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Determination of Design Criteria for Floating Portable Toilet Applied at Flood Prone Area

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Abstract

Communities living in flood-prone areas generally experience difficulty accessing toilet facilities when the water level fluctuates. Information on providing toilets that can adapt to changes in the water level at disaster sites has yet to be published. In addition, the obstacles often faced in the provision of toilets are difficulty in distribution because they cannot be disassembled, toilets are unstable when placed above the water level, and they are not environmentally friendly. The availability of a comprehensive type of floating portable toilet that is suited for installation in advance (before flooding) and adapts to floating conditions should be more investigated. This research aims to select critical criteria for floating portable toilet design. Interpretive Structural Modelling (ISM) is used to determine the most essential Criteria (P). Secondary data collected include information related to toilet design that has been carried out in various countries, and primary data is collected by distributing questionnaires to as many as 22 selected key respondents. The results showed that the critical factors in designing a floating portable toilet were classified into 6 (six) important parameters, namely: Design and Environmental Management System, Safety, Cleanliness, Amenities, and facilities, Ease of Mobility, and Length of construction time.

Keywords: floating portable toilet; sanitasi; flood prone area; design and environtmental management system.

Introduction

Floodable areas are among the most productive in the world, which explains the tremendous human exploitation of these areas' natural resources. The occurrence of flooding is linked to the annual increase in the water level of rivers (Pedro et al., 2020). The event exhibits a degree of regularity due to its occurrence within a well-established timeframe. Nevertheless, the substantial magnitude of the fluctuation in the elevation poses challenges in the construction of toilets since they must be positioned at very elevated heights. Additional issues include the erosion and collapse of riverbanks and an escalation in the practice of open defecation, which can be attributed to the prolonged duration of the flood event. The phenomena hold significant importance within the context of floodplains.

Hydrometeorological disasters such as floods, whether inundation, surface runoff, flash floods due to seasonal changes, or tidal surges, are recurring occurrences in Indonesia (BNPB, 2021). The duration of each flood varies, ranging from 1 day to several weeks (Djonoputro et al., 2010; Mulyani et al., 2017) and even up to several months in various other countries (Pedro et al., 2020). The inundation height also fluctuates between 0.5 m to 2.0 m in Indonesia, reaching 9.0 in Cambodia (Balzer & Pon, 2003) and 10.0 m in various other countries (Pedro et al., 2020). Flood conditions are emergencies where the environment is destroyed because water, garbage, dirt, mud, and debris or chunks of houses are inundated. In places where it was especially severe, floods submerged houses, and their contents and sometimes also caused casualties. However, at the same time, the lack of adequate sanitation technologies for flood-prone areas has a detrimental effect on locals' quality of life.

The evacuation process and logistics for sanitation facilities, specifically for toilets in Indonesia, often need to be addressed and sometimes go unnoticed. In fact, after the disaster, health threats often appeared in the evacuation sites due to the provision of makeshift sanitation facilities. The public toilet in question is a sanitation facility that accommodates the need to defecate that is used by the general public, regardless of the user's age or gender. Portable itself means something easy to carry around (ATI, 2016).

Based on the results of previous research (Reina, 2015), it was stated that: (a) The crucial needs of refugees are toilets that are easy for volunteers to carry and comfortable to use; (b) Products must be specially designed for Indonesians so that they have comfortable dimensions and accessories that suit their needs; (c) A good toilet has an integrated exhaust system, thereby reducing the possibility of disease transmission and foul odors; (d) The problem with the toilets used so far is that they were built with makeshift materials, without regard to the exhaust system, and needed adequate lighting; (e) The portable toilets sold in the market have large and heavy dimensions that hinder their distribution.

This is in line with the 2018 Sphere document, consideration of the inclusive use of appropriate toilet facilities and materials is urgently needed. This relates to concerns about hygiene and odor, cultural taboos, physical accessibility, and privacy and safety that need to be anticipated when using the toilet or latrines.

Another problem often encountered during emergency response activities at disaster evacuation sites in Indonesia is the unavailability of stable toilets against fluctuations in water level and current speed. Even though it has been designed to be relatively light, it has not been assembled, making it easy to disassemble and transport to locations that are difficult to reach by vehicles. In addition, the maximum use of the product is 90 days because, according to Law No. 7 of 2012 Article 22, after 90 days, refugees are no longer the responsibility of the government (Reina, 2015). So efforts must be made so that the septic tank's life can last less than 90 days without emptying it using the bioactivator concept (Amelia, 2022).

Many forms and designs of portable toilets, from simple to complex, have been mass-produced. Even the standard toilet designs for particular recreational locations in Asian countries have issued technical guidelines (ASEAN, 2016). This guideline is very comprehensive for application on the ground. Of course, it is impossible to be adopted in its entirety for the needs of an emergency response. Recent years of scientific publications on sanitation technology reveal a wide range of options, including water-based solutions, urine diversion toilets (Muench, 2011), composting toilets (Berger, 2011), and ecological sanitation (Ecosan) (Hu et al., 2016), which have potential for application in rural areas.

