A FRAMEWORK TO IMPROVE THE PRODUCT DEVELOPMENT PROCESS TO ACHIEVE MORE EFFECTIVE SANITATION RESPONSE DURING EMERGENCIES

DISSERTATION

Submitted in partial fulfilment of the requirements for a Doctoral Degree from Institut Teknologi Bandung

By

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(Environmental Engineering Doctoral Study Program)

INSTITUT TEKNOLOGI BANDUNG

2016

ABSTRACT

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Sanitation, the management of human excreta, solid waste, sullage, storm water, sewage effluent, industrial waste and hazardous waste, is important in the aftermath of a disaster. Excreta disposal, the safe collection, storage, treatment and disposal/re-use/recycling of human urine and faeces, is one of the most critical aspects of sanitation, because it helps prevent faecal-oral disease. Innovation is needed to address shortcomings in existing solutions to implement sanitation during emergencies. However, there is limited understanding of whether these products are being developed in an effective manner, leaving no basis for determining whether and how existing practices can be improved.

The dissertation explores the process of developing emergency sanitation products and proposes ways to improve product development in the sector. This is achieved through a combination of qualitative and quantitative methods such as case studies, semi-structured interviews, and structured questionnaires, in particular with stakeholders (customers, suppliers, product developers and intermediaries) of the emergency sanitation product development process as well as end users affected by the Mount Sinabung volcano eruption in Indonesia and Typhoon Haiyan in the Philippines.

The process of developing emergency sanitation products can be divided into eight iterative stages: identify opportunity, determine approach to develop product, determine design requirements, generate and communicate ideas, evaluate and select ideas, evaluate prototype in-house, test working prototype, and promote end product. Field testing is considered vital to determining whether a product is ready for implementation. Barriers to product development in the emergency sanitation sector include poor design requirements, inadequate knowledge capture and learning and disjointed processes. There are many areas in which support to suppliers and product developers can be improved, especially in understanding design requirements and evaluating prototypes. There is also potential to engage end users more actively in the process.

Measures to support the product development process can be categorised into six types of approaches: capturing, documenting and disseminating knowledge and

data; standards and procedures; tools for design and evaluation; expert review; methods for evaluating prototypes, and; tools for disseminating the end product. All 35 measures identified in this dissertation were scored by stakeholders as useful, while ease of implementation varied more widely. This underlined the need to evaluate the measures in-depth.

Three measures were evaluated in-depth: the documentation and dissemination of emergency scenarios, and end user needs, and; a decision support tool for choosing a suitable product. The evaluation demonstrated the different ways in which these measures could contribute to product development. Case studies on emergency scenarios and data collection on end users can provide useful information. On the other hand, a decision support system is useful as a concept but needs to be developed further in order to be useful to product development in the emergency sanitation sector. These findings reflected the poor evidence in the sector, and the need to increase and improve the data that provides the foundation for making decisions during the product development process.

The findings were consolidated into a framework to improve product development in the emergency sanitation sector, focusing on the core problem of poor design requirements. Three key aspects of poor design requirements are: the overlooking of part of the solution, a poor understanding of design requirements on the part of designers, and poorly defined requirements. To improve design requirements, the root causes should be addressed holistically, which include: the lack of training in product development, research and writing design requirements; little data collection coupled with the poor dissemination of relevant data; inadequate equipment and facilities, and; the limited utilisation of tools to help develop design requirements.

A number of best practices for existing stakeholders to develop better design requirements were identified: consider all aspects of the solution, make use of as much data as possible, and define design requirements appropriately. These were applied to the design of a latrine suitable for Indonesian contexts by using tools such as a process tree. The resulting design focuses on facilitating cleanliness and ensuring the availability of water by implementing good drainage, ventilation, rainwater harvesting, low-flush technologies and so on.

The dissertation provides insight into the innovation process, in particular, the role of end users as well as suppliers and product developers. The findings offer a basis for improving innovation in the emergency sanitation as well as humanitarian sector. Findings are relevant to stakeholders of the emergency sanitation sector as well as the humanitarian sector in general, especially organisations and individuals involved in innovation.

Keywords: emergency sanitation; innovation, product development.

ABSTRAK

KERANGKA KERJA UNTUK RESPON SANITASI YANG LEBIH EFEKTIF DALAM MASA TANGGAP DARURAT, MELALUI PERBAIKAN PROSES PENGEMBANGAN PRODUK

Oleh

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Sanitasi, yaitu penanganan kotoran manusia, sampah padat, air limbah, air hujan, limbah industri, dan limbah berbahaya, penting dalam masa pascabencana. Diantaranya, aspek yang paling kritis adalah penanganan kotoran manusia (feces dan urin) – penampungan, pengolahan, dan pembuangannya – yang apabila dilaksanakan dengan baik, dapat mencegah penyakit fecal-oral secara signifikan. Diperlukan inovasi untuk mengatasi berbagai kekurangan di solusi pembuangan kotoran selama masa tanggap darurat. Namun, perihal apakah pengembangan produk sanitasi darurat dilaksanakan secara efektif, pemahamannya masih kurang saat ini. Tanpa dasar tersebut, sulit untuk memastikan bagaimana pelaksanaan yang sekarang umum dapat diperbaiki.

Disertasi ini menjelajahi proses pengembangan produk sanitasi darurat dan memberi berbagai usulan bagaimana pengembangan produk di sektor tersebut dapat menjadi lebih baik. Penyelidikan dilakukan melalui kombinasi metode kualitatif dan kuantitatif, yaitu: studi kasus, wawancara semi terstruktur, dan kuesioner terstruktur. Khususnya, dengan para pemeran utama di dalam proses pengembangan produk sanitasi darurat (pelanggan, pemasok, pengembang produk, dan perantara) dan para pengguna yang terkena bencana letusan Gunung Sinabung di Indonesia dan Taifun Haiyan di Filipina.

Proses pengembangan produk sanitasi darurat dapat dibagi menjadi delapan tahap berulang: kenali kesempatan, tentukan cara pendekatan pengembangan produk, tentukan persyaratan desain, generasi dan sampaikan ide, evaluasi purwa-rupa (prototype) secara internal, uji kinerja purwa-rupa, dan promosikan produk akhir. Untuk menentukan apakah sebuah produk siap untuk implementasi, pengujian di lapangan termasuk sangat penting. Contoh rintangan-rintangan terhadap pengembangan produk di sektor sanitasi darurat yaitu kekurangan dari persyaratan desain, penangkapan dan pembelajaran pengetahuan yang tidak memadai, dan proses-proses yang tidak berkesinambungan. Banyak celah di mana dukungan untuk pemasok dan pengembang produk dapat diperbaiki, terutama dalam pengertian persyaratan desain dan dalam evaluasi purwa-rupa. Para pengguna akhir juga dapat dilibatkan secara lebih aktif dalam proses tersebut.

Dukungan-dukungan untuk proses pengembangan produk dapat digolongkan menjadi enam tipe pendekatan: penangkapan, dokumentasi, dan penyebaran pengetahuan dan data; standar dan prosedur; sarana desain dan evaluasi; ulasan ahli; metode evaluasi purwa-rupa, dan; sarana penyebaran produk akhir. 35 cara yang diidentifikasi dalam disertasi ini dinilai berguna oleh para pemangku kepentingan, namun penilaian atas kemudahan implementasi lebih bervariasi. Hasil tersebut menekankan pentingnya evaluasi cara-cara tersebut dengan lebih mendalam.

Tiga tindakan dievaluasi secara mendalam: dokumentasi dan diseminasi skenario darurat, kebutuhan para pengguna, dan; sarana pendukung keputusan untuk memilih produk yang tepat. Hasil evaluasi menunjukkan berbagai cara di mana tindakan-tindakan tersebut dapat membantu pengembangan produk. Studi kasus skenario darurat dan pengumpulan data tentang para pengguna dapat memberikan informasi yang berharga. Di sisi yang lain, meskipun berguna sebagai konsep, sebuah sistem pendukung keputusan perlu dikembangkan lebih jauh agar berguna secara praktikal untuk sektor sanitasi darurat. Temuan-temuan ini mencerminkan kurangnya catatan data fakta dan kesaksian di sektor tersebut, dan perlunya peningkatan dan perbaikan data yang dapat memberikan dasar pengambilan keputusan semasa proses pengembangan produk.

Hasil temuan digabungkan menjadi sebuah kerangka kerja untuk memperbaiki pengembangan produk di sektor sanitasi darurat, dengan fokus di masalah inti, yaitu persyaratan desain yang kurang. Tiga aspek persyaratan desain yang kurang adalah: pengabaian sebagian solusi, kurangnya pengertian desainer atas persyaratan desain, dan persyaratan yang tidak dijelaskan dengan baik. Untuk memperbaiki persyaratan desain, sebab-sebab utama harus diatasi secara holistik, termasuk: kurangnya pelatihan di pengembangan produk, riset, dan penulisan persyaratan desain; kekurangan dalam pengumpulan data dan diseminasi data yang relevan; peralatan dan fasilitas yang tidak memadai, dan; kurangnya penggunaan sarana secara efektif.

Beberapa prosedur terbaik untuk para pemangku kepentingan untuk mengembangkan persyaratan desain yang lebih baik dicatat sebagai berikut: pertimbangkan seluruh aspek solusi, gunakan data sebanyak mungkin, dan definisikan persyaratan desain secara tepat. Prosedur-prosedur tersebut diterapkan kepada desain sebuah jamban yang cocok untuk konteks Indonesia, dengan mempergunakan sarana seperti pohon proses. Desain yang dihasilkan difokuskan untuk memudahkan kebersihan dan memastikan ketersediaan air melalui implementasi penyaluran air pembuangan yang baik, ventilasi, pemanfaatan air hujan, teknologi toilet efisiensi tinggi , dan seterusnya.

Disertasi ini menyediakan wawasan mengenai proses inovasi, khususnya tentang peran pengguna, pemasok, dan pengembang produk. Hasil-hasil temuan ini menawarkan sebuah dasar untuk memperbaiki inovasi di sektor sanitasi darurat dan sektor kemanusiaan. Temuan-temuan ini relevan kepada para pemangku

kepentingan sektor sanitasi darurat dan sektor kemanusiaan secara umum, terutama organisasi-organisasi dan individu-individu yang terlibat dalam inovasi.

Kata kunci: Sanitasi darurat; inovasi; pengembangan produk.

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PEDOMAN PENGGUNAAN DISERTASI

Disertasi Doktor yang tidak dipublikasikan terdaftar dan tersedia di Perpustakaan Institut Teknologi Bandung, dan terbuka untuk umum dengan ketentuan bahwa hak cipta ada pada pengarang dengan mengikuti aturan HAKI yang berlaku di Institut Teknologi Bandung. Referensi kepustakaan diperkenankan dicatat, tetapi pengutipan atau peringkasan hanya dapat dilakukan seizin pengarang dan harus disertai dengan kebiasaan ilmiah untuk menyebutkan sumbernya.

Memperbanyak atau menerbitkan sebagian atau seluruh disertasi haruslah seizin Dekan Sekolah Pascasarjana, Institut Teknologi Bandung.

ACKNOWLEDGMENTS

To everyone whom I have crossed paths with in the past three years, I am eternally grateful for the role you have played in my life in Bandung, whether big or small. In particular, I would like to thank:

Pak Agus Jatnika Effendi, my advisor, for always being encouraging of my ideas, providing helpful guidance and motivating me to carry on, and; Pak Tjandra Setiadi and Bu Prayatni Soewondo for their support throughout my time at ITB.

Fiona Zakari, Regina Yeo, Haudi Hasaya, Pak Andar Bagus, Ken Ushijima-san, Annisa Anindita for their collaboration and contributions to our research; our partners at UNESCO-IHE Institute of Water Education for their cooperation; the residents of Abucay Bunkhouse for brightening up my days in the Philippines, and; everyone who participated in my research.

The Examination Committee for their invaluable feedback towards improving my work.

The Bill and Melinda Gates Foundation for their support of the project Stimulating Location Innovation on Sanitation for the Urban Poor in Sub-Saharan Africa and South-East Asia, and; the International Relations Office for always being helpful with applying for visas and permits!

The staff, fellow PhD students and others at the Department of Environment Engineering for your warmth, which emanated even across language barriers, and; most especially Dyah Wulandari Putri and Bu Mimin, for always helping me out without complaint. I promise I'll get over my fear of speaking Bahasa soon...

My family, new friends and old friends for just being there, especially during the tough days, and adopting a lonely Singaporean into your various countries. In

particular, Mum and Dad, Alounny Lasy, Gwee Cai Lin, Pey Peixuan, Evelyn Valencia, Nguyen Quoc Hoa, Duc Ngoc Pham, Dian Apriadi, Sophia Pan, Colin Teo, Royce Chew and everyone at my old and current kost and at the badminton group.

Finally, this dissertation is dedicated to Pak Gunawan Sofyan.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

ACRONYM	Name	Page first used
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action	9
DFID	Department for International Development	9
DSS	Decision support system	32
EIO	European Integration Office	15
HIF	Humanitarian Innovation Fund	9
IDP	Internally displaced person	97
ITB	Institut Teknologi Bandung / Bandung Institute of Technology	7
LIPI	Lembaga Ilmu Pengetahuan Indonesia / Indonesian Institute of Sciences	141
NGO	Non-governmental organisation	12
PVMDG	Pusat Vulkanologi dan Mitigasi Bencana Geologi (Indonesia) / Centre for Volcanology and Geological Hazard Mitigation	97
OCHA	United Nationals Office for the Coordination of Humanitarian Affairs	29
SuSanA	Sustainable Sanitation Alliance	25
UK	United Kingdom	9
UN	United Nations	12
USAID	United States Agency for International Development	16
WASH	Water, sanitation and hygiene	11

Chapter I Introduction

Sanitation includes the management of human excreta, solid waste, sullage, storm water, sewage effluent, industrial waste and hazardous waste (UNICEF et al., 2008). These are important considerations during the aftermath of a disaster. Excreta disposal, the safe collection, storage, treatment and disposal/re-use/recycling of human urine and faeces, is one of the most critical aspects of sanitation, because it helps prevent faecal-oral disease. Innovation is needed to address shortcomings in existing solutions to implement sanitation during emergencies. However, there is limited understanding of whether emergency sanitation products are being developed in an effective manner. By exploring how emergency sanitation products are currently being developed, this dissertation proposes ways in which the product development process can be improved.

I.1 Background

During emergencies, safe sanitation is vital to minimise faecal-oral disease, as seen in the following studies:

- Following a flood in Bangladesh in 1999, respondents who used latrines were less likely to develop diarrhoea (15.9%) than those who did not (84.1%) (Kunii et al., 2002);
- In post-earthquake camps in Colombia in 1999, the use of a communal toilet instead of an individual toilet was significantly associated with Giardia infection (odds ratio [OR] = 3.9; 95% confidence interval [CI] = 1.2 – 16.2) (Lora-Suarez et al., 2014);
- In Kakuma refugee camp in 2005, sharing a latrine with three or more households (OR = 2.17, 95% CI = 1.01 – 4.68) was significantly associated with an increased risk of cholera (Shultz et al., 2009);
- In the same camp in 2009, sharing a communal latrine with neighbouring households (OR = 3.33, 95% CI = 1.34 – 8.30) and visible human faeces on the grounds of the compounds (OR = 6.50, 95% CI = 1.47 – 28.80) were

significantly associated with an increased risk of cholera (Mahamud et al., 2012).

Pathogens from the faeces of a sick person may cause disease because the pathogens can be transmitted through a number of sanitation pathways (Figure I.1). The consequences of this transmission can be significant. In camp situations, diarrhoeal diseases have accounted for more than 40% of deaths during the acute phase of an emergency (Connolly et al., 2004). During the Rwandan refugee crisis, there were at least 58,000 cases of symptomatic cholera occurring in the population of the 500,000 to 800,000 refugees in Goma, Zaire (Goma Epidemiology Group, 1995). Correspondingly, sanitation interventions help to reduce the risk of disease. Esrey et al. (1991) and Fewtrell et al. (2005) have reported a 36% expected reduction in diarrhoeal disease morbidity and a pooled relative risk of a reduction in illness of 0.68 (95% CI = 0.53 – 0.87) respectively due to sanitation interventions.

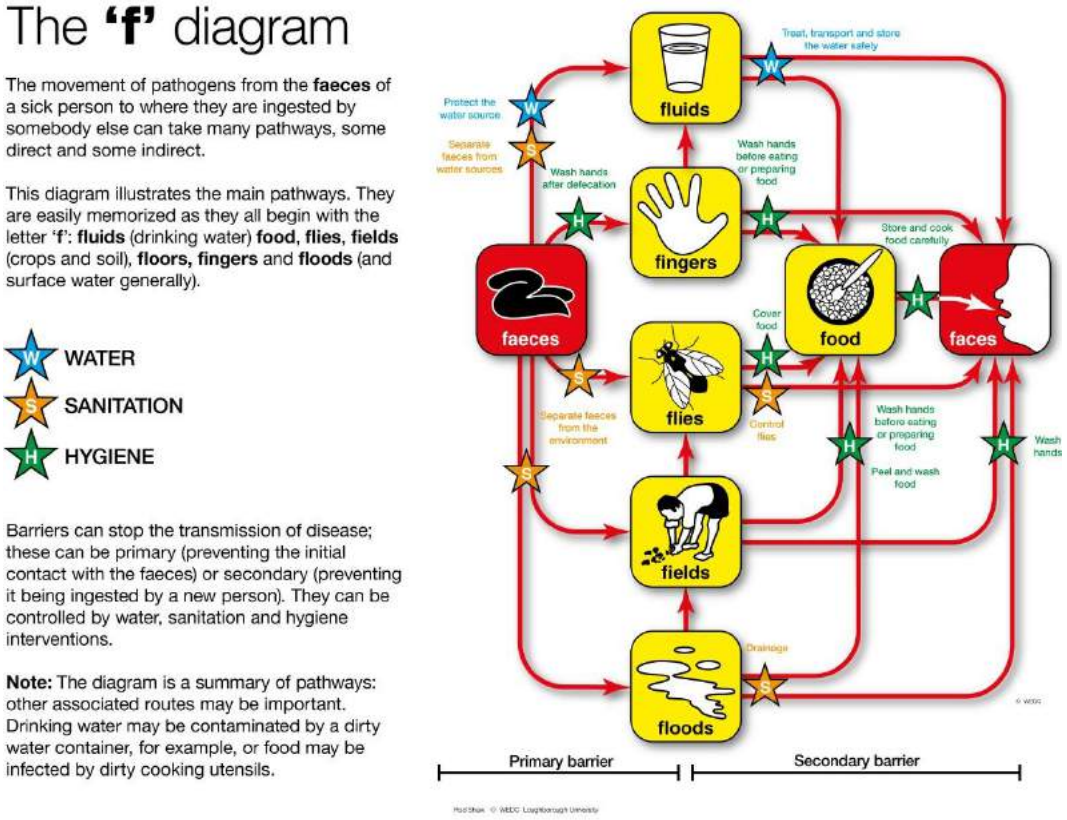


Figure I.1. Pathways illustrating how the faeces of a sick person can be ingested by somebody else (Shaw, 2013)

Unfortunately, emergency options that are currently available may not be adequate, particularly in urban settings. Commonly used facilities like defecation fields, trench latrines or communal latrines, fill up quickly. Maintaining hygienic conditions becomes difficult (Brown et al., 2012).

Sanitation in emergency situations differ from non-emergency situations because of the urgent need to ensure the survival of disaster-affected populations. The emergency phase can range from a few days or weeks to many months or years. In emergencies, appropriate sanitation measures should be implemented immediately (The Sphere Project, 2011). On the first day of an emergency response, a humanitarian worker would assess their agency's contingency stocks, consult their equipment catalogue, then order the relevant products (Bastable and Lamb, 2012). Non-emergency situations do not have the same sense of urgency. Sanitation interventions can be carefully planned and implemented.

Due to the urgent and temporary nature of emergencies, sanitation measures are designed to meet short-term needs. Temporary options that are used during emergencies, such as demarcated defecation areas and trench latrines (The Sphere Project, 2011), are very rarely considered in a non-emergency situation. Likewise, solutions for non-emergency situations are not always suitable for emergency situations. There is a clear need for better sanitation products for emergency situations to improve the delivery of emergency sanitation interventions to meet excreta disposal needs and hence reduce the risk of faecal-oral disease (Figure I.2).

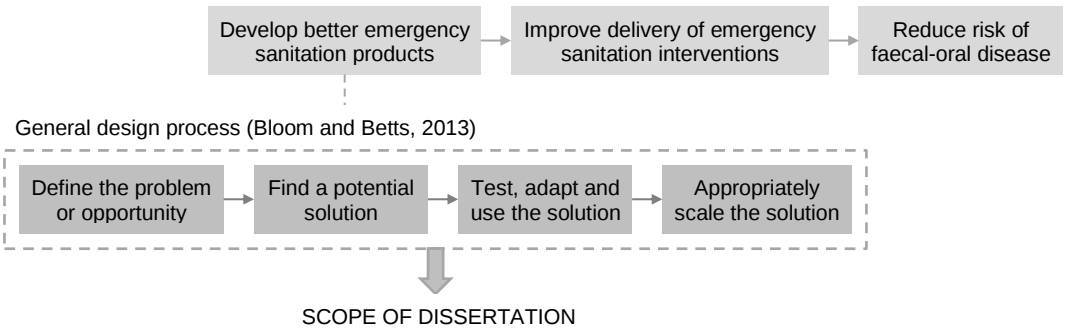


Figure I.2. Role of product development in emergency sanitation

Organisations have been actively involved in developing products. However, the humanitarian as well as emergency sanitation sector does not clearly understand whether the current practices involved in developing products are effective. Consequently, there is a lack of a basis for determining whether and how existing practices can be improved so that products can be developed more effectively.

I.2 Problem statement

There is limited understanding of the practices used and the challenges faced by customers, suppliers and product developers to develop products for the emergency sanitation sector. As a result, the sector is unable to identify improvements so that products can be developed in an effective manner. Unless changes are made, products will fail to meet the standards and needs for safe excreta disposal during emergencies, contributing to the risk of faecal-oral disease.

I.3 Aims and objectives

The dissertation explores whether emergency sanitation products are being developed in an effective manner and proposes ways to improve product development practices. This dissertation is based on exploratory research to understand the practices involved in developing products and the measures that could facilitate the process (Figure I.3).

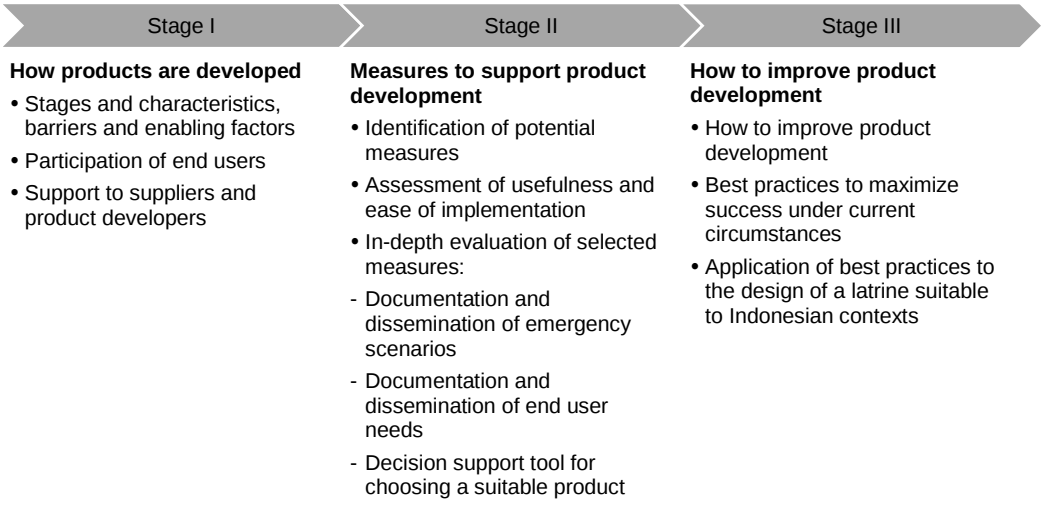


Figure I.3. Aims and objectives

The aims and objectives of this dissertation are realised in three stages. The first stage seeks to understand the practices that are involved in and the barriers to developing products. It examines the role of end users as well as suppliers and product developers. The second stage identifies potential measures to help suppliers and product developers develop products more effectively, and assesses their usefulness and ease of implementation. Selected measures are evaluated in depth. Based on findings from the first two stages, a framework to improve product development, focusing on improving the understanding of design requirements, is proposed.

I.4 Benefits of the research

Findings from the research will be relevant to stakeholders of the emergency sanitation sector as well as the humanitarian sector in general, especially organisations and individuals involved in innovation. The dissertation will provide insight into the innovation process, in particular, the role of end users as well as suppliers and product developers. The findings will offer a basis for improving innovation in the emergency sanitation as well as humanitarian sector.

I.5 Hypothesis

A better understanding of the practices involved in developing emergency sanitation products will lead to a more effective product development process.

I.6 Scope

The dissertation's scope is delineated as follows:

- Sanitation includes many aspects of maintaining hygienic conditions, but this dissertation focuses on the safe management of human urine and faeces (i.e. excreta disposal).
- Innovation may be described as a means of adaptation and improvement by finding and scaling solutions to problems, in the form of products, processes or wider business models (Betts and Bloom, 2014). The dissertation deals with the innovation of physical objects for emergency sanitation

infrastructure. Other types of solutions (e.g. hygiene promotion) are not considered.

- Only solutions for the emergency phase are discussed. The recovery and rehabilitation phase, as well as development sector, are not within the scope of the dissertation.
- The humanitarian sector largely responds to disasters in developing countries, as developed countries generally have the resources to respond with little outside assistance. Hence, this dissertation focuses on emergency sanitation products for developing countries.

I.7 Research approach

The overall approach to the research was exploratory. A combination of qualitative and quantitative methods was used to achieve the aims and objectives. The methods included case studies, semi-structured interviews, and structured questionnaires (Figure I.4).

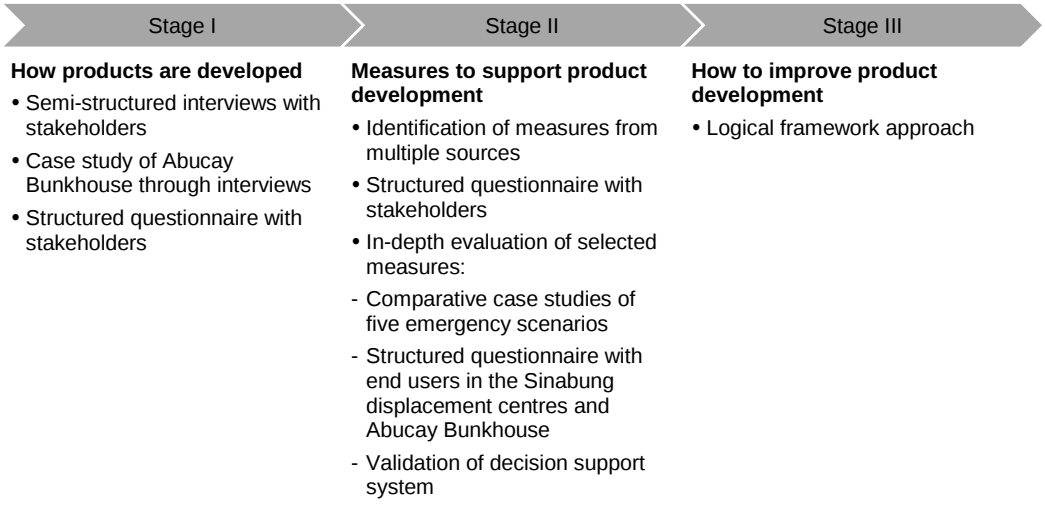


Figure I.4. Research approach

First, semi-structured interviews were conducted to understand the practices involved in and the barriers to developing products. A case study, based on unstructured interviews, explored the participation of end users. A structured stakeholder survey assessed the support provided to suppliers and product developers. Second, measures to support product development were identified.

Using a structured questionnaire, stakeholders assessed the usefulness and ease of implementation of these measures. Three of these measures were evaluated in depth through case studies, on-site surveys, etc. Finally, the logical framework approach was adapted to organise the findings into appropriate recommendations for improving product development, with a focus on design requirements.

I.8 Implementation of the research

The research presented in the dissertation was implemented by the author except in the following cases: one stakeholder interview was conducted together with an Bachelor's student from the Department of Environment Engineering, Institut Teknologi Bandung (ITB); interviews with residents at Abucay Bunkhouse were translated with the help of volunteers from the bunkhouse; survey responses and data input for the Sinabung displacement centres were carried out by a Master's student from the same department, and; survey responses from Abucay Bunkhouse were collected and translated by a team of volunteers from the bunkhouse.

I.9 Outline of the dissertation

Chapter I explained the need to understand how products are developed in the emergency sanitation sector. The aims, objectives, benefits, hypothesis, scope and research approach of the dissertation were presented. Chapter II will review the literature on innovation in the humanitarian sector and in the emergency sanitation sector specifically. It will provide the framework within which the research gaps that this dissertation addresses were identified. Chapter III will explain the methodology used to collect and analyse the data in the dissertation.

Chapter IV will describe the practices involved in and the barriers to developing products. It will further examine the role of end users as well as suppliers and product developers. Chapter V will identify potential measures to help suppliers and product developers develop products better, and assess their usefulness and ease of implementation. Selected measures will be evaluated in depth. Based on the findings from the previous two chapters, Chapter VI will propose a framework

to improve product development, focusing on design requirements. Best practices that stakeholders can apply to increase the likelihood that their product would be successfully sold or implemented are identified and demonstrated.

Finally, Chapter VII presents the summary, contributions and conclusions of the research, along with suggestions for further work.

Chapter II Literature review

This chapter reviews the literature related to innovation in the humanitarian sector in general and in the emergency sanitation sector specifically. It provides the context in which the research gaps that this dissertation addresses were identified. First, Section II.1 traces the growth of innovation as a field of study in the humanitarian sector. The section classifies the types of literature available and describes the concepts that have been explored by various authors. Second, Section II.2 analyses innovation and innovation concepts in the emergency sanitation sector. It assesses the importance placed on innovation and examines studies focusing on innovation. Section II.3 provides an overview of the logical framework approach, describing the aspects that have been applied in this dissertation.

II.1 Humanitarian innovation

There has been growing recognition of the importance of innovation in the humanitarian sector. White (2008) noted that there was an increasing feeling among humanitarian practitioners that more should be done to innovate. Recently, an independent review recommended that the United Kingdom's (UK) Department for International Development (DFID, 2011b) should facilitate innovation in the humanitarian sector and its application. As a result, DFID (2012) made the promotion of innovation a core strategy, including supporting the development of new products and the large-scale testing of potential solutions. The Humanitarian Innovation Fund (HIF) and Humanitarian Innovation Project are two other initiatives that have been established to focus on innovation (Ramalingam et al., 2015).

