		Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2018 Massoud et al., 2009
	Low maintenance	X	X		X		Akhoundi & Nazif, 2018 Garrido-Baserba et al., 2018 Massoud et al., 2009 Salamirad et al., 2021 Soedjono et al., 2019
	Reliability	X	X	X	X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Cossio et al., 2020 Massoud et al., 2009
	Adaptability to influent quality		X		X		Bernal, 2018 Garrido-Baserba et al., 2018 Massoud et al., 2009 Garrido-Baserba et al., 2014 Akhoundi & Nazif, 2018
	Centralization level		X	X	X		Bernal, 2018 Massoud et al., 2009 Bảo et al., 2012 Akhoundi & Nazif, 2018
	Climate independency		X		X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Garrido-Baserba et al., 2014 Salamirad et al., 2021
	Energy use	X			X		Garcia et al., 2022 Cossio et al., 2020 Kaminsky et al., 2013 Massoud et al., 2009 Garrido-Baserba et al., 2014 Akhoundi & Nazif, 2018
	Locally available construction resources	X	X		X		Garrido-Baserba et al., 2014 Kaminsky et al., 2013 Massoud et al., 2009 Salamirad et al., 2021
	Product use				X		Garrido-Baserba et al. (2014) Salamirad et al., 2021 Soedjono et al., 2019
	Upgrade potential	X					Akhoundi & Nazif, 2018 Bernal, 2018 Kaminsky et al., 2013 Salamirad et al., 2021
	Removal efficiency	X		X	X		Akhoundi & Nazif, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2014 Massoud et al., 2009 Salamirad et al., 2021 Soedjono et al., 2019
	Resource recovery potential	X			X		Akhoundi & Nazif, 2018 Bảo et al., 2012 Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2014

							Garrido-Baserba et al., 2018 Salamirad et al., 2021
	Surface area	X	X	X	X		Bernal, 2018 Cossio et al., 2020 Garrido-Baserba et al., 2014 Massoud et al., 2009 Salamirad et al., 2021
	Treatment capacity				X		Bernal, 2018 Garrido-Baserba et al., 2014 Kaminsky et al., 2013 Salamirad et al., 2021 W&B, n.d.
	Durability	X			X		Garrido-Baserba et al., 2018 Salamirad et al., 2021

** = Mentioned by respondents in follow-up question

Appendix 4. Q-sort statements by type and associated criteria

Table A3. Statements in the Q-set according to the criteria they allude to and their type.

Type	Criteria	Stat. #	Statement
Social / Institutional	Cultural Alignment	1	It should be provided by a person / association from my own country.
	Community Health	2	It should minimize our exposure to our domestic wastewater.
	Nuisance	3	It should be aesthetically appealing.
	Nuisance; Community Health	4	It should not smell or attract pests.
	Community participation; Public awareness	5	Community members should understand how the system / solution works before it is put in the community.
	Ease of Use	14	It should be simple (low-tech, easy to understand).
	Ease of Use	16	It should work with minimal human intervention.
	Job creation; Policy alignment	28	Members of the community should **install and commission** the treatment system.
	Job creation; Policy alignment	29	Members of the community should **operate** the treatment system.
	Job creation; Policy alignment	30	Community members should maintain the system.
	Collaboration	33	There should be external support after implementation for monitoring / maintenance.
	Institutional capacity / Management structure	34	Management structure should be defined before implementation.
Environmental	Environmental friendly	6	It should minimize discharge of pollutants into the river.
	Geographical limitations; Product disposal; Toxicity of products	7	It should be easy to collect and dispose of the waste products (solids / sludge).
	Environmentally friendly; Wastewater produced; Toxicity of products	21	It should prevent untreated wastewater from **toilets** from reaching the river.
	Environmentally friendly; Wastewater produced; Toxicity of products	22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.
	Resource recovery potential; Water use; Reuse potential / acceptance	23	Treated wastewater should be apt for reuse.
Economic	Capital expenditure (CAPEX)	8	The initial investment should be low.
	Operational expenditure (OPEX)	9	Maintenance should be cheap.
	Income potential / Cost effectiveness	10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)
	Availability of funding / subsidies	11	Subsidies should be available for the solution / technology.

Technical	Expertise required	12	An external organization or person should operate the treatment system.
	Expertise required	13	Installation and commissioning of the treatment should be done by an external organization / person.
	Low maintenance	15	It should require little maintenance to operate.
	Complexity	17	It should be quick to build / implement.
	Reliability	18	It should have been successful in nearby communities.
	Energy use	19	It should have low energy requirements.
	Locally available construction resources	20	Construction / replacement parts should be found in the country.
	Surface area	24	It should have a low spatial footprint (take up little space).
	Centralization level; Treatment capacity	25	System should treat domestic wastewater from a large number of households (50+).
	Upgrade potential	26	It should allow for future expansion or upgrades.
	Durability	27	It should be sturdy and hard to vandalize.
	Sewerage coverage	31	It should not require changes in infrastructure at **household level**.
	Sewerage coverage	32	It should accommodate to existing infrastructure.

Appendix 5. Q-sort statements

Table A4. Q-set in English and Bahasa.

	English	Bahasa Indonesia
Umbrella Question	**Umbrella Question (Community)**	
	"What do you think is most important when a decentralized domestic wastewater treatment system is implemented in **your community**?"	"Menurut Anda apa yang paling penting ketika sistem pengolahan air limbah domestik yang terdesentralisasi diterapkan di **komunitas Anda**?"
	Umbrella Question (Specialists)	
	"What do you think is most important when a decentralized domestic wastewater treatment system is implemented in **a community**?" **Context:** Dense, urban, low-middle income, riverside community	"Menurut Anda, apa yang paling penting ketika sistem pengolahan air limbah domestik yang terdesentralisasi diterapkan **di masyarakat**?" **Konteks:** Masyarakat padat, perkotaan, berpenghasilan menengah ke bawah, tepi sungai
#	**Statements**	
1	It should be provided by a person / association from my own country.	Itu harus disediakan oleh seseorang / asosiasi dari negara saya sendiri.
2	It should minimize our exposure to our domestic wastewater.	Ini harus meminimalkan paparan kita terhadap air limbah domestik kita.
3	It should be aesthetically appealing.	Itu harus menarik secara estetika.
4	It should not smell or attract pests.	Seharusnya tidak mencium atau menarik hama.
5	Community members should understand how the system / solution works before it is put in the community.	Anggota masyarakat harus memahami bagaimana sistem/solusinya bekerja sebelum diterapkan di komunitas.
6	It should minimize discharge of pollutants into the river.	Ini harus meminimalkan pembuangan polutan ke sungai.
7	It should be easy to collect and dispose of the waste products (solids / sludge).	Seharusnya mudah untuk mengumpulkan dan membuang produk limbah (padatan / lumpur).
8	The initial investment should be low.	Investasi awal harus rendah.
9	Maintenance should be cheap.	Biaya perawatan harus murah.
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	Ini harus memberikan banyak layanan kepada komunitas saya (sanitasi masyarakat, pengolahan air limbah, energi dan produksi biogas ...)
11	Subsidies should be available for the solution / technology.	Subsidi harus tersedia untuk solusi / teknologi.
12	An external organization / person should operate the treatment system.	Organisasi / orang eksternal harus mengoperasikan sistem.
13	An external organization / person should **install and commission** the treatment system.	Organisasi / orang eksternal harus menginstal dan menugaskan sistem.
14	It should be simple (low-tech, easy to understand).	Itu harus sederhana (teknologi rendah, mudah dimengerti).
15	It should require little maintenance to operate.	Seharusnya membutuhkan sedikit perawatan untuk beroperasi.
16	It should work with minimal human intervention.	Ini harus bekerja dengan intervensi manusia minimal.
17	It should be quick to build / implement.	Itu harus cepat untuk membangun / mengimplementasikan.
18	It should have been successful in nearby communities.	Seharusnya berhasil di komunitas terdekat.
19	It should have low energy requirements.	Itu harus memiliki kebutuhan energi yang rendah.
20	Construction / replacement parts should be found in the country.	Konstruksi / suku cadang harus ditemukan di negara ini.

21	It should prevent untreated wastewater from **toilets** from reaching the river.	Ini harus mencegah air limbah yang tidak diolah dari **toilet** mencapai sungai.
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	Ini harus mencegah air limbah **dapur / cucian** yang tidak diolah mencapai sungai.
23	Treated wastewater should be apt for reuse.	Air limbah yang diolah harus tepat untuk digunakan kembali.
24	It should take up little space.	Seharusnya memakan sedikit ruang.
25	System should treat domestic wastewater from a large number of households (50+).	Sistem harus mengolah air limbah domestik dari sejumlah besar rumah tangga (50+).
26	It should allow for future expansion or upgrades.	Ini harus memungkinkan ekspansi atau peningkatan di masa mendatang.
27	It should be sturdy and hard to vandalize.	Itu harus kokoh dan sulit untuk dirusak.
28	Members of the community should **install and commission** the treatment system.	Anggota masyarakat harus **memasang** dan **mengkomisikan** sistem pengolahan.
29	Members of the community should **operate** the treatment system.	Anggota masyarakat harus **mengoperasikan** sistem pengolahan.
30	**Maintenance** should be done by community members.	**Pemeliharaan** harus dilakukan oleh anggota masyarakat.
31	It should not require changes in infrastructure at **household level**.	Seharusnya tidak memerlukan perubahan infrastruktur di **tingkat rumah tangga**.
32	It should accommodate to existing infrastructure.	Harus menyesuaikan dengan infrastruktur yang sudah ada.
33	There should be external support after implementation for monitoring / maintenance.	Harus ada dukungan eksternal setelah implementasi untuk pemantauan / pemeliharaan.
34	Management structure should be defined before implementation.	Struktur manajemen harus didefinisikan sebelum implementasi.

Appendix 6. Participation letter for respondents

English version

Dear participant,

You are being invited to participate in a research study titled "Exploring stakeholder priorities regarding DEWATS in the Brantas river basin". This study is being done by Valeria Martinez Rodriguez from the TU Delft and is part of the Brantas Water Quality Footprint project from the TU Delft.

Research Purpose
The purpose of this research study is to explore the perspectives and priorities of different stakeholders to identify criteria and challenges for the implementation of decentralized wastewater treatment systems in the Brantas. It will take you approximately 1.5 hours to complete. We will be asking you to organize a list of 34 statements into three piles (most important, least important, neutral), and then arrange them from most important to least important. The placement of the cards will be written down by the researcher and, a short questionnaire and discussion will follow to give some insight into your response.

Data Usage, Management & Anonymity
The data will be used for an Environmental Engineering Master thesis which will be presented and archived at the Delft University of Technology in the Netherlands. The research will be made publicly available in the TU Delft Academic Repository and could be published in the future if the evaluation committee sees fit. Because responses are anonymous, we believe there are no known risks associated with this research study. Still, your personal identifying information will **never** be made public, and all responses will be anonymized.

To the best of our ability your answers in this study will remain confidential. We will minimize any risks by anonymizing any Personal Data that was collected. You will be provided a participant number which will be associated to your Q-set, so your name will not be associated to your responses in any way. Lastly, data will be stored in secure online project folder from the TU Delft which can only be accessed by the main researchers.

Withdrawal from the study
Your participation in this study is entirely voluntary **and you can withdraw at any time**. You are free to omit any questions. You can request for your Q-sort to not be included in the study up to three (3) days after completed (to give researchers enough time to find a new participant if needed). In case you would like to retract any of the responses given during the follow-up interview (if it took place), this can be done up to one (1) month after the researcher has explained to you how given statements are being reported. Any statements will be incorporated in the final report only after you have agreed to their inclusion.

For questions or comments, please contact:

Valeria Martinez Rodriguez (Principal Investigator)

Bahasa version

Peserta yang terhormat,

Anda diundang untuk berpartisipasi dalam studi penelitian berjudul "Menjelajahi prioritas pemangku kepentingan mengenai DEWATS di DAS Brantas". Studi ini sedang dilakukan oleh Valeria Martinez Rodriguez dari TU Delft dan merupakan bagian dari proyek Brantas Water Quality Footprint dari TU Delft.

Tujuan Penelitian
Tujuan dari studi penelitian ini adalah untuk mengeksplorasi perspektif dan prioritas pemangku kepentingan yang berbeda untuk mengidentifikasi kriteria dan tantangan untuk penerapan sistem pengolahan air limbah terdesentralisasi di Brantas. Ini akan membawa Anda sekitar 1,5 jam untuk menyelesaikannya. Kami akan meminta Anda untuk mengatur daftar 34 pernyataan menjadi tiga tumpukan (paling penting, paling tidak penting, netral), dan kemudian mengaturnya dari yang paling penting hingga yang paling tidak penting. Penempatan kartu akan ditulis oleh peneliti dan, kuesioner singkat dan diskusi akan mengikuti untuk memberikan beberapa wawasan tentang tanggapan Anda.

Penggunaan Data, Manajemen & Anonimitas
Data akan digunakan untuk tesis Master Teknik Lingkungan yang akan dipresentasikan dan diarsipkan di Delft University of Technology di Belanda. Penelitian ini akan tersedia untuk umum di TU Delft Academic Repository dan dapat dipublikasikan di masa depan jika komite evaluasi merasa cocok. Karena tanggapannya anonim, kami yakin tidak ada risiko yang diketahui terkait dengan studi penelitian ini. Namun, informasi identitas pribadi Anda tidak akan **pernah** dipublikasikan, dan semua tanggapan akan dianonimkan.

Untuk yang terbaik dari kemampuan kami, jawaban Anda dalam studi ini akan tetap rahasia. Kami akan meminimalkan risiko apa pun dengan menganonimkan Data Pribadi apa pun yang dikumpulkan. Anda akan diberikan nomor peserta acak yang akan dikaitkan dengan Q-set Anda, sehingga nama Anda tidak akan dikaitkan dengan tanggapan Anda dengan cara apa pun. Terakhir, data akan disimpan dalam folder proyek online yang aman dari TU Delft yang hanya dapat diakses oleh peneliti utama.

Penarikan dari studi
Partisipasi Anda dalam studi ini sepenuhnya sukarela **dan Anda dapat menarik diri kapan saja**. Anda bebas untuk menghilangkan pertanyaan apa pun. Anda dapat meminta Q-sort Anda untuk tidak dimasukkan dalam penelitian hingga tiga (3) hari setelah selesai (untuk memberi peneliti cukup waktu untuk menemukan peserta baru jika diperlukan). Jika Anda ingin menarik kembali salah satu tanggapan yang diberikan selama wawancara tindak lanjut (jika itu terjadi), ini dapat dilakukan hingga satu (1) bulan setelah peneliti menjelaskan kepada Anda bagaimana pernyataan yang diberikan dilaporkan. Setiap pernyataan akan dimasukkan dalam laporan akhir hanya setelah Anda menyetujui penyertaannya.

Untuk pertanyaan atau komentar, silakan hubungi:

Valeria Martinez Rodriguez (Peneliti Utama)

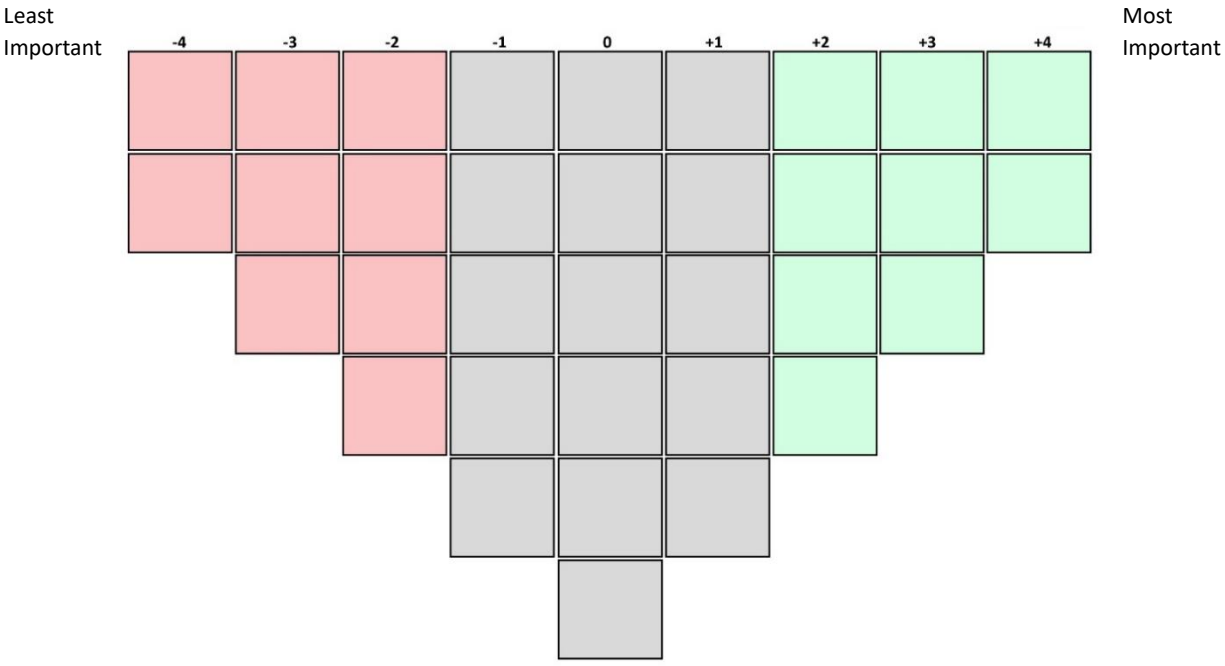
Appendix 7. Example survey score sheet

English version

Survey ID (NNNN): *4-digit date-month of your birth*

Age (TTTT): *Please fill in your year of birth (e.g. 1970)*

Q-Sort Scoresheet:



Q-Sort 2: Please explain why you chose statements that are (+4) and (-4).