The National Disaster Management Agency (BNPB) has yet to explicitly issue technical guidelines for planning toilets that can be used during the emergency response process in flood disaster zones or residential areas constantly flooded with water. Unfortunately, the availability of portable toilets in Indonesia is still limited to lightweight and easy-to-carry toilets. However, the provision of portable toilets in which lightweight, can be disassembled, can be afloat, and stable against the influence of discharge, flow velocity, and currents, eco-friendly solar lighting, simple drinking water, and septic tank systems are not much reported and studied in detailed. Of the various types, conditions, and functions described above, to design a technically feasible floating portable toilet (ASEAN, 2016), we should consider the following parameters: (A) Design and Environmental Management System; (B) Amenities and facilities; (C) Cleanliness; and (D) Safety.

(Mahmud et al., 2023) introduced a user-friendly floating WASH platform for the 'Bede' community where hygienic toilet facilities are provided, fecal sludge management, wastewater treatment, and potable water generation facilities for the maximum number of people with the most diminutive possible dimensions. At the same time, they claim its ease of movability is also considered so that people can quickly move it during their migration. However, these structures are not portable or challenging to be disassembled at all.

Based on the problems described above, this paper aims to determine the order of the essential parameter criteria to be considered in designing floating portable toilets suitable for installation in advance (before flooding) and adapting to floating conditions when floods happen. It can also be used in residential areas that live in rivers or swamps.

Methods

This research was initiated by collecting secondary data from relevant references related to floating portable toilets, especially regarding the regulations, rules, and minimum standards needed to design toilets in recreational, public, and disaster areas. Then from this information, a floating toilet was intended as an initial design. However, to obtain an appropriate format and meet the standard criteria used in flood response, expert input is needed in determining the most critical parameters that must be prioritized and the components or elements of each parameter that are also the most important are met. From the results of the selected experts' input, the initial design was readjusted. The flow of research conducted can be seen in Fig.1. below.

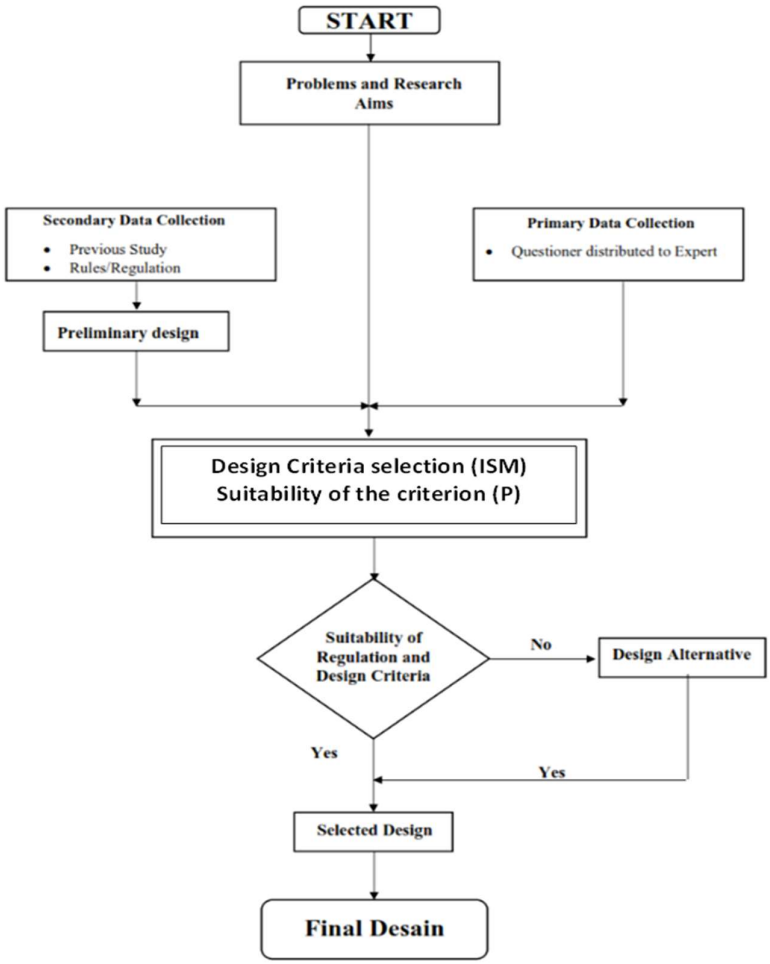

Figure 1. Research flowchart.

Guidelines, Regulations, and Standards used

Several types of toilets are usually used in evacuation sites for natural disaster victims, including cabin toilets, mobile toilets, Bus toilets, Knock Down MCK, and Portable Toilets (Asbahdin, 2018). Several other variants of the latest technology are called eSOS (Emergency Sanitastion Operation System) (Flex, 2023), Blue Diversion Toilet–

Eawag, The Swiss Federal Institute of Aquatic Science and Technology (Blue Diversion, 2023), The Autarky Toilet– Eawag, The Swiss Federal Institute of Aquatic Science and Technology (Eawag, 2023), and the Bio Toilet - LIPI Project (LIPI, 2023) have been applied in various locations.