The humanitarian sector is relatively new to research on innovation. The Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) study titled 'Innovations in international humanitarian action' (Ramalingam et al., 2009) is widely considered the first comprehensive study about innovation in the humanitarian sector. This means that the literature on

humanitarian innovation is approximately one century younger than the overall innovation management field (Bessant et al., 2014). However, interest in humanitarian innovation has been growing, with, for example, the Centre for Research in Innovation Management at the University of Brighton conducting a study on the ecosystem of actors and factors shaping innovation with the humanitarian sector (Ramalingam et al., 2015).

Not many publications on the topic exist. The publications that do exist may be classified into four types:

- Individual case studies of the innovation process, documented by organisations such as ALNAP and HIF;
- Studies on a specific group of stakeholders. For example, Betts et al. (2012) reported on the economic lives of refugees and displaced people in Uganda;
- Sector-specific analyses, such as the emergence of new medical practices through Médecins Sans Frontières' activities (Bradol and Vidal, 2011) and a comparison of product development between the shelter sector and the building industry (Haas et al., 2013), and;
- The application of concepts to understand or manage innovation. For instance, Bloom and Betts (2013) argue for a bottom-up approach to innovation to complement the conventional top-down approach of the humanitarian sector.

According to Bloom and Betts (2013), it is best to understand innovation as a process because it allows ideas to be tracked from inception to development. The decision-making processes, barriers and opportunities at each stage can then be identified. Within the humanitarian sector, three models of the innovation process have been proposed or used (Figure II.1).

It is also useful to understand the innovation process as part of a system. How an organisation approaches, facilitates and supports innovation processes depends on the dynamics of the sector. By improving the system, the benefits of investment in

humanitarian innovation can be maximised (Bessant et al., 2014). Based on five case studies spanning cash-based programming, community therapeutic care, transitional shelter and mobile technologies, Ramalingam et al. (2009) recognise relationships, capacities and sectoral issues as contextual factors that affect innovation. From the perspective of innovation management, based on a review of the general innovation ecosystems and management literature, Bessant et al. (2014) identify key challenges to introducing innovation management to the humanitarian sector: core capacity; ambidexterity; entrepreneurship; the user; open innovation; incentives and structures, and; the ecosystem. Using an ecosystems approach, research by Ramalingam et al. (2015) considered eight components of innovation: resources, roles, relationships, rules, routines, results, restrictions and recommendations. Of these eight aspects, routines – patterns of activity and behaviour that form the building blocks of the innovation ecosystem – are similar to the concept of innovation as a process.

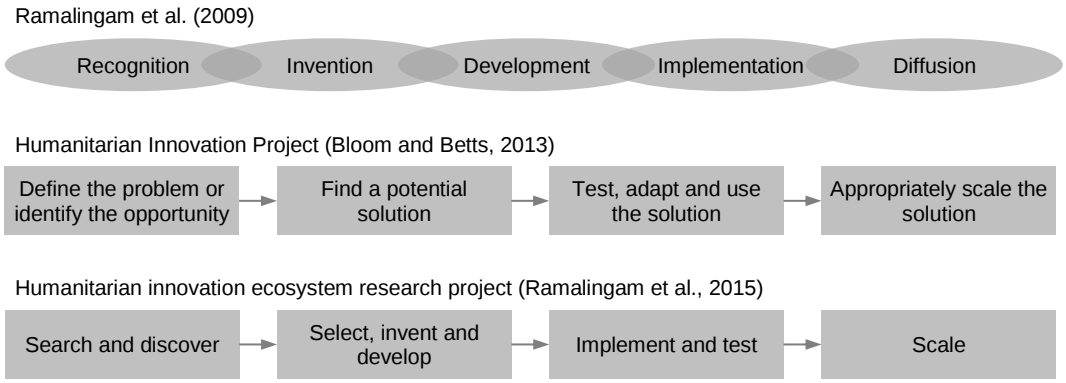


Figure II.1. Models of the humanitarian innovation process proposed or used by Ramalingam et al. (2009), Blooms and Betts (2013) and Ramalingam et al. (2015) respectively

The concepts have typically been used to understand innovation within the humanitarian sector in general. However, there are likely to be substantial differences between the sectors. As Ramalingam et al. (2015) recognised, the humanitarian innovation system has diverse professional competencies and norms. Therefore, the authors had also carried out case studies of five sectors, including one on the water, sanitation and hygiene (WASH) sector which will be discussed in the following section.

II.2 Emergency sanitation innovation

Although not specifically referred to as the need for "innovation", the need for new sanitation products was recognised as early as 1995 when non-governmental organisations (NGOs), United Nations (UN) agencies and the Red Cross came together to discuss ideas for improving emergency sanitation practices. One recommendation at that time was to develop standard sanitation kits that would allow humanitarian practitioners to respond to emergencies quickly and effectively (Adams, 1996). Since then, gaps in emergency sanitation products and technologies have continued to be identified (Bastable and Lamb, 2012; Brown et al., 2012; Johannessen, 2011; Ruberto and Johannessen, 2009), with donors also showing more interest in funding innovation (Bastable and Lamb, 2012). The increasing attention given to innovation in emergency sanitation is evidenced by the recent effort to determine gaps in emergency WASH as part of HIF. An extensive consultation conducted with 909 people from different stakeholder groups showed that excreta disposal was a significant gap in the sector (Bastable and Russell, 2013) (Table II.1).

Table II.1 Gaps in the emergency water, sanitation and hygiene sector as identified by Bastable and Russell (2013). Gaps related to emergency sanitation products are highlighted

1.	Latrines in locations where no pits are possible (urban, high water table / flooding)
2.	Community participation and empowerment of vulnerable groups, including monitoring and evaluation from the outset
3.	Latrine emptying and desludging
4.	Hygiene promotion and the importance of understanding context, including socio-anthropology issues
5.	Community led total sanitation and sanitation marketing
6.	Urban alternatives for excreta disposal
7.	Exit strategies and sustainability issues from the outset
8.	Final sewage disposal options after desludging and treatment
9.	Further development of non-toilet options / early response / mobile
10.	Hand washing hardware and promotion and sustainability (including soap and non-soap options)
11.	Water treatment, particularly bulk and point of use household filters, including cost and sustainability issues
12.	The need for low-tech WASH solutions acceptable and sustainable by locals

Many publications present innovations at various stages of development: implemented (Bastable and Lamb, 2012; Coloni et al., 2012; Singh, 2012; Haucke

and Kreutzer, 2011; Patel, 2011), piloted during an emergency (Patel, Brooks, and Bastable, 2011), tested in a laboratory or non-emergency setting (Malambo, 2014; Nobela, 2014; Pérez, 2014; Spit et al., 2014), or proposed (Brdjanovic et al., 2015; Kinstedt, 2012; Mwase, 2006; Paul, 2005). However, the authors rarely describe the activities they undertake to reach that stage of product development. Therefore, readers do not have the opportunity to understand the processes involved in product development.

Singh (2012) is one exception. The author had designed and implemented a household trench latrine following the floods in Pakistan in 2010. His process included: discussing pre-flood defecation practices with affected people and local staff; sketching a concept; obtaining feedback from colleagues, partner staff, and beneficiaries, and; developing a drawing based on the feedback. The paper provided insight into the innovation process, however, this represents one specific case that should not be generalizable to the emergency sanitation sector as a whole.

Some publications also document or report on activities that are part of the innovation process: workshops (McBride, 2013; Johannessen, 2011; Ruberto and Johannessen, 2009), gap analyses (Bastable and Russell, 2013; Brown et al., 2012), laboratory and / or field trials (Malambo, 2014; Nobela, 2014; Pérez, 2014; Spit et al., 2014; Patel et al., 2011). With some exceptions, there is little reflection on how these activities contribute to the innovation process, for example: the Stoutenburg workshops brought in a product design company to function as facilitators because the company could think of new ways to do things (Johannessen, 2011); Patel et al. (2011) argued that emerging technologies required validation from field-based research and development rather than anecdotal evidence.

There have been three studies that specifically investigate aspects of innovation related to emergency sanitation. The University of Glasgow and Oxfam GB (2011) discussed barriers to the transfer of water supply and sanitation technologies from other sectors to the humanitarian sector as well as recommendations for enabling

technology transfer. For example, the authors found that technologies developed through collaboration between practitioners, industry and academia turned out to be the most cost effective. Rush and Marshall (2015) carried out a case study on the WASH sector as part of the humanitarian innovation ecosystem research project. However, the focus on WASH in general rather than sanitation specifically may overlook issues that are particular to the sub-sector.

Shaylor (2010) focuses on the attitudes of engineers towards implementing urine diversion in emergencies. Explanations for negative attitudes towards urine diversion include the lack of understanding of and first-hand experience with alternative systems and urine diversion as well as the belief that available evidence is biased by donors and heavy subsidies. Using Lewin's theory of change model, the author identifies factors to help introduce urine diversion for emergencies (Figure II.2).

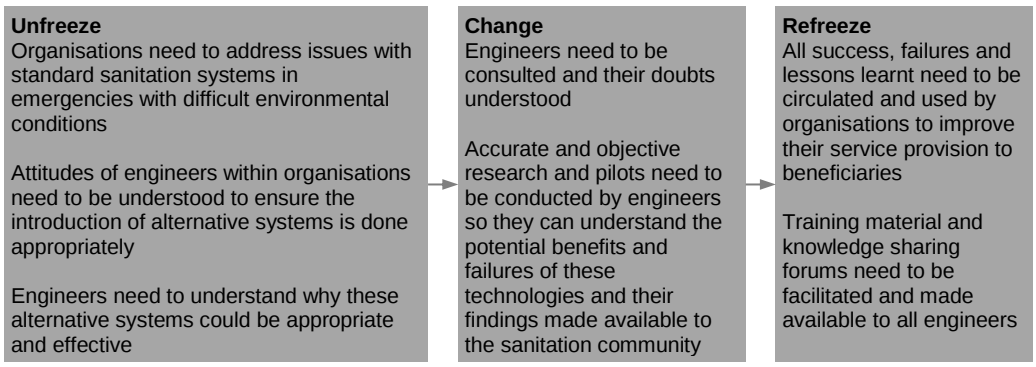


Figure II.2 Approach to introducing urine diversion in emergencies proposed by Shaylor (2010) based on Lewin's theory of change

Shaylor (2010)'s thesis is particularly useful for understanding why humanitarian practitioners may not be receptive to new ideas and how it may be overcome.

II.3 Logical framework approach

The logical framework approach refers to an analytical process and set of tools used to support objective-oriented project planning and management. Although the approach can be applied differently, the underlying principles are similar.

The logical framework approach should be considered an aid to think. Applying the logical framework approach allows information to be analysed and organised in a systematic manner. The approach comprises two stages: the analysis phase and planning phase. A set of tools for each of these two stages are provided. During the analysis phase, stakeholder, problem, objective and strategy analyses can be carried out. During the planning phase, the logical framework matrix is developed, along with activity and resource schedule (EIO, 2011).

Among the tools, it may be argued that the problem analysis and objective analysis are the most critical stages of the logical framework approach, because it guides subsequent decision-making on priorities (strategy analysis) and project planning. The problem analysis identifies problems of an existing situation and the cause and effect relationships between the problems, represented in a problem tree. The objective analysis reverses the problems into solutions, represented in an objective tree (Figure II.3). In this way, strategic objectives are based firmly on identified priority problems.

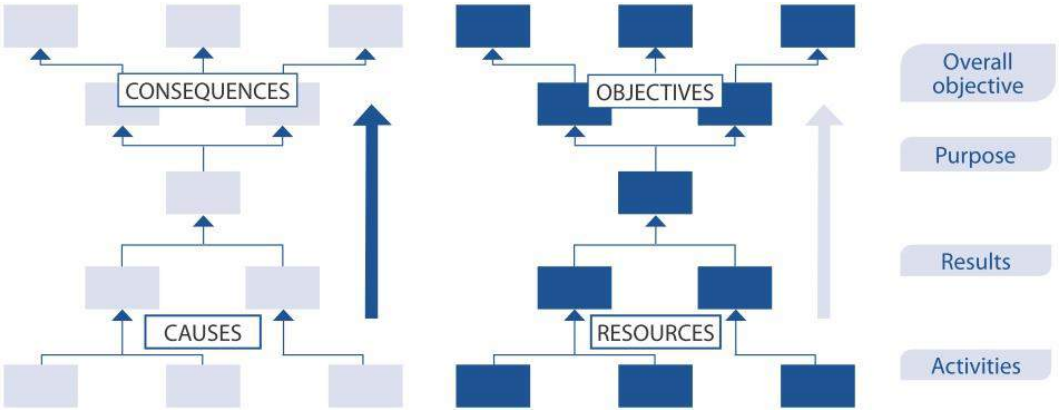


Figure II.3 Relationship between the problem analysis (left) and objectives analysis (right) (EIO, 2010)

After completing the two steps of the problem analysis and objective analysis, alternative strategies are analysed. Considerations may be strategic, social / distributional, financial, economic, technical or environmental. The chosen strategy is then elaborated in a logical framework matrix. The logical framework matrix comprises four columns and four (or more) rows summarising the key

elements of the project: objectives, assumptions, indicators and sources of verification. In other words, the objective tree comprises the first column of the logical framework matrix.

The logical framework approach was original developed and used in the science and private sectors. In the 1970s, it was formally adopted as a planning tool for overseas development activities by the United States Agency for International Development (USAID).

The logical framework approach was developed to plan and manage complex projects. If applied correctly and wisely, it lays the foundation for successful project or program implementation, because it can also be used to implement, follow up and evaluate projects (Örtengren, 2011). Among the advantages of the logical framework approach are:

- It asks fundamental questions and analyses weakness so as to provide decision makers with better and more relevant information;
- It allows for the systematic and logical analysis of inter-related elements. This constitutes a well-designed project.
- It improves planning by emphasising relationships between project elements and external factors.
- It provides a better basis for systematic monitoring and analysis of the effects of projects (EIO, 2010)

Furthermore, the logical framework approach is used by and familiar to numerous donors and NGOs such as the Australian Agency for International Development (2005), DFID (2011a) and Swedish International Development Cooperation Agency (Örtengren, 2004). Therefore, in addition to the benefits of the logical framework described above, the approach was considered to be an effective medium to communicate the findings of the dissertation.

However, the following limitations of the approach should be noted:

- It may lead to rigidity in project administration if the objectives and external factors specified at the outset are over-emphasised.
- It is a general analytic tool. It is policy-neutral on questions such as cost and feasibility of strategies and technology, effects on the environment, access to resources, and so on. It does not replace and should be completed by other tools such as target-group analysis, cost benefit analysis, impact analysis, and so on (EIO, 2010).

II.4 Conclusion

The humanitarian sector is relatively new to research on innovation but is rapidly developing its understanding of humanitarian innovation by applying concepts such as the innovation process, contextual factors and the ecosystems approach. Many of these concepts have yet to be studied with respect to emergency sanitation. Indeed, there is very limited literature in the emergency sanitation sector that focuses on the innovation process. Only one paper presented a case study on how an idea was developed to end product, while only three studies considered the factors that enabled or hindered innovation. Therefore, there are many gaps in the field of emergency sanitation innovation research that can and need to be addressed.

Given that the innovation process forms the building block of the innovation ecosystem, this dissertation focuses on understanding the processes undertaken by organisations and individuals to develop emergency sanitation solutions from idea to end product. Addressing this gap would provide a firm basis for identifying specific areas where the product development process could be improved.

Finally, the findings of the research are synthesized and communicated by applying problem analysis and objective analysis under the logical framework approach, due to its ability to systematically analyse and organise information.

Chapter III Methodology

The previous chapter called attention to the limited literature on the innovation process in the emergency sanitation sector. Consequently, achieving the aim of the dissertation first requires an understanding of these processes to provide a basis for identifying ways to improve product development. The overall approach was exploratory, relying on a combination of qualitative and quantitative methods to achieve the aims and objectives.

The research was in three stages. First, interviews and surveys helped to understand the practices involved in and barriers to developing emergency sanitation products. A case study at a transitional settlement explored the participation of end users. A stakeholder survey assessed the support provided to suppliers and product developers (Section III.2). Second, measures to support product development were identified. Using a questionnaire, stakeholders assessed the measures' usefulness and ease of implementation. Three of these were evaluated in depth (Section III.2). Finally, the logical framework approach was applied to organise the findings into appropriate recommendations for improving product development, focusing on design requirements (Section III.3).

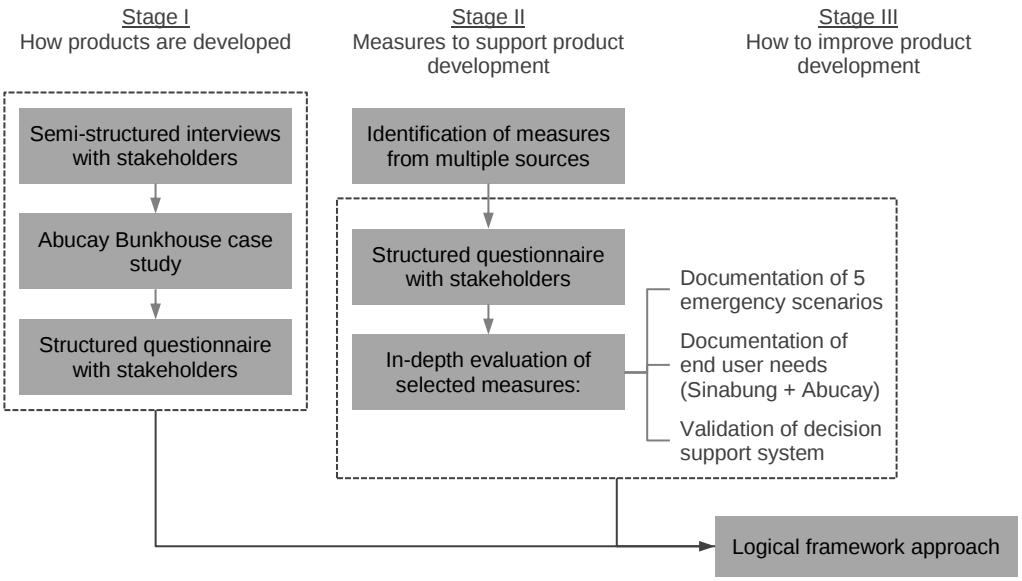


Figure III.1. Research methodology

The type of data collected are summarised in Table III.1.

Table III.1 Key sources of data used

Source	Description	Purpose of data
Semi-structured interviews	- 19 stakeholders involved in developing emergency sanitation products	- Understand the processes involved in and barriers to developing products in the emergency sanitation sector
	- 44 residents (representing end users) of Abucay Bunkhouse, Philippines	- Understand how end users might engage with product development activities
Structured questionnaire	- 67 stakeholders involved in emergency sanitation	- Assess the level of support provided to suppliers and product developers - Assess the usefulness and ease of implementation of identified measures to support product development
	- 150 people affected by the Mount Sinabung volcano eruption, Indonesia - 126 residents of Abucay Bunkhouse, Philippines	- Evaluate the usefulness of documenting data on end user needs
Case studies	- Five past natural disasters in developing countries	- Evaluate the usefulness and ease of implementation of documenting and disseminating data on emergency scenarios
	- Validation of a decision support system developed by UNESCO-IHE	- Evaluate the usefulness and ease of implementation of decision support tools for choosing a suitable emergency sanitation product

III.1 How products are developed

In the initial stage of the research, stakeholders who play an active role in the product development process (namely customers, suppliers, product developers, domain experts) (Subsection III.1.1) and end users residing in a transitional settlement in Tacloban City, the Philippines (Subsection III.1.2), were interviewed. A wider set of stakeholders were then surveyed to assess the support provided to suppliers and product developers (Subsection III.2).

III.1.1 Semi-structured interviews with stakeholders

The aim of the interviews with stakeholders was to understand the processes involved in and barriers to developing products in the emergency sanitation sector. Interviews were considered to be suitable to achieving the aim because there have been very few studies related to the research questions. This part of the research comprised three stages: interview schedule development, data collection and data analysis (Figure III.2).

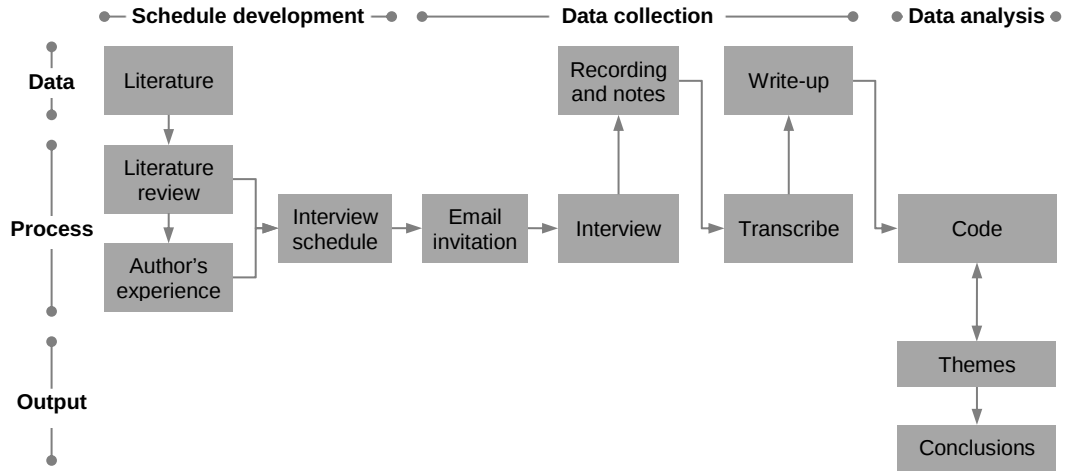


Figure III.2. Methodology for stakeholder interviews

III.1.1.1 Interview schedule development

Literature on innovation in the emergency sanitation sector, innovation in the humanitarian sector and product development in general were reviewed. Complemented by the experience gained from the author's participation in activities related to emergency sanitation innovation, an interview schedule was developed (Table III.2).

Table III.2 Stakeholder interview schedule. Questions were tailored to the interviewee's involvement in the product development process.

Category	Themes of questions
Context	Interest in emergency sanitation; products developed and under development; list of customers or suppliers; demand for and sales of products; reasons for developing a new product
Product development process	How a product is developed from opportunity identification to promotion of end product; tools and methods used; length of process
Barriers and enabling factors	Challenges faced; factors that make the process easier; recommendations for improvement

III.1.1.2 Data collection

This part of the research targeted organisations and individuals from the United Kingdom (UK) or Indonesia who were previously or currently involved in developing emergency sanitation products. These countries were chosen due to the author's presence in the aforementioned countries during this part of the research because it allowed face-to-face interviews to be conducted. The full list

of organisations and individuals that met the criteria for the target population was compiled while preparing for the stakeholder survey described in Subsection III.1.3. Respondents from other countries who happened to be in the UK / Indonesia or requested to be part of the interviews were also included in the study.

Potential interviewees were invited by emails. The invitations described the purpose of the study as well as reasons why the organisation or individual had been contacted. If there was no response from the invitee, a reminder email was sent one week later. Two invitees did not respond to the emails. No one refused to be interviewed. 18 interviews with 19 persons were conducted between April and September 2014. All interviews were carried at a location requested by the interviewee. Two interviews were conducted by phone and three by Skype.

The semi-structured approach allowed flexibility for themes to be followed up and explored as they arose. Interviews lasted between half-an-hour and three-and-a-half hours. The total duration of the interviews was approximately 22 hours. All interviews were digitally recorded and complemented by handwritten notes. Based on the recordings, a partial transcription of each interview was prepared and sent to the interviewee for review and approval. Where clarifications were required, follow-up questions were sent and the answers were incorporated into the write-up. The reviews were completed in January 2015.

III.1.1.3 Data analysis

The data was analysed using thematic analysis. Coding was an iterative process. The text was analysed line by line and reduced to concepts through codes. The codes and texts were constantly compared to develop and refine relevant groupings of data. Logical groups of concepts were clustered as categories. The data was carefully read and re-read. Initial codes were categorised, re-categorised and condensed to identify relationships between themes and properties of the categories (Figure III.3). QDA Miner Lite (version 1.3), a computer-aided qualitative data analysis software, was used to extract, organise and code the data (Figure III.4). Informal conversations with other stakeholders, a desk study of

documents relevant to the research questions and the author's personal involvement in emergency sanitation activities helped to contextualise the themes identified in the interviews. Within each category, coded lines of text were compiled into tables in Microsoft Word 2010 so that independent observations could be identified and categorised from the data.

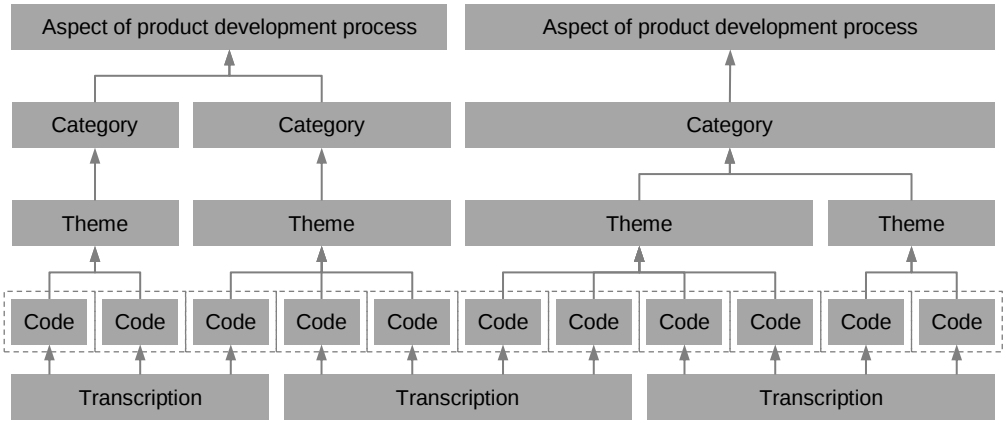


Figure III.3. Coding process for stakeholder interviews

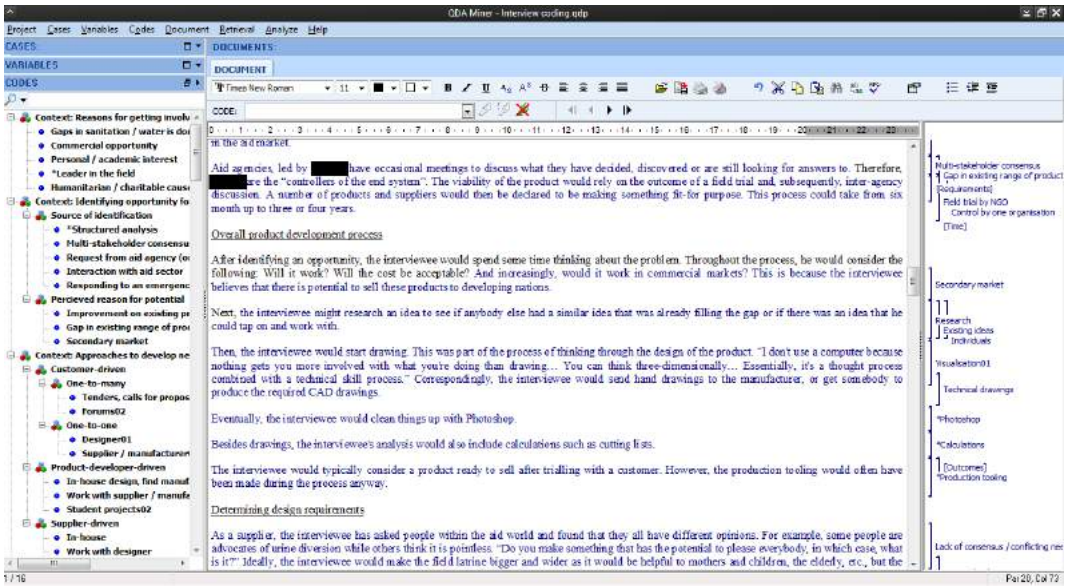


Figure III.4. Screenshot showing the coding of stakeholder interviews in QDA Miner Lite

III.1.1.4 Ethical considerations

There are very few organisations and individuals involved in developing products for the emergency sanitation sector. Some of these organisations and individuals

have a public profile or work on well-known projects. There were concerns that an interviewee would be identified and that the reputations and relationships of the interviewee or the organisation they represented might subsequently be affected. As such, confidentiality was of greatest priority in this study. Potential interviewees were assured that: their participation and profile would remain confidential except to the people directly involved in the research; digital recordings would be destroyed once the study had ended, and; they would have an opportunity to review the interview write-up and to identify any information that they did not want to be revealed in any publications. Written consent from the interviewees was sought before the commencement of the interview. The interviewee's consent to be recorded was also verbally confirmed before the recording was started.

III.1.2 Case study of end users in a transitional settlement

The aim of the case study in Abucay Bunkhouse, Tacloban City, the Philippines, was to better understand how end users might engage with product development activities. Interviews were randomly conducted with 44 residents of the bunkhouse from March to May 2015 using the interview questions listed in Table III.3. Volunteers from the bunkhouse assisted the author with translating the questions and answers as required.

Table III.3 Abucay Bunkhouse case study interview questions

Theme	Questions
Awareness of the purpose of UNESCO-IHE's and author's activities	Do you know why UNESCO-IHE put the eSOS® smart toilet in Abucay Bunkhouse? If so, why? Do you know why we are conducting surveys on your latrines? If so, why?
Importance of understanding the purpose	Do you think it is important to know: why UNESCO-IHE put the smart toilet in the bunkhouse, and; why we are conducting surveys about your latrines? Why or why not?
Opinion towards field testing and research; factors affecting opinion	After explaining the purpose of the activities: What do you think about UNESCO-IHE trying new things and conducting experiments at the bunkhouse? Do you think the money spent on the smart toilet should be spent on fixing problems in the bunkhouse instead? Why or why not? What is your feeling towards us asking you questions about your latrines?
Factors enabling participation in field testing	Did you attend UNESCO-IHE's briefing about the smart toilet? Why or why not? Have you tried the smart toilet? If not, why? The first time you tried the smart toilet, why did you try it?

Responses were written down and analysed using thematic analysis similar to the methodology described in Subsection III.1.1.3.

Abucay Bunkhouse was chosen as the case study location because the UNESCO-IHE Institute for Water Education was testing a prototype of an emergency toilet that they had developed at the bunkhouse. The toilet was known as the eSOS® smart toilet. This allowed the interview questions to be related directly to the field testing of the eSOS® toilet.

III.1.3 Structured questionnaire of stakeholders

The aims of the stakeholder survey were to: one, assess stakeholder opinions on the level of support provided to suppliers and product developers at key stages of developing emergency sanitation products (Stage 2 of research), and; two, the usefulness and ease of implementation of identified potential measures to support suppliers and product developers (Stage 3). This section of the research comprised three components: questionnaire development, data collection and data analysis (Figure III.5).