	Statement #	Reason
Most Important (+4)		
Most Important (+4)		
Least Important (-4)		
Least Important (-4)		

Survey ID (NNNN): ☐
4-digit date-month of your birth

Age (TTTT): ☐
Please fill in your year of birth (e.g. 1970)

Gender: ☐ Woman ☐ Man

Your Affiliates: ☐ Government ☐ Community ☐ LSM
☐ Industry / business ☐ Academy ☐ Other: _____

Please answer the following questions.

	Yes	No
I interact with the river in work, household, or recreation.	☐	☐
I live near (less than 1 Km) from Brantas river.	☐	☐
I use river water for washing, bathing, cooking, and cleaning.	☐	☐
My family and I were affected by diseases caused by the water of the Brantas river.	☐	☐
I know where the wastewater from my house ends up.	☐	☐
My house is connected to the city's sewage system.	☐	☐

In my opinion, Brantas water quality?

- ☐ Unpolluted
- ☐ Slightly polluted
- ☐ Sometimes polluted
- ☐ Polluted
- ☐ Heavily polluted

In my opinion, Brantas is mainly polluted by:

- ☐ Agriculture
- ☐ Livestock
- ☐ Industry
- ☐ Domestic waste
- ☐ Solid waste (garbage)
- ☐ Other: _____

Where does wastewater go from your home?

- ☐ Community Sanitation Center (CSC)
- ☐ Septic tank at home
- ☐ Community septic tank
- ☐ Connection to the municipal sewage system
- ☐ Other: _____
- ☐ I don't know

0) Any statements that were unclear or confusing?

1) Is there any other factor not presented in the Q-set that you would consider important? ("Create a new item"). Where would you rank it?

2) Additional comments about the domestic wastewater treatment situation in the city? In the Brantas? ("Overall view of the subject matter").

3) Any additional comments?

Bahasa version

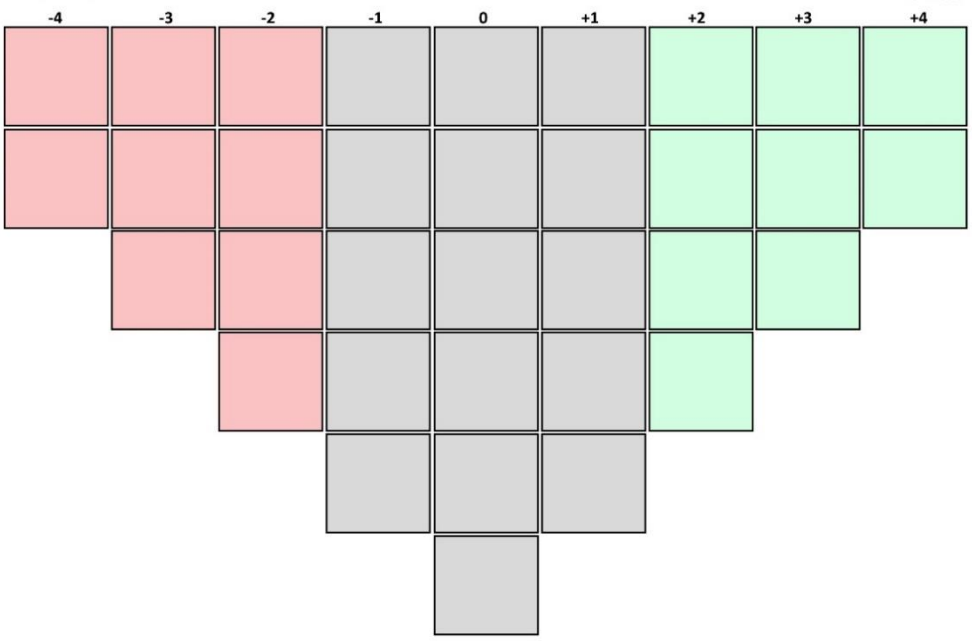
ID Survei (NNNN):
4 digit tanggal-bulan lahir Anda

Umur (TTTT):
Mohon diisi tahun kelahiran Anda (misal. 1970)

Q-Sort Lembar Skor:

Paling tidak penting

Paling penting



Q-Sort 2: Mohon dijelaskan mengapa Anda memilih pernyataan-pernyataan yang (+4) dan (-4).

	Pernyataan #	Alasan
Paling penting (+4)		
Paling penting (+4)		
Paling tidak penting (-4)		
Paling tidak penting (-4)		

ID Survei (NNNN): *4 digit tanggal-bulan lahir Anda* ☐

Umur (TTTT): *Mohon diisi tahun kelahiran Anda (misal. 1970)* ☐

Jenis kelamin: ☐ Perempuan ☐ Laki-laki

Afiliasi Anda: ☐ Pemerintah ☐ Masyarakat ☐ LSM

☐ Industri / bisnis ☐ Akademisi ☐ Lain-lain: _____

Mohon dijawab pertanyaan-pertanyaan berikut.

	Betul	**Tidak**
Saya berinteraksi dengan sungai dalam pekerjaan, rumah tangga, atau rekreasi.	☐	☐
Saya tinggal dekat (kurang dari 1 Km) dari sungai Brantas.	☐	☐
Saya menggunakan air sungai untuk mencuci, mandi, memasak dan bersih-bersih.	☐	☐
Keluarga saya dan saya terkena penyakit yang diakibatkan oleh air sungai Brantas.	☐	☐
Saya tahu di mana air limbah dari rumah saya berakhir.	☐	☐
Rumah saya terhubung ke sistem pembuangan limbah kota.	☐	☐

Menurut pendapat saya, kualitas air Brantas?

- ☐ Tidak tercemar
- ☐ Sedikit tercemar
- ☐ Kadang tercemar
- ☐ Tercemar
- ☐ Sangat tercemar

Menurut pendapat saya, Brantas terutama tercemar oleh:

- ☐ Pertanian
- ☐ Ternak
- ☐ Industri
- ☐ Limbah domestik
- ☐ Limbah padat (sampah)
- ☐ Lainnya: _____

Kemana perginya air limbah dari rumah Anda?

- ☐ Pusat Sanitasi Masyarakat (CSC)
- ☐ Septic tank di rumah
- ☐ Tangki septik komunitas
- ☐ Koneksi ke sistem pembuangan limbah kota
- ☐ Lainnya: _____
- ☐ Saya tidak tahu

0) Apakah ada pernyataan yang tidak jelas atau membingungkan?

1) Apakah ada faktor lain yang tidak disajikan dalam daftar pertanyaan yang Anda anggap penting? ("Buat item baru"). Di mana Anda akan memberi peringkat?

2) Komentar tambahan tentang situasi pengolahan air limbah domestik di kota? Di Brantas? ("Pandangan keseluruhan tentang pokok bahasan").

3) Ada komentar tambahan?

Appendix 8. Q-methodology Miro setup for online respondents

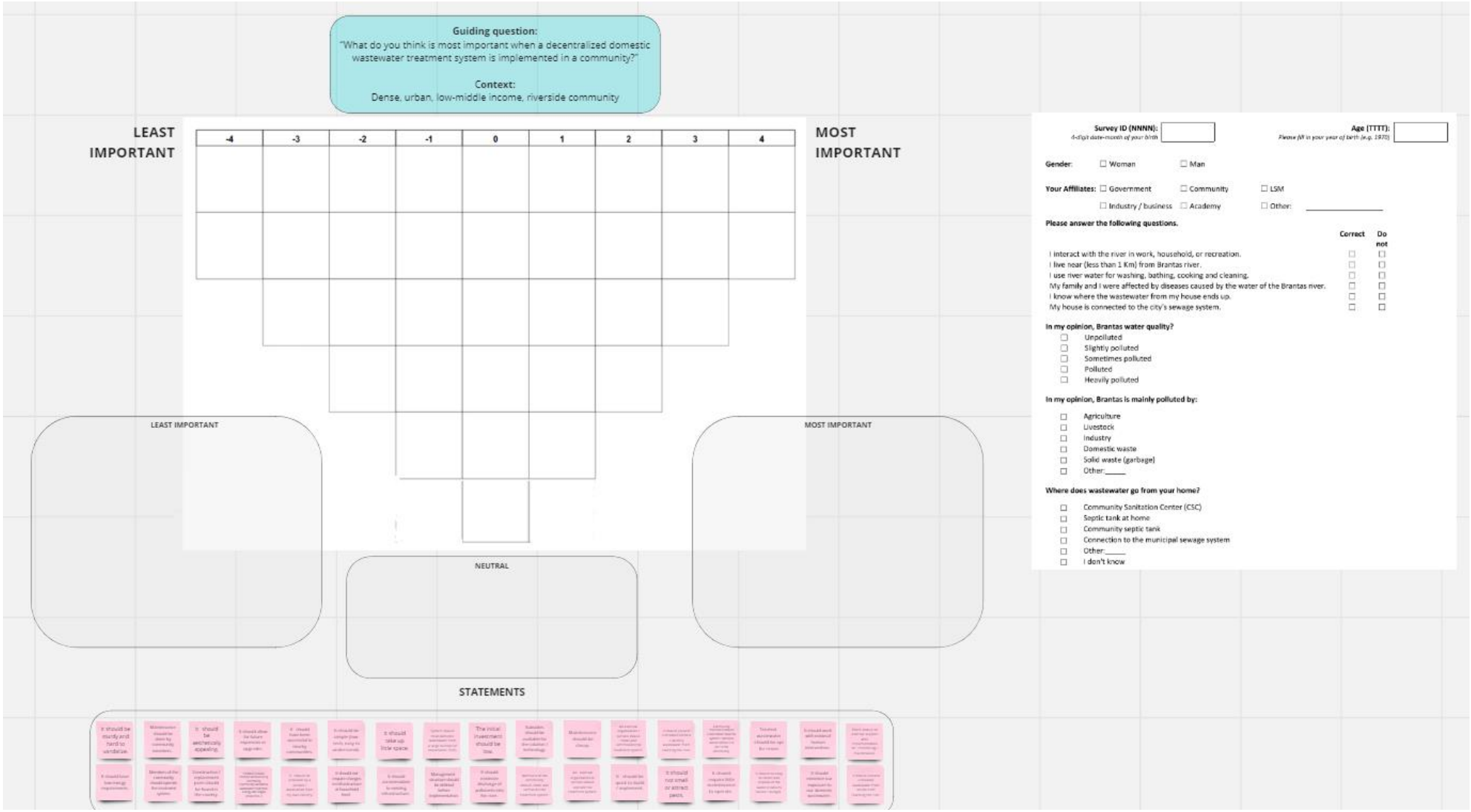


Figure A2. Miro board used for online data collection.

Appendix 9. Q-sorts conducted (raw data)

The following tables include the raw data for each participant's response to the Q-sorting exercise. Each row shows the response from the respective participant, labelled as Q1, Q2, Q3, and so on until Q38. Each column represents a different statement from the Q-set, ranging from s1 until s34. The numbers, ranging from -4 to +4 represent the score that each statement was given per participant according to their placement in the sorting grid.

Table A5. Q-sort responses per statement per participant (part 1/2).

	s 1	s 2	s 3	s 4	s 5	s 6	s 7	s 8	s 9	s 10	s 11	s 12	s 13	s 14	s 15	s 16	s 17	s 18	s 19	s 20	s 21	s 22	s 23	s 24	s 25	s 26	s 27	s 28	s 29	s 30	s 31	s 32	s 33	s 34
Q1	-1	0	1	2	0	1	-1	-2	2	0	3	-3	-1	4	3	-2	-2	-3	2	1	1	2	3	0	-3	-2	-1	0	1	-1	-4	-4	4	0
Q2	1	-3	3	2	2	3	0	-1	2	-1	1	-4	-3	0	0	0	-1	-2	0	-1	4	4	-4	-2	-2	0	1	-3	1	2	-1	-2	3	1
Q3	0	1	-1	-3	1	1	2	-2	-1	0	0	-4	-2	3	3	4	4	-1	1	-1	1	2	-4	-1	0	-2	3	-3	2	0	0	-2	2	-3
Q4	-1	0	-1	2	1	3	-2	2	2	4	1	-2	-1	1	-2	0	1	0	-3	0	4	2	-4	-3	-1	-4	3	-3	-2	-1	0	0	1	3
Q5	0	-3	-2	-1	1	0	2	-1	4	0	2	-2	-1	-3	4	-3	1	-1	0	-4	3	2	0	-1	0	-4	2	3	3	1	1	-2	-2	1
Q6	-2	0	0	2	2	1	0	0	3	-2	-2	-4	-3	3	3	-3	-1	-4	2	-1	4	2	-1	0	-1	-3	-1	0	1	1	4	1	-2	1
Q7	0	0	-4	0	2	1	1	-2	-1	4	3	-2	-2	0	0	-3	-2	-1	-1	-4	1	1	3	-3	1	4	0	2	2	2	-1	-1	3	-3
Q8	-3	3	-4	-1	4	3	1	-2	0	-2	0	-3	-3	2	0	1	-4	-1	0	0	3	1	-1	-2	-1	-1	-2	1	2	2	1	0	2	4
Q9	-4	-2	0	1	2	0	-1	3	1	-1	-3	-3	-2	1	1	-4	3	4	1	4	0	0	0	-1	-2	-3	3	2	2	2	-1	-1	0	-2
Q10	-3	2	-1	1	1	2	-1	4	4	-1	-2	-3	-4	3	3	-1	1	-2	3	-2	2	2	0	0	-3	-1	1	-4	0	0	-2	0	0	1
Q11	-1	0	1	0	2	3	-3	-4	-3	2	2	-1	-3	-2	0	-1	4	1	-2	1	0	0	-2	-1	3	-1	-2	1	1	3	-4	0	4	2
Q12	0	2	0	-3	2	2	0	0	4	2	4	0	0	1	-1	1	1	3	-1	-3	1	1	-1	-3	3	-2	-4	-1	-1	-2	-4	-2	3	-2
Q13	-1	1	-2	1	4	4	1	-2	0	2	-1	-4	-4	0	1	-3	0	-3	0	-1	3	3	3	0	-1	-1	-2	2	2	1	2	-2	0	-3
Q14	1	1	0	2	4	2	1	-1	0	-2	-2	-4	-2	-1	0	-4	2	0	-3	3	3	3	0	-3	2	0	-2	-1	-1	4	-1	-3	1	1
Q15	-1	1	-3	-1	2	0	0	4	3	-3	0	-4	-4	3	4	2	1	1	1	3	0	-1	-2	0	-2	-1	1	-3	0	-1	-2	-2	2	2
Q16	-3	3	0	2	4	2	1	0	-1	-4	2	-4	-3	2	1	1	-1	-1	-2	0	3	3	-3	0	-2	-2	-1	0	1	4	-2	0	-1	1
Q17	0	0	-4	-1	2	2	-1	-4	4	3	-3	1	-3	0	1	-1	0	0	-1	-3	3	2	1	-2	1	-2	-1	2	3	4	-2	1	0	-2
Q18	0	-3	-2	2	2	3	3	-4	1	-2	-4	-3	-3	2	0	0	-1	1	1	1	2	3	-1	-1	-1	-2	4	-1	1	4	0	0	-2	0

Table A6. Q-sort responses per statement per participant (part 2/2).

	s 1	s 2	s 3	s 4	s 5	s 6	s 7	s 8	s 9	s 10	s 11	s 12	s 13	s 14	s 15	s 16	s 17	s 18	s 19	s 20	s 21	s 22	s 23	s 24	s 25	s 26	s 27	s 28	s 29	s 30	s 31	s 32	s 33	s 34
Q19	0	0	-3	0	1	3	2	-2	3	1	0	-1	-4	2	2	-3	-1	-4	0	-2	2	1	1	-3	3	-2	-1	1	4	4	-1	-2	0	-1
Q20	-2	-4	-2	2	0	0	0	-2	2	-1	-4	-3	-3	1	2	-1	1	4	3	-2	0	0	-1	1	-1	0	1	3	3	4	2	1	-3	-1
Q21	-2	1	-3	-2	4	0	-1	-1	0	-1	-3	-4	1	1	-2	0	2	-1	-2	0	0	1	2	-3	1	2	-4	3	0	4	-1	2	3	3
Q22	-4	-4	-3	1	3	1	-1	-1	-3	4	4	-1	0	-1	0	0	-2	-2	-2	3	0	1	1	-3	2	-1	-2	1	2	2	0	3	0	2
Q23	-3	-1	1	-4	0	3	1	0	4	2	2	0	0	3	4	-1	0	2	3	-3	1	1	1	-2	-2	-2	-1	-1	2	-1	-3	-4	0	-2
Q24	-3	-1	0	-3	2	0	1	-1	0	3	-3	-4	-4	-2	0	1	-1	3	0	-1	1	1	3	1	-2	4	-2	-2	2	2	0	2	-1	4
Q25	-1	-1	-4	3	4	4	1	-2	1	3	0	-4	1	-3	-1	0	-1	-2	0	-1	1	2	3	0	2	1	0	-3	-2	0	2	-3	2	-2
Q26	-3	-1	-3	0	1	4	1	-2	3	1	0	2	1	2	3	-1	2	-1	4	-2	0	0	0	-4	0	-1	-2	-2	2	3	-3	-1	1	-4
Q27	-4	-1	-2	2	2	3	3	0	-2	0	-1	-2	-4	0	-1	-3	-1	1	2	-2	0	2	4	-3	-3	0	1	1	4	0	-1	1	1	3
Q28	-2	1	-4	2	1	2	0	2	-1	-2	1	0	0	0	1	0	-1	-2	2	0	3	4	4	-3	-1	1	3	-1	-2	-4	-3	-1	-3	3
Q29	-4	-1	2	0	2	-2	1	-3	-1	4	-2	-2	-3	3	0	-3	0	0	0	1	-1	-1	2	1	3	4	1	2	-1	-2	0	-4	1	3
Q30	2	-3	-4	-2	3	1	-1	3	1	-1	1	1	0	0	-2	0	0	-3	-1	-3	2	0	-2	-4	2	1	-1	3	4	4	-1	0	2	-2
Q31	-3	-3	-4	0	4	1	0	-3	4	0	3	-2	-2	2	1	1	3	2	0	-1	-1	-2	2	-4	1	0	1	0	-1	3	-2	-1	-1	2
Q32	-2	0	0	1	2	2	3	1	0	-4	-1	-1	-2	4	1	-3	-1	0	-3	4	1	1	-3	-2	2	0	-2	3	2	3	-1	-1	-4	0
Q33	1	1	-1	0	4	0	0	3	4	-2	0	-2	-1	3	2	-4	-2	-3	-4	3	1	-1	-3	-1	-1	-2	-3	0	1	1	0	2	2	2
Q34	-3	1	2	1	-1	-1	1	2	-2	1	-1	3	-1	0	0	-3	-4	-3	0	4	3	0	-2	3	0	1	-2	-1	-2	0	4	2	2	-4
Q35	1	-3	-4	1	-1	0	0	-2	1	4	-1	-2	-3	1	-1	0	-3	-2	3	2	0	-1	-4	2	0	3	3	-2	0	4	-1	1	2	2
Q36	-1	-3	0	0	-1	0	1	0	-2	-4	2	-1	-3	4	0	-1	-2	3	-2	0	3	2	1	-4	2	3	-3	1	1	4	-2	1	2	-1
Q37	1	1	-3	0	-1	-2	1	2	2	-2	2	-4	-3	3	-2	-3	0	2	-1	3	4	4	3	1	0	-1	-4	-2	0	0	-1	0	-1	1
Q38	-4	1	-2	2	3	-2	0	-2	3	-3	4	-3	0	1	2	2	-1	-1	0	1	0	0	-3	-2	-4	-1	-1	-1	1	3	1	0	2	4

Appendix 10. KADE output

Appendix 10.1 Correlation matrix

Table A7. Correlations between the Q-sort respondents.