Toilet designs and products that can float on the lake have also been carried out. However, they still use post-use blackwater extraction and disposal procedures (Balzer & Pon, 2003). Another Ecosan Group (Winblad & Simpson-Hébert, 2004) has initiated the use of waterless toilets, called Urine-Diverting Dehydrating Toilets (UDDT) (Uddin et al., 2011), which are applied in Bangladesh and Mozambique. Unfortunately, in Indonesia, culturally and religiously, the use of this type of toilet is not possible to use. This floating toilet is implemented in communities whose residents live in floating houses on rivers or lakes (Hagan et al., 2011). Although they are recommended for conditions in seasons with high water levels, there are limitations related to their use, namely from the aspects of maintenance (feces handling), smell, and user acceptance (Mkhize, 2017).

The main criteria for designing toilets for ASEAN countries, according to ASEAN Public Toilet Standard, 2016, are (1) Design and Environmental Management System. According to (Hapsari, 2016), attention to the anthropometric rules for people with disabilities should be considered for designing toilets; (2) Convenience and supporting facilities. Inside a toilet, there is a space requirement for human movements, such as rubbing the body, pouring, and drying (Hapsari, 2018); (3) Building cleanliness; (4) Safety of construction. By American standards (ANSI, 2016), the essential criteria they need to consider include:

1. Structure housing can be mobile trailers or prefabricated if it is in the compartment; privacy should be assured.
2. The interiors shall have a finished surface of solid that can be sanitized.
3. Spaces should be adequate for the user with minimum inside dimensions.
4. Ventilation, inside latch door, waste tank vented, affordable for disabled person, equipped with light, and no more than two units toilets be tethered together.

However, for special needs in evacuation sites, other criteria are needed, such as (5) Ease of mobility (Asbahdin, 2018); and (6) Speed of construction time (Asbahdin, 2022). Table 1. summarizes information on regulations or guidelines published related to criteria for regular and emergency toilets available.

Table 1. Selected Regulations available related to the Portable Toilet Criteria.

Regulation Titles	Reference Issuing Agencies	Source of References
Humanitarian Charter and Minimum Standards in Humanitarian Response	The Sphere Project	International
Facilities and Accessibility Standards in Buildings and Health Service Facilities Environment	Kementerian Pekerjaan Umum dan Perumahan Rakyat Direktorat Jenderal Cipta Karya Direktorat Bina Penataan Bangunan	National
Guidelines for Public Toilet Standards in Indonesia	Asosiasi Toilet Indonesia	National
Indonesian Public Toilet Standards	Kementrian Kebudayaan dan Pariwisata	National

Table 1. Selected Regulations available related to the Portable Toilet Criteria (continued).

Regulation Titles	Reference Issuing Agencies	Source of References

Occupational Health and Safety Management System (Toilet Maintenance SOP)	Universitas Diponegoro	National
Regulation Of The Minister Of Health Of The Republic Of Indonesia Number 57 Of 2014 About Standard Of Office Facilities And Infrastructure In The Environment Ministry of Health Number 57 Year 20 Tentang Pelayanan Publik	Undang-Undang Menteri Kesehatan	National
About Standard Of Office Facilities And Infrastructure In The Environment Ministry Of Health Number 57 Year 20 Tentang Pelayanan Publik	Undang-Undang Republik Indonesia	National
Regulation Of The Minister Of Health Of The Republic Of Indonesia Number 57 Of 2014 About Standard Of Office Facilities And Infrastructure In The Environment Ministry Of Health Number 57 Year 20	Badan Nasional Penanggulangan Bencana	National
Regulation Of The Minister Of Health Of The Republic Of Indonesia Number 48 Of 2016 About Office Health And Safety Standards Number 48 Of 2016 About Office Occupational Safety And Health Standards	Undang-Undang Menteri Kesehatan	National

Preliminary design of Floating Portable Toilet

Flood-prone regions, including coastal areas, estuaries, swamps, high groundwater areas, and areas susceptible to frequent floods, provide significant challenges for deploying technology sanitation solutions (Djonoputro et al., 2010). Hence, in this study, the toilet is designed to be portable and float. It can be easily installed in advance (before flooding) and adapted to floating conditions or in conditions of waterlogged ground surface. Referring to the guidelines, regulations, and toilet standards issued by various countries, the first step in designing a floating portable toilet is to visualize it as a design that can be modified according to the needs and input of experts.

Determination of Design Criteria (P)

Several methods can be used to determine design criteria, including the Analytical Hierarchy Procedure (AHP) method. Previous studies (Amelia, 2022; Asbahdin, 2018) used the AHP (The Analytical Hierarchy Process) method to produce the following design criteria: convenience, mobility, energy requirements, water requirements, safety and comfort, speed of construction/installation time, suitability of sanitation culture, weather resistance, and quality of materials (construction). Then they also determined the dimensions of the toilet with a length of 160 cm, a width of 100 cm, and a height of 247 cm, according to the Indonesian Public Toilet Standard Book by the Ministry of Culture and Tourism.