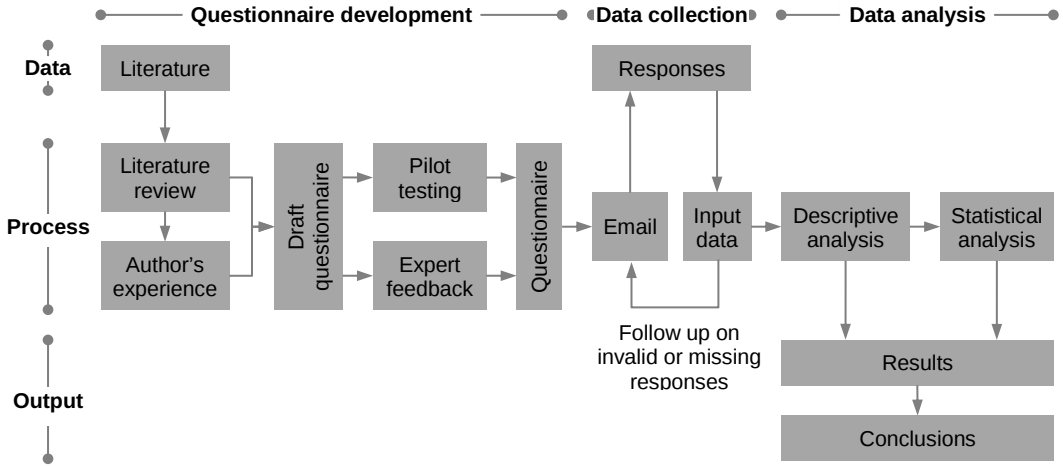


Figure III.5. Methodology for stakeholder survey

III.1.3.1 Questionnaire development

A draft questionnaire was developed in accordance with the approach used to develop the stakeholder interview schedule (Subsection III.1.1.1). In April 2014,

the draft was piloted. Feedback was obtained from ten people who had knowledge of emergency sanitation and / or product development and the questionnaire was revised accordingly. The final survey was a self-administered structured questionnaire created in Microsoft Word as a 97 – 2003 document. The questionnaire started with basic demographical questions and the respondent's nature of involvement in the sector. Thereafter, the questionnaire was divided into two parts addressing the two objectives of the survey.

III.1.3.2 Data collection

The respondents targeted for the survey represented four categories of stakeholders involved in developing products for the emergency sanitation sector: customers, existing and potential suppliers, existing and potential product developers, and intermediaries. An initial list of 181 target respondents was compiled from sources on emergency sanitation innovation-related activities or outputs, such as: publications about new technologies and field trials; websites of suppliers, product developers and projects, and; participant lists from workshops like the emergency sanitation workshop and exhibitions like AidEx. Contact details could not be found for 14 persons and email addresses were out of date for 16 persons. 14 persons replied that they were irrelevant to the survey's aims. Therefore, 137 persons from the list were invited. The survey was also posted in the Sustainable Sanitation Alliance (SuSanA) forum and emailed to the Sustainable Sanitation in Emergency and Reconstruction Working Group mailing list. Six persons replied using this avenue. Another 19 respondents were identified through snowball sampling.

The survey was conducted between June and September 2014. Individuals or organisations on the list were emailed personalised survey invitations with a soft copy of the questionnaire attached. The invitations described the purpose of the study as well as reasons why the individual or organisation had been invited. If there was no response, a first reminder was sent one week later. A second reminder was sent two weeks after that. In the invitation as well as the questionnaire, invitees were promised complete confidentiality. They were also

offered to be sent a copy of the results if they completed the questionnaire. 67 responses were received. Therefore, the overall response rate was 41.4%.

The responses were input into a Microsoft Excel 2010 spreadsheet. If there were invalid or missing responses, the respondent was contacted to clarify their answers. Up to two reminders were sent.

III.1.3.3 Data analysis

Respondents indicated their answers on a seven-point Likert-type scale. Three types of scales were used: Agree – Disagree; Small – Large; Difficult – Easy. The scale used depended on the nature of the question. The data compiled in Microsoft Excel was extracted into RStudio (version 0.98.1062) for descriptive as well as statistical analysis:

- Descriptive statistics: mean; median; minimum and maximum value; inter-quartile range; percentage 'Agree' / 'Small' / 'Difficult'; percentage 'Disagree' / 'Large' / 'Easy';
- Statistical interference: Wilcoxon signed rank or rank sum test at 5% significance levels ($p \leqslant 0.05$) with the following hypotheses:

    - ♦ Null hypothesis: The median is neutral. Alternative hypothesis: The median is not neutral (two-tail test);
    - ♦ Null hypothesis: The median is a specific response (e.g. 'Somewhat large'). Alternative hypothesis: The median is larger than a specific response (one-tail test), and;
    - ♦ Null hypothesis: There is no difference in mean ranks between the two sets of responses. Alternative hypothesis: There is a difference in mean ranks between the two sets of responses (two-tail test).

Where required for the analysis, the responses were transformed to the corresponding ordinal values (e.g. -3 for 'Strongly disagree', 0 for 'Neutral' and +3 for 'Strongly agree').

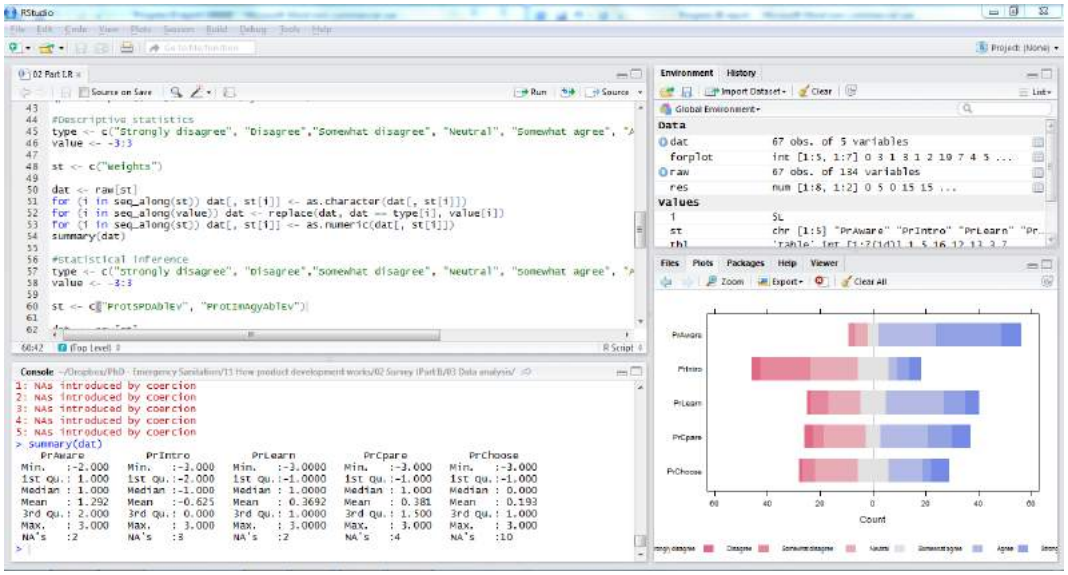


Figure III.6. Screenshot of data analysis in RStudio

III.2 Measures to support product development

In the next stage of the research, measures to help suppliers and product developers develop products were identified from various sources (Subsection III.2.1). Stakeholders were surveyed to assess the usefulness and ease of implementation of these identified measures (Subsection III.2.2). Selected measures (the documentation and dissemination of typical emergency scenarios; the documentation and dissemination of challenges faced by end users, and; a decision support tool for choosing a suitable product) were evaluated in depth (Subsection III.2.3).

III.2.1 Identification of measures

Potential measures were identified and shortlisted from various sources. Existing measures were identified through a literature review on emergency sanitation innovation (see Section II.2). Additional ideas were brainstormed based on the author's participation in innovation-related activities for emergency sanitation. For instance, during the literature review, the author found it difficult to find data on emergency sanitation scenarios. Concepts and methods used in product design and development were studied and adapted to the emergency sanitation context. Measures considered unfeasible for the emergency sanitation sector were excluded. For example, user-led methods, commonly used for designing consumer

products, were judged to be impractical due to the difficulties in accessing end users and emergency settings.

III.2.2 Structured questionnaire of stakeholders

The measures identified in the previous subsection were compiled into the questionnaire. Feedback on the draft was incorporated into the final list of measures. The methodology for this part of the research was described in Subsection III.1.3.

III.2.3 In-depth evaluation of selected measures

Not all 35 measures identified in the previous subsection could be evaluated in detail. Therefore, three measures were selected to be evaluated in greater depth: the documentation and dissemination of emergency scenarios (Subsection III.2.3.1); the documentation and dissemination of end user needs (Subsection III.2.3.2), and; a decision support system for choosing an emergency sanitation product (Subsection III.2.3.3).

III.2.3.1 Documentation of emergency scenarios through case studies

This section explored the usefulness and ease of implementation of documenting and disseminating data on emergency scenarios through case studies of previous disasters. A preliminary framework was developed based on the literature review (Subsection V.3.1.1) to provide a structure for collecting, analysing and comparing data on emergency scenarios (Figure III.7).

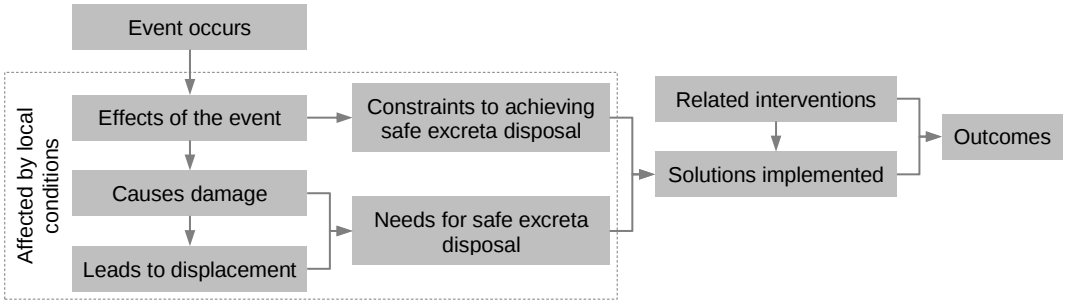


Figure III.7. Initial conceptual framework for case studies

The ReliefWeb disaster database (http://reliefweb.int/disasters), which is operated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), was the basis for identifying potential case studies. This was because ReliefWeb "has been the leading source for reliable and timely humanitarian information on global crises and disasters since 1996". Disasters that were considered for case studies were those listed by the ReliefWeb database between the year 2000 and 2010. This resulted in 1,311 disasters. Then, disasters with more than 1,000 documents were selected. 18 disasters met the criteria. Finally, disasters in developed countries, medical disasters and agricultural disasters were excluded. This left 12 disasters. The eventual cases were chosen using a maximum variation cases approach with the aim of gathering information on the significance of various circumstances. The final cases were chosen to vary the type of disaster and location, while at the same time prioritising disasters for which most documents were available.

All the data for the case studies was collected from the public domain. Documents were primarily from the ReliefWeb database because it collects "updates and analysis from more than 4,000 global information sources". These included content related to analyses, appeals, assessments, evaluations and lessons learned, manuals and guidelines, maps, news and press releases, situation reports and UN documents. To focus on emergency sanitation, only documents relevant to the theme "Water Sanitation Hygiene" were downloaded. Situation reports from the OCHA as well as USAID were also collected because these provided an overview of the context, particularly with regard to damage and displacement. References to other relevant sources were located and a wider internet search was carried out to identify relevant documents.

QDA Miner Lite (version 1.2) was used to extract, organise and code the data. Each document downloaded was extracted into the software. Content relevant to each category of the conceptual framework was coded accordingly. The coded content for each case was then compiled into a Microsoft Word table arranged by

category and in chronological order. From there individual case study findings were written up methodically.

The comparative analysis applied a cross-case synthesis technique. A table was used to capture the findings from the case studies in a uniform structure. Rating scales were used whenever possible to facilitate comparison between each case. For each category, similarities and differences were identified and matched with other categories in order to detect patterns for possible correlations.

III.2.3.2 Documentation of end user needs with a structured questionnaire

This section of the dissertation explored the usefulness of documenting and disseminating data on end user needs. A survey, complemented by other data collection methods, was conducted at Abucay Bunkhouse in the Philippines over a seven-week period from March to May 2015, and analysed together with data collected by a Masters student at the Sinabung displacement centres in Indonesia in September 2014. The research comprised three steps: questionnaire development, data collection and data analysis.

Questionnaire development

The questionnaire was first developed by the Masters student for the Sinabung displacement centres in Indonesia. The questions were structured according to Rosenquist (2005)'s explanation on the physiological factors of sanitation: physiological needs, safety and security needs, health, inter-personal needs, status needs and needs for denial. A site visit was made in March 2014, where the draft questions were piloted with residents at the displacement centres. The questionnaire was modified accordingly.

The questionnaire for Abucay Bunkhouse in the Philippines was adapted by the author from the questionnaire used at the Sinabung displacement centres. Additional questions were included based on the author's observations and preliminary interviews at the bunkhouse. The questions were tested with a number of residents, modified accordingly and translated to Tagalog.

Data collection

At both study locations, the minimum number of samples required (n) for the target population (N) was calculated using Slovin's formula with a confidence interval of 90% (i.e. e = 10% = 0.10):

$$n = \frac{N}{1 + Ne^2}$$

At the Sinabung displacement centres, at least 100 responses were required. Residents available at the time of the Masters student's visit were randomly sampled. The questionnaire was administered through oral interviews. 150 responses were collected.

At Abucay Bunkhouse, at least 90 responses were required. The author sought to obtain a minimum number of responses from each sub-population categorised according to gender, age group and building number so as to get a more representative sample. However, any resident who wanted to complete the questionnaire was welcomed. Three volunteers from the bunkhouse were recruited and trained to collect the data. The responses were input into a Microsoft Excel 2010 spreadsheet. If there were invalid or missing responses, the answers were clarified with the respondents. 126 responses were collected. The survey was complemented by direct observations on site, follow-up interviews with a number of survey respondents and informal conversations with residents as well as the camp manager.

Data analysis

Variables were measured on the five-point Likert-type scale. The data compiled in Microsoft Excel was extracted into RStudio (version 0.99.447) for statistical analysis. For comparative analysis between and within the study locations, the Wilcoxon rank sum test was used to compare mean ranks between two sets of responses between the study locations, related variables and sub-populations. To explore the correlation between related variables, Spearman's correlation was

used to measure the strength of the monotonic relationship. All tests were conducted at 5% significance levels ($p \leqslant 0.05$).

III.2.3.3 Validation of a decision support system

This section of the dissertation explored the usefulness and ease of implementation of a decision support tool for choosing a suitable product by validating a decision support system (DSS) developed by Zakaria et al. (2015). Utilising data collected from the case studies in Subsection III.2.3.1, four components of the DSS were validated, the: sanitation options offered by the developers, screening criteria, compatibility matrix and evaluation criteria. There were three steps in the validation process, explained in the following paragraphs.

Step 1: Compare DSS with case study findings

To validate the sanitation options and screening criteria, a list of sanitation options and screening criteria was compiled from each case study. One by one, this list was compared to the options and criteria offered by the DSS. Any discrepancy or missing option or criteria was carefully considered and classified as an issue or non-issue. The issues were compiled in a list of recommendations.

Step 2: Verify logic of compatibility matrix

Each sanitation option in the DSS is categorised into one of the six available components in the sanitation chain. Using binary codes, the compatibility matrix defines whether one option can be implemented in the same chain with another option. There are only two possible combinations of binary codes (Table III.4). The next step was to verify whether the compatibility matrix contained any invalid binary codes. Mistakes were corrected based on the author's judgement.

Step 3: Test case using the 2004 Indian Ocean tsunami in Indonesia

To validate the screening criteria, compatibility chain and evaluation process more comprehensively, one case study from Subsection III.2.3.1 was used as a test case for the DSS. Data from the 2004 Indian Ocean earthquake and tsunami helped to determine responses to the screening criteria and input scores to the evaluation

criteria. If relevant data was not available, responses were based on assumptions regarding the context in the test case. After unfeasible sanitation options were screened out using the screening criteria, every possible sanitation chain was built, noted down and scored using the evaluation criteria. Therefore, the output of the test case was a list of possible sanitation chains and corresponding scores. The entire process was recorded in a Microsoft Excel spreadsheet.

Table III.4 Valid binary codes in decision support system compatibility matrix

	Option A	Option B
Option A	1	0
Option B	0	1

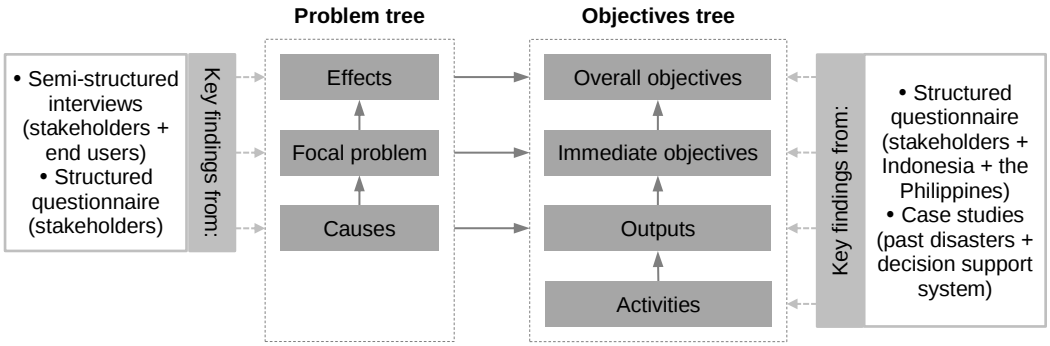
	Option A	Option B
Option A	1	1
Option B	1	1

III.3 How to improve product development

The findings from Section III.1 and III.2 were analysed so as to recommend activities to improve product development, focusing on improving design requirements. The problem analysis and objective analysis from the logical framework approach described in Section II.3 were applied to ensure that framework addressed the root causes of inadequate design requirements.

First, using problem analysis, the causes and effects of the problem were thoroughly analysed. A problem tree allows the causes and effects of the problem to be visualised and the relationship between different problems to be understood. This meant that the root causes, rather than symptoms of the root causes, could be identified and addressed (Figure III.8). The steps applied were:

- Step 1: Identify major existing problems, based on research findings;
- Step 2: Select a focal problem for analysis;
- Step 3: Look for related problems to the focal problem;
- Step 4: Construct the problem tree by establishing a hierarchy of cause and effect relationships;
- Step 5: Connect the problems with cause-effect arrows to clearly show the key links, adapted from (EIO, 2011).



Problem and objective analysis adapted from Örtengren (2004)

Figure III.8. Relationship between problem and objective analysis

Next, objectives were formulated to tackle the root causes and mitigate their negative effects by reversing the problem tree. The steps applied were:

- Step 1: Reformulate the problems in the problem analysis into desirable and realistically achievable positive situations;
- Step 2: Work from bottom up to ensure the cause-effect relationships have become means-end relationships, revising statements and adding / deleting objectives if necessary;
- Step 3: Draw connecting lines to indicate the means-end relationships, adapted from EIO (2011).

Finally, potential activities to achieve outputs that dealt with the root causes were suggested.

Chapter IV How products are developed

The first stage of the dissertation explores the practices involved in and the barriers to developing products in the emergency sanitation sector (Section IV.1). It also examines the roles of end users (Section IV.2) as well as suppliers and product developers (Section IV.3) in the product development process. These findings provide a basis for the measures identified to help products be developed more effectively (Chapter V).

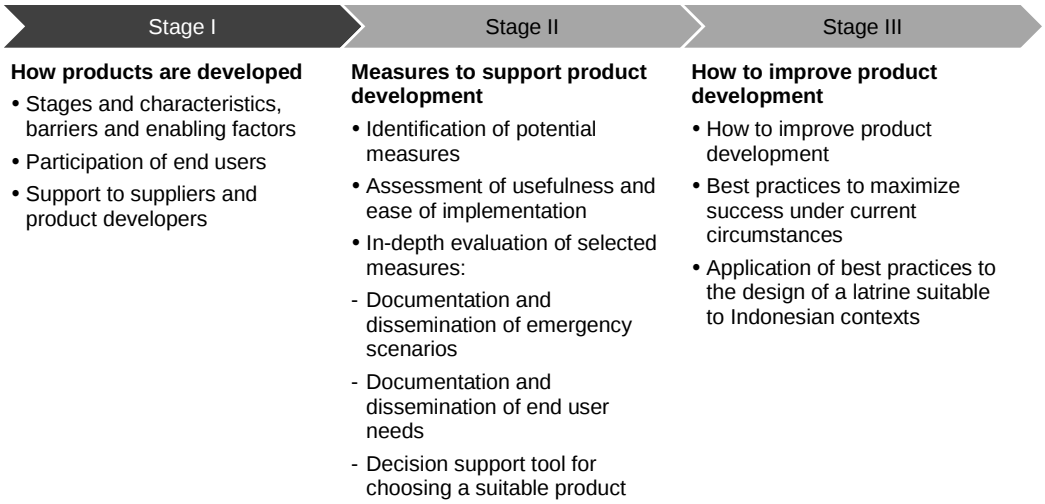


Figure IV.1. Aims and objectives of first stage of dissertation

IV.1 Stakeholder interviews: Process and barriers

The research started by exploring the practices involved in and the barriers to developing products. 19 persons based in five countries were interviewed. The interviewees represented humanitarian practitioners, suppliers, designers, academics and students. The data analysis identified 1,140 observations in total, describing six aspects of product development. Each aspect of product development will be discussed in this section:

- The context within which organisations and individuals innovate (Subsection IV.1.1);
- The product development process (Subsection IV.1.2.1);

- Characteristics and feelings about product development (Subsection IV.1.2.2);
- Barriers to product development (Subsection IV.1.3.1);
- Enabling factors (Subsection IV.1.3.2);
- Recommendations (Subsection IV.1.3.3).

Observations refer to one or more statements made by an interviewee in the interview write-ups that describe one standalone point. These statements were also classified as: a general statement describing a theme; an example illustrating a theme; an explanation of a theme's significance; outcomes or consequences of a theme, or; an observation opposing a theme (counterpoint). Themes refer to groups of observations that describe the same concept. Figure IV.2 breaks down the themes and observations that were identified in the stakeholder interviews by aspect of product development and type of observation.

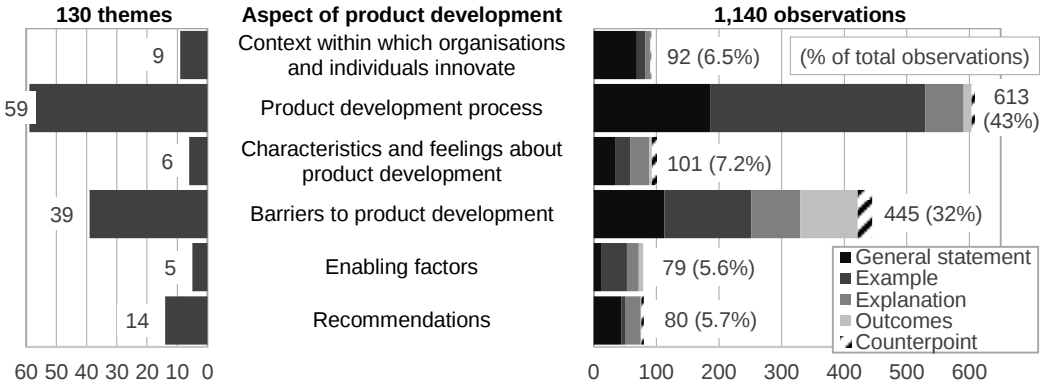


Figure IV.2. Total themes and observations from stakeholder interviews

This section summarises the categories and themes describing each aspect of product development. To allow the 'voices' of the stakeholders to be heard, the interviewees are quoted verbatim as much as possible.

IV.1.1 Context within which organisations and individuals innovate

Besides humanitarian agencies and the private sector, non-government organisations (NGOs), universities, donors and individuals are also involved in emergency sanitation products. Stakeholders can be classified into four roles:

- Customers who purchase or implement emergency sanitation products, typically humanitarian agencies (Figure IV.3 no. 1.1);
- Existing and potential suppliers of products, normally companies but also NGOs (no. 1.2);
- Existing and potential product developers who design products but do not supply the end product, such as profit and non-profit organisations, individual designers, researchers and students (no. 1.3), and;
- Intermediaries (e.g. sanitation experts, academics, donors) who do not directly develop products but are involved in other ways (e.g. expertise, research, testing, funding) (no. 1.4).

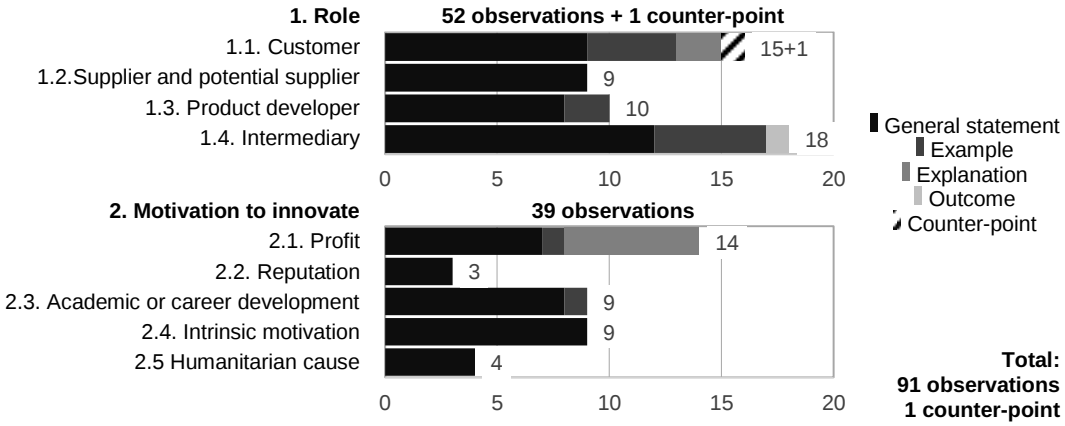


Figure IV.3. Aspect 1: Context within which organisations and individuals innovate

As Figure IV.3 also shows, profit (no. 2.1) and making a difference (no. 2.5) are not the only reasons why stakeholders develop products for the emergency sanitation sector. Stakeholders may benefit academically or career-wise through their participation (no. 2.3), or it may just be "something I enjoy doing" (no. 2.4).

IV.1.2 Stages and characteristics of product development

This subsection describes two aspects of product development: the stages of developing a product from identifying an opportunity to promoting the end product (Subsection IV.1.2.1) and the overall characteristics of and stakeholders' feelings towards the state of product development in the emergency sanitation sector (Subsection IV.1.2.2).

IV.1.2.1 Stages of product development

Based on the interviews, the process of developing a product is broken down into eight iterative stages, starting with identifying an opportunity and ending with promoting the end product (Figure IV.4). 613 observations and 59 themes describe the eight stages (Figure IV.5).

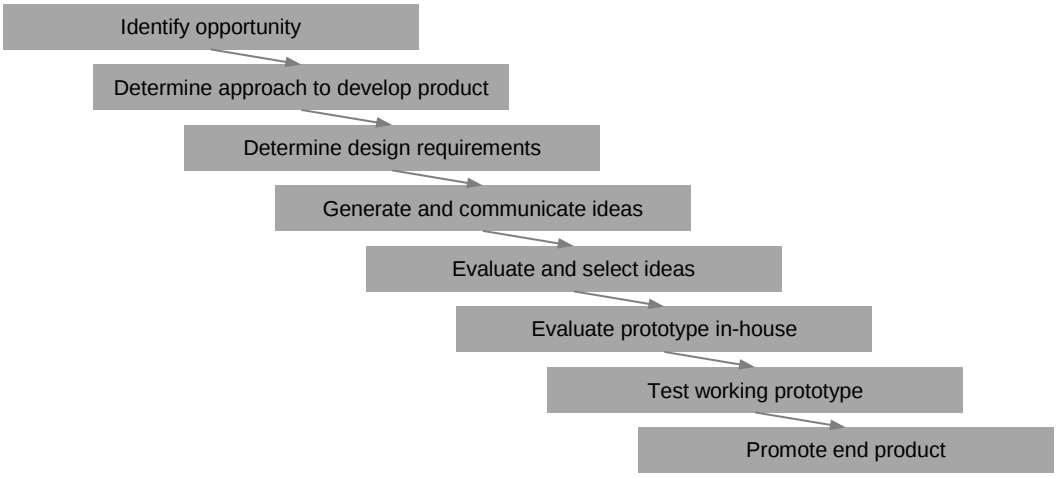


Figure IV.4. Product development process

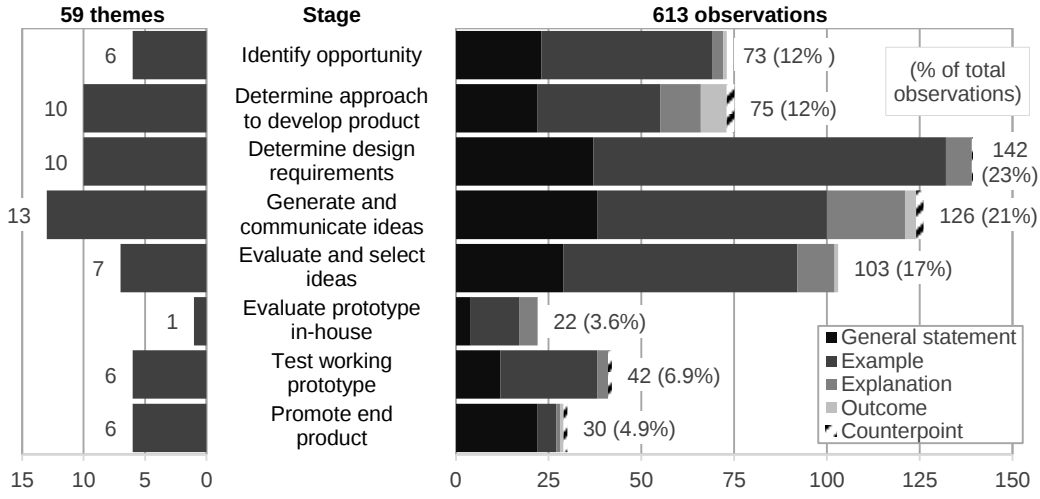


Figure IV.5. Aspect 2: Stages of product development

The number of observations in each of the 59 themes range from 1 to 49. There are significantly more themes and observations from the early stages of the product development process (e.g. determine design requirements: 142 of 613 observations = 23%) compared to the latter stages (e.g. test working prototype: 44

observations = 7.2%). This suggests that many existing activities focus on exploring requirements and ideas and that many ideas are not followed through to the later stages of building and testing a prototype.