Participant		M47BS	M44BS	F48GS	F47GS	F36AS	M63AS	M44GS	M40GS	F29GS	F34GS	F55CS	F53CS	F50AM	F27AM	F34AM	F26AM	F29GM	M45GM	F48GM	M44GM	F53CM	M77CM	M53GM	M47CS	M39CS	M49CS	F31CS	F25CS	F41CS	M53CS	F30CS	M66CM	F67CMa	M70CM	F67CMb	F69CM	F66AM	F31AM
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38
M47BS	Q1	100	43	18	10	19	33	27	28	16	43	13	22	40	19	34	31	12	12	39	-8	1	8	52	-8	19	33	28	27	22	-8	18	6	26	-5	7	17	30	34
M44BS	Q2	43	100	41	51	30	44	16	36	11	43	27	16	34	49	29	54	19	51	35	11	4	7	21	14	29	17	23	9	-4	23	14	17	29	-4	32	28	15	39
F48GS	Q3	18	41	100	24	19	21	7	23	13	34	17	23	23	13	46	34	16	38	26	13	-2	-13	34	-1	13	33	-1	-4	-5	9	19	3	-3	-21	14	1	-4	21
F47GS	Q4	10	51	24	100	16	25	-3	24	16	38	21	28	11	27	28	30	14	23	11	-14	-1	21	9	-3	24	1	9	24	-8	6	19	1	29	-7	19	-10	16	24
F36AS	Q5	19	30	19	16	100	47	28	19	23	20	2	9	43	18	6	19	48	33	57	41	-3	13	41	5	17	26	28	14	-6	31	34	14	14	-32	-4	-2	9	21
M63AS	Q6	33	44	21	25	47	100	-1	50	28	63	-16	-19	59	33	29	52	29	49	51	44	13	6	17	13	16	18	30	18	4	6	10	40	50	20	10	8	32	38
M44GS	Q7	27	16	7	-3	28	-1	100	29	-8	-3	26	27	57	22	-19	7	50	7	57	8	32	38	21	22	49	34	43	11	27	48	32	-1	-1	-8	21	38	8	0
M40GS	Q8	28	36	23	24	19	50	29	100	4	33	21	13	49	38	37	68	38	41	49	15	53	35	11	36	24	18	50	24	8	26	31	39	45	-3	21	32	28	61
F29GS	Q9	16	11	13	16	23	28	-8	4	100	35	12	-14	23	33	40	23	14	40	12	54	12	4	22	9	-8	18	36	1	15	1	26	40	21	-3	-1	13	19	11
F34GS	Q10	43	43	34	38	20	63	-3	33	35	100	-13	8	33	18	67	44	19	31	32	22	4	-19	43	23	11	35	36	42	-3	-3	20	11	33	-4	14	-1	32	31
F55CS	Q11	13	27	17	21	2	-16	26	21	12	-13	100	33	19	45	-3	27	31	3	24	-3	38	42	-1	14	9	17	13	-22	20	18	31	11	6	-20	11	24	-6	11
F53CS	Q12	22	16	23	28	9	-19	27	13	-14	8	33	100	7	13	14	8	29	-24	23	-31	13	1	55	-9	16	39	-11	-4	-7	25	31	-6	11	-28	-26	18	18	3
F50AM	Q13	40	34	23	11	43	59	57	49	23	33	19	7	100	51	3	41	56	41	67	29	29	25	24	27	58	31	50	17	21	21	17	27	21	9	2	12	28	6
F27AM	Q14	19	49	13	27	18	33	22	38	33	18	45	13	51	100	19	51	29	44	43	8	49	16	-8	16	39	11	23	11	17	18	25	54	42	-4	1	38	43	19
F34AM	Q15	34	29	46	28	6	29	-19	37	40	67	-3	14	3	19	100	41	-8	21	9	10	7	-14	28	13	-4	11	11	23	0	-3	33	21	46	-17	19	6	34	48
F26AM	Q16	31	54	34	30	19	52	7	68	23	44	27	8	41	51	41	100	19	46	34	16	29	20	8	15	7	11	31	20	-12	14	22	58	44	-1	1	37	34	61
F29GM	Q17	12	19	16	14	48	29	50	38	14	19	31	29	56	29	-8	19	100	44	74	43	36	21	32	25	24	55	28	-4	-3	47	39	16	14	-20	18	19	9	3
M45GM	Q18	12	51	38	23	33	49	7	41	40	31	3	-24	41	44	21	46	44	100	44	62	11	7	8	24	26	26	43	16	3	7	35	42	8	-16	40	24	16	22
F48GM	Q19	39	35	26	11	57	51	57	49	12	32	24	23	67	43	9	34	74	44	100	29	25	27	39	6	31	59	38	8	11	51	39	43	34	-11	21	32	21	14
M44GM	Q20	-8	11	13	-14	41	44	8	15	54	22	-3	-31	29	8	10	16	43	62	29	100	11	-1	14	35	-2	24	36	-16	11	9	34	28	-7	-19	28	19	3	14
F53CM	Q21	1	4	-2	-1	-3	13	32	53	12	4	38	13	29	49	7	29	36	11	25	11	100	36	-14	39	20	13	29	0	19	40	38	25	33	-23	3	35	21	30
M77CM	Q22	8	7	-13	21	13	6	38	35	4	-19	42	1	25	16	-14	20	21	7	27	-1	36	100	-9	22	29	14	33	13	13	29	35	20	18	6	21	27	5	29
M53GM	Q23	52	21	34	9	41	17	21	11	22	43	-1	55	24	-8	28	8	32	8	39	14	-14	-9	100	9	4	66	22	13	6	6	34	3	-1	-24	-16	10	6	9
M47CS	Q24	-8	14	-1	-3	5	13	22	36	9	23	14	-9	27	16	13	15	25	24	6	35	39	22	9	100	17	-7	49	3	34	-11	23	-3	-6	-13	25	17	21	13
M39CS	Q25	19	29	13	24	17	16	49	24	-8	11	9	16	58	39	-4	7	24	26	31	-2	20	29	4	17	100	26	23	26	17	9	27	-16	-7	-1	20	-11	6	6
M49CS	Q26	33	17	33	1	26	18	34	18	18	35	17	39	31	11	11	11	55	26	59	24	13	14	66	-7	26	100	24	9	-13	35	47	13	3	-14	8	17	-10	16
F31CS	Q27	28	23	-1	9	28	30	43	50	36	36	13	-11	50	23	11	31	28	43	38	36	29	33	22	49	23	24	100	43	25	10	30	19	2	-18	8	29	18	19
F25CS	Q28	27	9	-4	24	14	18	11	24	1	42	-22	-4	17	11	23	20	-4	16	8	-16	0	13	13	3	26	9	43	100	1	-6	18	4	-8	-18	-10	3	26	8
F41CS	Q29	22	-4	-5	-8	-6	4	27	8	15	-3	20	-7	21	17	0	-12	-3	3	11	11	19	13	6	34	17	-13	25	1	100	-26	22	12	-8	5	20	6	-1	-8
M53CS	Q30	-8	23	9	6	31	6	48	26	1	-3	18	25	21	18	-3	14	47	7	51	9	40	29	6	-11	9	35	10	-6	-26	100	24	23	29	-15	13	38	-3	7
F30CS	Q31	18	14	19	19	34	10	32	31	26	20	31	31	17	25	33	22	39	35	39	34	38	35	34	23	27	47	30	18	22	24	100	18	8	-57	16	26	9	45
M66CM	Q32	6	17	3	1	14	40	-1	39	40	11	11	-6	27	54	21	58	16	42	43	28	25	20	3	-3	-16	13	19	4	12	23	18	100	52	12	-5	51	32	20
F67CMa	Q33	26	29	-3	29	14	50	-1	45	21	33	6	11	21	42	46	44	14	8	34	-7	33	18	-1	-6	-7	3	2	-8	-8	29	8	52	100	20	8	18	36	45
M70CM	Q34	-5	-4	-21	-7	-32	20	-8	-3	-3	-4	-20	-28	9	-4	-17	-1	-20	-16	-11	-19	-23	6	-24	-13	-1	-14	-18	-18	5	-15	-57	12	20	100	11	3	4	-12
F67CMb	Q35	7	32	14	19	-4	10	21	21	-1	14	11	-26	2	1	19	1	18	40	21	28	3	21	-16	25	20	8	8	-10	20	13	16	-5	8	11	100	2	-3	19
F69CM	Q36	17	28	1	-10	-2	8	38	32	13	-1	24	18	12	38	6	37	19	24	32	19	35	27	10	17	-11	17	29	3	6	38	26	51	18	3	2	100	42	14
F66AM	Q37	30	15	-4	16	9	32	8	28	19	32	-6	18	28	43	34	34	9	16	21	3	21	5	6	21	6	-10	18	26	-1	-3	9	32	36	4	-3	42	100	14
F31AM	Q38	34	39	21	24	21	38	0	61	11	31	11	3	6	19	48	61	3	22	14	14	30	29	9	13	6	16	19	8	-8	7	45	20	45	-12	19	14	14	100

Appendix 10.2 Unrotated factor matrix

Table A8. Unrotated factor matrix retrieved from data by KADE Software for the extraction of 7 factor solutions.

Nm ↑	Participant	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
1	M47BS	0.467	0.03	-0.3062	-0.0615	0.2254	0.0188	-0.279
2	M44BS	0.5891	0.1902	-0.1745	0.0829	0.0487	0.0228	0.2184
3	F48GS	0.3526	-0.0198	-0.3421	-0.0868	-0.073	0.0362	0.2031
4	F47GS	0.3437	0.0788	-0.2928	0.1643	-0.0487	0.0464	0.0898
5	F36AS	0.4749	-0.1954	-0.1278	-0.2299	0.1282	0.0124	0.2094
6	M63AS	0.5692	0.403	-0.0472	-0.1492	0.3297	0.0662	0.2133
7	M44GS	0.4647	-0.5061	0.3461	-0.0576	0.1724	0.1244	-0.3006
8	M40GS	0.7172	0.1572	0.0492	0.198	-0.0636	0.0425	-0.1395
9	F29GS	0.3754	0.2664	0.0112	-0.1779	-0.0825	0.0385	0.1917
10	F34GS	0.5367	0.3764	-0.4703	-0.3286	0.1593	0.1309	-0.0138
11	F55CS	0.3267	-0.2451	0.149	0.3311	-0.2955	0.1416	0.0448
12	F53CS	0.2279	-0.4976	-0.3866	0.3358	0.0991	0.1721	-0.2161
13	F50AM	0.6732	-0.0864	0.2362	-0.2047	0.3962	0.0473	-0.018
14	F27AM	0.6079	0.0995	0.2301	0.2999	0.1142	0.0683	0.0725
15	F34AM	0.4236	0.4304	-0.4753	-0.0072	-0.1857	0.164	-0.0319
16	F26AM	0.6439	0.3737	-0.0643	0.3349	0.0234	0.1057	0.0634
17	F29GM	0.5995	-0.4628	0.1715	-0.1078	0.0795	0.0743	0.2538
18	M45GM	0.6003	0.2458	0.1336	-0.2962	-0.0518	0.0528	0.431
19	F48GM	0.7602	-0.3077	0.0684	-0.0683	0.3667	0.0416	0.1895
20	M44GM	0.3665	0.0551	0.2233	-0.5034	-0.1618	0.1089	0.3994
21	F53CM	0.4557	-0.0483	0.3788	0.291	-0.1839	0.1326	-0.2083
22	M77CM	0.3452	-0.1143	0.3259	0.2185	-0.1411	0.0948	-0.0945
23	M53GM	0.3886	-0.2269	-0.5076	-0.3281	0.197	0.1038	-0.1247
24	M47CS	0.3206	0.077	0.3462	-0.1853	-0.3246	0.1214	-0.3076
25	M39CS	0.3611	-0.2145	0.0639	-0.1128	0.0067	0.0136	-0.1334
26	M49CS	0.4816	-0.4614	-0.2082	-0.1912	0.1242	0.0716	0.0694
27	F31CS	0.5768	0.0772	0.2359	-0.2955	-0.04	0.0462	-0.2938
28	F25CS	0.223	0.122	-0.1423	-0.1365	0.0773	0.0039	-0.4139
29	F41CS	0.1363	0.0106	0.312	-0.2402	-0.139	0.0675	-0.2646
30	M53CS	0.3506	-0.4209	0.0788	0.2899	0.109	0.0967	0.212
31	F30CS	0.6183	-0.2498	-0.0659	-0.0461	-0.4373	0.1216	-0.1191
32	M66CM	0.4369	0.3075	0.2151	0.2439	0.1783	0.0847	0.2391
33	F67CMa	0.4022	0.3008	-0.0218	0.4413	0.1963	0.1193	0.0974
34	M70CM	-0.1952	0.2957	0.2163	0.0807	0.378	-0.1176	0.0409
35	F67CMb	0.2184	0.104	0.175	-0.1332	-0.2545	0.0637	0.1586
36	F69CM	0.4073	0.0189	0.3008	0.3181	0.0976	0.0841	-0.0676
37	F66AM	0.3619	0.3465	0.0048	0.1073	0.2864	0.0561	-0.2886
38	F31AM	0.4737	0.2438	-0.2857	0.2204	-0.2886	0.1268	-0.0048

Appendix 10.3 Selecting the number of factors

Since the CFA method can result in the arbitrary retention of too many factors, five parameters were explored to decide how many factors to keep for the factor rotation step in the factor analysis. First, the "Kuiser-Guttman criterion" says that factors with an eigenvalue (EV) greater than 1.00 should be kept. As seen in TABLE A11, all solutions except for the 6-Factor solution fit this condition. Second, the Scree test uses visual inspection of a line plot of the EV recovered from a PCA and factors before the change in slope are kept. Third, factors with 2 or more significant factor loadings (SFL) should be retained. The SFL can be calculated as follows (Brown, 1980):

Significant factor loading (SFL) = 2.58 x (1 ÷ √# of Q-set items)
= 2.58 x (1 ÷ √34)
= 0.44 (1)

According to the SFL parameter, Factor 1 (17 SFL), Factor 2 (4 SFL), Factor 3 (3 SFL), and Factor 4 (2 SFL) should be retained for rotation.

For the fourth parameter, known as "Humphrey's Rule", factors for which the cross product of their two highest loadings (regardless of sign) exceeds twice the standard error (SE) are considered significant (Watts & Stenner, 2012; Brown, 1980). The SE can be calculated as:

$$\textbf{Standard error (SE)} = 1 \div (\sqrt{\#\text{ of items in Q-set}})$$
$$= (1 \div \sqrt{34}) = 0.1715 \approx 0.17$$
$$\rightarrow 0.17 \times 2 = 0.34 \quad (2)$$

Upon calculation, the following cross products were obtained:

Table A9. Cross product of the highest loadings for each factor.