Another method commonly used to determine the design criteria for a problem is Interpretive Structural Modelling (ISM). ISM is defined as a methodology used to formulate a structure by analyzing quite complex system elements (Attri et al., 2013). It can also be expressed as a way of interpreting objects and systems graphically. The questions include assessment factors, policy objectives, targets, and others (Ahmad & Qahmash, 2021; Janes, 1988; Lendaris, 1980; Sushil, 2012).

The general procedures in the ISM method (Janes, 1988) are (a) Identifying issues or problems to be resolved; (b) deciding on the type of ISM to be built; (c) Select participants or respondents and become facilitators; (d) Design criteria (P) must have been prepared and used in gathering information questionnaire distributed; (e) The

research team compiled a complex matrix of element interactions (A); (f) Present a diagram of ISM results; (g) The research team can discuss internally related to the results of the answers from the respondents.

Primary data is collected through a survey method by sending/distributing questionnaires to experts or experts in determining design criteria (P) from the most important to the least important.

Experts Opinion

According to (Singarimbun & Sofian, 2012), the non-probability sampling method is a method that involves identifying samples based on expertise. The sampling of selected respondents was determined subjectively from elements of academia, agencies or government, and related communities. In this study, 22 key respondents were selected. Identifying key figures used as respondents had considered their abilities, integrity, background, and experience in their respective fields for input of ideas and thoughts, which were the focus of the research.

The key persons selected were from (a) the Aceh Province Irrigation Service / 1 person; (b) Aceh Public Works and Spatial Planning Service / 2 people; (c) Public Housing and Settlement Area Office of Aceh / 2 people; (d) Aceh Disaster Management Agency for Emergency Response / 2 people; (e) Lecturer at Syiah Kuala University, Faculty of Engineering, Department of Chemical Engineering / Civil Engineering / 4 people; (f) Lecturers at Teuku Umar University, Faculty of Engineering, Department of Public Health, three people; (g) 2 lecturers at Samudra University, Faculty of Civil Engineering / Environmental Engineering; (h) Community Users in Locations Affected by Floods / 3 people; (i) Head of UPTD TDMRC / 1 person; (j) TDMRC Researcher / 1 person; and (k) Non-Governmental Organizations Originating from HaKa / 1 person.

The selection of selected criteria refers to related references and rules, regulations, and standards in force in America (ANSI, 2016), ASEAN (ASEAN, 2016), and Indonesia (ATI, 2016). The criteria in question are presented in Table 2.

Table 2. List of selected floating portable toilet design criteria (P).

No	Code of Criteria (P-i) dan (P-j)	Explanation of each Criteria selected
1	P1	Design and Environmental Management System
2	P2	Convenience and supporting facilities
3	P3	Building cleanliness
4	P4	Safety of construction
5	P5	Ease of mobility
6	P6	Speed of construction time

Table 3. Symbol Description for Each Criterion (P).

Symbol	Description of each Criterion (P)
V	Criteria-i is more important than Criteria -j
A	Criteria -j is more important than Criteria -i
X	Both Criteria are equally/important
0	Both Criteria are equally unimportant

All selected key respondents are asked to fill in the prepared table using special symbols, namely (V, A, X, O) (Sushil, 2012). This symbol is a symbol of assessment of the intended Criterion (P). The assessment

given is based on the perception of respondents who consider that Parameter - i is more important than Parameter - j, and so on. The symbols and descriptions of P used are shown in Table 3.

Results

Based on considerations of regulations, provisions, rules, and standards used in Indonesia, the results of the initial design of the floating portable toilet can be seen in Fig. 2 below. This toilet is designed to be disassembled, carried by four-wheeled vehicles (cars), and stable above the flood water level or can float. In this paper, the stability of the building is not part of the study.

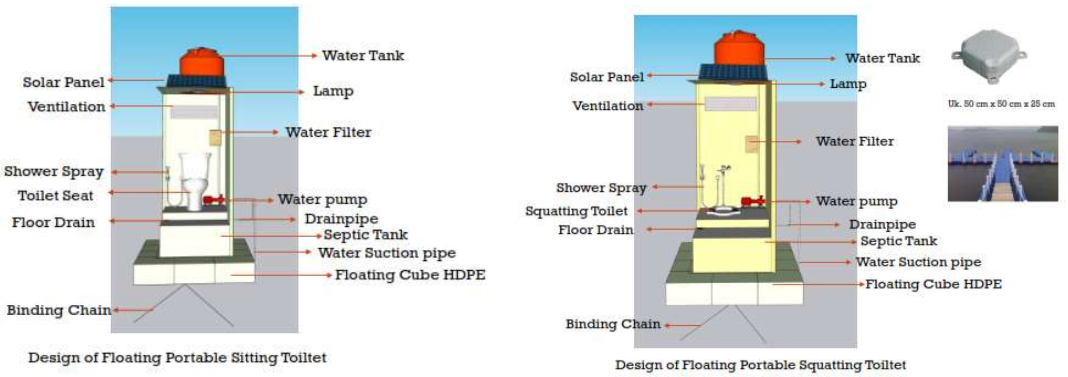

Figure 2. Initial Design Plan of Floating Portable Toilet.