Stage 1: Identify opportunity

Product development is initiated when a stakeholder sees an opportunity to improve existing products (e.g. "I thought it wasn't very good") (Figure IV.6 Theme 1.1: 16 of 36 observations in Category 1 = 23%) or fill a gap in the market (e.g. "Nobody really seemed to be looking at it" (Theme 1.2: 15 of 36 observations = 34%).

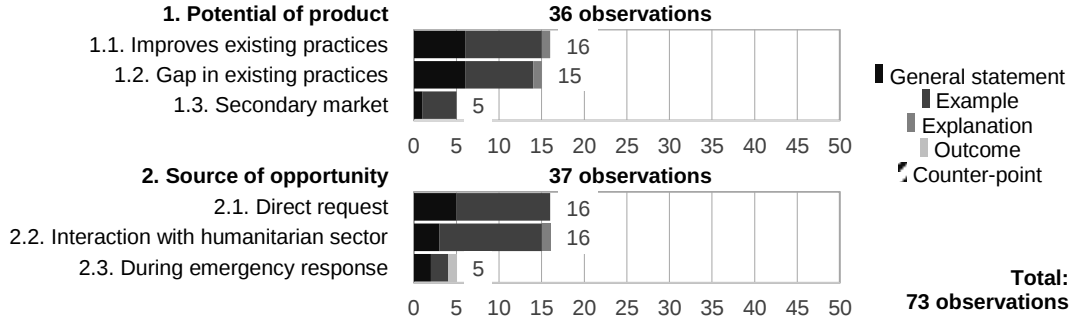


Figure IV.6. Stage 1: Identify opportunity

Suppliers and product developers might be "asked" to "help develop a product" or humanitarian agencies could publish various forms of requests to provide a solution (e.g. a call for proposals) (Theme 2.1: 16 of 37 observations in Category 2 = 43%). Alternatively, stakeholders could recognise that there is a demand for a new product when they interact with humanitarian practitioners or disaster settings (e.g. "see what is in the field and what people are using") (Theme 2.2: 16 of 37 = 43%). Less often, humanitarian practitioners are compelled to come up with solutions "on the spot" during emergency response (Theme 2.3: 5 of 37 = 15%).

Stage 2: Determine approach to develop product

Product development is typically initiated by humanitarian agencies (Figure IV.7 Category 1: 50 of 75 observations in Stage 2 = 67%). The approach they use

depends somewhat on the nature of the problem. However, “what has worked out well” for many practitioners is “working directly with suppliers” because suppliers can “design things as per what they can build” (Theme 1.3: 16 of 52 observations in Category 1 = 31%). One practitioner felt that the designs product developers come up with “may not suit any particular manufacturer” (Theme 1.4: 9 of 52 = 17%).

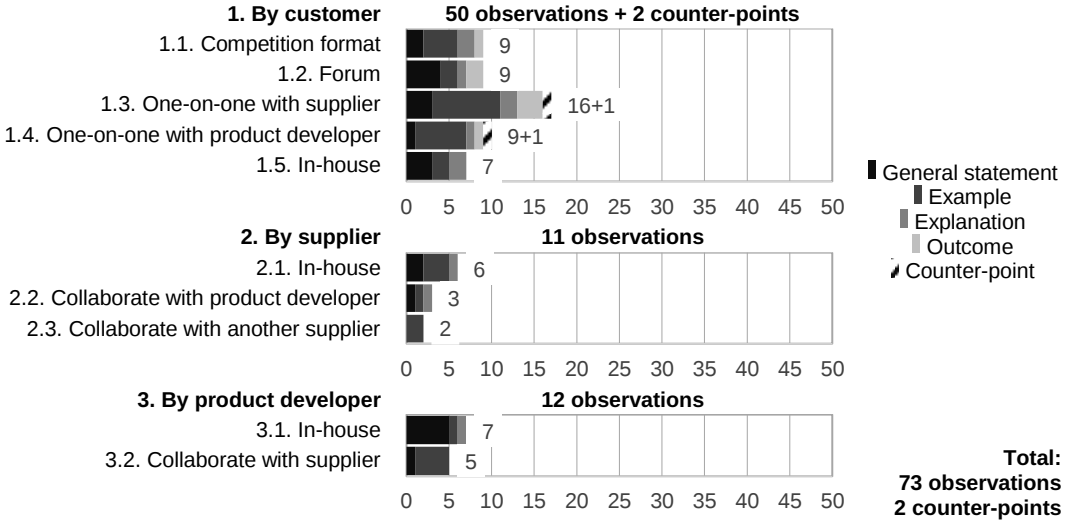


Figure IV.7. Stage 2: Determine approach to develop product

Besides approaching suppliers and product developers directly, agencies may organise competitions, tenders or calls for proposals (Theme 1.1: 9 of 52 observations = 17%) as well as workshops and “brainstorming events” (Theme 1.2: 9 of 52 = 17%). Rather than relying on others, one agency regularly builds their own prototypes “from A to Z” and “make detailed manuals” on how to construct technologies (Theme 1.5: 7 of 52 = 13%).

A lot of the time, suppliers develop products independently, partly because “an awful lot of kit... has to be very simplistic”. One supplier claimed that he could “make virtually anything that could be needed in the aid world in terms of “delivery mechanisms” (Theme 2.1: 6 of 11 = 55%). However, any product that is “quite advanced” would be developed in collaboration with the customer or a product developer. One supplier has a dedicated design partner who does “80% of the design work” (Theme 2.2: 3 of 11 = 27%).

Stage 3: Determine design requirements

Generally, the first step in designing a product is to determine the design requirements. Design requirements are obtained from a combination of sources. Most of the time, the humanitarian practitioner (customer) "talked them through what we wanted" or the supplier or product developer would be "asking questions" or considering "feedback" (Figure IV.8 Theme 1.2: 19 of 63 observations in Category 1 = 30%). Those with access to emergencies are able to observe how existing solutions "can be bettered or improved" (Theme 1.1: 9 of 63 = 14%). Occasionally, they may rely on their own opinion of what is appropriate (Theme 1.5: 9 of 63 = 14%).

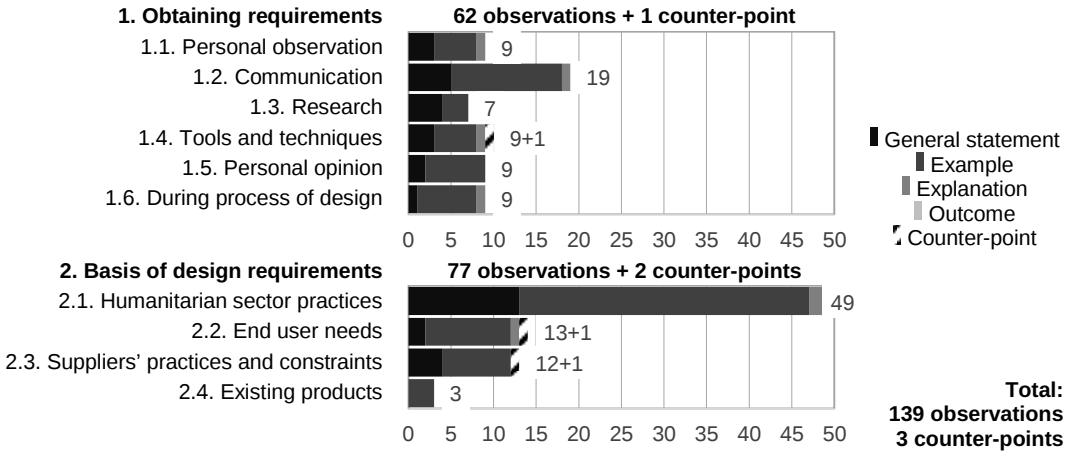


Figure IV.8. Stage 3: Determine design requirements

Using tools and techniques is not uncommon (Theme 1.4: 9 of 63 = 14%). Two humanitarian practitioners (customers) would often provide "specifications" or a "design brief". One consultant (product developer) would write his own design brief. Simple techniques, such as making specifications "measureable", help ensure that appropriate design requirements are written. More formalised tools (e.g. TRIZ) were used by one student design project. There were also two examples of suppliers and product developers surveying end users. On the other hand, another supplier "don't do a lot of writing a brief".

Design requirements emphasise humanitarian sector practices and needs, particularly logistics, rapid deployment and cost, which impact weight, volume

and packaging (Theme 2.1: 49 of 79 observations in Category 2 = 62%). There is significantly less emphasis on the needs and constraints of suppliers (e.g. “if it is viable to manufacture”) (Theme 2.3: 12 of 79 = 15%) and end users (“reasons why people do and don’t use latrines”) (Theme 2.2: 13 of 79 = 16%). One interviewee even questioned “whether the customer has ever talked to, or considered, the end user”.

Stage 4: Generate and communicate ideas

Ideas can come from anywhere. One humanitarian practitioner felt that designers (product developers) were “very good at brainstorming” (Figure IV.9 Theme 1.3: 12 of 46 observations in Category 1 = 26%) compared to suppliers, although suppliers could “sometimes... come up with neat ideas” (Theme 1.2: 6 of 46 = 13%). For example, one design team “made ten ideas, all different kinds, really completely out-of-the-box”. Another common approach is to “adapt an existing product” (Theme 1.5: 15 of 46 = 33%).

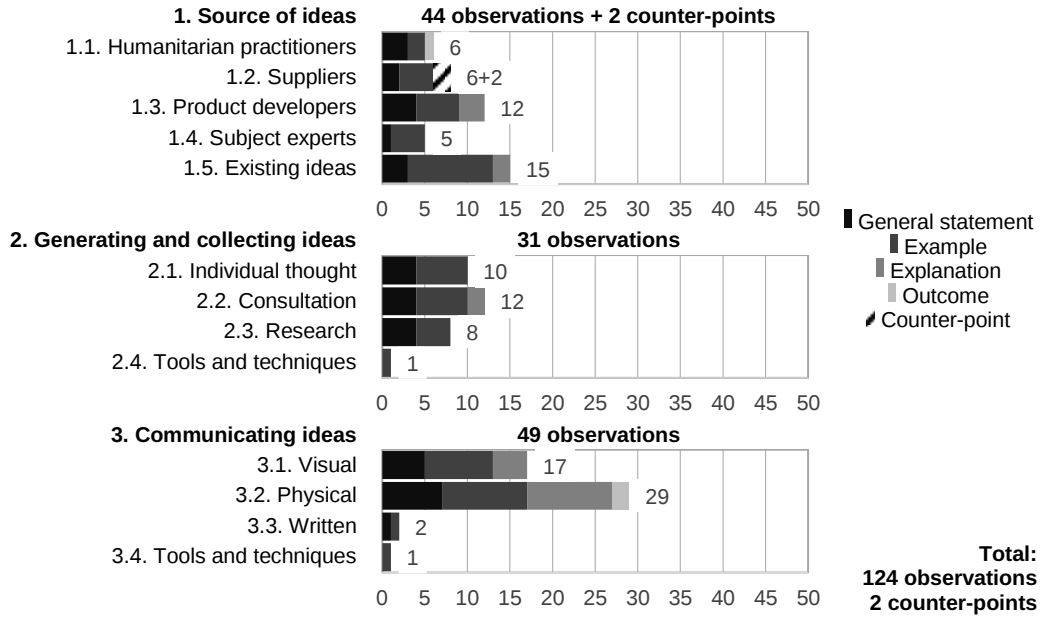


Figure IV.9. Stage 4: Generate and communicate ideas

The communication of ideas visually (Theme 3.1: 17 of 49 observations in Category 3 = 46%) and through prototypes (e.g. “very little ones made of Costa Coffee cups” (Theme 1.2: 29 of 49 = 59%) plays a significant role in the design

process. In particular, prototyping was described as “very, very, very important”. Besides being “part of the process of thinking through the design”, hand sketches, CAD drawings and prototypes allow ideas to be evaluated. One consultant (product developer) develops an idea to a “photo-realistic visualised product” for feedback to “see whether or not it’s going to be worth taking forward to prototype”. Another designer (product developer) found that, despite having systematically determined the design requirements, customers “wanted different stuff” after they saw a physical prototype.

Tools and techniques can but are very rarely used to generate and communicate ideas (Theme 2.4 and 3.4). There was only one example where a student design project (product developer) used ACCREx and SCAMPER for brainstorming. They subsequently used Idea Cards to describe their ideas.

Stage 5: Evaluate and select ideas

In general, suppliers and product developers rely more on “questions / concerns / comments” from humanitarian practitioners (customers) than on “assessing the idea against the design requirements” (Figure IV.10 Category 1: 33 observations vs. Category 2: 21 observations). For example, one design project (product developer) “went to our sponsor, presented all the ideas and they had to choose the final ones.” One explanation is that writing a design brief or specifications in the first place is not common. Another explanation is that humanitarian agencies are the “buyers of the product”, hence their opinion matters more.

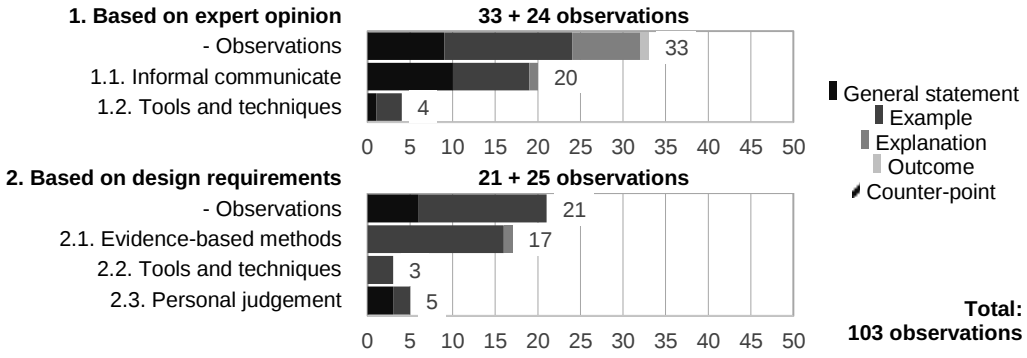


Figure IV.10. Stage 5: Evaluate and select ideas

Despite the importance of humanitarian practitioner feedback, their opinion is rarely collected and assessed systematically. Rather, the feedback is communicated "face-to-face" or through "emails". As a result, "it is always a little bit of a judgement call" to decide what feedback to implement (Theme 1.1: 20 of 24 observations in Category 1 = 83%). Only occasionally are tools used (e.g. feedback form, voting, ranking, reverse logic) to evaluate and select ideas (Theme 1.2: 4 of 24 = 17%).

To assess a design requirement, there is typically some form of experimentation, testing, simulation or calculation (Theme 2.1: 17 of 25 observations in Category 2 = 68%). However, the methods used are not necessarily robust. For example, one supplier exposed prototypes to surrounding environmental conditions for two to three months without following any industry-standard testing protocol. Subsequently, design choices are made based on the judgement of the decision maker (Theme 2.3: 5 of 25 = 20%). Only occasionally are formalised tools (e.g. concept scoring) used to support the decision-making process (Theme 2.2: 3 of 25 = 25%).

Stage 6: Evaluate prototype in-house

Selected ideas are designed in detail and eventually manufactured into a prototype for field testing. Before a prototype is sent to the field, it usually has to be informally evaluated in-house by the customer, supplier or product developer. For example, one humanitarian practitioner (customer) was trying a product in his mobile home at the time of the interview. He had also put "one of my team member's children on top of it". One humanitarian agency (customer) decides that a prototype is ready for testing by organising a meeting and coming "to a consensus... based upon our collective experience". "There's not a process" that they follow to make a decision (Figure IV.11).

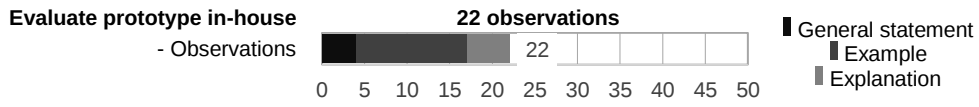


Figure IV.11. Stage 6: Evaluate prototype in-house

Stage 7: Test working prototype

A prototype is mostly tested in emergency settings, for example, by "just sending them out with the next deployment" (Figure IV.12 Theme 2.1: 9 of 16 observations in Category 2 = 60%). "It is usually always the NGO who will monitor and evaluate equipment" (Theme 1.1: 14 of 16 observations in Category 1 = 88%). Engineering-based technologies (e.g. desludging, faecal sludge, wastewater treatment) are more likely to be tested in non-emergency settings compared to user-based products. Of the seven observations regarding the testing of prototypes in non-emergency settings, six were about engineering-based technologies (Theme 2.2).

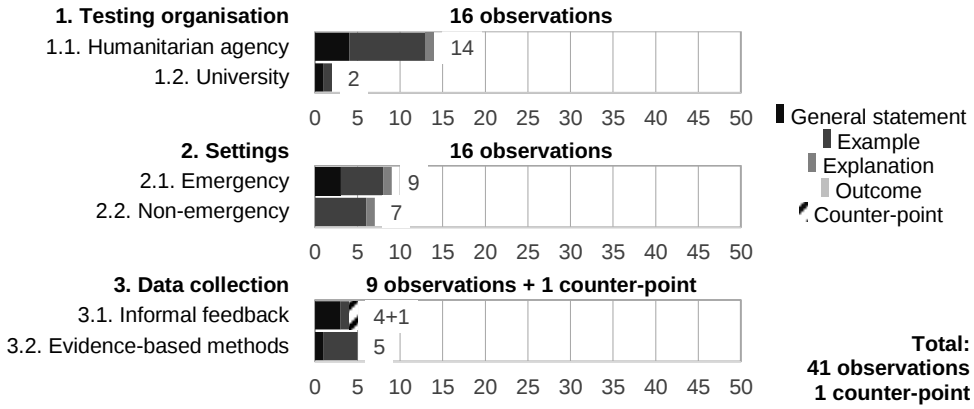


Figure IV.12. Stage 7: Test working prototype

For engineering-based technologies (e.g. treatment), it is straightforward to gather quantitative data on its performance. Four of the five observations relevant to evidence-based methods of data collection were about technical requirements (Theme 3.2). However, user-based products are commonly evaluated by collecting informal feedback from field staff with "no formal evaluation procedure". For example, one humanitarian practitioner stated that "we just get it out there, get it used and get feedback from some of the WASH staff on the job" (Theme 3.1: 4 of 10 observations in Category 3 = 40%).

Stage 8: Promote end product

A prototype is typically considered ready for sale after successful field testing. In the emergency sanitation sector, "the big bodies will buy equipment and distribute

it to small, local NGOs". "With a lot of NGOs now, it is all to do with long-term framework agreements." (Figure IV.13 Theme 1.1: 16 of 17 observations in Category 1 = 94%). "Marketing is done on a fairly personal level", therefore "you have to have a very strong relationship". Humanitarian agencies may also help to "share the information" and promote products to other countries and NGOs (Theme 2.1: 9 of 13 observations in Category 2 = 69%).

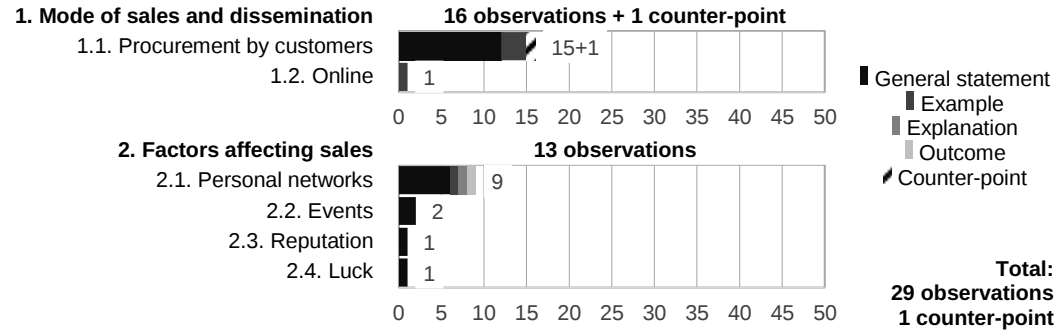


Figure IV.13. Stage 8: Promote end product

IV.1.2.2 Characteristics of and feelings towards product development

There were six themes describing the characteristics of and stakeholders' feelings towards product development (Figure IV.14, Theme 1.1 – 2.2). These are briefly described in the following paragraphs.

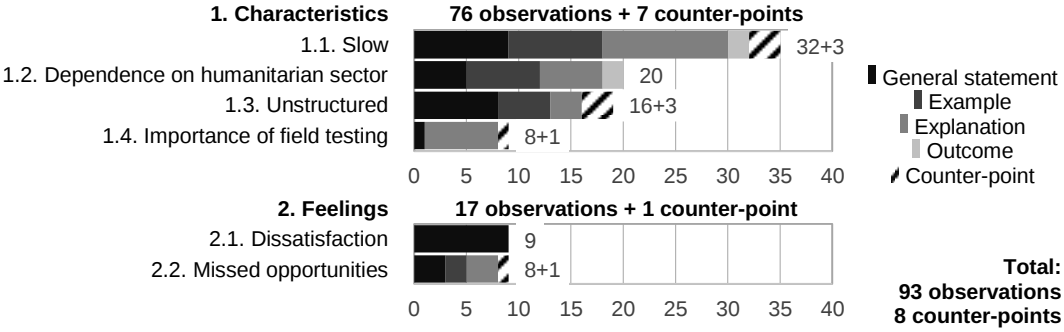


Figure IV.14. Aspect 3: Characteristics of and feelings towards product development

Slow: Product development "always takes a lot longer" than one would expect, between one and five years, according to interviewees. One supplier stated that "it takes an awful long time for humanitarian organisations (customers) to even start thinking of adopting a product" (Theme 1.1: 35 observations).

Dependence on the humanitarian sector: Humanitarian agencies (customers) are "setting the pace". Suppliers and product developers rely on humanitarian practitioners to provide design requirements, give feedback on ideas and test prototypes in the field. One interviewee even claimed that a certain humanitarian agency was the "controller of the end system". At the same time, suppliers and product developers often encounter situations where they receive "no response" to emails or humanitarian practitioners are "not there" for meetings. Thus suppliers and product developers cannot "push them along". The product development process becomes unreliable because it is difficult to predict whether development on a product would continue (Theme 1.2: 20 observations).

Unstructured process: With few exceptions, stakeholders have "no fixed process" to develop products. Tools are rarely used and decision-making is largely based on informal evaluation, feedback and communication. Even if evidence is gathered, the data is often poor (Theme 1.3: 16 observations and 3 counter-examples).

Importance of field testing: Field testing is "vital", mainly to ensure that a product is "ready for the uneducated user" because "with excreta disposal there are a lot of cultural issues". Suppliers and product developers generally only consider a product ready for sale after a field trial (Theme 1.4: 8 observations).

Dissatisfaction and missed opportunities: Many interviewees expressed "frustration" towards how products were currently being developed. One supplier said, "I don't really understand how to deal with it" (Theme 2.1: 9 observations). Shortcomings in the process lead to good ideas and opportunities being "missed" (Theme 2.2: 8 observations).

IV.1.3 Barriers and enabling factors

The previous subsection described the practices involved in developing an emergency sanitation product. This subsection examines the factors that prevent or facilitate these processes. In the previous subsection, it was noted that there

was a certain level of dissatisfaction towards the current state of product development. In line with that finding, interviewees discussed barriers much more than enabling factors. Barriers accounted for 32% of all interview observations.

IV.1.3.1 Barriers to product development

Barriers to product development may be classified into six categories and 37 themes. The first three categories (design requirements, knowledge capture and learning, disjointed processes) are directly related to the process of developing products while the other categories (resources and capacity, relationships between stakeholders, structures and mind-sets) refer to wider contextual issues (Figure IV.15). There are many interrelations between these themes, for example, the poor quality of feedback and data (under knowledge capture and learning) leading to poor design requirements.

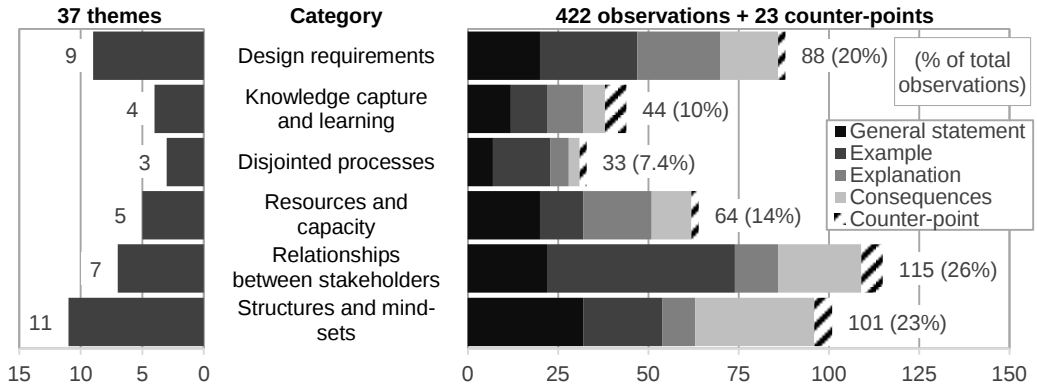


Figure IV.15. Aspect 4: Barriers to product development

Design requirements

Stakeholders face numerous challenges when determining design requirements. Humanitarian practitioners (customers) and experts (intermediaries) have "very diverse opinions" such that "if you talk to ten engineers, you get ten different points". One supplier summed up the dilemma as follows: "Do you make something that has the potential to please everybody, in which case, what is it?" Even one humanitarian practitioner was developing "two alterative options that generally vary a bit in price" so that other customers could "see which one they prefer" (Figure IV.16 Theme 9: 22 of 88 observations in barrier = 25%).

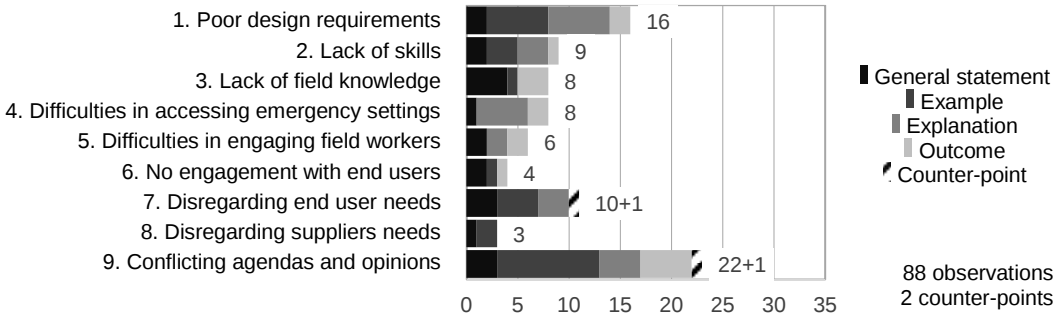


Figure IV.16. Barrier 1: Design requirements

When design briefs are used, "specifications are really, really lousy". Design requirements are often poorly written or communicated (Theme 1: 16 of 88 = 18%). However, the "ability of organisations to produce a refined brief" is lacking. For example, humanitarian agencies (customers) "don't understand... that design is normally for a specific lifetime" (Theme 2: 9 of 88 = 10%).

Furthermore, there is a feeling that end users (Theme 7: 9 of 88 = 10%) and suppliers (Theme 8: 3 of 88 = 3.4%) are overlooked, with customers "arrogant" enough to say that "we represent the end users and we know what they want". One supplier said, "I sometimes wonder… whether the customer has ever talked to, or considered, the end user."

At the same time, many suppliers and product developers "don't have the field knowledge" (Theme 3: 8 of 88 = 9.1%) due to their inability to "travel to some disaster areas" (Theme 4: 8 of 88 = 9.1%), "engage with field officers" (Theme 5: 6 of 88 = 6.8%) and "have a way to contact end users" (Theme 6: 4 of 88 = 4.5%). As a result, they develop products that "don't always fit with the reality".

Knowledge capture and learning

It is "incredibly hard" to get "any sort of formalised product evaluation feedback". One supplier said that "the only time we get feedback is if there is a problem". During design, it is not uncommon to get "no response" from humanitarian practitioners (customers) even if the practitioner was the one who asked the supplier or product developer "at the beginning to help develop a product". For

field testing, “finding places to test them” was described as one of the “most difficult things”. Once in the field, it is “very difficult” to “get evidence” due to the lack of facilities and equipment (Figure IV.17 Theme 2: 17 of 38 observations in barrier = 45%). The lack of feedback means that suppliers and product developers cannot make “continuous improvement”. Furthermore, humanitarian agencies that are “too slow in feedback” can “lose the interest of manufacturers”.

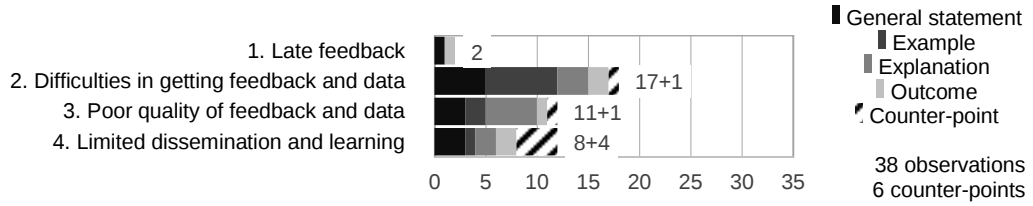


Figure IV.17. Barrier 2: Knowledge capture and learning

Finally, “a lot of good information never got published” and humanitarian agencies (customers) “don’t retain a lot of knowledge or history of what they've been doing” (Theme 4: 8 of 38 = 21%). Without learning from past mistakes, humanitarian agencies will be “repeating conversations again and again and again and not really moving forward very quickly”.

Disjointed processes

Suppliers and product developers often do not consider or are unaware of all aspects of the solution (e.g. “people forget that they should fit in the whole chain”). One supplier was unable “to decide what the product should look like” because of “other issues further down the line causing problems” which he had no control over. An engineer (product developer) working independently would develop “a device that would work properly” but was not “commercially available and viable” (Figure IV.18, Theme 1: 9 of 31 observations in barrier = 29%).

There are barriers to transitioning from one stage of product development to the next, especially for “up-scaling”, to “convince manufacturers and suppliers to invest” and to get people to buy the end product. With product developers, situations are encountered where “you've got the design and you need to find

someone to manufacture it and it may not suit any particular manufacturer" or "nobody wants to actually make the product" (Theme 2: 20 of 31 = 65%). As a result, suppliers and product developers "can do a lot of design work, put something together, but nothing gets used".