Factor	Two highest loadings	Cross product
1	0.7172 and 0.7602	0.55
2	-0.5061 and -0.4976	0.25
3	-0.5076 and -0.4753	0.24
4	-0.5034 and 0.4413	0.22
5	-0.4373 and 0.3962	0.17
6	0.164 and 0.1721	0.03
7	-0.4139 and 0.431	0.18

If Humphrey's Rule is applied strictly, only Factor 1 should be retained. However, Watts & Stenner (2012) explains that the rule can be explained more loosely, by considering factors whose cross products are higher than just the SE. In this case, Factors 2, 3, 4, 5, and 7 could now be kept if the rule is applied more loosely. The Scree test was ultimately omitted since it was found to be the less common criteria used by Q-methodologists according to a literature review of Q-studies (Zambrano et al., 2023), as well as for the bias and uncertainty that comes with its visual interpretation. Lastly, the composite reliability of the factors was calculated as well. This last parameter looks at the "reliability" of a factor based on the number of distinguishing statements that compose it, as well as the number of respondents that load significantly on that factor (Brummelkamp, 2020). The factor is then considered reliable if the composite reliability (CR) is equal to or higher than 0.94 (Ghazali, 2018). The CR is calculated as follows, and the results of the CR calculation can be observed on TABLE A10:

$$\textbf{Composite reliability (CR)} = 0.8p / (1 + (p - 1) * 0.8)$$
$$p = \text{number of flagged Q-sorts for the respective factor}$$
$$0.8 = \text{average reliability coefficient (Watts \& Stenner, 2012)} \quad (3)$$

Table A10. Composite reliability (CR) for all factor solutions and factors.

Number of factor solutions	Factor number						
	1	2	3	4	5	6	7
2	0.98	0.98					
3	0.98	0.97	0.98				
4	0.98	0.97	0.95	0.97			
5	0.97	0.97	0.96	0.97	0.92		
6	0.97	0.97	0.96	0.97	0.92	–	
7	0.92	0.97	0.94	0.96	0.92	–	0.94

From the CR test, it was determined that Factors 1, 2, 3, and 4 were reliable in most of the factor solutions. Ultimately, after examining multiple selection parameters, both the 3- and 4-Factor solutions were selected to move forward with the analysis since they passed most of the tests. An overview of the rules and the performance of the different factors can be seen in TABLE A11, where factors highlighted in dark blue pass the respective criteria while light blue indicates that those factors should be retained if the rule is applied loosely (which is possible to do in the case of Humphrey's Rule, as explained earlier).

Table A11. Overview of the factor selection tests.

Selection parameter	Factors to keep						
	1	2	3	4	5	6	7
0. Rule of thumb	Keep 4 to 6 factors						
1. "Kuiser-Guttman Criterion"							
2. Significant Factor Loading (SFL)							
3. "Humphrey's rule"							
4. Scree Test	Keep 5 Factors						
5. Composite reliability							

Furthermore, these are the smallest number of solutions to include a substantial percentage of the respondents (82% and 84% respectively; see TABLE A12 below), while maintaining a distribution of respondents that retains high enough CR, which can be valuable for the factor interpretation. Additionally, the 3- and 4-Factor solutions were analyzed and interpreted in order to identify what additional factors contribute to the understanding of the overall narrative.

Table A12. Flagged and unflagged respondents for the different factor solutions.

Factors rotated	Factor							Total of respondents	
	1	2	3	4	5	6	7		
#	Respondents per factor (before flagging)							#	%
2	23	15						38	100
3	14	11	13					38	100
4	12	10	7	9				38	100
5	11	8	7	9	3			38	100
6	11	8	7	9	3	-		38	100
7	5	8	6	7	7	-	5	38	100
#	Respondents per factor (after flagging)							#	%
2	15	13						28	74
3	12	9	10					31	82
4	11	9	5	7				32	84
5	7	8	6	8	3			32	84
6	7	8	6	8	3	-		32	84
7	3	7	4	6	3	-	4	27	71
#	Unflagged respondents per factor							#	%
2	8	2						10	26
3	2	2	3					7	18
4	1	1	2	2				6	16
5	4	0	1	1	0			6	16
6	4	0	1	1	0	-		6	16
7	2	1	2	1	4	-	1	11	29

Appendix 10.4 3-Factor Solution

Table A13. Factor groups (FG) and factor loadings per Q-sort for the 3-Factor solution.

Part. No.	Q-sort	Factor Group	Factor 1	F1	Factor 2a	F2a	Factor 2b	F2b	Factor 3	F3
1	M47BS	F1-8	0.4632	Flagged	0.3109		-0.3109		0.0394	
2	M44BS	F1-6	0.5672	Flagged	0.2014		-0.2014		0.2268	
3	F48GS	F1-13	0.3809	Flagged	0.3049		-0.3049		-0.0609	
4	F47GS	F1-11	0.4091	Flagged	0.2055		-0.2055		-0.0215	
5	F36AS	F2-8	0.2424		0.4372	Flagged	-0.4372		0.1736	
6	M63AS	F1-4	0.617	Flagged	-0.0204		0.0204		0.328	
7	M44GS	F3-5	-0.1913		0.5263		-0.5263		0.5274	
8	M40GS	F1-7	0.5125		0.2195		-0.2195		0.4802	
9	F29GS	F1-12	0.3857	Flagged	-0.0277		0.0277		0.25	
10	F34GS	F1-1	0.797	Flagged	0.1223		-0.1223		-0.0299	
11	F55CS	F2-11	-0.0203		0.3122		-0.3122		0.3019	
12	F53CS	F2-2	0.0411		0.6389	Flagged	-0.6389		-0.198	
13	F50AM	F3-1	0.2444		0.3314		-0.3314		0.589	Flagged
14	F27AM	F3-3	0.3182		0.1517		-0.1517		0.5551	Flagged
15	F34AM	F1-2	0.7617	Flagged	0.0238		-0.0238		-0.099	
16	F26AM	F1-3	0.6545	Flagged	0.0463		-0.0463		0.3577	
17	F29GM	F2-3	0.0071		0.6165	Flagged	-0.6165		0.4721	
18	M45GM	F3-7	0.4501		0.0622		-0.0622		0.4819	Flagged
19	F48GM	F2-4	0.2517		0.6068	Flagged	-0.6068		0.4956	
20	M44GM	F3-11	0.1457		0.0678		-0.0678		0.4017	Flagged
21	F53CM	F3-2	0.0598		0.1449		-0.1449		0.5735	Flagged
22	M77CM	F3-9	-0.021		0.1592		-0.1592		0.4612	Flagged
23	M53GM	F2-5	0.364		0.5426	Flagged	-0.5426		-0.1824	
24	M47CS	F3-8	0.0677		-0.0129		0.0129		0.4731	Flagged
25	M39CS	F2-10	0.0627		0.3327		-0.3327		0.2566	
26	M49CS	F2-1	0.1287		0.6795	Flagged	-0.6795		0.0989	
27	F31CS	F3-4	0.2826		0.152		-0.152		0.5397	Flagged
28	F25CS	F1-14	0.2835		0.061		-0.061		0.0279	
29	F41CS	F3-12	-0.0686		-0.0414		0.0414		0.3311	
30	M53CS	F2-7	-0.0746		0.4878	Flagged	-0.4878		0.2507	
31	F30CS	F2-6	0.2671		0.5327	Flagged	-0.5327		0.3063	
32	M66CM	F3-10	0.3442		-0.096		0.096		0.4516	Flagged
33	F67CMa	F1-9	0.4397	Flagged	-0.031		0.031		0.2418	
34	M70CM	F2-9	-0.0546		-0.4054		0.4054	Flagged	0.0709	
35	F67CMb	F3-13	0.108		-0.0302		0.0302		0.2767	
36	F69CM	F3-6	0.1098		0.0921		-0.0921		0.486	Flagged
37	F66AM	F1-10	0.4284	Flagged	-0.0966		0.0966		0.2413	
38	F31AM	F1-5	0.5846	Flagged	0.1366		-0.1366		0.0717	

Table A14. Factor characteristics for the 3-Factor solution.

	Factor 1	Factor 2a	Factor 3
No. of Defining Variables	12	8	10
Avg. Rel. Coef.	0.8	0.8	0.8
Composite Reliability	0.98	0.97	0.976
S.E. of Factor Z-scores	0.141	0.173	0.155
Eigenvalue (EV)	4.94	3.8	4.56
% Explained Variance	13	10	12
Total % Explained Variance			35

3- Factor Solution Factor Array - statement rankings

Table A15. Factor array showing Q-sort values, ranks, and z-scores for each statement.

Items ranked at +4
Items ranked higher than in other factors
High tie
Low tie
Items ranked lower than in other factors
Items ranked at -4

		Q-Sort Value			Rank			Z-Scores		
Stat. #	**Statement**	**F1**	**F2a**	**F3**	**F1**	**F2a**	**F3**	**F1**	**F2a**	**F3**
Social / Institutional										
1	It should be provided by a person / association from my own country.	-2	-1	-3	29	23	31	-1.13	-0.66	-1.28
2	It should minimize our exposure to our domestic wastewater.	1	-1	-1	12	21	25	0.53	-0.52	-0.75
3	It should be aesthetically appealing.	-1	-3	-2	24	32	29	-0.57	-1.53	-1.08
4	It should not smell or attract pests.	1	-2	1	10	26	12	0.58	-0.85	0.42
5	Community members should understand how the system / solution works before it is put in the community.	3	3	4	5	5	2	1.24	1.1	1.8
14	It should be simple (low-tech, easy to understand).	4	2	1	1	9	11	1.6	0.72	0.52
16	It should work with minimal human intervention.	-1	-1	-3	21	22	30	-0.22	-0.53	-1.13
28	Members of the community should install and commission the treatment system.	-3	0	2	31	17	9	-1.26	0.2	0.75
29	Members of the community should operate the treatment system.	0	3	3	15	4	5	0.36	1.23	1.12
30	Maintenance should be done by community members.	1	3	4	13	3	1	0.52	1.3	2.03
33	There should be external support after implementation for monitoring / maintenance.	1	0	0	11	15	19	0.56	0.37	-0.02
34	Management structure should be defined before implementation.	2	-3	1	8	30	10	0.81	-1.02	0.59
Environmental										
6	It should minimize discharge of pollutants into the river.	2	4	3	9	2	4	0.61	1.47	1.21
7	It should be easy to collect and dispose of the waste products (solids / sludge).	0	0	2	20	16	8	-0.1	0.32	0.8
21	It should prevent untreated wastewater from toilets from reaching the river.	3	2	2	4	7	6	1.28	0.83	1.03
22	It should prevent untreated kitchen / laundry wastewater from reaching the river.	2	1	3	7	14	3	0.98	0.41	1.35
23	Treated wastewater should be apt for reuse.	-2	0	2	27	18	7	-0.99	0.17	0.84
Economic										
8	The initial investment should be low.	2	-2	-2	6	28	26	1	-0.86	-0.82
9	Maintenance should be cheap.	4	4	-1	2	1	22	1.58	2.21	-0.32
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production...)	-3	2	-1	30	8	23	-1.13	0.77	-0.33
11	Subsidies should be available for the solution / technology.	0	1	-2	17	11	28	0.14	0.63	-0.99
Technical										
12	An external organization / person should operate the treatment system.	-4	0	-4	34	19	34	-2.3	0.06	-2.11
13	An external organization / person should install and commission the treatment system.	-4	-1	-4	33	24	33	-1.84	-0.71	-1.77
15	It should require little maintenance to operate.	3	2	0	3	6	18	1.37	0.96	-0.01
17	It should be quick to build / implement.	0	1	0	19	12	20	0.09	0.5	-0.13
18	It should have been successful in nearby communities.	-2	0	0	26	20	15	-0.69	-0.12	0.25
19	It should have low energy requirements.	1	1	-1	14	13	24	0.37	0.43	-0.51
20	Construction / replacement parts should be found in the country.	0	-4	1	16	33	14	0.33	-1.65	0.34
24	It should take up little space.	-1	-4	-3	22	34	32	-0.36	-1.93	-1.33
25	System should treat domestic wastewater from a large number of households (50+).	-3	1	0	32	10	17	-1.38	0.71	0.06
26	It should allow for future expansion or upgrades.	-2	-2	1	28	29	13	-1.06	-0.97	0.36
27	It should be sturdy and hard to vandalize.	0	-1	-2	18	25	27	0.1	-0.78	-0.93
31	It should not require changes in infrastructure at household level.	-1	-3	-1	25	31	21	-0.59	-1.39	-0.16
32	It should accommodate to existing infrastructure.	-1	-2	0	23	27	16	-0.43	-0.86	0.19

3- Factor Solution Consensus vs. Disagreement

Social / Institutional
Environmental
Economic
Technical

Table A16. Q-sort values for statements sorted by Consensus vs. Disagreement including distinction per category (low Z-score variance = high consensus; high Z-score variance = high disagreement)

Stat. #	Statement	Factor 1	Factor 2a	Factor 3	Z-Score Variance
21	It should prevent untreated wastewater from toilets from reaching the river.	3	2	2	0.034
33	There should be external support after implementation for monitoring / maintenance.	1	0	0	0.058
17	It should be quick to build / implement.	0	1	0	0.069
1	It should be provided by a person / association from my own country.	-2	-1	-3	0.071
5	Community members should understand how the system / solution works before it is put in the community.	3	3	4	0.091
6	It should minimize discharge of pollutants into the river.	2	4	3	0.13
7	It should be easy to collect and dispose of the waste products (solids / sludge).	0	0	2	0.137
16	It should work with minimal human intervention.	-1	-1	-3	0.144
18	It should have been successful in nearby communities.	-2	0	0	0.15
22	It should prevent untreated kitchen / laundry wastewater from reaching the river.	2	1	3	0.151
29	Members of the community should operate the treatment system.	0	3	3	0.151
3	It should be aesthetically appealing.	-1	-3	-2	0.153
19	It should have low energy requirements.	1	1	-1	0.184
32	It should accommodate to existing infrastructure.	-1	-2	0	0.187
27	It should be sturdy and hard to vandalize.	0	-1	-2	0.206
14	It should be simple (low-tech, easy to understand).	4	2	1	0.219
31	It should not require changes in infrastructure at household level.	-1	-3	-1	0.258
13	An external organization / person should install and commission the treatment system.	-4	-1	-4	0.268
2	It should minimize our exposure to our domestic wastewater.	1	-1	-1	0.31
15	It should require little maintenance to operate.	3	2	0	0.333
30	Maintenance should be done by community members.	1	3	4	0.379
4	It should not smell or attract pests.	1	-2	1	0.407
26	It should allow for future expansion or upgrades.	-2	-2	1	0.419
24	It should take up little space.	-1	-4	-3	0.42
11	Subsidies should be available for the solution / technology.	0	1	-2	0.459
23	Treated wastewater should be apt for reuse.	-2	0	2	0.571
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production...)	-3	2	-1	0.603
34	Management structure should be defined before implementation.	2	-3	1	0.665
28	Members of the community should install and commission the treatment system.	-3	0	2	0.717
25	System should treat domestic wastewater from a large number of households (50+).	-3	1	0	0.757
8	The initial investment should be low.	2	-2	-2	0.758
20	Construction / replacement parts should be found in the country.	0	-4	1	0.875
12	An external organization / person should operate the treatment system.	-4	0	-4	1.143
9	Maintenance should be cheap.	4	4	-1	1.163

Factor Interpretations

- **3-F1**

Eigenvalue: 4.94	# Items included (crib sheet): 29 (85.3%%)
Explained variance: 13%	# Items included (draft 2): 31 (91.2%)
Respondents with significant loading: 12	# Items included (final draft): 30 (88.2%)

Keywords: Community health, basic current needs, simplicity, overall affordability, funding, socialization, collaboration.

It is important for the system to prevent the discharge of pollutants from untreated blackwater and greywater from reaching the river nearby (6:+2; 21:+3; 22:+2*), since the handling of domestic wastewater is of big concern for river and human health. This should be accomplished while minimizing our exposure to our domestic wastewater* (2:+1)*, smells and pests* (4:+1)*.*

The initial investment needed for the system should be low (8:+2), *as this could facilitate the obtention of funding* (11:0) *and allow the system to service more people. A new system could need a considerable amount of space and changes in existing infrastructure* (24:-1)*, especially if this is non-existent* (31:-1)*, but funding may be limited to make the system larger than needed. Therefore, it would be preferrable if it is designed to service less than 50 households* (25:-3) *and focus on the current needs rather than accommodating for future expansion or upgrades* (26:-2)*. For this same reason, services such as energy and biogas production, or the possibility of reusing the treated wastewater are not currently a priority* (10:-3; 23:-2).

Affordability however should not only refer to the initial investment. The maintenance of the system should also be cheap in order for the solution to be maintained by the community in the long-run, independently from the availability of government funding (9:+4). *Being sturdy, even if this means compromising aesthetics* (3:-1), *would also allow for lower maintenance costs even if the risk of vandalism is not a concern* (27:0), *since it would reduce the amount of repairs needed due to regular wear and tear. However, cheaper maintenance may imply that some necessary tasks, such as the sludge and waste product collection and disposal, may not be as straightforward* (7:0)*. It should also have a low energy requirement as this could lower the costs of operation* (19:+1).