The selected experts are academics, NGO activists, staff at BPBA who have experience, activists, and research related to disasters. According to experts, the most important criteria (P) to consider are; (a) P1-Design and Environmental Management System; (b) P4-Safety of construction; (c) P2-Covenience and supporting facilities; (d) P3-Building cleanliness; (d) P6-Length of construction time: and (e) P5-Ease of mobility. This result aligns with the criteria built in ASEAN (ASEAN, 2016). However, in the criteria document, ASEAN does not use parameters P6 and P5.

The mapping of the General Criteria structure in planning a portable floating toilet based on the opinions of the exhibitors is presented in Fig. 3. as follows. The sequence of parameters from the most critical/necessary level to no less important must be prepared in building floating portable planning.

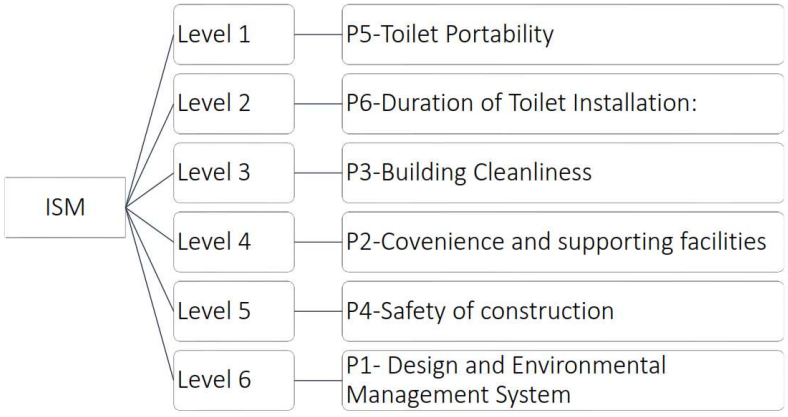

Figure 3. Results of Application ISM in Determining Level of Important Criteria.

Discussion

There is no singular solution for addressing sanitation challenges, especially for latrine designing in flood-prone regions from a universal technological standpoint. Instead, various technological configurations must be implemented with due consideration to the specific social and environmental contexts in which they are to be deployed. Hence, considerations for obtaining optimal design drawings are carried out by analyzing the results of expert opinions on the order of the most critical and not-too-important parameters that need to be adopted. Level 6 to level 1 is described as follows: Each level is equipped with supporting elements that become the design details of the floating portable toilet. These elements are selected based on the regulations, rules, and design criteria from the references referred.

1. **Design and environmental management system (P1)**. This criterion contains essential supporting elements, including (a) The materials and methods utilized to construct an ecologically friendly toilet. Environmentally friendly building materials such as recycled or rapidly renewable materials and low-VOC (volatile organic compound) coatings should be considered; (b) Water Conservation can be adopted through dual-flush technology, which allows residents to select between a low-water flush for liquid waste and a higher-water flush for solid waste. That it can cut down on overall water consumption; (c) Installation of a greywater system to reuse sink and shower water for flushing, hence lowering freshwater demand in Indonesia, is a must. Since using toilet tissue is not the culture of most ASEAN country people, especially in Aceh; (d) Accommodate diffable residents.
2. It is critical to ensure **the safety of a construction (P4) floating portable toilet** since it involves the well-being of users and the protection of the environment and neighboring places. The following are important safety factors to consider when building and using a floating portable toilet: (a) For floating portable toilets, the most important thing to consider is floatation and stability. The toilet is designed with buoyant materials or pontoons that give enough stability to keep the toilet floating (Mahmud et al., 2023). The structure should be built to withstand various water conditions, such as waves and currents. The primary adaptation for this type of toilet is the elevation of the entire treatment system, unless for the black and grey water installation, so that it is positioned beyond the reach of floodwaters and can operate effectively. In field trials of various technological options, the raised options have consistently proven to be more suitable and acceptable to the resident affected (Morshed & Sobhan, 2010); (b) Anchor and Mooring System should be developed to keep the floating toilet securely in place, preventing it from drifting away or being affected by changing tides and currents; (c) Emergency Situations include safety features such as lifebuoys, emergency communication devices, and clear signage to guide users in case of emergencies should be included in the design; (d) Sufficient lighting; (e) Non-slippery floor surface is an important consideration as well. Given the emergency response situation, a wet environment is quite dangerous for the elderly and disabled people.
3. **Convenience and supporting facilities (P2)** are the third parameter that is also important after P1 and P4. The most important comfort is the suitability of space in the toilet. When engaging in activities like bathing, washing, and using the bathroom, individuals require adequate physical space to accommodate their movements their requirements. The toilet should be developed to adhere to established ergonomic standards for individuals of all age groups, hence guaranteeing operational convenience. Some parameters should be included in this criteria: (a) Toilets must be designed according to anthropometric conditions and individual ergonomics in Indonesia (Hapsari, 2018); (b) This spray nozzle and a small vessel of water should be provided. Moeslem people do not use paper for cleaning their bowls; (b) There is a sink and glass; (d) Garbage cans; (e) The women's toilet is separated from the men's toilet; (f) The availability of all necessary Information signs: (g) The design of the toilet looks attractive, simple and easy to access; (h) Luggage hanger and hand soap holder can be added optionally.
4. **Building cleanliness includes some aspects (P3)** such as: (a) Adequate air circulation & ventilation system; (b) Good smell and no dirty areas; (c) Floors should be kept clean and dry; (d) Trained personnel in the facility for

cleaning and maintenance; (e) Customers' suggestion box; (f) Regular cleaning and maintenance of the toilet premises.