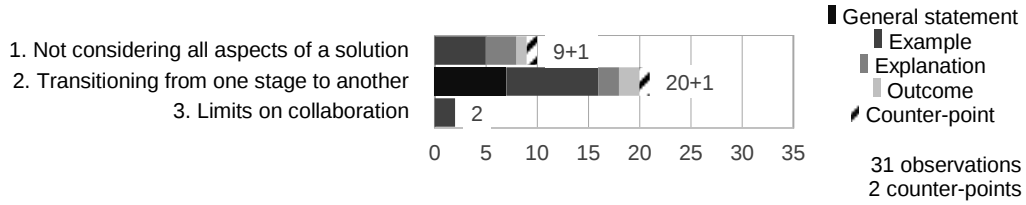


Figure IV.18. Barrier 3: Disjointed processes

Resources and capacity

Besides funding (Figure IV.19, Theme 5: 20 of 62 observations in barrier = 32%), developing a product also requires a range of knowledge, including sanitation, engineering, product design, commercial expertise, research methods and so on. Understandably, "nobody understands everything from A to Z". However, there were instances of projects which "had different kinds of people who had no clue what they were doing." Suppliers and product developers do not have all the expertise and resources necessary to develop products (Theme 2: 9 of 62 = 15%) and yet do not receive the required support from humanitarian agencies (customers) (Theme 3: 6 of 64 = 9.7%) who lack time, money and expertise (Theme 1: 24 of 62 = 39%). These factors combined make it extremely challenging to develop a product using the appropriate resources and capacity.

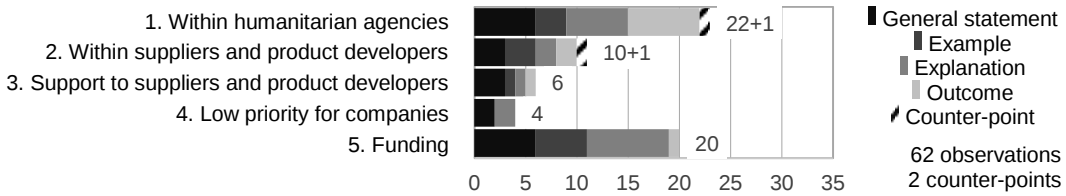


Figure IV.19. Barrier 4: Resources and capacity

Relationships between stakeholders

Product development involves collaboration between humanitarian practitioners (customers), suppliers, product developers and intermediaries, all of whom have

"different goals and mandates". This leads to a "collision of cultures" such that "people do not work together". Examples include: engineers versus logisticians; short-term response versus long-term sustainability; technical feasibility versus commercial viability; solving the problem versus publishing a paper; interviewing end users versus asking humanitarian practitioners; laboratory tests versus simple tests, and; academic approach versus engineering design (Figure IV.20 Theme 1: 26 of 115 observations in barrier = 23%).

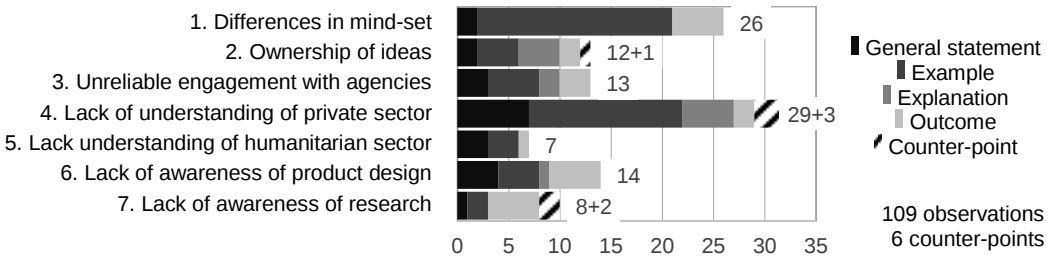


Figure IV.20. Barrier 5: Relationships between stakeholders

One continuing source of conflict is with intellectual property and the ownership of ideas. There are cases where a product being developed "suddenly springs up in the market at one-third the cost" (Theme 2: 12 of 115 = 10%). Engaging with humanitarian agencies (customers) is particularly frustrating. Although they can be "very interested" in a product, they will never promise that "if you develop it, I will order 1,000 pieces from you" (Theme 3: 13 of 115 = 11%). Frustrations also arise when determining design requirements and obtaining feedback.

Underlying these frustrations is a perception of the lack of respect, understanding or awareness towards each other, especially toward the private sector (mainly suppliers). One supplier felt that humanitarian agencies (customers) "don't actually want the people who allow them (suppliers) to do that (deliver aid) to have any say or to make a living out of it" (Theme 4: 29 of 115 = 25%). Stakeholders are "not familiar with product design" and have "no idea what the investment costs actually are with respect to time, energy and design process, but also with tooling, manufacturing and stock". Therefore, they do not "see the value of the external product designer" (Theme 6: 14 of 115 = 12%). From the research

perspective, “evidence wasn’t being gathered properly” because of a “lack of good, robust experimental design” (Theme 7: 8 of 115 = 7.0%). As a result, many people in the sector “just do innovation by addition”, i.e. “just try something” with “no methodology behind it”.

At the same time, stakeholders do not always appreciate, or make the effort to understand, the needs and limitations of humanitarian agencies (customers). One humanitarian practitioner said that companies were “just proposing their products and... not willing to make any modifications” (Theme 5: 7 of 115 = 6.1%).

Structures and mind-sets

How the humanitarian sector operates accounts for many of the barriers that have been discussed. For humanitarian agencies (customers), “operational work and the related needs have nearly always priority” (Figure IV.21 Theme 1.1: 18 of 84 observations under Category 1 = 21%). Therefore, it is no surprise that they lack the time, resources and expertise to provide good quality and timely design requirements, feedback and evaluation, and lessons learned.

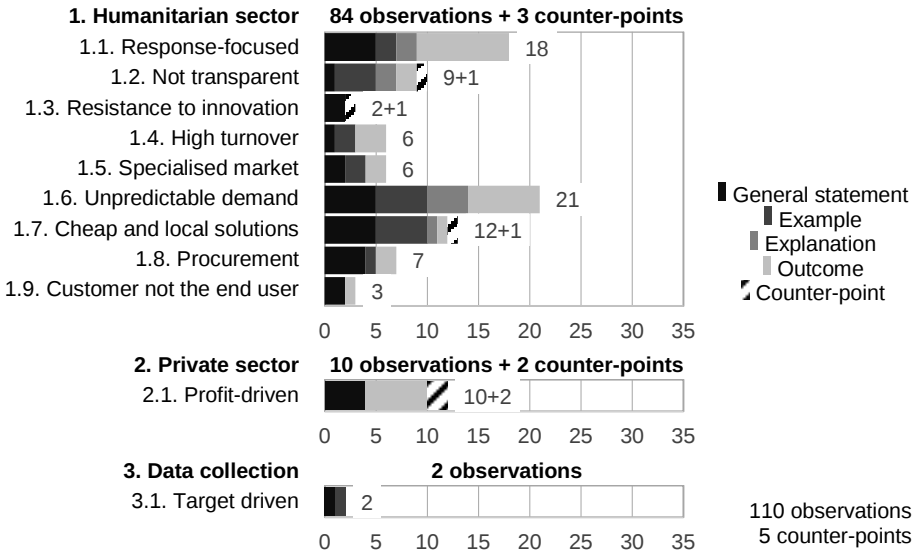


Figure IV.21. Barrier 6: Structures and mind-sets

“High turnover of staff” (Theme 1.4: 6 of 84 = 7.1%) compounds this issue. Humanitarian agencies “can be quite disjointed”. It becomes “quite hard to engage

with field officers" because planned activities (e.g. field testing) may fall through due to someone leaving.

From the market perspective, the humanitarian sector uses products that "you cannot sell anywhere else" (Theme 1.5: 6 of 84 = 7.1%), where demand is unpredictable because "only in a disaster do you actually sell your products" (Theme 1.6: 21 of 84 = 25%), "cost is always a massive factor" and agencies (customers) prefer to procure and implement products "in-country, on-site" (Theme 1.7: 12 of 84 = 14%). These characteristics have "nothing to do with the retail market". Hence, it is understandable that suppliers and product developers lack the field knowledge and have to rely on humanitarian practitioners.

IV.1.3.2 Enabling factors

Barriers to product development dominated the discussion with interviewees, but positive factors were also pointed out. 79 observations classified into five themes were identified (Figure IV.22).

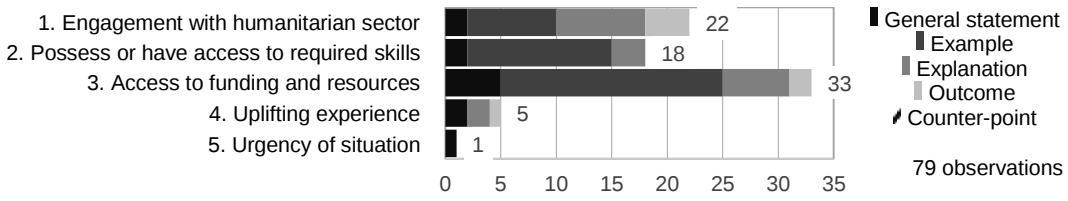


Figure IV.22. Aspect 5: Enabling factors

Engagement with humanitarian sector: Access to humanitarian practitioners, especially "good links with the field", allows suppliers and product developers to be "in touch with what's necessary" and have "access to people who can give you feedback on things and then also to test things" (Theme 1: 22 observations).

Possess or have access to required skills: Developing a product requires a range of skills and expertise. Particular barriers are the lack of understanding of the humanitarian sector, commercial principles, product design and research methodologies. This limits the ability to formulate design requirements and gather

proper evidence. Conversely, having these skills and expertise would confer an advantage to the supplier or product developer. “In the university”, for example, it “is very easy to gather people with different expertise” (Theme 2: 18 observations).

IV.1.3.3 Recommendations

Interviewees suggested ways in which product development in the emergency sanitation sector could be improved. 80 observations and 14 themes were identified and classified into 5 categories corresponding to the barriers discussed in Subsection IV.1.3.1 (Figure IV.23). From this it can be seen that the recommendations addressed barriers that had previously been identified by the interviewees. However, even though design requirements represented a major category of barrier, there was only one recommendation related to it. This suggests that the sector as a whole might not have given much thought to how design requirements should be improved.

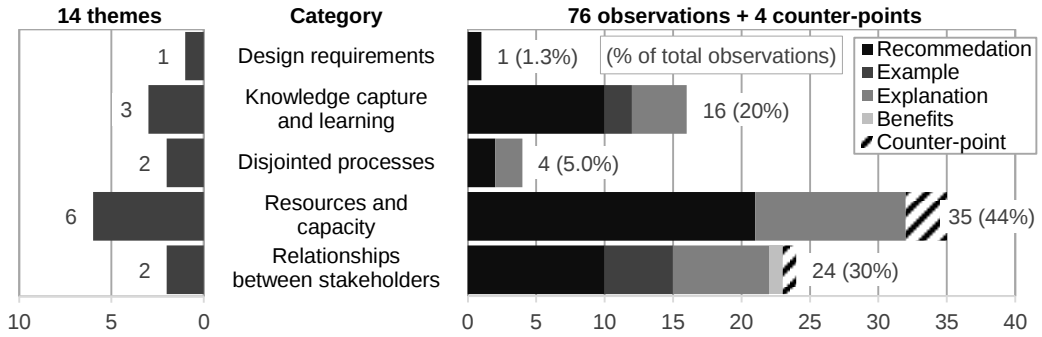


Figure IV.23. Aspect 6: Recommendations to improve product development

Knowledge capture and learning

One supplier asserted that there “definitely is a market for somebody in the industry to specifically gather feedback”. One suggestion involved a “technical review panel with really good field engineers and people involved in procurement”. There should be “suitably qualified people who can provide the right level of feedback” and “really be able to assess and review of some of these products well” (Figure IV.24 Theme 1: 6 of 16 observations in category = 38%). In addition, “rather than talking about things”, humanitarian agencies (customers)

"need to get more trials out there". Ideally, prototypes "should be trialled in various locations internationally" (Theme 2: 4 of 16 = 25%). One professor (intermediary) also suggested that "better use could be made of the lessons learned" (Theme 3: 4 of 16 = 25%).

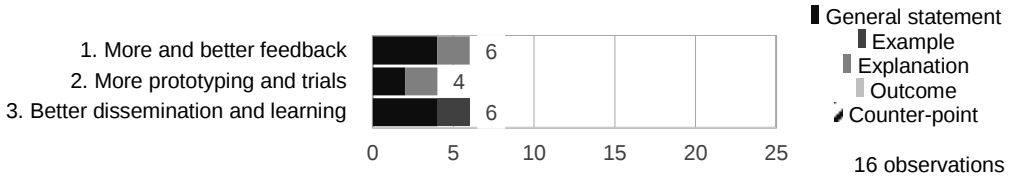


Figure IV.24. Knowledge capture and learning

Resources and capacity

Involving more people increases the collective expertise of the stakeholders involved in the product development process (Figure IV.25 Theme 1: 12 of 32 observations in category = 38%). One designer (product developer) suggested that the emergency sanitation sector should "prove the value of the product designer and hire one". The sector does not have to "reinvent this idea of how we develop a process of identifying a need, putting a design brief together, refining that brief and getting it through to a product" (Theme 4: 7 of 32 = 22%). All that is required is "a finer attunement of the humanitarian organisations (customers) to those commercial and product disciplines" (Theme 2: 6 of 35 = 19%). For example, "if you comply to legislation you follow a certain structure and you prevent failure and mis-investments" (Theme 3: 4 of 35 = 13%).

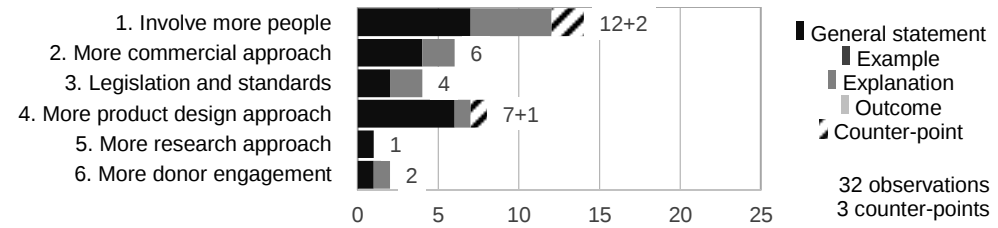


Figure IV.25. Resources and capacity

Relationships between stakeholders

The lack of collaboration between humanitarian agencies (customers), suppliers, product developers and researchers (intermediaries) is a substantial barrier to the

product development process. To address this barrier, one suggestion was to "provide a place or environment to allow people to move forward together". It is "hugely important" that humanitarian agencies (customers) and the private sector (suppliers and product developers) understand each other because "that is where you start to break down those barriers". Humanitarian agencies should "make more effort to involve the product designer, NGO, supplier and everybody who has something to do with this innovative process of developing new products". For instance, humanitarian agencies could take stakeholders "to the refugee camps, explain more about it and make them more aware of what they are doing it for" (Figure IV.26, Theme 1: 21 of 23 observations in category = 91%).

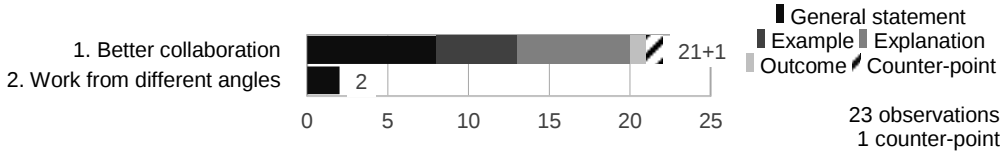


Figure IV.26. Relationships between stakeholders

IV.1.4 Summary

This section described findings of interviews with stakeholders who had been involved in developing products. The product development process can be divided into eight iterative stages: identify opportunity, determine approach to develop product, determine design requirements, generate and communicate ideas, evaluate and select ideas, evaluate prototype in-house, test working prototype and promote end product. During this process, field testing is considered vital to determining whether a product is ready for implementation.

Barriers, enabling factors and recommendations were also described. Three categories referred to barriers that were directly related to the process of developing products. Of these three categories, design requirements (20%) represented the greatest proportion of total observations related to barriers, followed by knowledge capture and learning (10%) and disjointed processes (7.4%). However, even though design requirements represented a major category of barrier, there was only one recommendation related to it. This suggests that the

sector as a whole might not have given much thought to how design requirements should be improved.

The findings suggest wide scope for improvement, with complex inter-related issues affecting the entire product development process. In the following sections, the participation of end users (Section IV.2) and support provided to suppliers and product developers (Section IV.3) are investigated further.

IV.2 Abucay Bunkhouse case study: Participation of end users

End users are critical stakeholders of any product development process. However, in reality in the emergency sanitation sector, end users are only stakeholders of the product development process to the extent that they use (or misuse) the products provided to them. End users are rarely genuinely consulted during the product development process, with humanitarian practitioners (customers) claiming that they know what end users want. The aim of this case study was to better understand how end users might engage with product development activities.

IV.2.1 Context

Abucay Bunkhouse is a transitional settlement located in Tacloban City, Leyte Province, Region VIII, the Philippines. The bunkhouse comprises 200 families (877 persons) affected by Typhoon Haiyan in November 2013 and awaiting relocation by the government. In March, the UNESCO-IHE Institute of Water Education installed a prototype of the eSOS® smart toilet at the bunkhouse for field testing (Figure IV.27).

UNESCO-IHE started by briefing the residents of Abucay Bunkhouse about the eSOS® smart toilet. Then, UNESCO-IHE went around the bunkhouse to ask if the household wanted to register for 1 of the 100 smart keys that would allow them access to the smart toilet. UNESCO-IHE personally demonstrated the use of the smart toilet to each resident who registered. UNESCO-IHE gave a free 'I ♥ eSOS toilet' t-shirt to everyone who used the toilet at least five times as an incentive to participate in the field testing.

Figure IV.27. eSOS® smart toilet prototype tested at Abucay Bunkhouse (Source: Fiona Zakaria and author)

Some field data was collected automatically by the eSOS® smart toilet, such as number of users, amount of water in the tanks, volume in the excreta tank and so on. The UNESCO-IHE team also collected data manually, such as swab samples for *E.* coli counts, surveys with residents and so on. Complementing UNESCO-IHE's field testing, the author studied Abucay Bunkhouse's access to sanitation through a structured questionnaire complemented by interviews, informal conversations, observations and secondary data (see Subsection V.3.2 for results).

Within the context of these activities, 21 female and 13 male residents were randomly interviewed by the author. The aim of the interviews was to explore: their awareness of the purpose of the activities carried out by UNESCO-IHE and the author; their opinion on the importance of being aware of the purpose; their opinion towards the activities (Subsection IV.2.2); factors affecting their opinion, and; factors affecting their participation in field testing (Subsection IV.2.3).

IV.2.2 Opinion on field testing and research

32% of responses incorrectly stated the purpose of the activities and 57% were unaware of the purpose (Figure IV.28 Q1). This was even though the purpose had been explained at UNESCO-IHE's briefing and during the author's survey respectively. In addition, the team was at the bunkhouse every day during the study period. 19 interviewees (43%) thought that UNESCO-IHE had put the

eSOS® smart toilet at Abucay Bunkhouse to help the residents (e.g. for people who did not have their own latrine, for when their latrine became clogged, etc.). Although 74% of responses alluded to the importance of knowing the purpose, only one interviewee had taken the initiative to learn more about the activities by asking the camp manager and UNESCO-IHE (Q2).

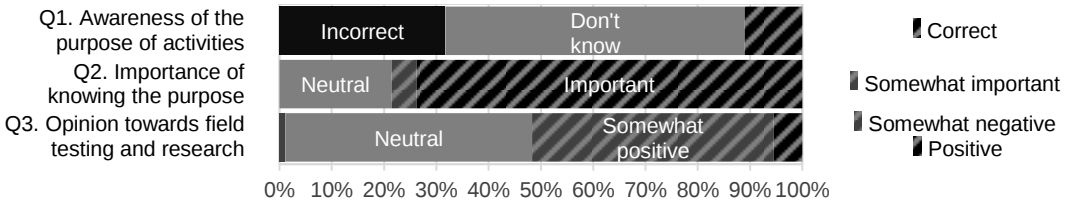


Figure IV.28. End user opinions towards field testing and research

Thus, the purpose of the activities carried out by UNESCO-IHE and the author was clearly explained during the interview. The explanation emphasised that the eSOS® smart toilet was not installed just to help the Abucay Bunkhouse residents. Based on this explanation, only one response displayed a negative sentiment towards the activities. The most common response was along the lines of "it's okay". 48% of responses expressed a somewhat positive or positive sentiment towards the activities, such as "happy to help others", "thankful", "happy to participate" and so on (Figure IV.28 Q3).

IV.2.3 Factors affecting opinion towards and participation in activities

Although the main intention of the eSOS® smart toilet was not to benefit the Abucay Bunkhouse residents, the respondents' sentiment toward the activities of UNESCO-IHE and the author were tied to how they benefited from the smart toilet. The ability of the toilet to help them was a positive contributing factor (Table IV.1 no. A1: n = 21). For instance, one benefit of the toilet compared to their own latrine was that there was no need to collect water for anal cleansing and washing. Therefore, some respondents were "grateful" that UNESCO-IHE was showing concern for them (A3: n = 8). Furthermore, the convenient location of the toilet (C2: n = 4) and the unavailability of their own latrine at that time (C3: n = 4) drove some respondents to try the toilet. On the other hand, the existence of

other problems that needed solving (B1: n = 7) and the inability of the toilet to help them (B2: n = 3) were negative contributing factors. x

Table IV.1 Factors affecting end user opinion toward and participation in the activities of UNESCO-IHE and the author

A. Why respondent has positive opinion of activities	**C. Why respondent tried the smart toilet**
1. The eSOS® smart toilet helps us (n = 21)	1. I was curious (n = 17)
2. It is a unique experience (9)	2. It was convenient (4)
3. You are showing concern for us (8)	3. Own latrine was not available or working (4)
4. It is a chance to learn about something new (7)	4. Someone recommended the toilet to me (1)
5. We are only here temporarily (3)	
6. It is a chance to help others (3)	
7. It is a chance to talk about my problems (1)	
B. Why respondent had negative opinion of activities	**D. Why respondent had not tried the toilet**
1. There are other problems that need solving (n = 7)	1. It is far (n = 11)
2. The smart toilet does not help me (3)	2. I'm afraid (e.g. of being locked inside) (3)
	3. I have no key (3)
	4. I already have a latrine; the smart toilet is not supposed to be for me; shy; other people were using the toilet; the toilet was dirty (1 each)

The number of times each factor was mentioned is indicated in the brackets

Because many of the features were new to the residents (e.g. smart key, washer, button to get water from the washer, timer for discharging water from the washer, automatic lights, etc.), curiosity was a major factor in respondents trying the eSOS® smart toilet (C1: n = 17). In general, they were positive about experiencing something unique (e.g. “first of its kind”) (A2: n = 9) and learning something new (A4: n = 7).

IV.2.4 Summary

In the case study, almost all of the respondents were unaware of the purpose of the field testing and research being carried out by UNESCO-IHE and the author even though there were some efforts to communicate the purpose to them and even though the majority thought that it was important to know the purpose. Their opinion towards field testing and, by extension, surveys and interviews, were invariably tied to whether the eSOS® smart toilet benefitted them or their fellow residents. Many other factors expressed by the respondents (satisfying curiosity, participating in something unique, learning something new, helping others) may

also be construed as benefitting them in some way. This suggests that end users are not particularly concerned about or do not think to question the purpose of such activities, but this does not prevent them from participating in the activities. Findings from the case study provide many ways in which end users can be motivated to be actively involved in product development activities. As Subsection V.3.2 will show, this is beneficial because more and better data collection on end users would be very useful in helping suppliers and product developers develop products.

IV.3 Stakeholder survey: Support to suppliers and product developers

Suppliers and products developers are integral to the product development process in the emergency sanitation sector. This is because they are responsible for the design, manufacture and supply of the end product. Therefore, the support they receive from other stakeholders, particularly customers, is critical to determining the success of the product. The aim of the survey was to assess stakeholders' opinions on the level of support suppliers and product developers receive overall and during key stages of the product development process (Figure IV.29).

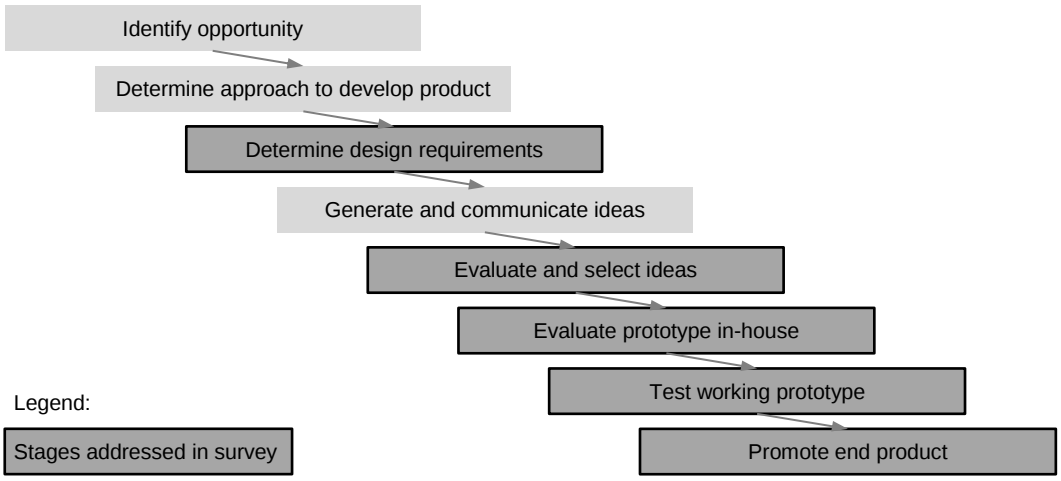


Figure IV.29. Stages of product development addressed in stakeholder survey

IV.3.1 Respondent profile

67 people representing a range of demographic profiles and stakeholder interests responded to the questionnaire. It is interesting that 76% of the respondents were

from high-income countries, while only 19% of respondents were from low and lower-middle income countries. This may partly explain the lack of field knowledge and difficulties in accessing emergency settings and engaging end users described in the stakeholder interviews, because emergency sanitation products are typically implemented in lower-income countries (Figure IV.30).

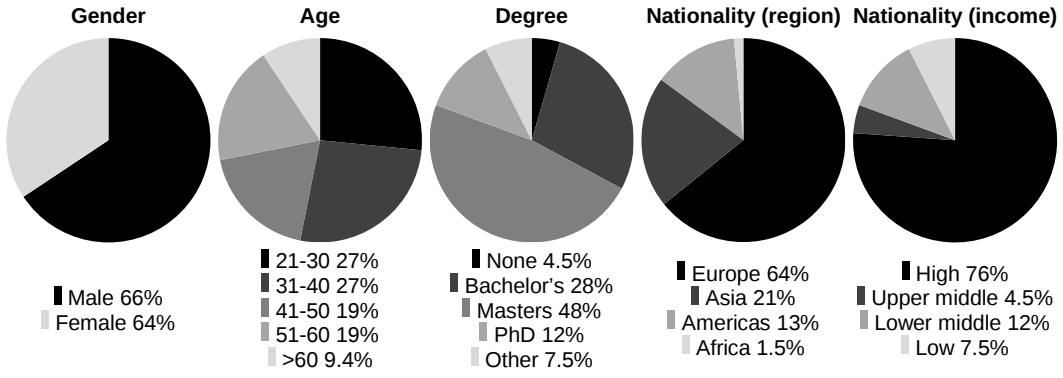


Figure IV.30. Demographic profile of survey respondents

61% of respondents were either existing or potential suppliers or product developers. 25% indicated that they supported the product development process rather than being directly involved (i.e. intermediaries). There were comparatively fewer respondents from the customer group. This could be explained by the fact that not many humanitarian practitioners are actively engaged in developing products for emergency sanitation. Unfortunately, this made it difficult to obtain statistically significant conclusions from the customer sub-group (Figure IV.31).

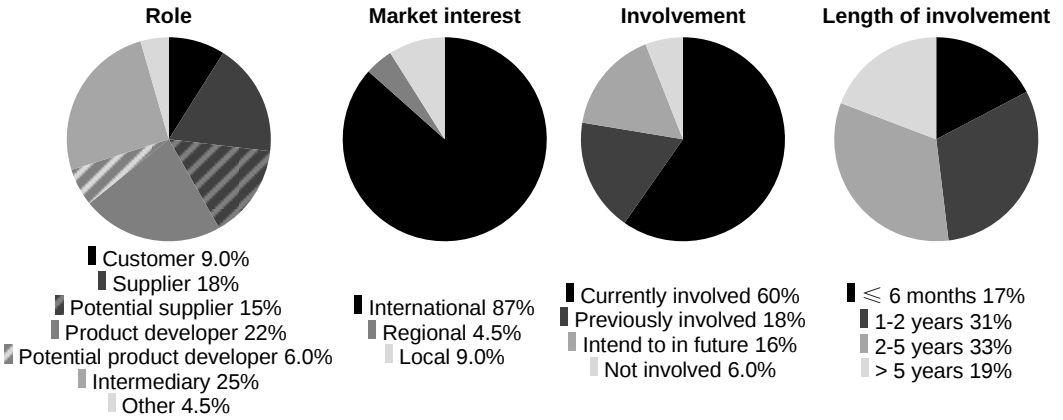


Figure IV.31. Involvement in emergency sanitation of survey respondents

IV.3.2 Support for product development

Respondents indicated their level of agreement towards 22 statements that were related to product development in the emergency sanitation sector. The responses were measured on a seven-point Likert-type scale. Results from the descriptive analysis and statistical inference are presented in this subsection. The Wilcoxon signed rank or rank sum test was used to determine, at 5% significance levels, whether:

- the median of the overall response deviated from 'Neutral', showing that the respondents agreed or disagreed with a statement overall;
- there was a difference in mean ranks between two statements, showing that respondents agreed with one statement more than another, and
- there was a difference in mean ranks between suppliers and product developers, showing that suppliers agreed or disagreed more than product developers with a statement.

There was a lack of consensus by the respondents (44% agreement vs. 45% disagreement) about whether suppliers and product developers received adequate guidance when developing new products for the emergency sanitation sector (Table IV.2 no. 1a: $p = 0.66$). On the other hand, the respondents agreed that there should be more support provided to suppliers and product developers in all four stages addressed by the survey: understanding design requirements (bi: 99% agreement, $p = 5\times10^{-13}$); evaluating product concepts (bii: 92%, $p = 4\times10^{-13}$); evaluating prototypes (biii: 95%, $p = 2\times10^{-12}$), and; promoting available products (biv: 78%, $p = 2\times10^{-9}$).

There was stronger agreement among product developers than suppliers that there should be more support in understanding design requirements (bi: $p = 3\times10^{-3}$) and evaluating product concepts (bii: $p = 0.038$) than evaluating prototypes (biii: $p = 0.47$) and promoting available products (biv: $p = 0.35$). This is possibly because product developers are more heavily involved in determining design requirements and generating ideas while suppliers are more often asked to manufacture designs

that have already been done by product developers. Respondents felt that more support should be provided to understanding design requirements and evaluating prototypes compared to promoting available products (bi vs. biv: $p = 0.011$; bii vs. biv: $p = 0.043$).