It is important for the system to be simple and require little maintenance to operate (14:+4; 15:+3)*, preferably needing little human intervention but not greatly automated* (16:-1)*. Regardless of the complexity of the system, community members should understand how the system works before it is put in the community* (5:+3). *This way they could operate and maintain the system themselves if necessary* (29:0; 30:+1). *This socialization should take place even if a similar solution has been successful nearby* (18:-2), *since this neighbouring success may provide some familiarity with the system but it does not necessarily indicate that implementation will be a success.*

However, neither should community members be expected to install and commission the treatment system themselves (28:-3), *nor should the responsibility of installing, commissioning and operating the treatment system rely solely on organizations external to the community* (13:-4; 12:-4). *There should be active collaboration from both parties throughout all project phases, including external support after implementation to successfully monitor and maintain the system* (33:+1), *making the solution more sustainable. It is therefore important for responsibilities to be clear before implementation, and for a management structure for the system to be defined in advanced* (34:+2).

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
13. An external organization / person should install and commission the	10. It should provide multiple services to my community	18. It should have been successful in nearby communities.	16. It should work with minimal human intervention.	29. Members of the community should operate the treatment system.	4. It should not smell or attract pests.	8. The initial investment should be low.	15. It should require little maintenance to operate.	14. It should be simple (low-tech, easy to understand).
12. An external organization / person should operate the treatment	28. Members of the community should install and commission the treatment	23. Treated wastewater should be apt for reuse.	24. It should take up little space.	20. Construction / replacement parts should be found in the	33. There should be external support after implementation	22. It should prevent untreated kitchen / laundry	21. It should prevent untreated wastewater from toilets from	9. Maintenance should be cheap.
	25. System should treat domestic wastewater from a large number	26. It should allow for future expansion or upgrades.	32. It should accommodate to existing infrastructure.	11. Subsidies should be available for the solution / technology.	2. It should minimize our exposure to our domestic wastewater.	34. Management structure should be defined before implementation.	5. Community members should understand how the system / solution works	
		1. It should be provided by a person / association from my own	3. It should be aesthetically appealing.	27. It should be sturdy and hard to vandalize.	30. Maintenance should be done by community members.	6. It should minimize discharge of pollutants into the river.		
			31. It should not require changes in infrastructure at household	17. It should be quick to build / implement.	19. It should have low energy requirements.			
				7. It should be easy to collect and dispose of the waste products				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus Statements

Figure A3. Composite Q-sort for Factor 1, 3-Factor solution.

Table A17. Crib sheet for Factor 1, 3-Factor solution.

Items ranked at +4		**F1**	**C or D**	**F2a**	**F3**
14	It should be simple (low-tech, easy to understand).	4	D*	2	1
9	Maintenance should be cheap.	4	D*	4	-1
Items ranked higher in Factor 1 array that in other factor arrays					
15	It should require little maintenance to operate.	3		2	0
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3	C	2	2
8	The initial investment should be low.	2	D*	-2	-2
34	Management structure should be defined before implementation.	2		-3	1
4	It should not smell or attract pests.	1		-2	1
33	There should be external support after implementation for monitoring / maintenance.	1		0	0
2	It should minimize our exposure to our domestic wastewater.	1	D*	-1	-1
19	It should have low energy requirements.	1		1	-1
27	It should be sturdy and hard to vandalize.	0	D*	-1	-2
3	It should be aesthetically appealing.	-1	D	-3	-2
16	It should work with minimal human intervention.	-1		-1	-3
24	It should take up little space.	-1	D*	-4	-3
31	It should not require changes in infrastructure at **household level**.	-1	D	-3	-1
Items ranked lower in Factor 1 array that in other factor arrays					
5	Community members should understand how the system / solution works before it is put in the community.	3		3	4
6	It should minimize discharge of pollutants into the river.	2	D*	4	3
30	**Maintenance** should be done by community members.	1	D*	3	4
29	Members of the community should **operate** the treatment system.	0	D*	3	3
17	It should be quick to build / implement.	0		1	0
7	It should be easy to collect and dispose of the waste products (solids / sludge).	0		0	2
18	It should have been successful in nearby communities.	-2	D	0	0
23	Treated wastewater should be apt for reuse.	-2	D*	0	2
26	It should allow for future expansion or upgrades.	-2		-2	1
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	-3	D*	2	-1
28	Members of the community should **install and commission** the treatment system.	-3	D*	0	2
25	System should treat domestic wastewater from a large number of households (50+).	-3	D*	1	0
Items ranked at -4					
13	An external organization / person should **install and commission** the treatment system.	-4		-1	-4
12	An external organization / person should operate the treatment system.	-4		0	-4
Additional items included in the analysis					
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2		1	3
11	Subsidies should be available for the solution / technology.	0		1	-2

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

- **3-F2a**

Eigenvalue: 3.8	# Items included (crib sheet): 28 (82.4%)
Explained variance: 10%	# Items included (draft 2): 32 (94.1%)
Respondents with significant loading: 8	# Items included (final draft): 32 (94.1%)

Keywords: Resource recovery, high removal, large capacity, make space available, financially accessible, long-term affordability, user-friendliness, active community role, function over aesthetics, infrastructure changes, prior socialization, low maintenance,

A wastewater treatment system should help minimize the discharge of pollutants into the river (6:+4) *by preventing untreated blackwater and greywater from reaching the waterbody* (21:+2; 22:+1). *However, it should also provide multiple services to the community, such as energy and biogas production* (10:+2).

It should be designed to treat domestic wastewater from a large number of households, serving 50 or more households (25:+1), *focusing on accommodating current needs rather than looking at possible upgrades from the start* (26:-2). *Although a larger treatment capacity may require a larger area, space availability should not be a constraint to the scale of the system* (24:-4). *It is okay to use up some additional land if the system will benefit more people. While the system's larger scale and multiple benefits may entail a higher initial investment* (8:-2), *the availability of subsidies can help to facilitate the accessibility of these solutions* (11:+1). *Energy requirements and maintenance costs however should be low to ensure its affordability in the long-run and to keep the system running up to standards* (19:+1; 9:+4).

Intervention from external entities and foreign experts is welcomed for the installation of the system, although it should not be required (1:-1; 13:-1) *since a community-based sanitation committee or group should take the lead in these initial stages* (28:0). *Community members should also take charge of daily operations of the system* (29:+3; 12:0), *considering that it is handling their own waste after all. Since the community is low-middle income, they would probably care mostly about the simplicity of the technology and the costs they would have to adopt beyond the available funding. Long-term affordability and user-friendliness* (9:+4; 14:+2) *are therefore vital for the system to remain operational and up to standard. Additionally, with a simple system the community could define the specifics of management and assign responsibilities after the system is commissioned and adjust it as they see fit, so a detailed management structure is not necessarily a prerequisite for implementation* (34:-3).

This active role should also extend to the maintenance of the system (30:+3). *The collection and disposal of waste products should be straightforward to facilitate the task for whoever is responsible of it* (7:0). *The task of the responsible community member would be facilitated further if the system worked with minimal human intervention* (16:-1). *However, for the community to effectively fulfil this responsibility, it is essential that members have a clear understanding of how the system functions before its implementation* (5:+3). *Nevertheless, ongoing external support for monitoring and maintenance would still be appreciated* (33:0). *A solution needing little maintenance would also be preferred, especially if the community itself is to maintain it* (15:+2). *Furthermore, if little maintenance is necessary and said maintenance is also cheap, it would not be a problem if any necessary replacement parts are not found in the country* (20:-4) *as these would not be required on a regular basis.*

Understandably, implementing a new wastewater treatment system cannot always accommodate to the infrastructure that is currently in place in the community (32:-2) *and changes at household*

level would probably be required (31:-3). *If a similar system has been successful in a nearby community, it could help validate the selected solution to get the community on board before such changes are done* (18:0). *Additionally, it would be ideal if the system could be built or implemented quickly to minimize disruptions to the community* (17:+1). *Lastly, it is acceptable if the system is not aesthetically appealing* (3:-3), *causes some nuisance like smell or pests* (4:-2), *or does not conceal the wastewater from our view* (2:-1), *as these aspects may not be essential for the functionality of the system.*

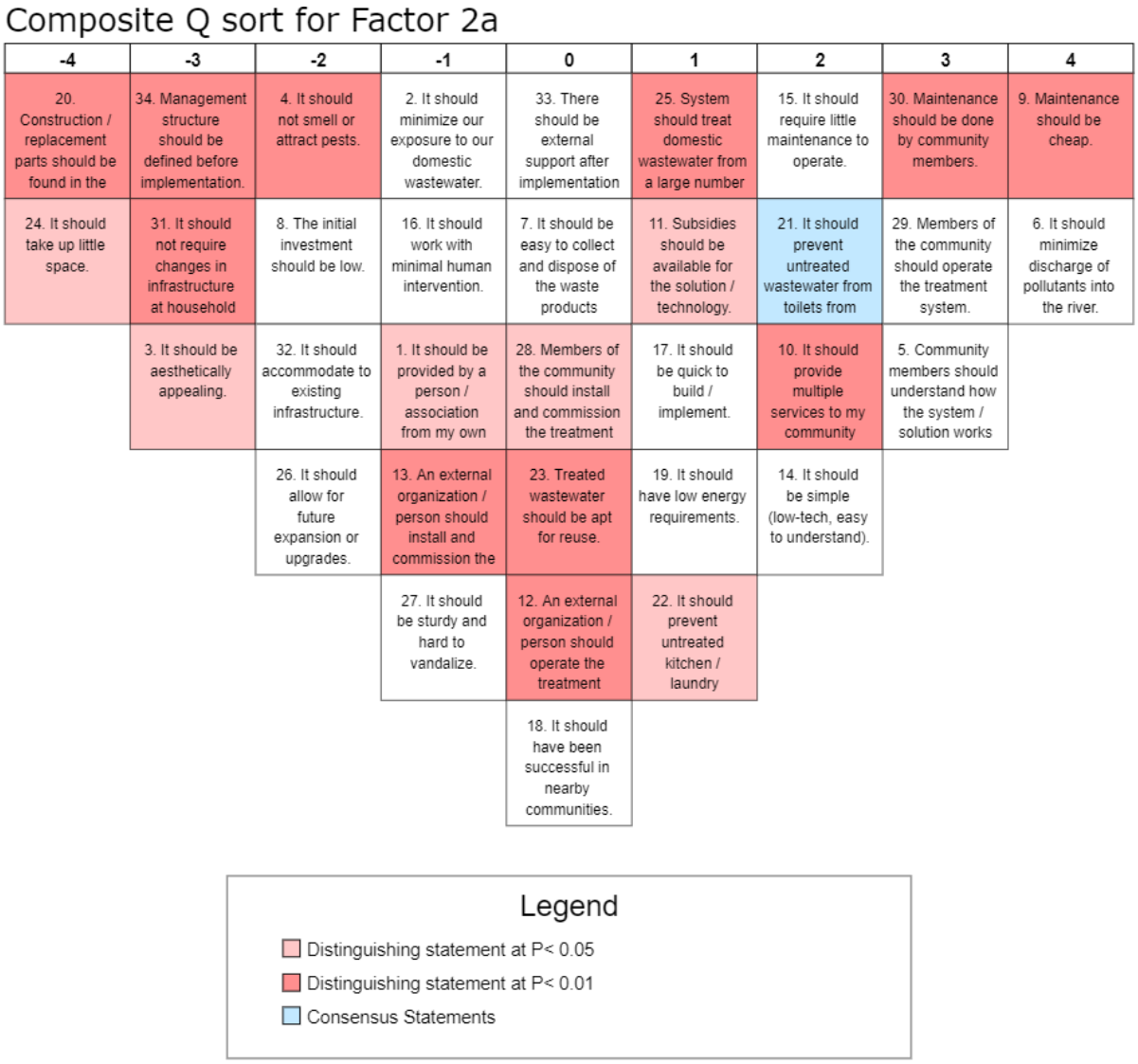


Figure A4. Composite Q-sort for Factor 2a, 3-Factor solution.

Table A18. Crib sheet for Factor 2a, 3-Factor solution.

Items ranked at +4		**F2a**	**C or D**	**F1**	**F3**
9	Maintenance should be cheap.	4	D*	4	-1
6	It should minimize discharge of pollutants into the river.	4		2	3
Items ranked higher in Factor 2a array that in other factor arrays					
29	Members of the community should **operate** the treatment system.	3		0	3
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production...)	2	D*	-3	-1
25	System should treat domestic wastewater from a large number of households (50+).	1	D*	-3	0
11	Subsidies should be available for the solution / technology.	1	D	0	-2
17	It should be quick to build / implement.	1		0	0
19	It should have low energy requirements.	1		1	-1
12	An external organization / person should operate the treatment system.	0	D*	-4	-4
18	It should have been successful in nearby communities.	0		-2	0
1	It should be provided by a person / association from my own country.	-1	D	-2	-3
13	An external organization / person should **install and commission** the treatment system.	-1	D*	-4	-4
16	It should work with minimal human intervention.	-1		-1	-3
Items ranked lower in Factor 2a array that in other factor arrays					
5	Community members should understand how the system / solution works before it is put in the community.	3		3	4
21	It should prevent untreated wastewater from **toilets** from reaching the river.	2	C	3	2
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	1	D	2	3
33	There should be external support after implementation for monitoring / maintenance.	0		1	0
7	It should be easy to collect and dispose of the waste products (solids / sludge).	0		0	2
2	It should minimize our exposure to our domestic wastewater.	-1		1	-1
4	It should not smell or attract pests.	-2	D*	1	1
32	It should accommodate to existing infrastructure.	-2		-1	0
8	The initial investment should be low.	-2		2	-2
26	It should allow for future expansion or upgrades.	-2		-2	1
34	Management structure should be defined before implementation.	-3	D*	2	1
31	It should not require changes in infrastructure at **household level**.	-3	D*	-1	-1
3	It should be aesthetically appealing.	-3	D	-1	-2
Items ranked at -4					
20	Construction / replacement parts should be found in the country.	-4	D*	0	1
24	It should take up little space.	-4	D	-1	-3
Additional items included in the analysis					
14	It should be simple (low-tech, easy to understand).	2		4	1
15	It should require little maintenance to operate.	2		3	0
30	**Maintenance** should be done by community members.	3	D*	1	4
28	Members of the community should **install and commission** the treatment system.	0	D	-3	2

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

- **3-F3**

Eigenvalue: 4.56	# Items included (crib sheet): 28 (82.4%)
Explained variance: 12%	# Items included (draft 2): 31 (91.2%)
Respondents with significant loading: 10	# Items included (final draft): 31 (91.2%)

Keywords: Water reuse, environment, community-led, extensive prior socialization, sense of belonging, simplicity, awareness, ownership, invest for future, support, easy waste disposal, , make space available, long-term affordability

A wastewater treatment system should help minimize the discharge of pollutants into the river (6:+3) *by preventing untreated wastewater, greywater mainly, from reaching the waterbody* (22:+3; 21:+2). *Additionally, the community should be able to reuse the treated wastewater* (23:+2). *This would help both community and environmental health.*

Community members should be in the forefront of the installation, commissioning (28:+2), *operation* (29:+3), *and maintenance* (30:+4) *of the domestic wastewater treatment system in their communities, not external entities* (12:-4; 13:-4) *such as government agencies or NGOs. It is therefore vital for the community members to understand how the system works and what is needed to operate it properly before it is put in the area* (5:+4), *since understanding it would be a great first step towards caring for it. As a simpler system would be easier to understand, it could be a good solution that the community could develop a strong sense of belonging towards* (14:+1). *Considering that this prior socialization is critical for the success of the system in the long run, the implementation of wastewater treatment systems should not be rushed to avoid wasting resources and investments* (17:0).

A "success story" from a similar system in a nearby community for example, could also help incentivise locals to be more accepting of the implementation of wastewater treatment technologies (18:0). *Even with an example to follow and a prior explanation of the system, external support should be available for the community to help with the monitoring and maintenance of the system* (33:0). *External knowledge and support is therefore welcome, and even contributions from entities or people abroad would be valuable and appreciated* (1:-3). *If the community is responsible for the maintenance, a system with less requirements in this field would be more appropriate* (15:0). *With this in mind, it should also be easy to collect and dispose of the waste products from the treatment processes to make the maintenance less challenging* (7:+2), *which could avoid people skipping necessary tasks and keep the system operating up to standard. Additionally, it would not be necessary for the system to be hard to vandalize since people would probably take better care of the system when they have this higher level of ownership and responsibility over it* (27:-2).

Furthermore it would be better if the system needs frequent human intervention to work properly (16:-3). *This way, the community could get more involved and their interest towards the system could grow by being able to interact with it and see how it works. This greater exposure to the processes involved* (2:-1) *could increase the people's awareness with respect to sanitation and wastewater treatment. Although the system does not need to be aesthetically appealing* (3:-2), *it would be favourable if the system did not attract pests or had strong smells* (4:+1). *This would be a greater nuisance than the system being unattractive and would even be a health risk for the community members, especially the ones more involved with the system.*

Additionally, the system should be designed with the future growth and needs of the community in mind, so it should be possible to expand or upgrade it if needed (26:+1). *In this case, it would then be preferable to have a slightly higher initial investment for a system which can be expanded when the time comes* (8:-2), *rather than needing to spend more in the future on a whole new system. This may lead to both maintenance costs and energy requirements being slightly higher* (9:-1; 19:-1), *but several other costs would have probably been reduced by having less third-party intervention. Besides, this investment would ultimately be for the benefit of the community.*

As more resources may be required, it would be more budget-friendly to use locally available materials and resources rather than importing them (20:+1), *which could increase cost greatly. Moreover, it would be better if there were subsidies available for the development of the whole project rather than for the technology itself* (11:-2). *In that case, the energy requirements would not be that relevant in the system selection, since budget would be less of a constraint* (19:-1). *Furthermore, additional space should be made available to allow the system to take up as much area as needed for the desired treatment capacity, or to be able to accommodate possible expansions in the future* (24:-3).