5. **Duration of Toilet Installation (P6).** The time required to build the toilet is also essential. When a flood occurs, emergency response activities must be able to provide toilet facilities so that residents who do not want to be evacuated can immediately use them. UNHCR (2016) mentioned Establishing a communal latrine system for the entire population within two weeks, including handwashing facilities and trained latrine attendants.
6. **Toilet Portability (P5)** means people can move the latrine around and construct it as conveniently as possible. They are self-contained, meaning all those necessary things are available in this single compartment. Critical parameter considerations may be: (a) Easy to transport by two-wheeled or four-wheeled vehicle; (c) Easy to disassemble or portable; (d) The building does not need to be dismantled; and (e) Latrine can be laid above water during emergencies and can also be above ground after flooding recede.

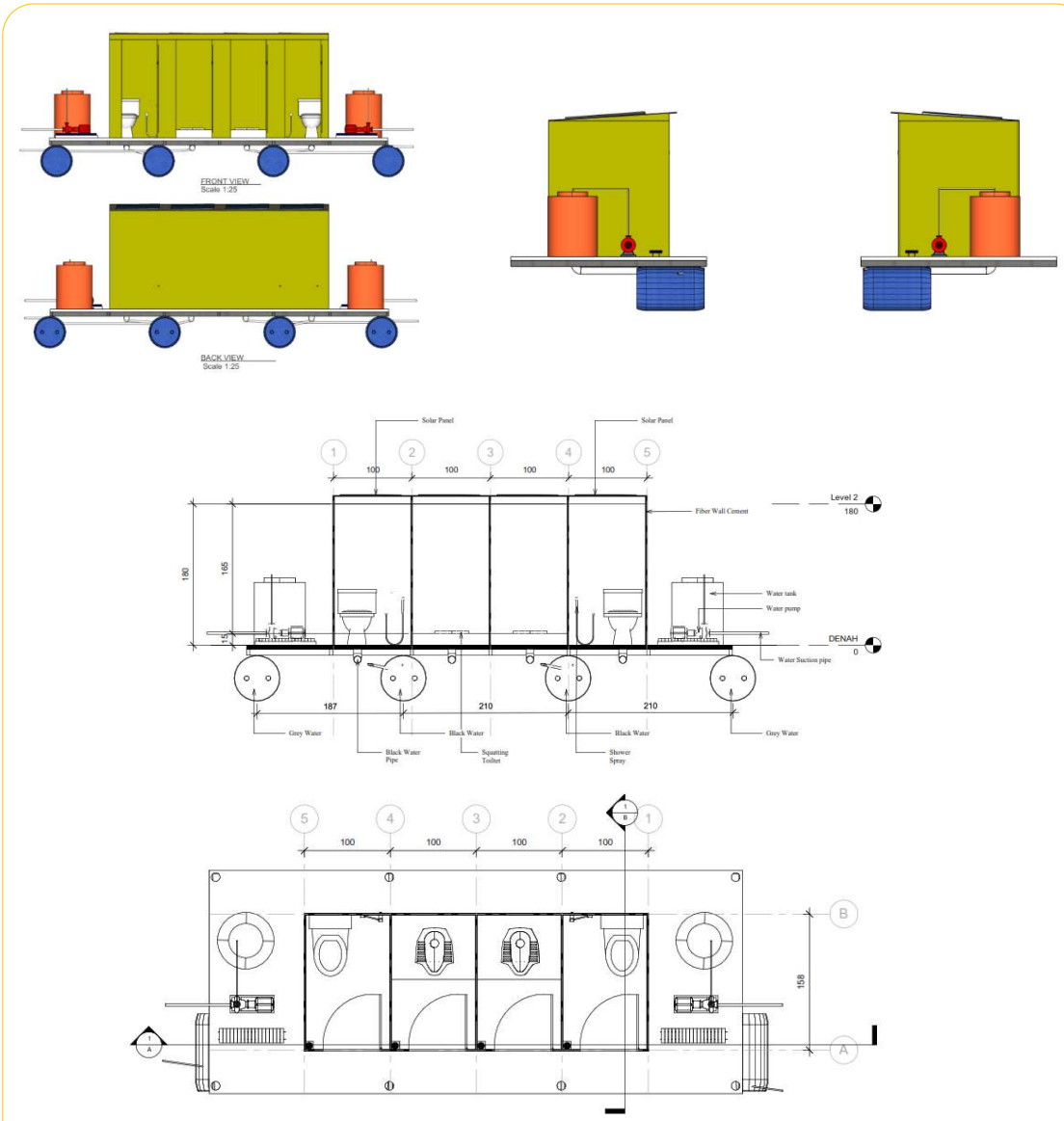

Figure 4. Final design of a floating portable toilet in a flood-prone area.