Table IV.2 Overall support for product development

1. To what extent do you agree with the following statements	Disagree	Agree	1st quartile	Median	3rd quartile	Mean	*p*	S vs. PD	Pairwise comparisons			
a. Suppliers and product developers receive adequate guidance when developing new products	45%	44%	-1	0	+2	+0.076	0.66	0.97	-			
b. There should be more support to suppliers and product developers in:									bi	bii	biii	biv
i. Understanding design requirements	0	99%	+2	+2	+3	+2.27	5×10-13	3×10-3	-	0.55	0.58	0.011
ii. Evaluating product concepts	0	92%	+2	+2	+3	+2.14	4×10-12	0.038	0.55	-	0.95	0.054
iii. Evaluating prototypes	0	95%	+2	+2	+3	+2.17	2×10-12	0.48	0.58	0.95	-	0.043
iv. Promoting available products	5%	78%	+1	+2	+2	+1.66	2×10-9	0.35	0.011	0.054	0.043	-

p = two-tail Wilcoxon signed rank test that the median is not zero. If $p < 0.05$, there is a statistically significant agreement or disagreement with the statement; S vs. PD = two-tail Wilcoxon rank sum test for difference in mean ranks between suppliers and product developers. If $p < 0.05$, there is a statistically significant difference between the response of suppliers and product developers; Pairwise comparisons = two-tail Wilcoxon signed rank test between two statements. If $p < 0.05$, there is a statistically significant difference between the responses for the two statements; The direction of the difference is determined from the descriptive statistics; Statistically significant values are underlined

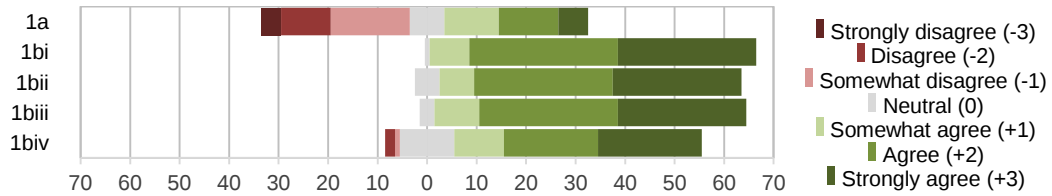


Figure IV.32. Overall support for product development

IV.3.2.1 Understanding design requirements

There was no consensus (42% agreement vs. 50% disagreement) on whether design requirements were clearly communicated to suppliers and product developers (Table IV.3 no. 1.1a: $p = 0.33$). There was also no consensus on how well suppliers and product developers understood the challenges faced during

emergencies, the requirements of implementing agencies and end user requirements (1.1bi – iii).

Table IV.3 Understanding design requirements

1.1. To what extent do you agree with the following statements	Disagree	Agree	1st quartile	Median	3rd quartile	Mean	*p*	S vs. PD	Pairwise comparisons		
a. Design requirements are clearly communicated to suppliers and product developers	50%	42%	-2	-1	+2	-0.22	0.33	0.32	-		
b. Suppliers and product developers understand:									bi	bii	biii
i. Challenges faced during emergencies	41%	50%	-1	+1	+2	0.20	0.33	0.25	-	0.38	0.60
ii. The requirements of implementing agencies	52%	38%	-1	-1	+1	-0.077	0.85	0.14	0.38	-	0.77
iii. End user requirements	45%	49%	-1	0	+1	+0.031	0.92	0.32	0.60	0.77	-
c. Suppliers and product developers have sufficient access to:									ci	cii	ciii
i. Implementing agencies	51%	34%	-1	-1	+1	-0.11	0.65	0.96	-	0.016	8×10^{-3}
ii. End users	60%	25%	-2	-1	+1	-0.81	7×10^{-4}	0.30	0.016	-	0.88
iii. Emergency settings	68%	26%	-2	-1	+1	-0.84	9×10^{-4}	0.074	8×10^{-3}	0.88	-
Refer to Table IV.2 for explanatory notes											

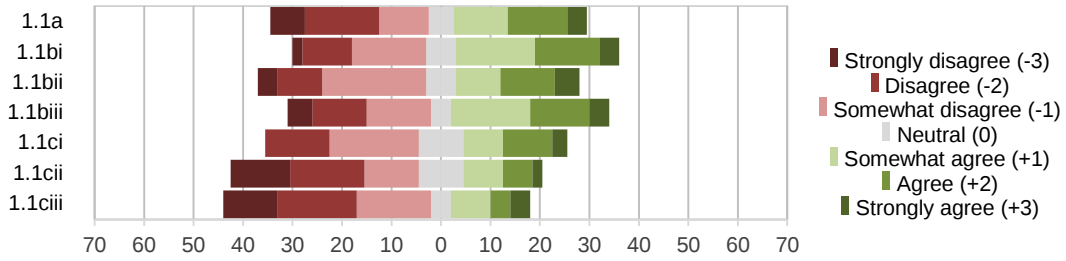


Figure IV.33. Understanding design requirements

Although there was no consensus (34% agreement vs. 51% disagreement) on whether suppliers and product developers had sufficient access to implementing agencies (1.1ci: p = 0.65), respondents disagreed that suppliers and product developers had sufficient access to end users (cii: 60% disagreement, $p = 7\times10^{-4}$) and emergency settings (ciii: 68%, $p = 9\times10^{-4}$). There was greater disagreement that suppliers and product developers had access to end users and emergency settings than to implementing agencies (ci vs. cii: p = 0.016; ci vs. ciii: $p = 8\times10^{-3}$).

IV.3.2.2 Evaluating concepts and prototypes

There was almost universal agreement among the survey respondents on the importance of evaluation: 98% and 97% of respondents agreed that evaluating proposed concepts and prototypes respectively were important respectively (Table IV.4 no. 1.2a: $p = 4\times10^{-13}$ and Table IV.5 no. 1.3a: $p = 9\times10^{-14}$).

Table IV.4 Evaluating concepts

1.2. To what extent do you agree with the following statements	Disagree	Agree	1st quartile	Median	3rd quartile	Mean	*p*	S vs. PD	Pairwise comparisons		
a. Evaluating concepts is an important stage of product development	0%	98%	+1	+2	+2	+2.51	$\underline{4\times10^{-13}}$	0.060	1.3a: 0.070		
b. Suppliers and product developers:									ci	cii	1.3
i. Have the means to evaluate proposed concepts	34%	58%	-1	+1	+2	+0.60	$\underline{4\times10^{-3}}$	0.95	0.055	-	0.20
ii. Can easily obtain feedback on proposed concepts	39%	52%	-1	+1	+2	+0.34	0.12	0.28	-	0.37	0.77
c. Implementing agencies:									bi	bii	1.3
i. Have the means to evaluate proposed concepts	22%	68%	0	+2	+2.5	+1.12	$\underline{1\times10^{-6}}$	0.36	0.055	-	0.36
ii. Are receptive to unfamiliar concepts	42%	46%	-1.5	0	+1	+0.07	0.78	0.41	-	0.37	0.19
Refer to Table IV.2 for explanatory notes											

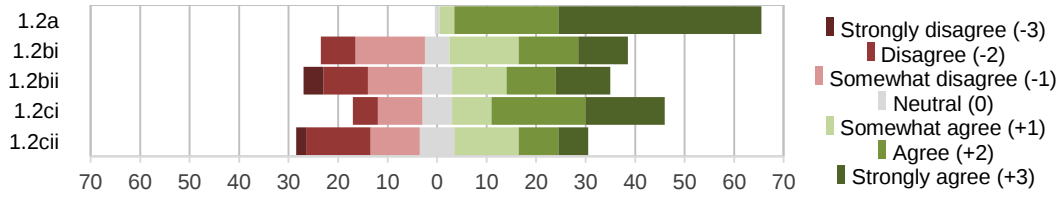


Figure IV.34. Evaluating concepts

The majority of respondents also agreed that implementing agencies as well as suppliers and product developers had the means to evaluate both proposed concepts and prototypes: 58% of respondents agreed that suppliers and product developers had the means to evaluate proposed concepts (Table IV.4 no. 1.2bi: $p = 4\times10^{-3}$); 68% agreed that implementing agencies had the means to evaluate proposed concepts (ci: $p = 1\times10^{-6}$); 72% agreed that suppliers and product developers had the means to evaluate prototypes (Table IV.5 no. 1.3bi: $p = 9\times10^{-}$

[6]), and; 78% agreed that implementing agencies had the means to evaluate prototypes (ci: $p = 2\times10^{-8}$).

Table IV.5 Evaluating prototypes

1.3. To what extent do you agree with the following statements	Disagree	Agree	1st quartile	Median	3rd quartile	Mean	*p*	S vs. PD	Pairwise comparisons		
a. Evaluating prototypes is an important stage of product development	2%	97%	+3	+3	+3	+2.64	9×10^{-14}	0.51	1.2: 0.070		
b. Suppliers and product developers:									ci	cii	1.2
i. Have the means to evaluate prototypes	20%	72%	0	+1	+2	+0.91	9×10^{-6}	0.90	0.044	-	0.20
ii. Can easily obtain feedback on prototypes	39%	55%	+1	+1	+2	+0.43	0.041	0.97	-	0.96	0.77
c. Implementing agencies:									bi	bii	1.2
i. Have the means to evaluate prototypes	16%	78%	+1	+2	+3	+1.42	2×10^{-8}	0.07	0.044	-	0.36
ii. Are receptive to unfamiliar products	32%	55%	-1	+1	+2	0.45	0.026	0.69	-	0.96	0.19
Refer to Table IV.2 for explanatory notes											

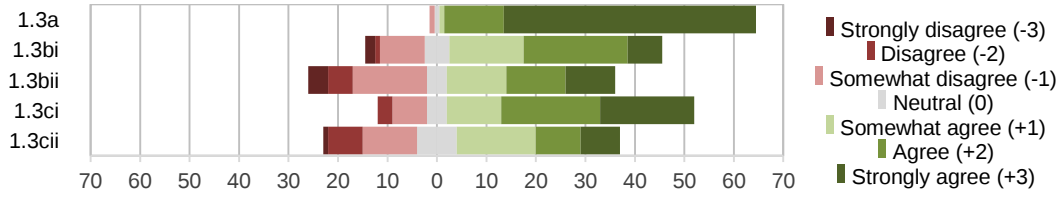


Figure IV.35. Evaluating prototypes

On the evaluation of prototypes, there was greater agreement that implementing agencies had the means to evaluate prototypes compared to suppliers and product developers (1.3bi vs. ci: $p = 0.044$). This was not an unexpected result, because humanitarian agencies have better access to emergency settings.

55% of the survey respondents agreed that suppliers and product developers could easily obtain feedback on prototypes (Table IV.5 no. 1.3bii: $p = 0.041$). On the other hand, the survey respondents neither agreed (52% agreement) nor disagreed (39% disagreement) that suppliers and product developers could easily obtain feedback on proposed concepts (Table IV.4 no. 1.2bii: $p = 0.12$). However, the

difference in agreement was not statistically significant (1.2bii vs. 1.3bii: p = 0.20).

IV.3.2.3 Promoting end products

83% of respondents agreed that they were aware of the products available on the market (Table IV.6 no. 1.4a: $p = 6\times10^{-9}$).

Table IV.6 Promoting end products

1.4. To what extent do you agree with the following statements	Disagree	Agree	1st quartile	Median	3rd quartile	Mean	p	S vs. PD	Pairwise comparisons			
a. I am aware of the products available on the market	11%	63%	+2	+3	+3	+1.25	6×10^{-9}	0.17	-			
b. It is easy to:									bi	bii	biii	biv
i. Introduce new products to potential customers	63%	19%	-1	+1	+2	-0.60	7×10^{-3}	0.26	-	2×10^{-4}	4×10^{-4}	2×10^{-3}
ii. Learn about new products	31%	54%	-1	+1	+2	+0.36	0.065	0.54	2×10^{-4}	-	0.90	0.38
iii. Compare competing products	37%	54%	0	+1	+2	+0.36	0.066	0.64	4×10^{-4}	0.90	-	0.41
iv. Choose an appropriate product to purchase	39%	40%	-2	0	+1	0.16	0.42	0.63	2×10^{-3}	0.38	0.41	-

Refer to Table IV.2 for explanatory notes

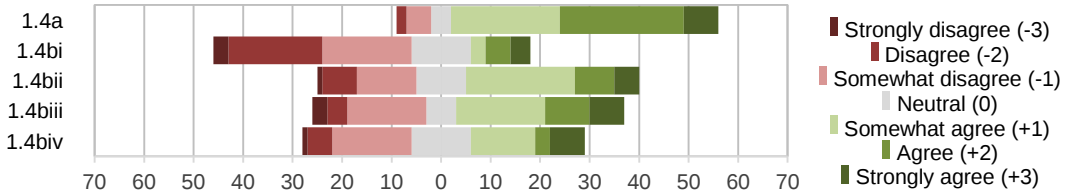


Figure IV.36. Promoting end products

This is an encouraging finding because available solutions let people identify opportunities for new products, understand requirements and standard practices in emergency response, benchmark ideas against existing ones and so on.

However, 63% of respondents disagreed that it was easy to introduce new products to potential customers (1.4bi: $p = 6\times10^{-3}$). Comparatively, there was statistically greater agreement that it was easy to learn about new products,

compare competing products and choose an appropriate product to purchase (1.4bi vs. bii – iv), although there was no consensus on these statements.

IV.3.3 Summary and discussion

There was clear agreement among stakeholders that suppliers and product developers should receive more support for product development, especially with understanding design requirements and evaluating prototypes. The disagreement (3 of 22 statements = 18%) or lack of agreement (10 of 17 = 59%) to the majority of the statements suggest that there are many areas in which support can be improved for suppliers and product developers. In particular, any improvement should prioritise overcoming difficulties in accessing emergency settings and end users.

IV.4 Conclusion

This chapter explored the practices involved in and the barriers to developing products in the emergency sanitation sector, further examining the role of end users as well as support to suppliers and product developers. The stakeholder interviews shed light on the product development process, which can be divided into eight iterative stages from identifying an opportunity to promoting the end product. During this process, the field testing stage is considered vital to determining whether a product is ready for implementation. Barriers to product development in the emergency sanitation sector include poor design requirements, inadequate knowledge capture and learning and disjointed processes. The findings suggest wide scope for improvement, with complex and inter-related issues affecting the entire product development process.

The case study with end users at Abucay Bunkhouse in the Philippines identified ways in which end users, who are not active stakeholders of the process, could be motivated to be more involved in product development activities.

Finally, the stakeholder survey showed clear agreement that suppliers and product developers should receive more support throughout the product development

process, especially with understanding design requirements and evaluating prototypes.

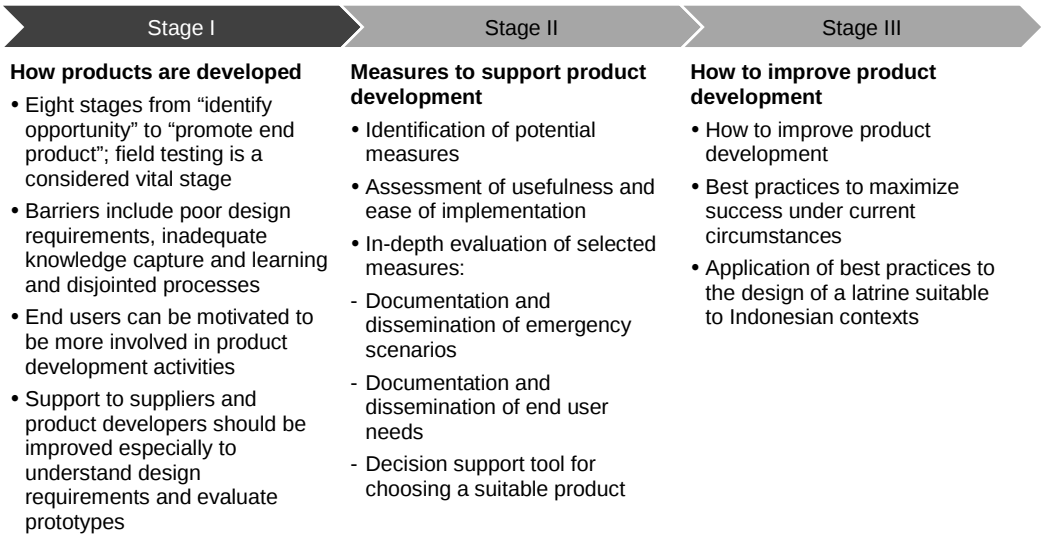


Figure IV.37. Key findings from first stage of dissertation

The next chapter will identify and assess potential measures to improve support to suppliers and product developers.

Chapter V Supporting product development

The previous chapter identified numerous areas where product development in emergency sanitation could be improved, such as in terms of design requirements and knowledge capture and learning. This chapter identifies and evaluates potential measures to support suppliers and product developers more effectively in the development of emergency sanitation products. A list of measures was identified and short-listed (Section V.1). These were compiled into a questionnaire so that stakeholders could provide their opinions on the usefulness and ease of implementation of the identified measures (Section 0). Selected measures were evaluated in greater depth (Section V.3) (Figure V.1).

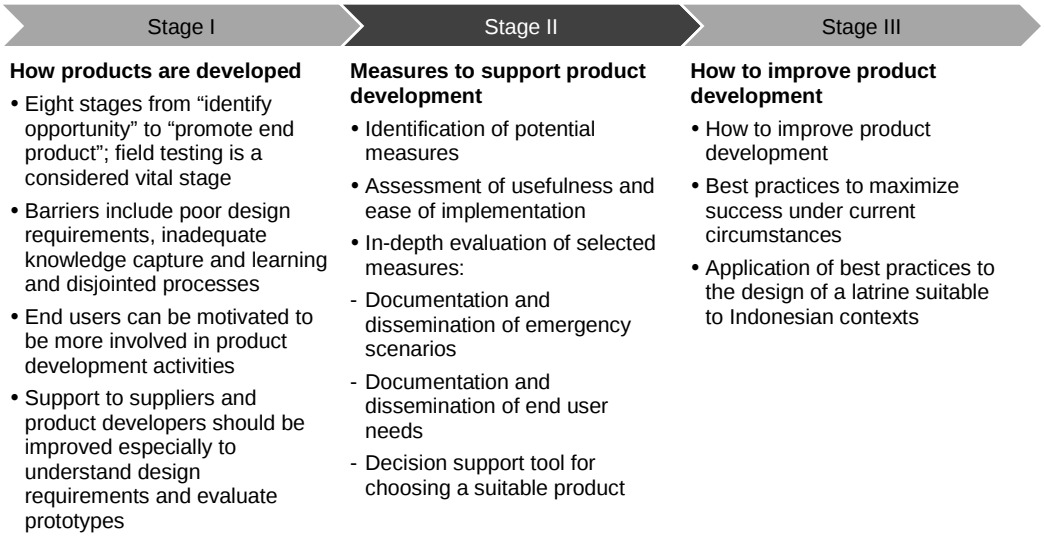


Figure V.1. Aims and objectives of second stage of dissertation

V.1 Approaches to improve product development

35 measures to help suppliers and product developers determine design requirements, evaluate and select ideas, evaluate prototypes and disseminate the end product (in line with the key stages of product development) were identified. These were classified into six approaches and are explained in the following subsections: capturing, documenting and disseminating knowledge and data; standards and procedures; tools for design and evaluation; expert review; methods for evaluating prototypes, and; tools for disseminating the end product.

V.1.1 Capturing, documenting and disseminating knowledge and data

Emergency sanitation can be considered to be a frontier design context (Green et al., 2006). It is a market outside the experience and expertise of most suppliers and product developers. End users are not usually represented among the organisations and individuals who develop emergency sanitation products. Many stakeholders are from high-income rather than low-income countries where the products are implemented. Therefore, suppliers and product developers generally lack knowledge on and access to end users and emergency settings.

A number of interviewees use the internet to find information about emergency sanitation. However, suppliers and product developers are generally unaware of the quantity and quality of data available. Locating information on emergency sanitation is difficult, especially for people unfamiliar to the sector. According to Brown et al. (2012), knowledge of 'what works' in water, sanitation and hygiene (WAS) is mostly held tacitly by humanitarian practitioners. Sources of information are diverse and separate. Case studies on emergency response are available but often not peer-reviewed. Where available, the information typically reflects in-agency policy rather than broader consensus.

Suppliers and product developers face difficulties in obtaining feedback on ideas and from field testing. In addition to the lack of or slow feedback, the information that is provided may not be of a quality useful to designing products. As a result, suppliers and product developers are unable to come up with appropriate designs.

11 measures related to capturing, documenting and disseminating data on emergency scenarios, challenges faced by implementing agencies and end users, the evaluation and performance of concepts, prototypes and existing products were identified. This information would compensate for, to some extent, suppliers' and product developers' lack of field knowledge, difficulties in accessing emergency settings and field workers, and the lack of engagement with end users. It would address some of the difficulties in obtaining feedback and data, contributing to improved learning in the sector.

V.1.2 Standards and procedures

There is a lack of structure in the product development process, partly because of the limited utilisation of product design and research methods. This contributes to poor design requirements, data and feedback.

Seven measures related to standards and procedures for describing design criteria and product specifications, indicators and testing methods for evaluating prototypes as well as the enforcement of product testing were identified. The benefits are that procedures reduce uncertainty in the process and standards facilitate better design requirements, data and feedback. For example, standards would provide a basis for comparing available and emerging products in an objective manner. The lack of an effective review system had already been noted by the University of Glasgow and Oxfam GB (2011). One of their suggestions was to implement standardised testing, a procedure that is already widely used in the water treatment industry.

V.1.3 Tools for design and evaluation

As one interviewee observed, “you don’t have to reinvent this idea of how we develop a process of identifying a need, putting a design brief together, refining that brief and getting it through to a product”. There are numerous tools, ranging from simple to complex, for designing and evaluating products, although they are not necessarily known to non-designers and non-engineers. For instance, Ozer (2002) presents methods for new product idea selection. Popular methods of analysis include checklists and scoring.

There are already examples of such tools being used in the development context. González et al. (2003) applied quality function deployment to design school furniture for developing countries. Snyder et al. (2006) used concept screening and scoring to design a portable sisal decorticator for Kenyan farmers.

Although the sector should not impose on the methodologies personally used by individuals to develop their products, certain concepts can be presented to help

suppliers and product developers think through and analyse their designs. Alternatively, these tools can be used by the humanitarian sector when they provide feedback. Nine tools to facilitate design and evaluation were identified.

V.1.4 Expert review

Suppliers and product developers in the emergency sanitation sector depend on the feedback of humanitarian practitioners to evaluate their ideas and prototypes. This can be a valuable practice because expert analysis can help predict the future success of new product ideas, provide diagnostic information for improving a new product idea, and fill the information gap when there is no hard data to make decisions (Ozer, 2002). Unfortunately, the unreliable engagement with humanitarian practitioners means that suppliers and product developers face difficulties when obtaining feedback. In addition, the feedback provided may not be of a quality useful to designing products.

Implementing an expert review system would simply formalise an existing widespread, though informal, practice in the emergency sanitation sector. The system could involve procedures where a supplier or product develop submits a design for evaluation by an appropriate group of humanitarian practitioners. Having a system in place would minimise issues where suppliers and product developers are unable to receive feedback on their designs and ensure that comments are provided by a suitable mix of experts.

V.1.5 Methods for evaluating prototypes

The field-testing of prototypes in emergency and non-emergency settings is considered a vital stage in the development of emergency sanitation products. Oxfam GB, for example, field-tested disposable and Peepoo bags in Port-au-Prince following the earth-quake in Haiti (Patel et al., 2011). However, humanitarian agencies sometimes face difficulties in finding appropriate places to test prototypes. Furthermore, the lack of suitable facilities and high-pressure situations faced during emergencies make it challenging for stakeholders to collect good quality data.

Although some stakeholders might disagree, design requirements do not necessarily have to be evaluated by testing a prototype in an emergency. As one interviewee observed, “in industry you will not test a practical solution but you will follow a standard”. Conceivably, designs could be evaluated using simulated environments or proxy users. For example, one design project from the stakeholder interviews used their fellow students to evaluate the usage of their toilet design. In another case, three faecal sludge sanitisation methods (lactic acid fermentation, urea treatment and hydrated lime treatment) were investigated using faecal sludge from pit latrines in Blantyre, Malawi (Spit et al., 2014).

Five alternatives to testing prototypes in emergency settings were identified. Although these alternatives are unlikely to replace field testing in emergencies, these methods can be implemented more easily and systematically, thus reducing the burden on humanitarian agencies who have limited capacity to test prototypes in emergency settings.

V.1.6 Tools for disseminating the end product

Suppliers and product developers face challenges when introducing new emergency sanitation products to potential customers. Currently, marketing relies largely on personal networks. Furthermore, some people believe that senior officers and procurement staff choose technologies that they know and think are appropriate. This makes it difficult for unfamiliar technologies to be implemented (University of Glasgow and Oxfam GB, 2011).

Tools have yet to be widely applied to facilitate the dissemination of products. Therefore, there is scope for providing tools to complement existing marketing practices. Shaylor (2010) recommended the use of accurate and objective research and pilots to allow engineers to understand the potential benefits and failures of alternative technologies. Zakaria et al. (2015) developed a decision support system for planners to choose appropriate sanitation options as a means to overcome intuition, the limited knowledge of decision-makers and preference for standard practices.

Six measures to directly and indirectly help promote products were identified. These measures involve making information on products more widely available and providing an objective basis for comparing different products.

V.1.7 Discussion

This section described different approaches to support suppliers and product developers in developing emergency sanitation products. Although each measure addresses one specific aspect of product development, these measures would likely be more effective when used in combination. Applying these measures could allow solutions to transition from idea to end product more smoothly, because suppliers and product developers would find it easier to make decisions at each stage of the process. However, these measures are not equally useful and easy to implement in practice. An extremely useful measure may require too many resources to implement. It is important to consider both usefulness and ease of implementation when determining which measure would benefit the emergency sanitation sector the most. These issues will be considered in the next two sections.

V.2 Stakeholder opinions on usefulness and ease of implementation

Respondents to the stakeholder survey presented in Section IV.3 also assessed the usefulness and ease of implementation of the 35 measures that were discussed in the previous section. The measures were classified under the four key stages of product development in the emergency sanitation sector, in line with the first section of the survey (Figure IV.29).

V.2.1 Usefulness

Respondents assessed the extent to which a measure would help suppliers and product developers in various aspects of product development on a seven-point Likert-type scale. The Wilcoxon tests were used to determine, 5% significance levels, whether:

- the median of the overall response was greater than ‘Neutral’, ‘Somewhat large’ and ‘Large’;

- there was a difference in medians between two measures, showing that one measure was rated as more useful than another in a statistically significant way, and;
- there was a difference in medians between suppliers and product developers, showing that suppliers rated one measure more or less useful than another in a statistically significant way.

In general, most respondents agreed that all the measures were useful, i.e. the median response to all the measures were 'Somewhat large', 'Large' or 'Very large'. Each measure obtained a percentage usefulness ranging from 67% to 95%.

V.2.1.1 Measures for understanding design requirements

All twelve measures except one measure had a median response of 'Large'. Ten of these measures had a statistically significant median of more than 'Large' (Table V.1: 1ai-iv, 1ci-vi). The development of a common standard for describing design criteria had the lowest median of 'Somewhat large' (1bi), while indicators for evaluating individual design criteria did not have a median that was significantly bigger than 'Large'.