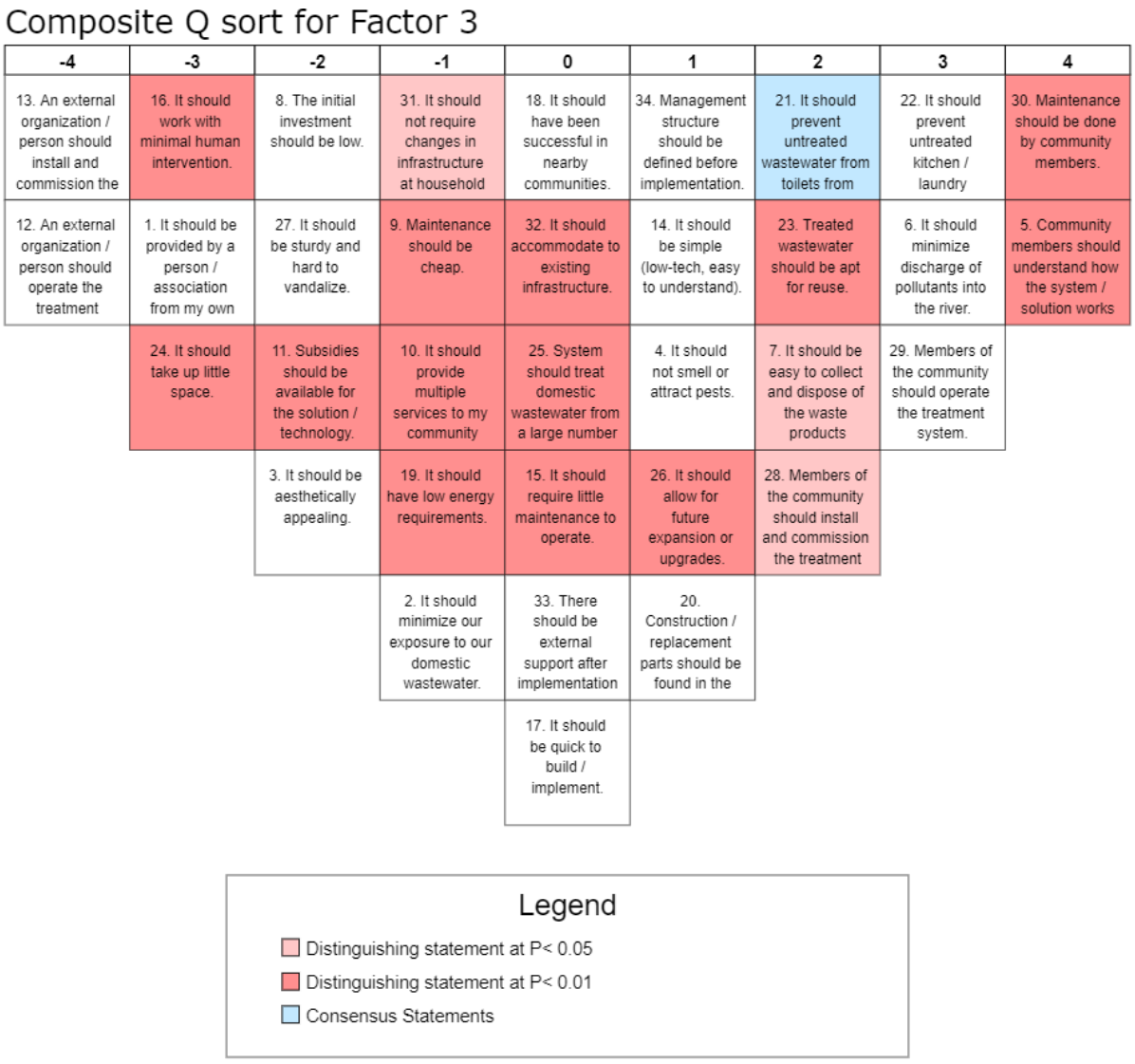


Figure A5. Composite Q-sort for Factor 3, 3-Factor solution.

Table A19. Crib sheet for Factor 3, 3-Factor solution.

Items ranked at +4		**F3**	**C or D**	**F1**	**F2a**
30	**Maintenance** should be done by community members.	4	D*	1	3
5	Community members should understand how the system / solution works before it is put in the community.	4	D*	3	3
Items ranked higher in Factor 3 array that in other factor arrays					
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	3		2	1
29	Members of the community should **operate** the treatment system.	3		0	3
23	Treated wastewater should be apt for reuse.	2	D*	-2	0
7	It should be easy to collect and dispose of the waste products (solids / sludge).	2	D	0	0
28	Members of the community should **install and commission** the treatment system.	2	D	-3	0
4	It should not smell or attract pests.	1		1	-2
26	It should allow for future expansion or upgrades.	1	D*	-2	-2
20	Construction / replacement parts should be found in the country.	1		0	-4
18	It should have been successful in nearby communities.	0		-2	0
32	It should accommodate to existing infrastructure.	0	D*	-1	-2
31	It should not require changes in infrastructure at **household level**.	-1	D	-1	-3
Items ranked lower in Factor 3 array that in other factor arrays					
21	It should prevent untreated wastewater from **toilets** from reaching the river.	2	C	3	2
14	It should be simple (low-tech, easy to understand).	1		4	2
15	It should require little maintenance to operate.	0	D*	3	2
33	There should be external support after implementation for monitoring / maintenance.	0		1	0
17	It should be quick to build / implement.	0		0	1
9	Maintenance should be cheap.	-1	D*	4	4
19	It should have low energy requirements.	-1	D*	1	1
2	It should minimize our exposure to our domestic wastewater.	-1		1	-1
8	The initial investment should be low.	-2		2	-2
27	It should be sturdy and hard to vandalize.	-2		0	-1
11	Subsidies should be available for the solution / technology.	-2	D*	0	1
16	It should work with minimal human intervention.	-3	D*	-1	-1
1	It should be provided by a person / association from my own country.	-3		-2	-1
Items ranked at -4					
13	An external organization / person should **install and commission** the treatment system.	-4		-4	-1
12	An external organization / person should operate the treatment system.	-4		-4	0
Additional items included in the analysis					
3	It should be aesthetically appealing.	-2		-1	-3
6	It should minimize discharge of pollutants into the river.	3		2	4
24	It should take up little space.	-3	D*	-1	-4

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

Appendix 10.5 4-Factor Solution

Table A20. Factor groups (FG) and factor loadings per Q-sort for the 4-Factor solution.

Part. No.	Q-sort	Factor Group	Factor 1	F1	Factor 2a	F2a	Factor 2b	F2b	Factor 3	F3	Factor 4	F4
1	M47BS	F1-7	0.4506	Flagged	0.3303		-0.3303		0.0586		0.0316	
2	M44BS	F1-6	0.5565	Flagged	0.1925		-0.1925		0.123		0.2423	
3	F48GS	F1-10	0.3721	Flagged	0.3282		-0.3282		-0.0025		-0.0557	
4	F47GS	F1-9	0.4182	Flagged	0.1732		-0.1732		-0.1241		0.1297	
5	F36AS	F2-8	0.2095		0.4856	Flagged	-0.4856		0.2283		0.0317	
6	M63AS	F1-5	0.5864	Flagged	0.033		-0.033		0.3919		0.1115	
7	M44GS	F2-7	-0.2292		0.5176		-0.5176		0.3149		0.419	
8	M40GS	F4-4	0.4971		0.1806		-0.1806		0.2201		0.5025	
9	F29GS	F1-11	0.358	Flagged	0.0259		-0.0259		0.3366		0.0392	
10	F34GS	F1-1	0.7691	Flagged	0.2203		-0.2203		0.2475		-0.2402	
11	F55CS	F4-6	-0.0153		0.2238		-0.2238		-0.0582		0.495	Flagged
12	F53CS	F2-5	0.0681		0.5432	Flagged	-0.5432		-0.4684		0.2067	
13	F50AM	F3-4	0.193		0.3758		-0.3758		0.5271		0.3194	
14	F27AM	F4-2	0.3082		0.0846		-0.0846		0.1998		0.6166	Flagged
15	F34AM	F1-2	0.7628	Flagged	0.0479		-0.0479		-0.0047		-0.08	
16	F26AM	F1-3	0.6573	Flagged	-0.0154		0.0154		0.0808		0.4814	
17	F29GM	F2-2	-0.0336		0.6231	Flagged	-0.6231		0.3112		0.3583	
18	M45GM	F3-3	0.4001		0.1424		-0.1424		0.5733	Flagged	0.132	
19	F48GM	F2-4	0.2119		0.6117	Flagged	-0.6117		0.3242		0.3972	
20	M44GM	F3-1	0.0857		0.1878		-0.1878		0.6277	Flagged	-0.0634	
21	F53CM	F4-1	0.0494		0.0723		-0.0723		0.1979		0.6255	Flagged
22	M77CM	F4-5	-0.0308		0.1012		-0.1012		0.1567		0.5005	Flagged
23	M53GM	F2-3	0.3406		0.6158	Flagged	-0.6158		0.0318		-0.2675	
24	M47CS	F3-5	0.029		0.0319		-0.0319		0.4719	Flagged	0.1957	
25	M39CS	F2-10	0.0364		0.3509	Flagged	-0.3509		0.2109		0.1556	
26	M49CS	F2-1	0.1		0.7087	Flagged	-0.7087		0.0993		0.0502	
27	F31CS	F3-2	0.2292		0.2243		-0.2243		0.5853	Flagged	0.1903	
28	F25CS	F1-12	0.2699		0.0999		-0.0999		0.126		-0.0694	
29	F41CS	F3-6	-0.103		0.0134		-0.0134		0.3999	Flagged	0.0557	
30	M53CS	F4-9	-0.072		0.4025		-0.4025		-0.1007		0.4615	Flagged
31	F30CS	F2-6	0.2396		0.5355	Flagged	-0.5355		0.1868		0.2684	
32	M66CM	F4-8	0.3385		-0.1417		0.1417		0.2059		0.4628	Flagged
33	F67CMa	F4-7	0.4585		-0.1216		0.1216		-0.0797		0.465	
34	M70CM	F2-9	-0.0469		-0.4146		0.4146	Flagged	0.0584		0.0366	
35	F67CMb	F3-7	0.0835		0.0046		-0.0046		0.3023		0.0922	
36	F69CM	F4-3	0.1064		0.0164		-0.0164		0.1298		0.574	Flagged
37	F66AM	F1-8	0.4232	Flagged	-0.1069		0.1069		0.1538		0.22	
38	F31AM	F1-4	0.593	Flagged	0.098		-0.098		-0.0686		0.2194	

Table A21. Factor characteristics for the 4-Factor solution.

	Factor 1	Factor 2a	Factor 3	Factor 4
No. of Defining Variables	11	8	5	7
Avg. Rel. Coef.	0.8	0.8	0.8	0.8
Composite Reliability	0.978	0.97	0.952	0.966
S.E. of Factor Z-scores	0.148	0.173	0.219	0.184
Eigenvalue (EV)	4.94	3.8	3.04	3.8
% Explained Variance	13	10	8	10
Total % Explained Variance				41

4- Factor Solution Factor Array - statement rankings

Items ranked at +4
Items ranked higher than in other factors
High tie
Low tie
Items ranked lower than in other factors
Items ranked at -4

Table A22. Factor array showing Q-sort values, ranks, and z-scores for each statement.

		Q Sort Value				Rank				Z-Scores			
Stat. #	**Statement**	**F1**	**F2a**	**F3**	**F4**	**F1**	**F2a**	**F3**	**F4**	**F1**	**F2a**	**F3**	**F4**
Social / Institutional													
1	It should be provided by a person / association from my own country.	-3	-2	-3	-1	-1.2	-0.92	-1.57	-0.67	30	26	31	25
2	It should minimize our exposure to our domestic wastewater.	1	-1	-3	-1	0.52	-0.5	-1.46	-0.64	13	21	30	23
3	It should be aesthetically appealing.	-1	-3	-2	-2	-0.59	-1.5	-0.77	-0.87	25	32	28	28
4	It should not smell or attract pests.	1	-1	1	0	0.6	-0.62	0.63	0	10	22	12	17
5	Community members should understand how the system / solution works before it is put in the community.	3	2	2	4	1.18	1.04	0.95	1.72	5	6	6	2
14	It should be simple (low-tech, easy to understand).	4	2	1	1	1.55	0.64	0.5	0.49	1	9	13	13
16	It should work with minimal human intervention.	0	-1	-2	-2	-0.04	-0.63	-0.76	-0.93	20	23	27	29
28	Members of the community should install and commission the treatment system.	-3	0	1	3	-1.3	-0.08	0.48	1	31	18	14	4
29	Members of the community should operate the treatment system.	0	3	4	1	0.34	1.05	1.39	0.69	15	5	1	10
30	Maintenance should be done by community members.	1	3	4	4	0.53	1.17	1.31	2.42	12	4	2	1
33	There should be external support after implementation for monitoring / maintenance.	1	0	-1	2	0.54	0.23	-0.68	0.92	11	17	25	6
34	Management structure should be defined before implementation.	2	-2	2	1	0.81	-1.01	0.92	0.6	8	27	7	11
Environmental													
6	It should minimize discharge of pollutants into the river.	2	4	1	2	0.61	1.62	0.72	0.82	9	2	11	8
7	It should be easy to collect and dispose of the waste products (solids / sludge).	-1	0	3	0	-0.09	0.47	1.06	-0.08	21	15	4	18
21	It should prevent untreated wastewater from toilets from reaching the river.	3	2	0	3	1.29	0.77	0.31	0.94	4	8	16	5
22	It should prevent untreated kitchen / laundry wastewater from reaching the river.	2	1	2	2	1.04	0.5	0.75	0.89	6	13	9	7
23	Treated wastewater should be apt for reuse.	-2	0	1	0	-0.98	0.46	0.75	-0.09	27	16	10	19
Economic													
8	The initial investment should be low.	2	-3	-2	-1	0.91	-1.16	-1.26	-0.38	7	30	29	22
9	Maintenance should be cheap.	4	4	-1	-1	1.48	2.25	0.11	-0.65	2	1	21	24
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production...)	-2	2	0	-2	-1.13	0.94	0.17	-0.69	29	7	20	26
11	Subsidies should be available for the solution / technology.	0	1	-4	0	0.22	0.51	-1.88	0.08	17	12	33	16
Economic													
12	An external organization / person should operate the treatment system.	-4	0	-3	-3	-2.35	-0.14	-1.82	-1.31	34	20	32	31
13	An external organization / person should install and commission the treatment system.	-4	-1	-4	-2	-1.87	-0.67	-2.19	-0.85	33	25	34	27
15	It should require little maintenance to operate.	3	3	0	-1	1.35	1.24	0.2	-0.34	3	3	18	21
17	It should be quick to build / implement.	0	1	-1	1	0.15	0.48	-0.22	0.39	19	14	22	14
18	It should have been successful in nearby communities.	-1	0	3	0	-0.58	-0.09	1.29	-0.12	24	19	3	20
19	It should have low energy requirements.	1	1	3	-3	0.46	0.64	0.96	-1.5	14	10	5	32
20	Construction / replacement parts should be found in the country.	0	-4	-1	2	0.29	-1.56	-0.52	0.8	16	33	24	9
24	It should take up little space.	-1	-4	-1	-4	-0.36	-1.72	-0.24	-2	22	34	23	34
25	System should treat domestic wastewater from a large number of households (50+).	-3	1	-2	3	-1.4	0.54	-0.73	1.33	32	11	26	3
26	It should allow for future expansion or upgrades.	-2	-2	0	1	-1.04	-1.03	0.44	0.5	28	28	15	12
27	It should be sturdy and hard to vandalize.	0	-1	2	-4	0.2	-0.64	0.77	-1.67	18	24	8	33
31	It should not require changes in infrastructure at household level.	-2	-3	0	-3	-0.62	-1.24	0.2	-0.96	26	31	19	30
32	It should accommodate to existing infrastructure.	-1	-2	0	0	-0.53	-1.03	0.21	0.17	23	29	17	15

4- Factor Solution Consensus vs. Disagreement

Social / Institutional
Environmental
Economic
Technical

Table A23. Q-sort values for statements sorted by Consensus vs. Disagreement including distinction per category (low Z-score variance = high consensus; high Z-score variance = high disagreement)

Stat. #	Statement	Factor 1	Factor 2a	Factor 3	Factor 4	Z-Score Variance
22	It should prevent untreated kitchen / laundry wastewater from reaching the river.	2	1	2	2	0.041
17	It should be quick to build / implement.	0	1	-1	1	0.072
5	Community members should understand how the system / solution works before it is put in the community.	3	2	2	4	0.091
1	It should be provided by a person / association from my own country.	-3	-2	-3	-1	0.112
16	It should work with minimal human intervention.	0	-1	-2	-2	0.113
3	It should be aesthetically appealing.	-1	-3	-2	-2	0.117
21	It should prevent untreated wastewater from toilets from reaching the river.	3	2	0	3	0.124
29	Members of the community should operate the treatment system.	0	3	4	1	0.154
6	It should minimize discharge of pollutants into the river.	2	4	1	2	0.161
14	It should be simple (low-tech, easy to understand).	4	2	1	1	0.195
7	It should be easy to collect and dispose of the waste products (solids / sludge).	-1	0	3	0	0.223
4	It should not smell or attract pests.	1	-1	1	0	0.262
32	It should accommodate to existing infrastructure.	-1	-2	0	0	0.265
31	It should not require changes in infrastructure at household level.	-2	-3	0	-3	0.292
33	There should be external support after implementation for monitoring / maintenance.	1	0	-1	2	0.351
13	An external organization / person should install and commission the treatment system.	-4	-1	-4	-2	0.418
23	Treated wastewater should be apt for reuse.	-2	0	1	0	0.429
30	Maintenance should be done by community members.	1	3	4	4	0.465
2	It should minimize our exposure to our domestic wastewater.	1	-1	-3	-1	0.491
18	It should have been successful in nearby communities.	-1	0	3	0	0.492
15	It should require little maintenance to operate.	3	3	0	-1	0.499
26	It should allow for future expansion or upgrades.	-2	-2	0	1	0.563
34	Management structure should be defined before implementation.	2	-2	2	1	0.61
24	It should take up little space.	-1	-4	-1	-4	0.625
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production…)	-2	2	0	-2	0.634
12	An external organization / person should operate the treatment system.	-4	0	-3	-3	0.668
28	Members of the community should install and commission the treatment system.	-3	0	1	3	0.733
8	The initial investment should be low.	2	-3	-2	-1	0.753
20	Construction / replacement parts should be found in the country.	0	-4	-1	2	0.794
27	It should be sturdy and hard to vandalize.	0	-1	2	-4	0.848
11	Subsidies should be available for the solution / technology.	0	1	-4	0	0.892
19	It should have low energy requirements.	1	1	3	-3	0.931
25	System should treat domestic wastewater from a large number of households (50+).	-3	1	-2	3	1.132
9	Maintenance should be cheap.	4	4	-1	-1	1.286

- **4-F1**

Eigenvalue: 4.94	# Items included (crib sheet): 24 (70.6%)
Explained variance: 13%	# Items included (draft 2): 27 (79.4%)
Respondents with significant loading: 11	# Items included (final draft): 27 (79.4%)

Keywords: Community health, basic current needs, simplicity, overall affordability, funding, socialization, collaboration, low maintenance.