Based on the above explanation, the final design of the floating portable toilet after being adjusted to the order of criteria (P) as a result of the ISM analysis is presented in Fig. 4. The design of this toilet has accommodated the needs of the user residents who live in flood-prone are.

To keep the building from tipping over in conditions of water depth below the ground floor of the toilet or in a situation where the building is not floating, the septic tank is designed using materials that withstand pressure or load on it. The building is also designed symmetrically to balance when used when floating and not.

The difference between the initial and final designs is that 4 (four) toilets are selected instead of one. Those are combined into one compartment with two types of squatting and sitting toilet bowls. For security, the water tanks are placed on the left and right sides of the compartment. The floating floor is a balancing platform for the construction, making it stable and a link between the toilet and the resident's living space. Septic tanks function as a support for floating buildings and can withstand or be stable in a dry environment as well.

Conclusions

By referring to various existing references, regulations, and standards, and the results of distributing questionnaire forms to relevant experts in determining the critical parameters that must exist in a toilet planner, it can be concluded that the order of the criteria from the most important is (a) Design and Environmental Management System; (c) Safety; (d) Cleanliness; (e) Amenities and facilities; (f) Ease of Mobility; and (g) Length of construction time. The final floating portable toilet design is in the form of a compartment placed on a floating floor or in a dry environment. Two squat-type latrines and two more sitting types are preferred and equipped with a water purification tank that uses solar panel-based energy. The septic tank system functions as a counterweight to the stability of the toilet above the water and can be seated on the ground.

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References

Ahmad, N., & Qahmash, A. (2021). SmartISM: Implementation and Assessment of Interpretive Structural Modeling. *Sustainability*, *13*(8801), 1–27. https://doi.org/https://doi.org/10.3390/su13168801

Amelia, A. (2022). Morphology Characterization Of Bioactivator Microorganisms In Product Of Septick Tank Phosphate Degradator. *Journal of Physics: Conference Series*. http://lib.unnes.ac.id/id/eprint/53173

ANSI. (2016). *American National Standard: For Sanitation, Non-Sewered Waste Disposal Systems: Minimum Requirements*. Portable Sanitation Association International.

Asbahdin, T. (2018). Perencanaan toilet portable di lokasi pengungsian korban bencana alam. Environmental Engineering. *Program Studi Teknik Lingkungan, Fakultas Teknik Sipil Dan Perencanaan, Universitas Islam Indonesia*. https://dspace.uii.ac.id/handle/123456789/13116

ASEAN. (2016). *Asean public toilet standard*.

ATI. (2016). Pedoman Standar Toilet Umum Indonesia. *Jakarta: Asosiasi Toilet Indonesia*, 4–10. https://www.bing.com/ck/a?!&&p=dea704ff0da11e81JmltdHM9MTY5MTg4NDgwMCZpZ3VpZD0yZmZhOTc0Zi04OGU5LTY3ZmEtMDY1MS04NmJmODliYjY2ZjAmaW5zaWQ9NTIyMw&ptn=3&hsh=3&fclid=2ffa974f-88e9-67fa-0651-86bf89bb66f0&psq=kementerian+kebudayaan+dan+pariwisata+portable+toilet+

Attri, R., Dev, N., & Sharma, V. (2013). Interpretive structural modelling (ISM) approach: an overview. *Research Journal of Management Sciences*, *2319*(2), 1171.

Balzer, T., & Pon, S. (2003). Traditional use and availability of aquatic biodiversity in rice-based ecosystems I. Kampong Thom Province, Kingdom of Cambodia. *FAO Aquaculture Newsletter*, *29*, 9–15. https://www.fao.org/fishery/docs/DOCUMENT/xishuangbanna/Xishuangbanna.pdf

Berger, W. (2011). Technology Review of Composting Toilets. Basic Overview of Composting Toilets (With or Without Urine Diversion) Sustainable Sanitation Practice. *Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn*.

Blue Diversion. (2023). *Field test Nairobi, Kenya in 2014*. Http://Www.Bluediversiontoilet.Com/Nairobi-Field-Test.Html.

BNPB. (2021). *Bencana Hidrometeorologi Dominan Sepanjang Awal Januari Hingga Akhir April 2021. 2021*. Https://Bnpb.Go.Id/Berita/Bencana-Hidrometeorologi-Dominan-Sepanjang-Awal-Januari-Hingga-Akhir-April-2021. https://bnpb.go.id/berita/bencana-hidrometeorologi-dominan-sepanjang-awal-januari-hingga-akhir-april-2021

Djonoputro, E., Blackett, I., Rosenboom, J., & Weitz, A. (2010). Understanding sanitation options in challenging environments. *Waterlines*, *29*(3), 186–203. https://doi.org/https://doi.org/10.3362/1756-3488.2010.020

Eawag. (2023). *Research Integrity at Eawag*. Https://Www.Eawag.Ch/Fileadmin/Domain1/Forschung/.