Table V.1 Measures for understanding design requirements

1. To what extent would the following measures help suppliers and product developers design products	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	$> +1$	$> +2$	S vs. PD	Pairwise comparisons: ai	aii	aiii	aiv	bi	bii	ci	cii	ciii	cvi	cv	cvi
a. Documenting and disseminating:																						
i. Typical emergency scenarios and corresponding design criteria	8%	86%	+1	+2	+2	+1.59	$\underline{9\times10^{-10}}$	$\underline{3\times10^{-4}}$	0.99	$\underline{4\times10^{-4}}$	-	0.27	$\underline{0.014}$	$\underline{0.045}$	$\underline{0.035}$	0.087	0.58	0.86	0.64	0.53	0.53	0.86
ii. Challenges faced by implementing agencies	5%	87%	+2	+2	+3	+1.82	$\underline{6\times10^{-11}}$	$\underline{2\times10^{-6}}$	0.88	$\underline{3\times10^{-3}}$	0.27	-	0.15	0.32	$\underline{2\times10^{-3}}$	$\underline{6\times10^{-3}}$	0.11	0.22	0.13	0.090	0.11	0.21
iii. Challenges faced by end users	2%	94%	+2	+2	+3	+2.09	$\underline{6\times10^{-12}}$	$\underline{2\times10^{-9}}$	0.13	$\underline{2\times10^{-3}}$	0.15	0.14	-	0.66	$\underline{3\times10^{-5}}$	$\underline{8\times10^{-5}}$	$\underline{3\times10^{-3}}$	$\underline{0.013}$	$\underline{5\times10^{-3}}$	$\underline{3\times10^{-3}}$	$\underline{5\times10^{-3}}$	$\underline{9.9\times10^{-3}}$
iv. The performance of existing products in emergencies	3%	91%	+2	+2	+3	+1.95	$\underline{4\times10^{-10}}$	$\underline{4\times10^{-8}}$	0.40	$\underline{8\times10^{-4}}$	0.32	0.66	-	$\underline{2\times10^{-4}}$	$\underline{4\times10^{-4}}$	$\underline{0.015}$	$\underline{0.039}$	$\underline{0.017}$	$\underline{0.010}$	$\underline{0.015}$	$\underline{0.032}$	
b. Developing:																						
i. A common standard for describing design criteria	23%	68%	0	+1	+2	+0.90	$\underline{3\times10^{-4}}$	0.60	1.00	$\underline{0.026}$	$\underline{0.035}$	$\underline{2\times10^{-3}}$	$\underline{3\times10^{-5}}$	$\underline{2\times10^{-4}}$	-	0.66	0.15	0.078	0.11	0.13	0.17	0.055

(continued on the following page)

1. To what extent would the following measures help suppliers and product developers design products	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	> +1	> +2	S vs. PD	Pairwise comparisons ai	aii	aiii	aiv	bi	bii	ci	cii	ciii	cvi	cv	cvi
(continued from the previous page)																						
ii. Indicators for evaluating individual design criteria	23%	70%	0	+2	+2	+1.07	4×10^{-6}	0.41	1.00	0.021	0.087	6×10^{-3}	8×10^{-5}	4×10^{-4}	0.66	-	0.30	0.17	0.22	0.27	0.31	0.13
c. Creating a design tool that includes:																						
i. Typical contexts of use for a specified product type	14%	81%	+1	+2	+2	+1.34	2×10^{-6}	0.023	1.00	0.099	0.58	0.11	4×10^{-3}	0.015	0.15	0.30	-	0.72	0.92	0.96	0.97	0.71
ii. Design criteria for a specified emergency scenario	14%	83%	+1	+2	+2	+1.43	4×10^{-7}	0.012	0.99	0.20	0.86	0.22	0.013	0.039	0.078	0.17	0.72	-	0.80	0.68	0.71	1.00
iii. Design requirements and product components which fulfil them	11%	82%	+1	+2	+2	+1.46	7×10^{-8}	6×10^{-3}	1.00	0.025	0.64	0.13	5×10^{-3}	0.017	0.11	0.22	0.92	0.80	-	0.88	0.85	0.78
iv. Relationships between various design requirements and product components	10%	83%	+1	+2	+2	+1.45	2×10^{-8}	6×10^{-3}	1.00	0.059	0.53	0.090	3×10^{-3}	0.010	0.13	0.27	0.96	0.68	0.88	-	0.95	0.65
v. Corresponding tool for evaluating product concepts	17%	77%	+1	+2	+2	+1.35	1×10^{-7}	0.046	1.00	0.044	0.53	0.11	5×10^{-3}	0.015	0.17	0.31	0.97	0.71	0.85	0.95	-	0.64
vi. Corresponding guidelines for evaluating prototypes	8%	85%	+1	+2	+2	+1.54	9×10^{-9}	9×10^{-4}	0.99	0.17	0.86	0.21	9.9×10^{-3}	0.032	0.055	0.13	0.71	1.00	0.78	0.65	0.64	-

> 0, > 1, > 2 = one-tail Wilcoxon signed rank test that the median is greater than 'Neutral', 'Somewhat large' and 'Large' respectively. If $p < 0.05$, the median response was greater than 'Neutral', 'Somewhat large' or 'Large' respectively; S vs. PD = two-tail Wilcoxon rank sum test for difference in mean ranks between suppliers and product developers. If $p < 0.05$, suppliers rated a measure more or less useful than product developers rated that measure; Pairwise comparisons = between two statements. If $p < 0.05$, respondents rated a statement more or less useful than another statement; The direction of the difference is determined from the descriptive statistics; Statistically significant values are underlined

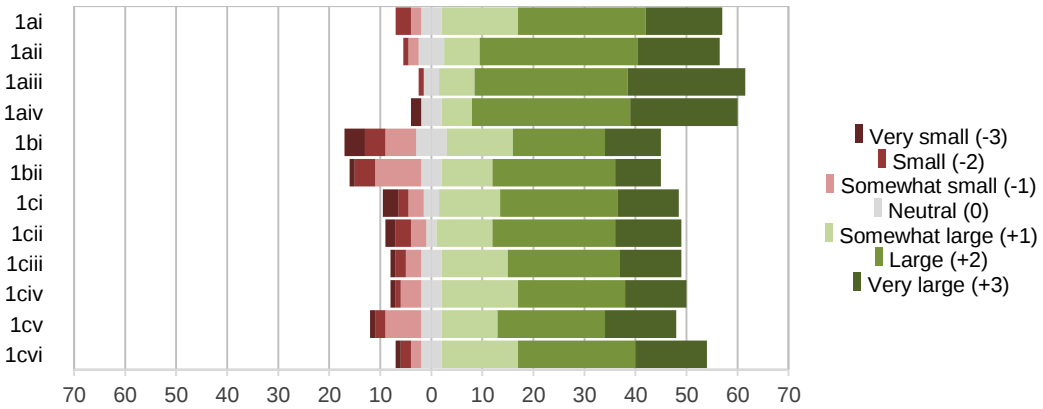


Figure V.2. Measures for understanding design requirements

Pairwise comparisons showed that the documentation and dissemination of the challenges faced by end users (Table V.1: 1biii) and the performance of existing products in emergencies (1biv) were considerd to be more useful than eight of the other measures.

V.2.1.2 Measures for evaluating concepts

All the measures except one measure had a median of 'Large'. These four measures (Table V.2: 2a, 2c-e) also had a statistically significant median of more than 'Large'. The measure that had the lowest median was a matrix to guide concept screening (non-weighted). This measure had a median of 'Somewhat large' (Table V.2: 2b). Pairwise comparisons confirm that concept screening (non-weighted) was considered to be less useful than three other measures.

Table V.2 Measures for evaluating concepts

2. To what extent would the following measures help suppliers and product developers choose concepts to develop further	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	> +1	> +2	S vs. PD	Pairwise comparisons a	b	c	d	e
a. Checklist of design requirements	8%	87%	+1	+2	+2	+1.71	2×10^{-9}	5×10^{-5}	0.91	1×10^{-3}	-	1×10^{-3}	0.13	0.15	0.40
b. Matrix to guide concept screening (non-weighted)	13%	73%	0	+1	+2	+1.04	8×10^{-6}	0.33	1.00	0.15	1×10^{-3}	-	0.095	5×10^{-6}	2×10^{-5}
c. Matrix to guide concept scoring (weighted)	9%	79%	+1	+2	+2	+1.40	1×10^{-7}	9×10^{-3}	1.00	0.08	0.13	0.095	-	4×10^{-3}	0.016
d. Documentation of results from the evaluation of similar product	2%	92%	+2	+2	+3	+2.05	4×10^{-11}	2×10^{-8}	0.27	0.12	0.15	5×10^{-6}	4×10^{-3}	-	0.53
c. A system where concepts can be reviewed by experts	2%	92%	+2	+2	+3	+1.98	1×10^{-11}	2×10^{-8}	0.54	0.023	0.40	2×10^{-5}	0.016	0.53	-

Refer to Table V.1 for explanatory notes

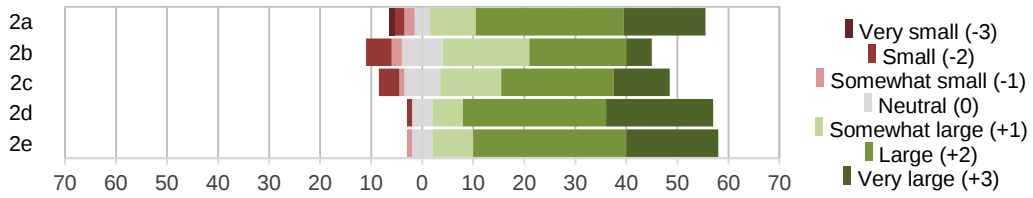


Figure V.3. Measures for evaluating concepts

V.2.1.3 Measures and methods for evaluating prototypes

All the six measures for evaluating prototypes received a median response of 'Large'. These medians were calculated to be significantly greater than 'Large'. Pairwise comparisons confirmed that there was no statistically significant difference in ratings for usefulness between all the six measures (Table V.3).

Table V.3 Measures for evaluating prototypes

3.1. To what extent would the following measures help suppliers and product developers evaluate prototypes	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	> +1	> +2	S vs. PD	Pairwise comparisons: a	bi	bii	ci	cii
a. Documenting and disseminating examples of how prototypes of various product types were evaluated	3%	87%	+2	+2	+2	+1.75	8×10^{-10}	2×10^{-6}	0.94	0.39	-	0.51	0.69	0.87	0.47
b. Developing guidelines that include:															
i. General methods for evaluating prototypes	3%	87%	+1	+2	+2	+1.69	2×10^{-10}	1×10^{-5}	0.99	0.29	0.51	-	0.90	0.47	0.21
ii. Tests for evaluating individual design criteria	2%	83%	+1	+2	+3	+1.70	3×10^{-10}	1×10^{-5}	0.98	0.021	0.69	0.90	-	0.57	0.30
c. Providing:															
i. A system where prototypes can be reviewed by experts	3%	89%	+1	+2	+3	+1.79	2×10^{-10}	4×10^{-6}	0.89	9.6×10^{-3}	0.87	0.47	0.57	-	0.61
ii. Facilities or locations for evaluating prototypes	5%	90%	+1	+2	+3	+1.83	2×10^{-9}	4×10^{-6}	0.69	0.013	0.47	0.21	0.30	0.61	-

Refer to Table V.1 for explanatory notes

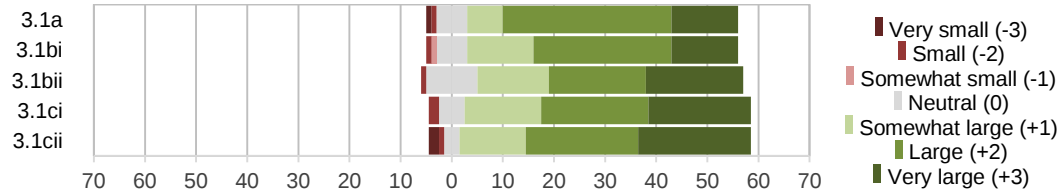


Figure V.4. Measures for evaluating prototypes

Table V.4 Methods of evaluating prototypes

3.2. To what extent would the following methods help suppliers and product developers evaluate prototypes	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	> +1	> +2	S vs. PD	Pairwise comparisons: a	b	c	d	e	f
a. Checking of product specifications against design requirements	6%	83%	+1	+2	+2	+1.52	8×10^{-9}	2×10^{-4}	1.00	0.028	-	0.29	0.55	0.52	4×10^{-6}	0.78
b. Inspection of prototypes by experts	3%	86%	+1	+2	+3	+1.77	1×10^{-10}	3×10^{-6}	0.93	9.5×10^{-3}	0.29	-	0.11	0.65	3×10^{-4}	0.20
c. Laboratory-based tests or experiments	9%	82%	+1	+2	+2	+1.38	5×10^{-8}	6×10^{-3}	1.00	6×10^{-3}	0.55	0.11	-	0.21	9×10^{-7}	0.76
d. Field testing under non-emergency settings	5%	89%	+1	+2	+2	+1.74	9×10^{-12}	3×10^{-6}	0.97	0.038	0.52	0.65	0.21	-	2×10^{-5}	0.33
e. Field testing under emergency settings	3%	94%	+2	+3	+3	+2.32	3×10^{-11}	1×10^{-9}	3×10^{-4}	0.065	4×10^{-6}	3×10^{-4}	3×10^{-7}	2×10^{-5}	-	3×10^{-6}
f. Benchmarking against existing products	8%	84%	+1	+2	+2	+1.50	2×10^{-9}	1×10^{-3}	1.00	0.036	0.78	0.20	0.76	0.33	3×10^{-6}	-

Refer to Table V.1 for explanatory notes

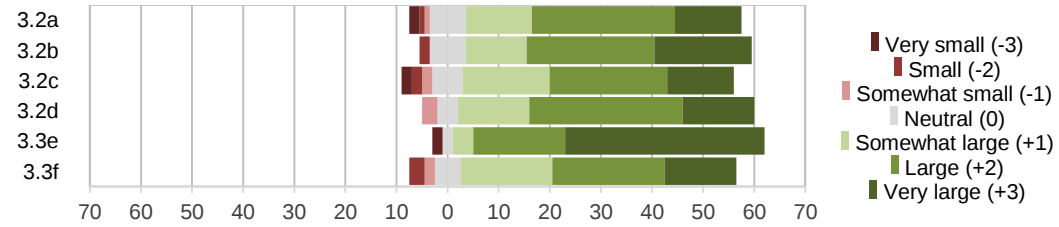


Figure V.5. Methods for evaluating prototypes

With regard to the methods for evaluating prototypes, there were six methods identified. Field testing under emergency settings had a median response of 'Very large' (Table V.4, 3.2). In addition, field testing under emergency settings vs considered to be more useful than the other methods for evaluating prototypes, although all of the other methods for evaluating prototypes had median responses of 'Large'.

V.2.1.4 Measures for promoting end products

Five measures to help suppliers and product developers promote end products were identified. All but one of the five measures received a median response of at least 'Large'. In addition, documenting and disseminating the performance of available products in emergencies had a median that was statistically greater than 'Very large'. Based on the pairwise comparisons, this measure was considered to be more useful than the other measures (Figure V.6, 4biv). A decision support tool for choosing a suitable product had the lowest median of 'Somewhat large' (4c).

V.2.1.5 Suppliers versus product developers

Compared to suppliers, product developers consistently evaluated the identified measures to be more useful (Table V.1 to V.5: S vs. PD). All 35 measures received a higher mean score (Mean) from product developers. This could be explained by a number of reasons. First, product developers play a greater role in design, while suppliers typically manufacture a design according to the customer's specifications. Hence, these measures are more relevant to product developers. Second, suppliers may not be aware of such measures and how measures can contribute to the product development process. Suppliers responded 'Don't know' to a measure 4.0% of the time (30 of 758 valid responses by

suppliers) while product developers only did so 1.1% of the time (7 of 665 responses).

Table V.5 Measures for promoting end products

4. To what extent would the following measures help suppliers and product developers promote end products	Small	Large	1st quartile	Median	3rd quartile	Mean	> 0	> +1	> +2	S vs. PD	Pairwise comparisons ai	aii	aiii	aiv	bi	bii	c
a. Documenting and disseminating:																	
i. A list of available products	6%	80%	+1	+2	+3	+1.58	3×10^{-8}	2×10^{-4}	0.98	0.049	-	0.68	0.62	6×10^{-3}	0.068	0.084	0.12
ii. Product specifications of available products	6%	86%	+1	+2	+3	+1.71	1×10^{-9}	5×10^{-5}	0.92	7×10^{-3}	0.68	-	0.92	0.016	0.026	0.034	0.046
iii. The performance of available products during testing	8%	89%	+1	+2	+3	+1.68	2×10^{-8}	6×10^{-5}	0.87	0.23	0.62	0.92	-	0.015	0.020	0.023	0.037
iv. The performance of available products in emergencies	3%	95%	+2	+2	+3	+2.18	5×10^{-11}	3×10^{-9}	6×10^{-3}	0.028	6×10^{-3}	0.016	0.015	-	7×10^{-6}	6×10^{-6}	4×10^{-5}
b. Enforcing:																	
i. A common standard for presenting product specifications	13%	67%	0	+2	+2	+1.16	1×10^{-6}	0.13	1.00	0.054	0.068	0.026	0.020	7×10^{-6}	-	0.87	0.86
ii. Product testing with associated protocols	14%	75%	0	+2	+2	+1.25	8×10^{-8}	0.096	1.00	0.020	0.084	0.034	0.023	6×10^{-6}	0.87	-	0.98
c. Creating a decision support tool for choosing a suitable product	11%	67%	0	+1	+2.5	+1.17	4×10^{-6}	0.089	1.00	0.023	0.12	0.046	0.037	4×10^{-5}	0.86	0.98	-

Refer to Table V.1 for explanatory notes

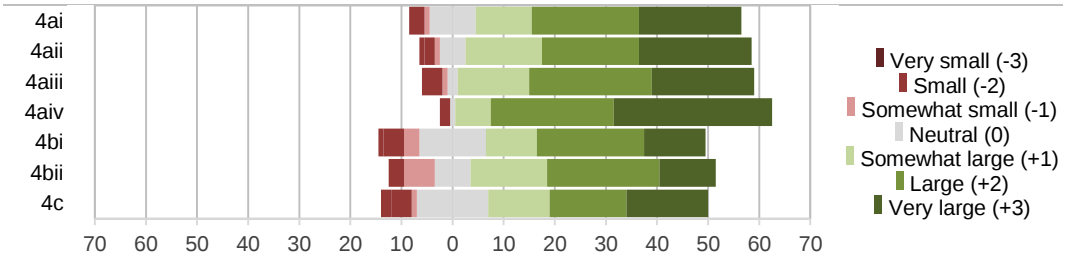


Figure V.6. Methods for promoting end products

V.2.2 Ease of implementation

Survey respondents were asked to assess the extent to which a measure would be easy to implement. In contrast to the responses on usefulness, stakeholder opinions on the ease of implementation of these measures were more divided. Two measures had the lowest median of 'Somewhat difficult': developing a common standard for describing design criteria (Table V.6, 1bi) and field testing

under emergency settings (3.2f). Most of the measures had a median of 'Neutral' (14 of 35 measures = 40%) or 'Somewhat easy' (17 of 35 = 49%). None of the measures had a median of 'Very easy'.

V.2.3 Combining usefulness with ease of implementation

To compare the identified measures by considering two factors of usefulness and ease of implementation, the usefulness and mean ease of implementation scores of each measure were added to obtain an overall score. Both factors were given equal weightage (Figure V.7).

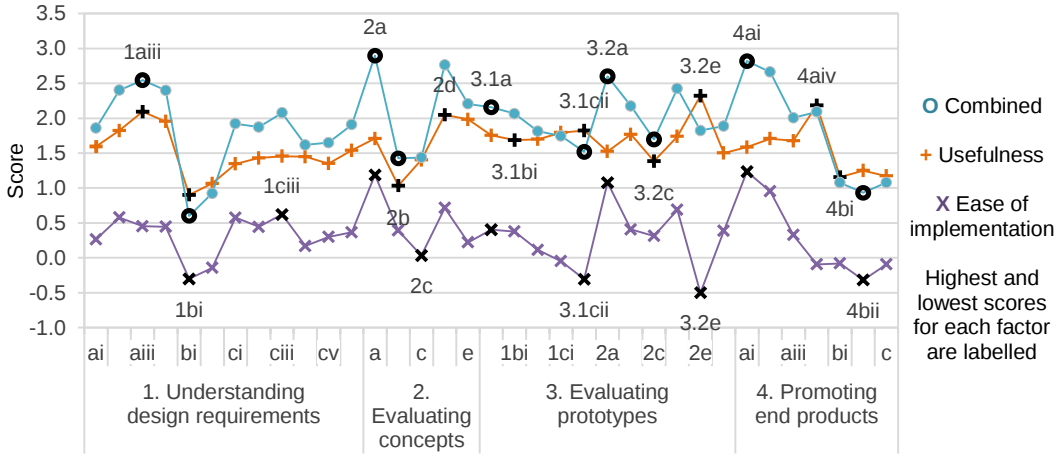


Figure V.7. Mean usefulness, ease of implementation and combined scores

Table V.6 Ease of implementation of identified measures

To what extent would the following measures be easy to implement?	Difficult	Easy	1st quartile	Median	3rd quartile	Mean
1. Understanding design requirements						
a. Documenting and disseminating:						
i. Typical emergency scenarios and corresponding criteria	31%	47%	-1	0	+3	+0.27
ii. Challenges faced by implementing agencies	25%	63%	-0.5	+1	+2	+0.58
iii. Challenges faced by end users	31%	59%	-1	+1	+2	+0.45
iv. The performance of existing products in emergencies	32%	55%	-1	+1	+2	+0.45
b. Developing:						
i. A common standard for describing design criteria	51%	37%	-2	-1	+1.5	-0.30
ii. Indicators for evaluating individual design criteria	48%	38%	-2	0	+1.5	-0.14
c. Creating a design tool that includes:						
i. Typical contexts of use for a specified product type	27%	63%	-1	+1	+2	+0.58

(continued on next page)

To what extent would the following measures be easy to implement?	Difficult	Easy	1st quartile	Median	3rd quartile	Mean
(continued from previous page)						
ii. Design criteria for a specified emergency scenario	31%	56%	-1	+1	+2	+0.44
iii. Design requirements and corresponding product components	24%	59%	0	+1	+2	+0.62
iv. Relationships between design requirements and product components	42%	44%	-1	0	+2	+0.17
v. Corresponding tool for evaluating product concepts	37%	50%	-1	+0.5	+2	+0.30
vi. Corresponding guidelines for evaluating prototypes	35%	48%	-1	0	+2	+0.37
2. Evaluating concepts						
a. Checklist of design requirements	14%	77%	+1	+1	+2	+1.19
b. Matrix to guide concept screening (non-weighted)	29%	47%	-1	0	+2	+0.39
c. Matrix to guide concept scoring (weighted)	40%	40%	-1	0	+1	+0.033
d. Results from the evaluation of similar products	24%	68%	0	+1	+2	+0.71
e. A system where concepts can be reviewed by experts	32%	49%	-1	0	+2	+0.22
3.1 Evaluating prototypes						
a. Examples of how prototypes were evaluated	26%	50%	-0.5	+0.5	+1	+0.40
b. Developing guidelines that include:						
i. General methods for evaluating prototypes	31%	52%	-1	+1	+1	+0.38
ii. Tests for evaluating individual design criteria	43%	44%	-1	0	+1	+0.11
c. Providing:						
i. A system where prototypes can be reviewed by experts	40%	40%	-1	0	+1	-0.048
ii. Facilities or locations for evaluating prototypes	44%	37%	-2	0	+1	-0.31
3.2 Methods for evaluating prototypes						
a. Checking of product specifications against requirements	13%	73%	0	+1	+2	+1.08
b. Inspection of prototypes by experts	28%	52%	-1	+1	+2	+0.41
c. Laboratory-based tests or experiments	33%	56%	-1	+1	+1	+0.31
d. Field testing under non-emergency settings	22%	61%	0	+1	+2	+0.69
e. Field testing under emergency settings	59%	38%	-2	-1	+1	-0.50
f. Benchmarking against existing products	29%	50%	-1	+0.5	+1.5	+0.39
4. Promoting end products						
a. Documenting and disseminating:						
i. A list of available products	9%	75%	+0.5	+1	+2	+1.23
ii. Product specifications of available products	17%	69%	0	+1	+2	+0.95
iii. The performance of available products during testing	30%	55%	-1	+1	+1	+0.33
iv. The performance of available products in emergencies	47%	44%	-1	0	+1	-0.094
b. Enforcing:						
i. A common standard for presenting product specifications	41%	37%	-1	0	+1	-0.079
ii. Product testing with associated protocols	46%	33%	-2	0	+1	-0.32
c. A decision support tool for choosing a suitable product	45%	36%	-1	0	+1	-0.094

Table V.7 lists the measures that achieved the highest usefulness and combined scores. With the exception of two measures (for Stage 1: Understanding design requirements and Stage 2: Evaluating concepts), there are changes to the measures that would be recommended if the decision were based on combined factors rather than solely usefulness. The analysis illustrates how the overall value of a measure is affected by both usefulness and ease of implementation. For example, field testing under emergency settings was assessed as the most useful but most difficult to implement among all the measures (3.2e: mean usefulness = +2.32; mean ease of implementation = -0.50; overall score = +1.82).

Table V.7 Measures with the highest usefulness and combined scores

Stage	Most useful measure	Highest combined score
1. Understanding design requirements	aiii. Documenting and disseminating the challenges faced by end users	aiii. Documenting and disseminating the challenges faced by end users
2. Evaluating concepts	d. Documentation of results from the evaluation of similar products	d. Documentation of results from the evaluation of similar products
3.1. Evaluating prototypes	ci. Providing a system where prototypes can be reviewed by experts	ai. Documenting and disseminating examples of how prototypes were evaluated
3.2. Evaluating prototypes: Methods	e. Field testing under emergency settings	a. Checking of product specifications against design requirements
4. Promoting end products	aiii. Documenting and disseminating the performance of available products in emergencies	ai. Documenting and disseminating a list of available products

V.2.4 Summary and discussion

Stakeholders surveyed clearly agreed that the identified measures would be useful to suppliers and product developers for developing emergency sanitation products. Measures related to documenting and disseminating data on existing products and end users were considered useful throughout the stages of product development. An expert review system and field testing under emergency settings were preferred for evaluating concepts and prototypes respectively. These results are in line with findings from the previous chapter on how product development works in the emergency sanitation sector, which included: difficulties in obtaining feedback and data when developing products, the reliance of suppliers and product developers on humanitarian practitioners for feedback, and the importance of field testing to determine if a product is ready to be implemented.

There was greater variation in the survey responses on ease of implementation. A combined score was obtained by adding the ease of implementation scores with the usefulness scores. The results demonstrated how factoring ease of implementation to usefulness could shift the perspective on whether a measure was worth implementing. Overall, the survey provided an indication of the general opinion towards the identified measures. However, these measures should be evaluated in greater depth to more comprehensively understand their contribution to the product development process.

V.3 In-depth evaluation of selected measures

The previous sections demonstrated that a range of measures existed to support product development in the emergency sanitation sector. These need to be evaluated in greater depth to more comprehensively understand their contribution to the product development process. Therefore, this section evaluates the usefulness and ease of implementation of three measures: the documentation and dissemination of emergency scenarios (Subsection V.3.1); of end user needs (Subsection V.3.2), as well as; a decision support tool for choosing a suitable product (Subsection V.3.3).

V.3.1 Documentation and dissemination of emergency scenarios

In general, stakeholder survey respondents were positive towards the documentation and dissemination of data to support suppliers and product developers in developing emergency sanitation products. All related measures, including data on emergency sanitation scenarios and corresponding design criteria received a median usefulness of ‘Large’ (Table V.1, 1ai) and a median ease of implementation of ‘Neutral’ (Table V.6, 1ai).

The in-depth evaluation of the documentation and dissemination of emergency sanitation scenarios was completed in two stages. First, a review of existing literature on emergency excreta disposal scenarios was conducted (Subsection V.3.1.1). Second, a cross-case comparison of five previous disasters was carried out (Subsection V.3.1.2).

V.3.1.1 Literature review

Literature that describe different emergency scenarios and their associated excreta disposal needs is limited (Table V.8). First, the literature that exists may not be comprehensive, as Mwaniki (2009) and Smith (2009) acknowledge of the lessons learned that they presented in their respective works. Second, there are many emergency scenarios that have not been covered. Floods and droughts are described but there is no comprehensive documentation on earthquakes, tsunamis or cyclones. Emergency scenarios in different environments are more widely examined, especially urban versus rural situations. However, specifics such as ground conditions have not been addressed.

Table V.8 Key literature of emergency sanitation scenarios

Reference	Subject	Elements
Chalinder (1994)	Typical water and sanitation scenarios	Types of disasters and impact on damage, displacement and needs; types of local conditions and impact on displacement, technical constraints and applicable solutions
PAHO (2002)	Types of hazards	Types of disasters and impact on damage
Buttle and Smith (2004)	Water and sanitation for cold regions	Cold conditions and corresponding technical constraints and applicable solutions
Forster (2009a)	Water and sanitation in rural floods	Rural floods and impact on needs, technical constraints and applicable solutions
Forster (2009b)	Water and sanitation in urban floods	Urban floods and impact on displacement, needs and applicable solutions
Mwaniki (2009)	WASH during rural floods	Rural floods and impact on damage, displacement, needs, technical constraints and applicable solutions
Smith (2009)	WASH during urban floods	Urban floods and impact on damage, displacement, needs, technical constraints and applicable solutions

Nevertheless, it is possible to identify and classify parameters that describe disasters, their impact, corresponding excreta disposal needs and applicable solutions. In general, a disaster can be characterised by its nature and the setting in which it occurs. The disaster causes damage which leads to displacement. This is the context within which excreta disposal response is implemented, with potential solutions restricted by needs and constraints arising from the disaster, local conditions, damage and displacement.

Table V.9 identifies excreta disposal scenarios that would impact design requirements. These descriptions are somewhat arbitrary and do not

comprehensively address the range of design considerations for excreta disposal which, according to Harvey (2007), include accessibility, safety, comfort and community desires, privacy and health.

Table V.9 Emergency scenarios and corresponding needs and constraints identified in the literature

	Scenario and corresponding needs and constraints	Reference
	Type of disaster	
Droughts	Damage due to lack of use; accumulation of solid matter in sewage systems	(PAHO, 2002)
Earthquake	Total or partial destruction of intake, transmission, treatment, storage, and distribution systems; interruption of access routes	"
Flood	Blockage due to excessive sedimentation; rupture of exposed pipes across and along rivers and streams; power cuts, road blockages, and disruption of communications	"
Hurricane	Rupture of mains and pipes in exposed areas; rupture or disjointing of pipes in mountainous areas; rupture and damage to tanks and reservoirs	"
Landslides	Total or partial destruction of the works, particularly in the path of active landslides; blocking of roads; blockage of sewage systems due to build-up of mud and stones	"
Volcanic eruptions	Total destruction of the infrastructure in the areas directly affected by pyroclastic flows and surges	"
	Settings	
Abundant surface water	Position of groundwater table is of special relevance	(Chalinder, 1994)
Arid areas	Space not usually such a limiting factor; unless the soils and / or rock are shallow	"
Existing settlements	Population frequently occupy public buildings and a large number of additional users will lead to overfull pits or septic tanks	"
Hilly or mountainous	Camp location will likely be on a slope or top; sides and tops of hills often have little soil cover, therefore impossible to dig deep pits	"
Cold	Decomposition of excreta greatly reduced; excreta has to be stored throughout winter in some cases; open defecation extremely uncomfortable; liquid in pit unable to soak away in winter; excreta freeze therefore pit may not fill up efficiently; soil that is stable in winter may grow soft in spring; additional snow loads on roof structures; logistics in mountainous areas challenging	(Buttle and Smith, 2004)
Urban	Increased pressure on facilities that may already be under strain; intensive septic tanks or latrine emptying in peri-urban areas; may need temporary public toilets	(Wisner and Adams, 2002)
Rural	Less often of great concern due to lower concentration of people and lesser risk of contamination through inadequate sanitation	"
	Combination of disaster and setting	
Urban flood	Vulnerable groups are at greatest risks and should be given priority; access to the city severed; if relocated into unofficial shelters there should not be permanent infrastructure	(Smith, 2009)
Urban flood	Often mass population displacements in a short period; women and adolescent girls may be vulnerable to sexual violence or exploitation; typical options include repairs to existing facilities, chemical toilets, packet latrines, bucket latrines and rapid kit latrines	(Forster, 2009b)
Rural flood	Limited land; high groundwater table; pits should be lined as pits dug below the water table may collapse; inaccessibility due to flooded roads and broken bridges; speed is a priority	(Mwaniki, 2009)

In conclusion, available literature on emergency sanitation scenarios is limited and currently not very useful for stakeholders to use as data to develop products. Clearly, there is a need to expand our understanding of emergency sanitation scenarios.

V.3.1.2 Case studies on emergency scenarios

The previous subsection concluded that available literature on emergency sanitation scenarios is limited and not particularly useful for stakeholders to develop products. There is a need for more and better data on emergency scenarios. This subsection evaluates whether compiling data from documents published about past emergencies would be effective for documenting data on emergency scenarios.

Case study results and outcomes

The case studies chosen represent a range of natural disasters and local settings (Table V.10). Individual case findings were written up in line with the conceptual framework (Figure III.7). The case studies are not presented in this dissertation but part of the data from Indonesia is analysed in Section VI.3 to design a latrine for Indonesian contexts.