The system should act as a reliable barrier, preventing untreated wastewater from toilets, kitchens, and laundry sources from reaching the river (21:+3; 22:+2), *since the handling of domestic wastewater is of big concern for river and human health. This should be accomplished while minimizing our exposure to our domestic wastewater* (2:+1), *smells and pests* (4:+1).

The initial investment needed for the system should be low (8:+2), *as this could facilitate the obtention of funding* (11:0) *and allow the system to service more people. Since a new system could need a considerable amount of space and changes in existing infrastructure* (24:-1), *but funding may be limited to make the system larger than needed, it would be preferrable if it is designed to service less than 50 households (25:-3) and focus on the current needs rather than accommodating for future expansion or upgrades (26:-2). For this same reason, services such as energy and biogas production, or the possibility of reusing the treated wastewater are not currently a priority (10:-2; 23:-2), since aiming for more sophisticated or advanced technology with more services from the get go would probably be too complex and too expensive* (14:+4; 8:+2).

Affordability however should not only refer to the initial investment. The maintenance of the system should also be cheap in order for the solution to be maintained by the community in the long run, independently from the availability of government funding (9:+4). *Being sturdy, even if this means compromising aesthetics* (3:-1), *would also allow for lower maintenance costs, since it would reduce the number of repairs needed due to regular wear and tear. Nonetheless, a cheaper maintenance may imply that some necessary tasks, such as the sludge and waste product collection and disposal, may not be as straightforward* (7:-1).

It is important for the system to be simple and require little maintenance to operate (14:+4; 15:+3), *preferably needing little human intervention but not extensive automation* (16:0). *Considering the low availability in human resource trained for sanitation tasks, and the low education level in the low-middle income communities, a greatly automated system may be too advanced or be prone to human error if its functioning is difficult to understand. A simple, low-maintenance system requiring sporadic human intervention would then be an ideal option. Nonetheless, regardless of the complexity of the system, community members should understand how the system works before it is put in the community* (5:+3). *This way they could operate and maintain the system themselves if necessary* (29:0; 30:+1). *This socialization should take place even if a similar solution has been successful nearby* (18:-1), *since the familiarity provided by this neighbouring success is appreciated, but it does not necessarily indicate that implementation will be a success.*

Nonetheless, it is not a problem if the system is not from within Indonesia, or even if it is provided by an Indonesian person or entity, since this could lead to possible funding and resources from abroad. This could ultimately be beneficial, as long as the local human resource is also being implemented and the Indonesian people benefit from the import and exchange knowledge (1:-3). *However, neither should community members be expected to install and commission the treatment system themselves* (28:-3), *nor should the responsibility of installing, commissioning, and operating the treatment system rely solely on organizations external to the community* (13:-4;

12:-4). *There should be active collaboration from both parties throughout all project phases, including external support after implementation to successfully monitor and maintain the system* (33:+1), *making the solution more sustainable. It is therefore important for responsibilities to be clear before implementation, and for a management structure for the system to be defined in advanced* (34:+2).

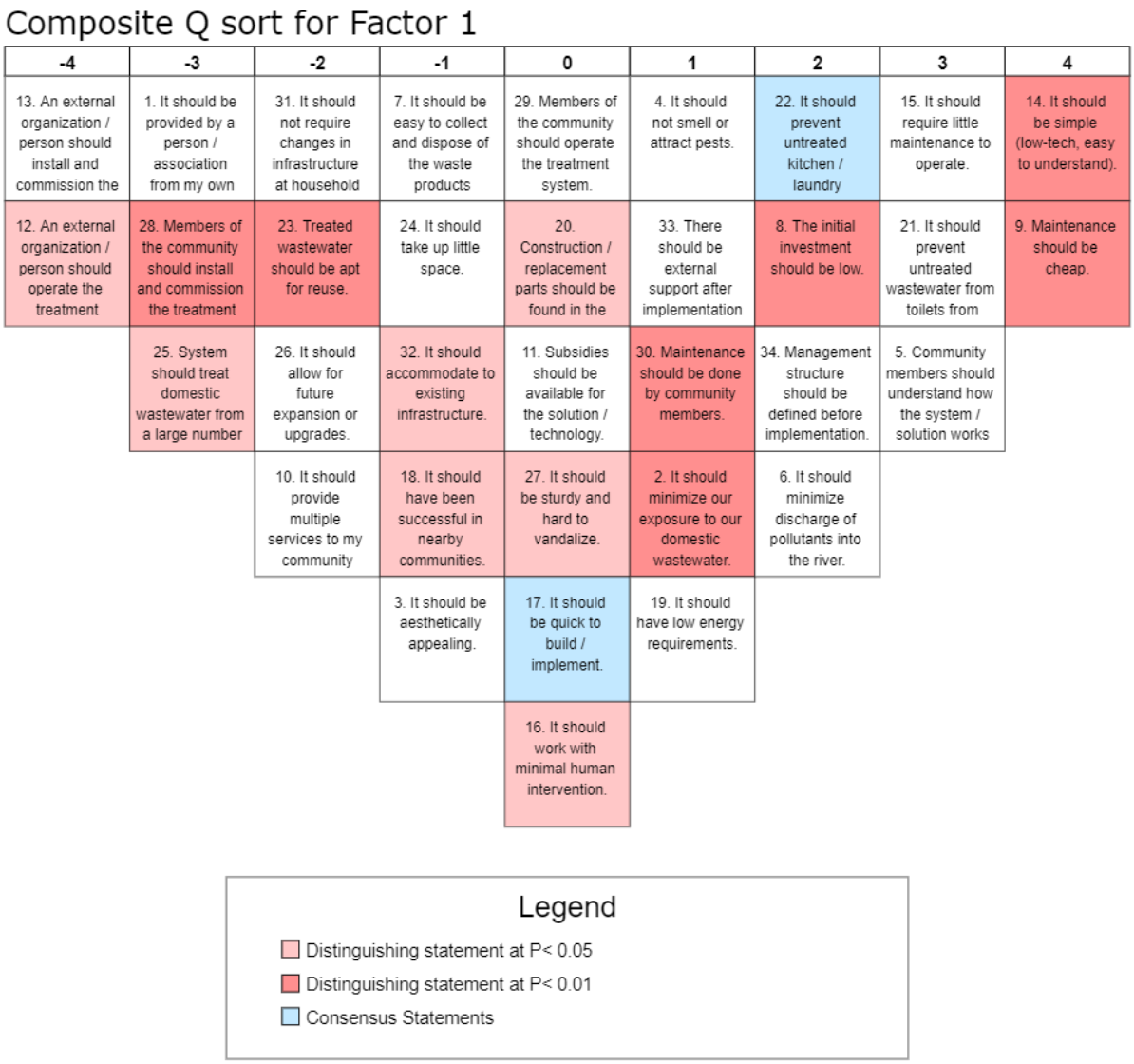


Figure A6. Composite Q-sort for Factor 1, 4-Factor solution.

Table A24. Crib sheet for Factor 1, 4-Factor solution.

Items ranked at +4		**F1**	**C or D**	**F2a**	**F3**	**F4**
14	It should be simple (low-tech, easy to understand).	4	D*	2	1	1
9	Maintenance should be cheap.	4	D*	4	-1	-1
Items ranked higher in Factor 1 array that in other factor arrays						
15	It should require little maintenance to operate.	3		3	0	-1
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3		2	0	3
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2	C	1	2	2
8	The initial investment should be low.	2	D*	-3	-2	-1
34	Management structure should be defined before implementation.	2		-2	2	1
4	It should not smell or attract pests.	1		-1	1	0
2	It should minimize our exposure to our domestic wastewater.	1	D*	-1	-3	-1
16	It should work with minimal human intervention.	0	D	-1	-2	-2
3	It should be aesthetically appealing.	-1		-3	-2	-2
24	It should take up little space.	-1		-4	-1	-4
Items ranked lower in Factor 1 array that in other factor arrays						
30	**Maintenance** should be done by community members.	1	D*	3	4	4
29	Members of the community should **operate** the treatment system.	0		3	4	1
7	It should be easy to collect and dispose of the waste products (solids / sludge).	-1		0	3	0
18	It should have been successful in nearby communities.	-1	D	0	3	0
23	Treated wastewater should be apt for reuse.	-2	D*	0	1	0
26	It should allow for future expansion or upgrades.	-2		-2	0	1
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	-2		2	0	-2
1	It should be provided by a person / association from my own country.	-3		-2	-3	-1
28	Members of the community should **install and commission** the treatment system.	-3	D*	0	1	3
25	System should treat domestic wastewater from a large number of households (50+).	-3	D	1	-2	3
Items ranked at -4						
13	An external organization / person should **install and commission** the treatment system.	-4		-1	-4	-2
12	An external organization / person should operate the treatment system.	-4	D	0	-3	-3
	Additional items included in the analysis					
5	Community members should understand how the system / solution works before it is put in the community.	3		2	2	4
33	There should be external support after implementation for monitoring / maintenance.	1		0	-1	2
11	Subsidies should be available for the solution / technology.	0		1	-4	0

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

- **4-F2a**

Eigenvalue: 3.8	# Items included (crib sheet): 19 (55.9%)
Explained variance: 10%	# Items included (draft 2): 24 (70.6%)
Respondents with significant loading: 8	# Items included (final draft): 24 (70.6%)

Keywords: high removal, resource recovery, make space available, low maintenance costs, community O&M, long-term affordability, user-friendly, prior socialization, low-maintenance, function over aesthetics, household changes acceptable

A wastewater treatment system should help minimize the discharge of pollutants into the river (6:+4*) by preventing untreated blackwater and greywater from reaching the waterbody* (21:+2; 22:+1). *However, it should also provide multiple services to the community, such as energy and biogas production* (10:+2), *which could help the community become more environmentally friendly. The system should focus on accommodating current needs rather than looking at possible upgrades from the start* (26:-2). *Although a larger treatment capacity may require a larger area, space availability should not be a constraint to the scale of the system* (24:-4). *It is okay to use up some additional land if the system will benefit more people.*

Nonetheless, the system's multiple benefits may entail a higher initial investment (8:-3) *which may not be affordable for low-middle income communities, which would prefer a low initial investment, when possible, but the availability of subsidies can help to facilitate the accessibility of these solutions* (11:+1). *Maintenance costs however should definitely be low to ensure its affordability in the long-run and to keep the system running up to standards* (9:+4). *External entities, such as government agencies, should install the system* (13:-1*). Intervention from third parties from abroad would also be welcomed, although it may be more difficult than engaging with local entities* (1:-2). *A community-based sanitation committee or group should still be involved in these initial stages* (28:0).

Community members should also take charge of daily operations of the system (29:+3; 12:0), *considering that it is handling their own waste after all. Since the community is low-middle income, they would probably care mostly about the costs they would have to adopt beyond the available funding and the simplicity of the technology. Long-term affordability and user-friendliness* (9:+4; 14:+2) *are therefore vital for the system to remain operational and up to standard. Additionally, with a simple system the community could define the specifics of management and assign responsibilities after the system is commissioned and adjust it as they see fit, so a detailed management structure is not necessarily a prerequisite for implementation* (34:-2). *This active role should also extend to the maintenance of the system* (30:+3). *However, for the community to effectively fulfil this responsibility, it is important that members have a clear understanding of how the system functions before its implementation* (5:+2). *A solution needing very little maintenance would also be preferred if the community itself is to maintain it* (15:+3). *If too much maintenance is required, then a different technology would be better. Furthermore, if little maintenance is necessary and said maintenance is also cheap, it would not be a problem if necessary replacement parts are not found in the country* (20:-4) *as these would not be required on a regular basis*.

Understandably, implementing a new wastewater treatment system cannot always accommodate to the infrastructure that is currently in place in the community (32:-2) *and changes at household level would probably be required* (31:-3). *Nonetheless, it would be ideal if the system could be built or implemented quickly to minimize disruptions to the community* (17:+1). *Lastly, it is acceptable if the system is not aesthetically appealing* (3:-3) *since this is not essential for the functionality of the system. Similarly, some nuisance like smell or pests are to be expected from a wastewater treatment system* (4:-1).

Composite Q sort for Factor 2a

-4	-3	-2	-1	0	1	2	3	4
20. Construction / replacement parts should be found in the	8. The initial investment should be low.	1. It should be provided by a person / association from my own	2. It should minimize our exposure to our domestic wastewater.	7. It should be easy to collect and dispose of the waste products	19. It should have low energy requirements.	5. Community members should understand how the system / solution works	15. It should require little maintenance to operate.	9. Maintenance should be cheap.
24. It should take up little space.	31. It should not require changes in infrastructure at household	34. Management structure should be defined before implementation.	4. It should not smell or attract pests.	23. Treated wastewater should be apt for reuse.	25. System should treat domestic wastewater from a large number	10. It should provide multiple services to my community	30. Maintenance should be done by community members.	6. It should minimize discharge of pollutants into the river.
	3. It should be aesthetically appealing.	26. It should allow for future expansion or upgrades.	16. It should work with minimal human intervention.	33. There should be external support after implementation	11. Subsidies should be available for the solution / technology.	21. It should prevent untreated wastewater from toilets from	29. Members of the community should operate the treatment system.	
		32. It should accommodate to existing infrastructure.	27. It should be sturdy and hard to vandalize.	28. Members of the community should install and commission the treatment	22. It should prevent untreated kitchen / laundry	14. It should be simple (low-tech, easy to understand).		
			13. An external organization / person should install and commission the	18. It should have been successful in nearby communities.	17. It should be quick to build / implement.			
				12. An external organization / person should operate the treatment				

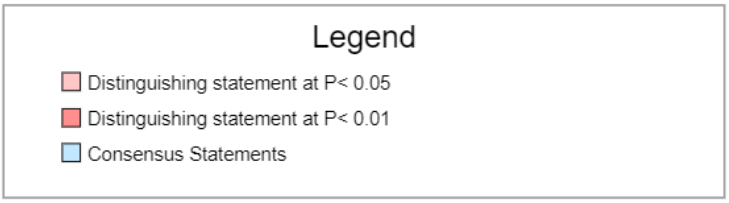


Figure A7. Composite Q-sort for Factor 2a, 4-Factor solution.

Table A25. Crib sheet for Factor 2a, 4-Factor solution.

Items ranked at +4		**F2a**	**C or D**	**F1**	**F3**	**F4**
9	Maintenance should be cheap.	4	D*	4	-1	-1
6	It should minimize discharge of pollutants into the river.	4	D*	2	1	2
Items ranked higher in Factor 2a array that in other factor arrays						
15	It should require little maintenance to operate.	3		3	0	-1
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy, and biogas production...)	2	D*	-2	0	-2
11	Subsidies should be available for the solution / technology.	1		0	-4	0
17	It should be quick to build / implement.	1	C	0	-1	1
12	An external organization / person should operate the treatment system.	0	D*	-4	-3	-3
13	An external organization / person should **install and commission** the treatment system.	-1		-4	-4	-2
Items ranked lower in Factor 2a array that in other factor arrays						
5	Community members should understand how the system / solution works before it is put in the community.	2		3	2	4
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	1	C	2	2	2
4	It should not smell or attract pests.	-1	D	1	1	0
34	Management structure should be defined before implementation.	-2	D*	2	2	1
26	It should allow for future expansion or upgrades.	-2		-2	0	1
32	It should accommodate to existing infrastructure.	-2	D	-1	0	0
8	The initial investment should be low.	-3		2	-2	-1
31	It should not require changes in infrastructure at **household level**.	-3		-2	0	-3
3	It should be aesthetically appealing.	-3	D	-1	-2	-2
Items ranked at -4						
20	Construction / replacement parts should be found in the country.	-4	D*	0	-1	2
24	It should take up little space.	-4		-1	-1	-4
Additional items included in the analysis						
1	It should be provided by a person / association from my own country.	-2		-3	-3	-1
21	It should prevent untreated wastewater from **toilets** from reaching the river.	2		3	0	3
14	It should be simple (low-tech, easy to understand).	2		4	1	1
29	Members of the community should **operate** the treatment system.	3		0	4	1
30	**Maintenance** should be done by community members.	3		1	4	4

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

- **4-F3**

Eigenvalue: 3.04	# Items included (crib sheet): 25 (73.5%)
Explained variance: 8%	# Items included (draft 2): 30 (88.2%)
Respondents with significant loading: 5	# Items included (final draft): 29 (85.3%)

Keywords: Community-run O&M, low external involvement, prior socialization, sense of belonging, prior management plan, welcome external knowledge, familiarity, community-led maintenance, easy waste product disposal, sturdy, low energy, funding for CAPEX and OPEX, community interest, no pests or smells.