Flex, D. (2023). *Connected toilet for emergency situations*. Https://Www.Flex.Nl/En/Case/Esos-Smart-Emergency-Sanitation/. https://www.flex.nl/en/case/esos-smart-emergency-sanitation/

Hagan, J., Hughes, R., & Smit, J. (2011). Designing gendersensitive sanitation for floating villages. *Towards Inclusive WASH: Sharing Evidence and Experience from the FIeld: A Series of 16 Case-Studies 12, 9. 8 FIg*. http://www.ircwash.org/sites/default/files/Hagan-2012-Designing

Hapsari, P. S. (2016). *Antrophometri dan aksesbilitas difabel pada toilet umum portabel di surakarta*. 181–188.

Hapsari, P. S. (2018). Studi Ergonomi, Antrophometri dan Aksesibilitas Difabel pada Paturasan Umum di Surakarta. *Institut Seni Indonesia Surakarta*.

Hu, M., Fan, B., Wang, H., Qu, B., & Zhu, S. (2016). Constructing the ecological sanitation: a review on technology and methods. Journal of Cleaner Production. *Journal of Cleaner Production*, *125*, 1–21. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.03.012

Janes, F. R. (1988). Interpretive structural modelling: A methodology for structuring complex issues. *Transactions of the Institute of Measurement & Control*, *10*(3), 145–154. https://doi.org/10.1177/014233128801000306

Lendaris, G. G. (1980). Structural Modeling—A Tutorial Guide. *IEEE Transactions on Systems, Man, and Cybernetics*, *SMC-10*(12), 807–840. https://doi.org/10.1109/TSMC.1980.4308410

LIPI. (2023). *Bio Toilet, Jamban Tanpa Limbah*. Http://Lipi.Go.Id/Lipimedia/Bio-Toiletjamban-Tanpa-Limbah/7603.

Mahmud, S. I., Islam, M. S., Tanvir Hossain, M., & Islam, T. (2023). Design of a Floating Wash Platform and Water Treatment Plant for Gypsy Community of Bangladesh. *SSRN Electronic Journal*, *December*, 1–7. https://doi.org/10.2139/ssrn.4442894

Mkhize, N. (2017). Promoting Sanitation and Nutrient Recovery Through Urine Separation: The Role of Health and Hygiene Education in the Acceptance, Utilisation, and Maintenance of Urine Diversion Toilets (UDDT) in Rural Communities of KwaZulu Natal (KZN) University of KwaZu. *University of KwaZulu-Natal Durban*.

Morshed, G., & Sobhan, A. (2010). The search for appropriate latrine solutions for flood-prone areas of Bangladesh. *Waterlines*, *29*(3), 236–245. https://doi.org/10.3362/1756-3488.2010.024

Muench, E. (2011). Technology Review of Urine Diversion Dehydration Toilets (UDDTs). Design Principles, Urine and Faeces Management Giz. *Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ), Eschborn*, *Oktober*.

Mulyani, I., Listiati, E., Susanti, B., & Suwarno, D. (2017). Evaluation of home sanitation system in tidal areas, a case study of Kemijen Village, Semarang, Indonesia. *International Journal of Scientific and Research Publications*, *7*(11), 208–218. https://doi.org/https://journal.ubaya.ac.id/index.php/jimus/article/view/908/712

Pedro, J., Oliveira, C., & Sperling, S. (2020). A review of sanitation technologies for flood-prone areas. *Journal of Water, Sanitation and Hygiene for Development*, *10*(3), 397–412. https://doi.org/https://doi.org/10.2166/washdev.2020.019

Reina. (2015). Perancangan toilet portable bagi para pengungsi bencana alam di lokasi pengungsian. *Jurnal Ilmiah Mahasiswa Universitas Surabaya*, *4*(1), 1–18. https://journal.ubaya.ac.id/index.php/jimus/article/view/908

Singarimbun, M., & Sofian, E. (2012). Metode Penelitian Survei. *Jakarta: LP3S*.

Sushil. (2012). Interpreting the interpretive structural model. *Global Journal of Flexible Systems Management*, *13*(2), 87–106. https://doi.org/10.1007/S40171-012-0008-3

Uddin, S., Ronteltap, M., & Van Lier, J. (2011). Assessment of urine diverting dehydrating toilets as a flood-resilient and affordable sanitation technology in the context of Bangladesh. *Journal of Water Sanitation and Hygiene for Development*, *3*(2), 87–95. https://doi.org/https://doi.org/10.2166/washdev.2013.113

UNHCR. (2016). UNHCR WASH Equipment Specifications. *Https://Www.Unhcr.Org/Media/Unhcr-Wash-Equipment-Specifications*, *December*.

Winblad, U., & Simpson-Hébert, M. (2004). Ecological Sanitation (Revised and Enlarged Edition). *Stockholm Environment Institute, Stockholm*.