A wastewater treatment system should help reduce the discharge of pollutants into the river (6:+1) *by preventing untreated wastewater, greywater mainly, from reaching the waterbody* (21:0; 22:+2). *Additionally, the community should be able to reuse the treated wastewater* (23:+1). *This could help reduce their water consumption and make the community more environmentally friendly. Community members should be in the forefront of the installation, commissioning* (28:+1), *operation* (29:+4), *and maintenance* (30:+4) *of the domestic wastewater treatment system in their communities, not external entities* (12:-3; 13:-4) *such as government agencies or NGOs. Therefore, community members should understand the workings of the system before it is put in the area* (5:+2). *This would also improve their awareness regarding the importance and benefits of proper wastewater handling and management. As a simpler system would be easier to understand, it could be a good solution that the community could develop a strong sense of belonging towards* (14:+1).

Considering that this prior socialization is critical for the success of the system in the long-run, as well as the development of a good system management plan (34:+2), *the implementation of wastewater treatment systems should not be rushed to avoid wasting resources and investments* (17:-1). *Appropriate system management could also help reduce costs in the long-run, since it could lead to more effective usage of available funding* (34:+2). *Additionally, a "success story" from a similar system in a nearby community for example, could also help incentivise locals to be more accepting of the implementation of wastewater treatment technologies* (18:+3). *However, even with a prior explanation of the system, external support should be available for the community to help with the monitoring and maintenance of the system* (33:-1). *External knowledge and support are therefore welcome, and even contributions from entities or people abroad would be valuable and appreciated* (1:-3).

Considering the potential difference in the lifespan of existing infrastructure compared to the system, this should be selected or designed in a manner that ensures its functionality remains unaffected even if the existing infrastructure requires replacing or modifying (31:0; 32:0). *Nonetheless, the government needs help with the maintenance of the wastewater infrastructure, since both budget and manpower are limited, so community participation is not just appreciated but necessary* (30:+4). *This community involvement is indispensable to prevent implemented systems to fall into disrepair. However, if the community is to be responsible for the maintenance, it should be easy to collect and dispose of the waste products from the treatment processes to make the maintenance less challenging* (7:+3), *which could avoid people skipping necessary tasks and keep the system operating up to standard. Additionally, considering the budget limitations stated, a sturdy system would be best since costs could be reduced with respect to repairs* (27:+2). *Maintenance costs could be decreased further by having a system with low energy requirements* (9:-1; 19:+3). *Additionally, since the community would prefer a user-friendly solution than some advanced technology, then the initial cost would not be a source of concern* (8:-2). *Hence, it would*

be better if there were subsidies available for the whole duration of the project rather than for the technology itself (11:-4).

Lastly, it would be better if the system needs some human intervention to work properly (16:-2). *This way, the community could get more involved and their interest towards the system could grow by being able to interact with it and see how it works. This greater exposure to the processes involved* (2:-3) *could increase the people's awareness with respect to sanitation and wastewater treatment. Although the system does not need to be aesthetically appealing* (3:-2), *it would be favourable if the system did not attract pests or had strong smells* (4:+1). *This would be a greater nuisance than the system being unattractive and would even be a health risk for the community members, especially the ones more involved with the system.*

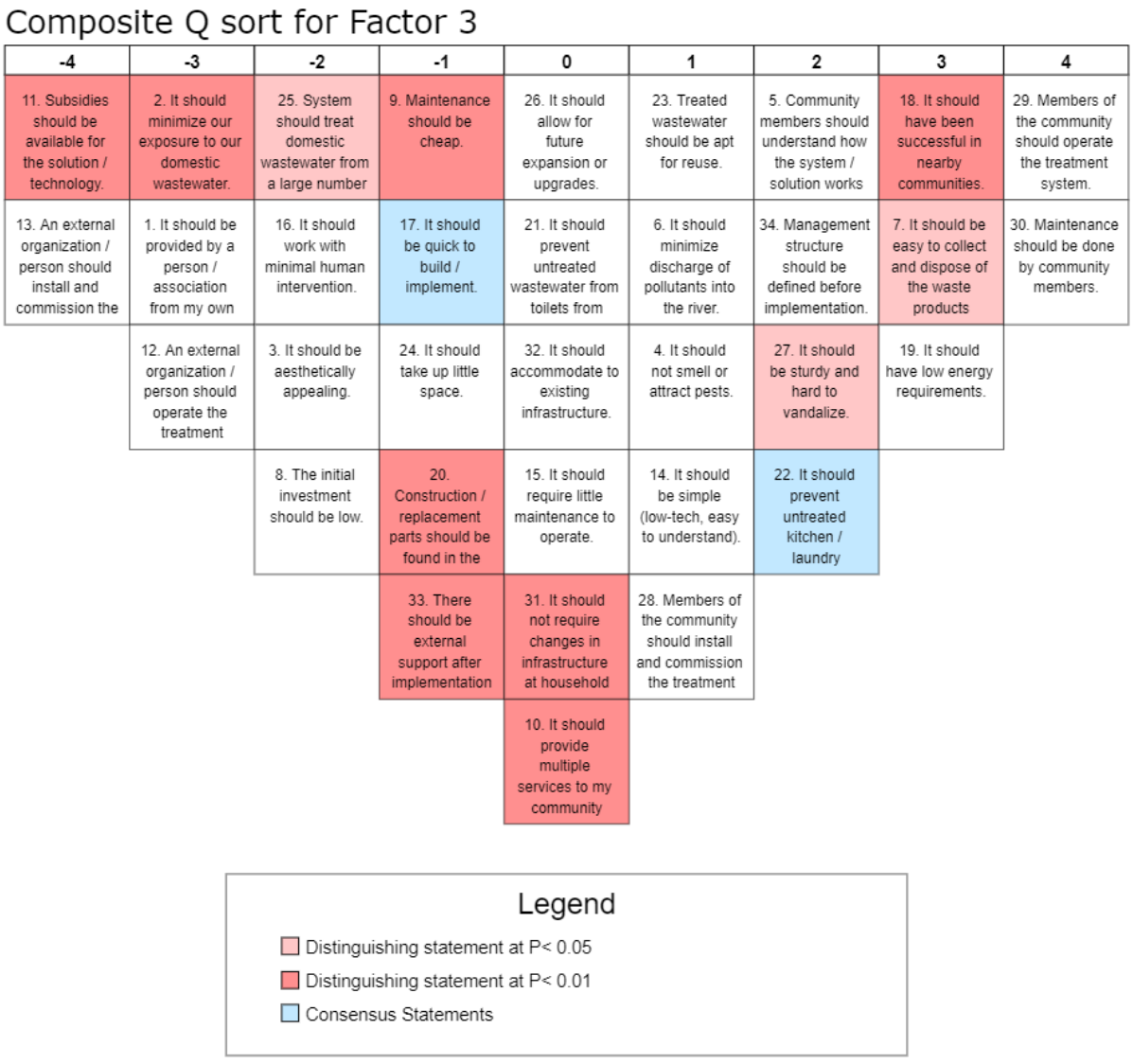


Figure A8. Composite Q-sort for Factor 3, 4-Factor solution.

Table A26. Crib sheet for Factor 3, 4-Factor solution.

Items ranked at +4		**F3**	**C or D**	**F1**	**F2a**	**F4**
29	Members of the community should **operate** the treatment system.	4		0	3	1
30	**Maintenance** should be done by community members.	4		1	3	4
Items ranked higher in Factor 3 array that in other factor arrays						
18	It should have been successful in nearby communities.	3	D*	-1	0	0
7	It should be easy to collect and dispose of the waste products (solids / sludge).	3	D	-1	0	0
19	It should have low energy requirements.	3		1	1	-3
34	Management structure should be defined before implementation.	2		2	-2	1
27	It should be sturdy and hard to vandalize.	2	D	0	-1	-4
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2	C	2	1	2
23	Treated wastewater should be apt for reuse.	1		-2	0	0
4	It should not smell or attract pests.	1		1	-1	0
32	It should accommodate to existing infrastructure.	0		-1	-2	0
31	It should not require changes in infrastructure at **household level**.	0	D*	-2	-3	-3
24	It should take up little space.	-1		-1	-4	-4
Items ranked lower in Factor 3 array that in other factor arrays						
5	Community members should understand how the system / solution works before it is put in the community.	2		3	2	4
6	It should minimize discharge of pollutants into the river.	1		2	4	2
14	It should be simple (low-tech, easy to understand).	1		4	2	1
21	It should prevent untreated wastewater from **toilets** from reaching the river.	0		3	2	3
9	Maintenance should be cheap.	-1	D*	4	4	-1
17	It should be quick to build / implement.	-1	C	0	1	1
33	There should be external support after implementation for monitoring / maintenance.	-1	D*	1	0	2
16	It should work with minimal human intervention.	-2		0	-1	-2
2	It should minimize our exposure to our domestic wastewater.	-3	D*	1	-1	-1
1	It should be provided by a person / association from my own country.	-3		-3	-2	-1
Items ranked at -4						
11	Subsidies should be available for the solution / technology.	-4	D*	0	1	0
13	An external organization / person should **install and commission** the treatment system.	-4		-4	-1	-2
Additional items included in the analysis						
3	It should be aesthetically appealing.	-2		-1	-3	-2
8	The initial investment should be low.	-2		2	-3	-1
12	An external organization / person should operate the treatment system.	-3		-4	0	-3
25	System should treat domestic wastewater from a large number of households (50+).	-2	D	-3	1	3
28	Members of the community should **install and commission** the treatment system.	1		-3	0	3

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.

- **4-F4**

Eigenvalue: 3.8	# Items included (crib sheet): 20 (58.8%)
Explained variance: 10%	# Items included (draft 2): 24 (70.6%)
Respondents with significant loading: 7	# Items included (final draft): 24 (70.6%)

Keywords: High capacity, infrastructure building, ready for growth, basic treatment, make space available, high community involvement, external support, extensive prior socialization

The overall health of the community should be a priority, so a wastewater treatment system does not need to be attractive to look at (3:-2). *Aesthetics could be addressed as an additional component after functionality has been resolved* (Q30). *Ideally it would not take such a long time to put the system in place* (17:+1) *since the faster it is built or installed, the faster the community can benefit from it, especially since water is such a vital resource* (Q11). *The intervention should service a large number of households* (25:+3), *even if the larger scale may require more energy to operate* (19:-3). *Although, this wider coverage may require some changes in infrastructure at household level, this is a necessary addition to any households still lacking drainage pipes or a connection to a treatment system* (31:-3). *The current state of infrastructure, which is characterized by low sewerage coverage, should be taken into account and the system should be designed accordingly* (Q14; 32:0) *since it is hard to transport wastewater from source to treatment if there is no available infrastructure of course.*

Additionally, the system should be designed or selected keeping the possible growth of the community in mind, so it should be possible to either expand its capacity or upgrade its technologies to accommodate the future needs (26:+1). *Understandably, this larger system with room for expansion would occupy a more extensive area* (24:-4), *but it is worth to sacrifice some space in the community in order to have a wastewater system that works and serves everyone* (see Q36 & Q30*). The system should also focus only on the effective treatment of the wastewater to prevent both blackwater and greywater, mainly the former, from reaching the river* (21:+3; 22:+2; 6:+2), *so a system that can provide additional services is not a priority* (10:-2).

When implementing a new domestic wastewater treatment system, the community itself should be involved in the process every step of the way. They should have a primary role in the construction or installation (28:+3), *but most importantly in the maintenance of the selected system* (30:+4). *This way, they can be self-sufficient and not depend on external entities for the system to remain operational* (12:-3; 13:-2). *It is not as important however that the system is provided by an Indonesian person or entity, since great collaboration can come from working with foreign groups* (1:-1; Q22*). Unfortunately, since not enough funding is available for maintenance* (Q36), *this should be cheap* (9:-1). *However, construction and replacement parts could be found within the country, as this can reduce costs and allow any necessary repairs to take place faster* (20:+2; Q32). *Nonetheless, since maintenance is not only a matter of budget or material availability, the great importance of community involvement and awareness comes back into play* (Q21), *which can be facilitated by implementing a simple, user-friendly system* (14:+1).

Handling the daily maintenance requirement of the system can harbour a great sense of ownership over it, which can be beneficial to avoid its neglect and possible acts of vandalism (27:-4; Q30 & Q36). Since *community participation is preferred, an automated system requiring little human intervention would not be ideal to promote the involvement of the locals* (16:-2). *Furthermore, even though a larger system may require more maintenance* (15:-1), *the community could still handle the responsibility with some external support to facilitate monitoring and make sure maintenance is being done correctly* (33:+2). *In order to adopt this level of responsibility*

however, extensive socialization should take please before implementation to make sure the community members understand the requirements of the system, how it works, and what tasks they will need to complete (5:+4).

Composite Q sort for Factor 4

-4	-3	-2	-1	0	1	2	3	4
27. It should be sturdy and hard to vandalize.	31. It should not require changes in infrastructure at household	10. It should provide multiple services to my community	15. It should require little maintenance to operate.	32. It should accommodate to existing infrastructure.	29. Members of the community should operate the treatment system.	33. There should be external support after implementation	25. System should treat domestic wastewater from a large number	30. Maintenance should be done by community members.
24. It should take up little space.	12. An external organization / person should operate the treatment	13. An external organization / person should install and commission the	8. The initial investment should be low.	11. Subsidies should be available for the solution / technology.	34. Management structure should be defined before implementation.	22. It should prevent untreated kitchen / laundry	28. Members of the community should install and commission the treatment	5. Community members should understand how the system / solution works
	19. It should have low energy requirements.	3. It should be aesthetically appealing.	2. It should minimize our exposure to our domestic wastewater.	4. It should not smell or attract pests.	26. It should allow for future expansion or upgrades.	6. It should minimize discharge of pollutants into the river.	21. It should prevent untreated wastewater from toilets from	
		16. It should work with minimal human intervention.	9. Maintenance should be cheap.	7. It should be easy to collect and dispose of the waste products	14. It should be simple (low-tech, easy to understand).	20. Construction / replacement parts should be found in the		
			1. It should be provided by a person / association from my own	23. Treated wastewater should be apt for reuse.	17. It should be quick to build / implement.			
				18. It should have been successful in nearby communities.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus Statements

Figure A9. Composite Q-sort for Factor 4, 4-Factor solution.

Table A27. Crib sheet for Factor 4, 4-Factor solution.

Items ranked at +4		**F4**	**C or D**	**F1**	**F2a**	**F3**
30	**Maintenance** should be done by community members.	4	D*	1	3	4
5	Community members should understand how the system / solution works before it is put in the community.	4	D	3	2	2
Items ranked higher in Factor 4 array that in other factor arrays						
25	System should treat domestic wastewater from a large number of households (50+).	3	D*	-3	1	-2
28	Members of the community should **install and commission** the treatment system.	3		-3	0	1
21	It should prevent untreated wastewater from **toilets** from reaching the river.	3		3	2	0
33	There should be external support after implementation for monitoring / maintenance.	2		1	0	-1
22	It should prevent untreated **kitchen / laundry** wastewater from reaching the river.	2	C	2	1	2
20	Construction / replacement parts should be found in the country.	2	D	0	-4	-1
26	It should allow for future expansion or upgrades.	1		-2	-2	0
17	It should be quick to build / implement.	1	C	0	1	-1
32	It should accommodate to existing infrastructure.	0		-1	-2	0
1	It should be provided by a person / association from my own country.	-1		-3	-2	-3
Items ranked lower in Factor 4 array that in other factor arrays						
14	It should be simple (low-tech, easy to understand).	1		4	2	1
15	It should require little maintenance to operate.	-1		3	3	0
9	Maintenance should be cheap.	-1	D*	4	4	-1
10	It should provide multiple services to my community (community sanitation, wastewater treatment, energy and biogas production...)	-2		-2	2	0
16	It should work with minimal human intervention.	-2		0	-1	-2
31	It should not require changes in infrastructure at **household level**.	-3		-2	-3	0
19	It should have low energy requirements.	-3	D*	1	1	3
Items ranked at -4						
27	It should be sturdy and hard to vandalize.	-4	D*	0	-1	2
24	It should take up little space.	-4		-1	-4	-1
Additional items included in the analysis						
3	It should be aesthetically appealing.	-2		-1	-3	-2
6	It should minimize discharge of pollutants into the river.	2		2	4	1
12	An external organization / person should operate the treatment system.	-3		-4	0	-3
13	An external organization / person should **install and commission** the treatment system.	-2		-4	-1	-4

For distinguishing statements: D* = significance at $p < 0.05$; D** = significance at $p < 0.01$.