Table V.10 List of case studies

Type of disaster	Location(s) of emergency	Date of disaster
Earthquake and tsunami	India, Indonesia, Maldives, Sri Lanka	December 2004
Earthquake	Java, Indonesia	May 2006
Tropical cyclone	Myanmar	May 2008
Earthquake (and cholera)	Haiti	January 2010
Floods	Pakistan	July 2010

The main similarities and differences between the scenarios and needs in the case studies are summarised in Table V.11. The studies provided insight into the effects of disaster-causing events, damage to housing and sanitation infrastructure, displacement patterns, excreta disposal needs, constraints to safe excreta disposal and the factors affecting outcomes of excreta disposal response, for example:

Table V.11 Cross-case comparison

Case	2004 Indian Ocean earthquake and tsunami					2006	2008	2010	2010
	Mainland India	**Andaman and Nicobar Islands**	**Indonesia**	**Maldives**	**Sri Lanka**	**Java**	**Myanmar**	**Haiti**	**Pakistan**
Event	Earthquake					Earthquake	Cyclone	Earthquake	Heavy rain
Effects									
Ground shaking	Weak	Very strong	Severe	ND	ND	Severe	No	Violent	No
Tsunami or storm surge	10m high; 3km penetration	Yes	10 – >30m; 0.5 – 2km	0.65 – 3.22m	5 – 6.2m; 0.5 – 3km	No	3.6 – 7m	No	No
Flooding	ND	Yes	ND	All but nine islands	Subsided in 30 minutes	No	15 – 27% of affected area	No	Flash floods; Floods to a year
Winds	No	No	No	No	No	No	High speed	No	No
Damage to sanitation facilities									
Physical	Yes	Yes	Yes	Yes	Yes	Slabs and pipes usable	Due to flooding	Evidence of old toilets being used	Due to force of floods
Flooding	ND	ND	Yes	Yes	Yes	No	Yes	No	With silt and debris
Displacement									
Escape and evacuation	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Initial movement to:	Inland; public structures	Capital; mainland; camps	Inland; public and high places	Own or another island	ND	Near homes	Search for necessities	Another region; near home; open; another house	Away from flooding
Key pattern	Mixed	Mixed	Mixed	Mixed	Mixed	Existing plots (74%)	Mixed	Mixed	Mixed
Large population movement	ND	ND	Yes	ND	Some between types of settlements	No	ND	Between types of settlements; day / night	Some secondary displacement
Transitional shelter	ND	ND	Barracks / temporary living centres	Temporary housing	Transitional camps	ND	Some "frontier" camps	Yes	ND

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Case	2004 Indian Ocean earthquake and tsunami					2006	2008	2010	2010
	Mainland India	Andaman and Nicobar Islands	Indonesia	Maldives	Sri Lanka	Java	Myanmar	Haiti	Pakistan
(continued from previous page)									
Period of displacement	Days to weeks	ND	Up to years	Up to one year	Days to months	Days	Weeks	Up to years	One month up to > one year
Excreta disposal: Significant need for...									
Excreta disposal overall	Only first few weeks	ND	Yes	Not significant	Yes	Yes	ND	Yes, but water initial priority	Yes
Containment	NR	Camps and islands	"Urgent"	Temporary latrines	Portable sanitation	"Urgent"	Top priority in camps	From Day 16	Trench latrines
Desludging	NR	Not reported	Needed but ND on urgency	Septic tanks	Yes	NR	NR	Yes	NR
Achieving safe excreta disposal: Significant constraints									
High water table	0.9 – 1.2m in some areas	ND	< 0.4m not uncommon	ND	Yes; also from rain	Occasionally reported	In delta areas and flood waters	NR	Shallow pits required; unable to dig
Lack of space	ND	ND	In some areas	ND	ND	ND	ND	Urban setting	ND
Permission to dig latrines	NR	NR	NR	NR	Private land	NR	NR	Private land or government	NR
Defecation habits	NR	NR	Little experience with latrines	NR	NR	NR	Yes	NR	Little experience with latrines
Privacy	NR	NR	Yes	NR	NR	NR	NR	NR	Due to purdah
Pre-disaster conditions									
Geography	Coastal, mostly rural					Varied	Varied	Urban	Varied
Major religion	Hindu		Muslim	Muslim	Buddhist	Muslim	Buddhist	Roman Catholic	Muslim
Latrines	Septic tank; pits		Septic tank; pits; pour-flush	Septic tank; flush	Septic tank	On-site sanitation	Pit	Septic tank; pit; flush; seated; bags	Mostly flush; also pits
Open defecation	57%		Common	10% in rural areas	High in fishing areas	"Widespread"	6 – 11%	9% in urban areas	23% due to purdah and agriculture
Legend	NR = not reported; ND = No conclusive data								

Impact of earthquakes versus impact of flooding: Ground shaking resulting from earthquakes can only cause physical damage. The case studies suggest that superstructures are vulnerable to ground shaking but latrine slabs, pipework and pits are less prone to damage. As a result, some latrines will still be functional. On the other hand, flooding leads to physical collapse as well as inundation and siltation, rendering latrines unusable without significant rehabilitation.

During flood events, local authorities evacuate people from risk areas. People, fearing the threat of flooding, also flee their homes. These people are likely to return once flood waters recede which, depending on the nature of the flooding, can take from days up to months. In contrast, evacuation and flight are rare in the event of an earthquake. Fear also plays a role during earthquakes but in a different way: people choose to stay in the open rather than inside buildings which may collapse.

High groundwater tables are more common when there is flooding but it is not clear the precise impact flooding has on groundwater tables, because the depth of groundwater also depends on climate, soil conditions and human activity.

Urban settings: Although Haiti was the only urban disaster studied, urban settings have distinct characteristics that create specific challenges for emergency response in general. In Haiti the lack of space and inability to dig due to paved streets were substantial challenges to providing latrines. Due to this it was hard to provide latrines with large-scale containment capacity. This in turn led to higher demands on desludging.

Dynamics of displacement: Displacement can be characterised by the types of settlements (e.g. camps), period of displacement and degree of population movement. The pattern of displacement is not as highly correlated with the effects of disaster because many other factors affect displacement. However, the pattern of displacement is important for identifying appropriate strategies for excreta disposal response.

The type of settlement impacts potential response strategies. Sanitation facilities which are already available (damaged or otherwise) could be rehabilitated for use. In all other cases new latrines would have to be provided. Where land is owned by a private landlord, obtaining permission to dig or install latrines can become significant issues. In such cases non-conventional solutions may need to be considered.

Period of displacement: People can be displaced from their homes for a few days or a few years. Long-term displacement increases demand on the capacity needed to contain excreta which then creates the need to desludge latrines. Latrines must last for the duration a settlement exists, hence design life is important.

V.3.1.3 Usefulness and ease of implementation

The previous subsections summarised findings from the literature review and case studies on emergency scenarios. This subsection will discuss the usefulness of existing literature and documenting case studies respectively to suppliers and product developers.

Existing literature

Existing literature on emergency scenarios is inadequate. Not many scenarios have been covered in available publications and useful data can only be found scattered within general literature on WASH in emergencies. In most cases, the information provided is not detailed. Therefore it does not help the supplier or product developer formulate design requirements. Another criticism is that many publications are considered grey literature. As Brown et al. (2012) noted, the literature typically reflect in-agency policy rather than broader consensus. Hence, there are concerns as to the validity of the information available to suppliers and product developers.

On the other hand, an inexperienced supplier or product developer would be able to gain a feel for the issues that were important to the emergency sanitation sector from existing literature. In that sense, going through case studies could

compensate to some extent for the lack of field knowledge among suppliers and product developers. The main challenge would be making this information easily accessible to suppliers and product developers then making them aware of the information's existence.

Case studies on emergency scenarios

Collecting and analysing the data was extremely tedious. Over 4,000 documents were downloaded from the online ReliefWeb database. Subsequently, each document had to be carefully studied in detail to identify the part of the document (a section, paragraph, table or figure) that was relevant to the conceptual framework. Unfortunately, many documents discussed sanitation in general but did not provide details (e.g. "CARE had constructed toilet facilities in the immediate aftermath of the tsunami"). Some documents were provided in a format (e.g. PDF) that could not be imported into QDA Miner Lite. Compiling data into a cohesive and accurate case study was difficult due to scattered reporting and unreliable, sometimes contradictory, data. It is also possible that data was collected during the disasters but not published. In some cases data collection may have been poor, although this appears to have improved with time. For example, data from the 2010 Haiti earthquake was considerably better than the 2004 Indian Ocean earthquake and tsunami. Furthermore, many documents were published for the purposes of accountability or fundraising and not appropriate to formulating design criteria.

Nevertheless, five detailed case studies were produced with information on: the local context; the event causing the disaster; effects of the event; the damage caused; displacement; excreta disposal needs; constraints to achieving safe excreta disposal; the excreta disposal response, and; outcomes. Their analysis generated useful insights on the impact of flooding, urban settings and displacement. A conceptual framework for assessing emergency sanitation technologies was proposed (Thye et al., 2014). The case studies provide valuable information that suppliers and product developers could use to understand the context in which their products would be implemented.

With regard to disseminating the data from the case studies, some of the case studies resulted in publications (Thye et al., 2013a, 2013b). Despite these successful examples, much of the data from the case studies is anecdotal and not of a quality required of an academic journal. It would be difficult for the case studies to be published in journals to be read by suppliers and product developers. Even if they were published, stakeholders may not have access to the journal or be aware that the paper exists.

Therefore, although the case studies produced information that would be useful to suppliers and product developers, there is still the issue of how to disseminate the information effectively.

V.3.2 Documentation and dissemination of end user needs

Survey respondents were positive towards the documentation and dissemination of data on challenges faced by end users. The measure received a median usefulness of 'Large' and the third-highest mean (+2.09) score among the twelve measures identified to support the understanding design requirements (Table V.1, 1aiii). The median ease of implementation response obtained was 'Somewhat easy' (Table V.6, 1aiii).

This subsection evaluates the usefulness of documenting and disseminating data on end users. The research draws on conclusions from the exploration of end user satisfaction towards and conditions of sanitation facilities based on surveys conducted in displacement centres in North Sumatra province, Indonesia, and in a transitional settlement in Leyte Province, the Philippines.

V.3.2.1 Background

The research was carried out at two locations. In September 2014, the first study was done in 13 displacement centres in North Sumatra, Indonesia, with people who were affected by the eruption of Mount Sinabung in September 2013. From March to May 2015, the second study was conducted in one transitional settlement in Leyte province, the Philippines, housing people affected by Typhoon

Haiyan in November 2014. Table V.12 summarises the background of the two studies.

Table V.12 Background of the two end user studies

Characteristic	A. North Sumatra, Indonesia	B. Leyte, the Philippines
Disaster event	Volcanic activity of Mount Sinabung in September 2013 and beyond, affecting communities around the volcano	Typhoon Haiyan in November 2013, affecting communities across Philippines along the typhoon track
Study location(s)	13 temporary settlements in Kabanjahe city and Berastagi subdistrict, Karo regency	One transitional settlement in Tacloban City, 1st district and capital of Leyte province
- Period of study	September 2014 (1 year after disaster)	March to May 2015 (about 1.5 years after disaster)
- People	7,238 people (2,086 households)	867 people (200 households)
Type of site(s)	Public buildings and tents	Bunkhouse (barracks)
Purpose of settlement	Places where people evacuated to and were staying while waiting to return home	Constructed in March 2014 for people to stay while awaiting relocation by the government

The first study was conducted by Haudi Hasaya (Masters student at Institut Teknologi Bandung) and the second study was conducted by the author

Mount Sinabung volcano eruption, Indonesia: Mount Sinabung is located in Karo regency, North Sumatra province, about 88 km from the provincial capital, Medan. A few years prior, on 29 August 2010, the volcano erupted for the first time after 400 years. This was followed by five major eruptions. Thousands of people were affected (IRIN, 2010). A few years later, on 15 September 2013, the Centre for Volcanology and Geological Hazard Mitigation (PVMDG: Pusat Vulkanologi dan Mitigasi Bencana Geologi) raised the alert level from II (Alert / Waspada) to III (Standby / Siaga). Although it was subsequently downgraded, PVMDG increased the level again to IV (Danger / Awas) on 23 November 2013. The level remained on IV until 8 April 2014 and on III until end May 2014.

Volcanic activity in September 2013 and eruptions from October 2013 to March 2014 led to villages that were within 5 km of the volcano's crater being evacuated by the government. The highest number of internally displaced persons (IDPs) was recorded on 12 February 2014, when there were 33,210 IDPs in 43 displacement centres (Karo District Government, 2015). IDPs stayed in churches, mosques, schools and tents. On 13 February, the National Task Force started facilitating the return of IDPs to their homes (OCHA, 2014). As of 3 September,

there were 7,572 IDPs in 18 displacement centres (Karo District Government, 2015).

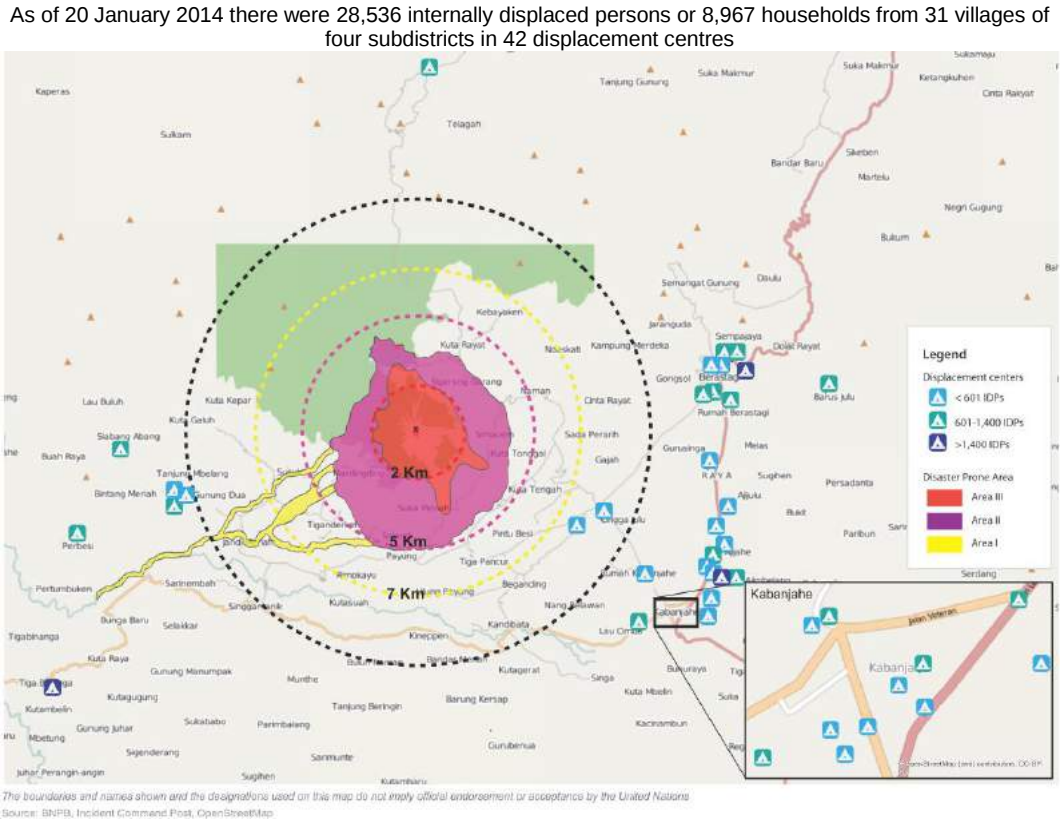


Figure V.8. Mount Sinabung volcanic activity as of 20 January 2014 (OCHA Indonesia, 2014)

Typhoon Haiyan, the Philippines: On 8 November 2013, Super Typhoon Haiyan made landfall in Eastern Samar province in the Eastern Visayas region (OCHA, 2013a: Sitrep no. 2). In Tacloban city, a storm surge led to flooding that was approximately 3 m high. Overall, the typhoon affected 33 provinces in nine regions (OCHA, 2013a: Sitrep no. 3) and displaced 4 million people in the Philippines (OCHA, 2013a: Sitrep no. 22).

To provide shelter while the government prepared permanent housing, the Department of Public Works and Highways constructed bunkhouses in Leyte and Samar provinces (Legaspi, 2013). The settlement in this study, Abucay Bunkhouse, was opened in March 2013 and housed 867 people from 200 families.

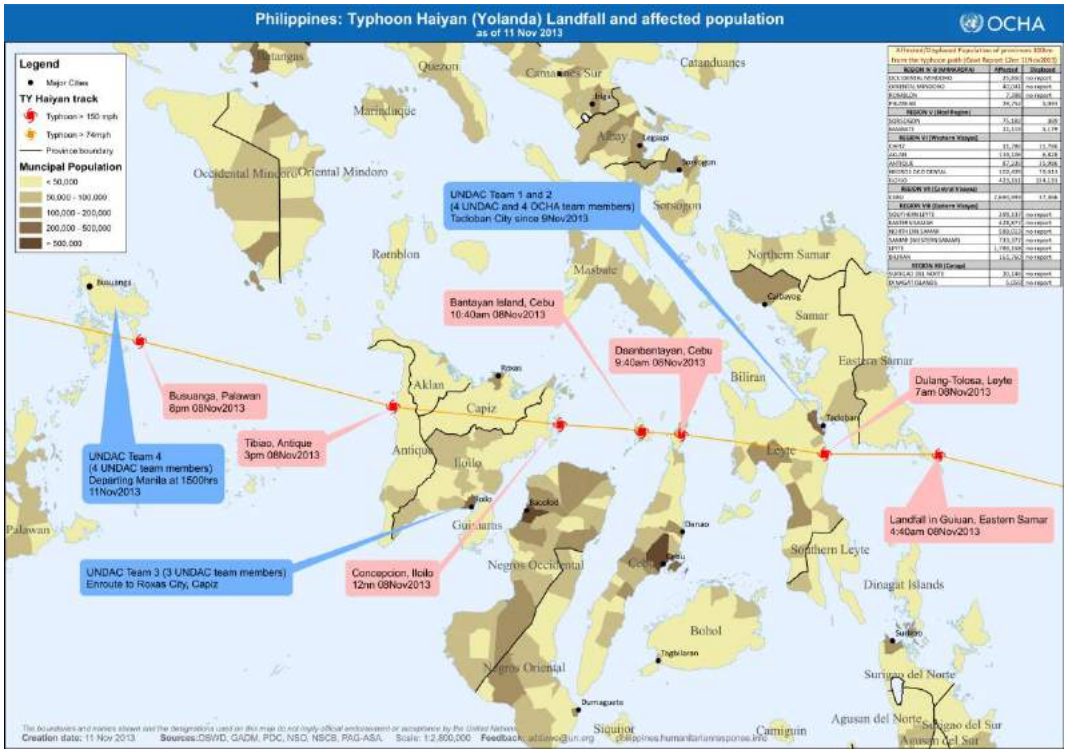


Figure V.9. Typhoon Haiyan landfall in the Philippines (OCHA, 2013b)

Provision of sanitation

There were several differences in the way sanitation was provided at the two study locations. Table V.13 summarises the implementation of sanitation at each location.

Table V.13 Implementation of sanitation facilities at the study locations

Characteristic	Displacement centres, Mount Sinabung	Abucay Bunkhouse, Typhoon Haiyan
Type(s) of latrine	Typically pour-flush to septic tank but designs varied between and within centres	Pour-flush latrine connected to a septic tank
Design life	Temporary and permanent	Temporary
Sharing	Communal, some with gender separation	Four to five households per latrine
Maintaining cleanliness	Everyone at the displacement centre	Each household responsible for their own latrine

Sinabung displacement centres: Latrines were donated by organisations such as the Department for Public Works (Dinas Pekerjaan Umum) and PT Angkasa Pura. The National Disaster Management Agency (Badan Nasional Penanggulangan Bencana) collected and allocated the latrines to different centres (Figure V.10).

Figure V.10. Examples of latrines at the Sinabung displacement centres (Source: Author, March 2014)

Although the latrines were pour-flush, their designs varied in type, construction material and superstructure between and even within displacement centres. All the latrine facilities were communal, but ten centres had separate male and female latrines.

Each displacement centre had a centre coordinator (koordinator posko) and residents' coordinator (koordinator warga) responsible for the facilities and people respectively. In theory, the centre and residents' coordinator cooperated in matters related to logistics, maintenance, cleanliness, and so on.

Abucay Bunkhouse: As they arrived at the bunkhouse, families were asked by the camp manager to share one latrine among four to five households. Because the bunkhouse was constructed by the government, there was only one design of latrine. The design comprised a toilet bowl enclosed by a timber frame and metal sheeting (Figure V.11). Latrines were built in rows of four with an additional bathing cubicle at either end. Each of the two blocks of latrines was connected to a septic tank.

Although households were responsible only for the maintenance of their own latrine, Abucay Bunkhouse had also established a WASH committee comprised of

residents to lead and organise the other residents on issues related to WASH, including sanitation. Samaritan's Purse, an NGO, was supporting the bunkhouse on WASH-related matters by providing cleaning materials, repairing latrines and so on. A camp manager (from the local government) and IDP leader (from the bunkhouse) dealt with general matters.

Figure V.11. Latrines at Abucay Bunkhouse (Source: Author, April 2015)

V.3.2.2 Respondent profile

Respondents to the questionnaire comprised 150 IDPs affected by the Mount Sinabung volcano eruption and temporarily staying at 13 of the 18 displacement centres that existed in September 2014 as well as 126 IDPs affected by Typhoon Haiyan and temporarily staying at Abucay Bunkhouse as of March 2015 (Figure V.12).

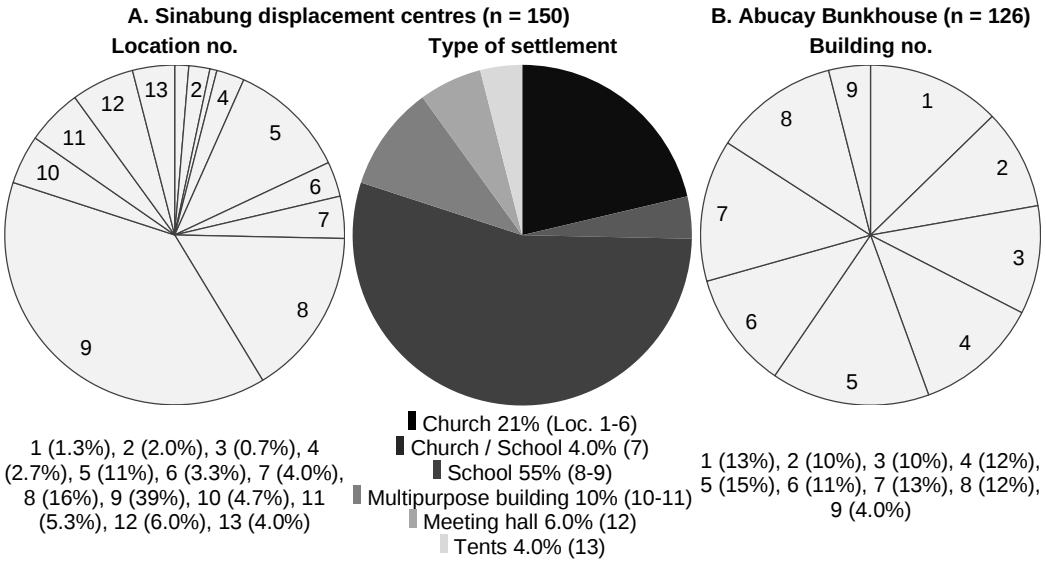


Figure V.12. Location profile of survey respondents

Sinabung displacement centres: Most of the IDPs were staying in public buildings, particularly in churches and schools. Churches and schools comprised 9 of the 13 locations studied. One location (no. 13: Gudang Jagung Konco) was a tented settlement. The displacement centres that were studied sheltered 103 – 1,594 people (average population per centre = 518). 0.38% – 3.6% of the population in each location was surveyed. The researcher sampled whoever was at the displacement centre when she visited.

93% of the families surveyed worked in the agricultural sector (Figure V.13: Farm owner or farm worker). Because many men worked in the fields and only returned to the displacement centre late at night or once a week, few men were at the centre during the survey. Hence, most of the respondents were female (71%). 0 – 1.7% of the male and 0.9 – 3.1% of the female population at each centre were surveyed (based on available data from six centres).

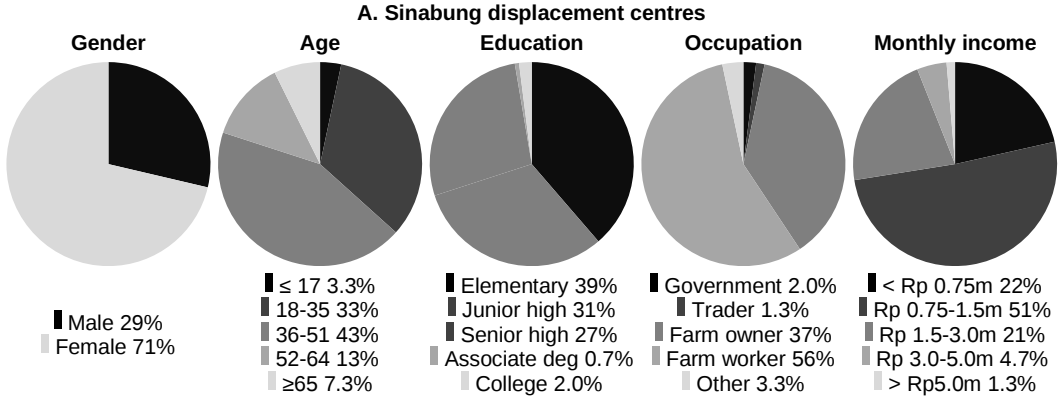


Figure V.13. Profile of survey respondents from the Sinabung displacement centres

Abucay Bunkhouse: The bunkhouse officially comprised 867 people and 200 families that stayed in nine buildings housing 34 – 113 people (mean = 90). 12% – 20% of the population in each building was surveyed. Although the situation was similar to the Sinabung displacement centres in that many men would only return to the bunkhouse at night or during the weekend, because the author was at the bunkhouse for two months, the author endeavoured to obtain a minimum number of responses from men. Therefore, the male-female ratio was more balanced

(Figure V.14: 46% male vs. 54% female). 20% of the male population and 22% of the female population were surveyed.

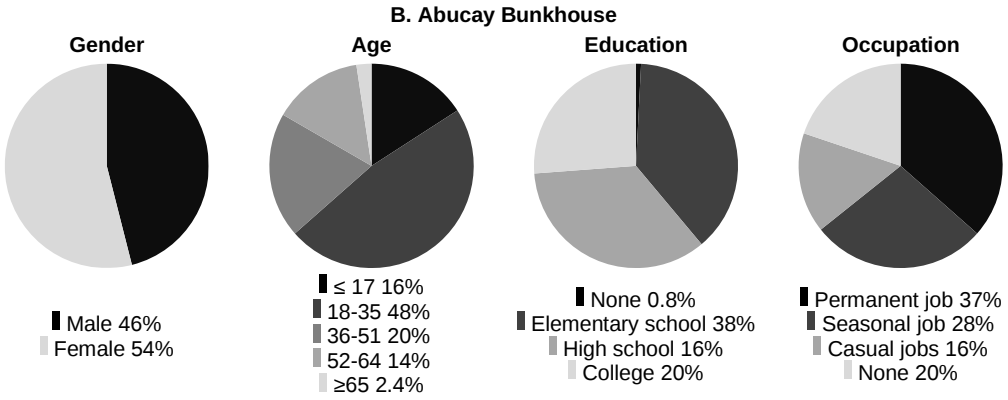


Figure V.14. Profile of survey respondents from Abucay Bunkhouse

Access to sanitation prior to disaster

The most significant difference between the sanitation behaviour of the respondents from the two study locations prior to the respective disasters was that 89% of respondents from the Sinabung displacement centres used squatting toilets compared to 48% of respondents from Abucay Bunkhouse (Figure V.15 vs. Figure V.16). Only one respondent from the displacement centres had a sitting toilet while 52% of respondents from the bunkhouse used a toilet bowl. 13% of respondents from the centres open defecated into the bush or river while 47% of respondents from the bunkhouse open defecated into the sea.

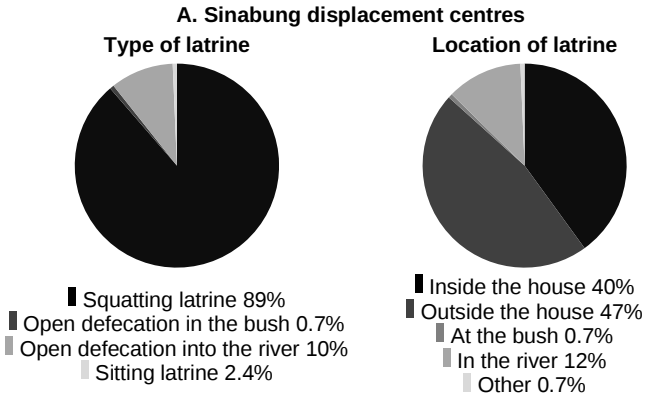


Figure V.15. Respondents' access to sanitation before the Mount Sinabung volcano eruption

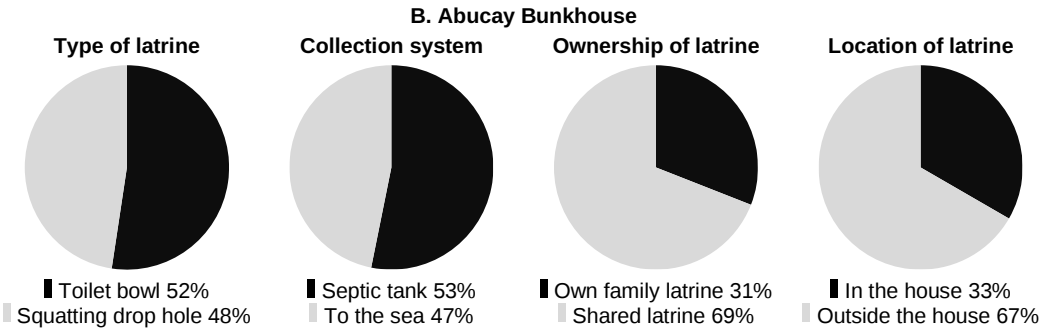


Figure V.16. Respondents' access to sanitation before Typhoon Haiyan

From the Sinabung displacement centres, 52% of farm owners had a latrine inside their house while only 27% of farm workers had a latrine inside the house, suggesting a disparity in sanitation access between high and low levels of income.

V.3.2.3 Findings

First, this subsection describes and compares the sanitation conditions at the two study locations, further exploring issues that may have impacted the sanitation conditions. Second, the subsection identifies factors that are significantly correlated with end user satisfaction and goes on to suggest how end user satisfaction may be maximised.

Sanitation conditions

Sanitation conditions were evaluated based on 17 indicators. The type of data collected for each indicator varied depending on the type of indicator but the typically involved end users responding to a question on a Likert-type scale. The responses were coded as indicating that a sanitation condition was: very unsatisfactory (-2), unsatisfactory (-1), neutral (0), satisfactory (+1) and very satisfactory (+2). The Wilcoxon rank sum test was used to determine, to a 5% significance, whether the indicators between the two locations differed in a statistically significant manner.

Indicators considered in the study (Figure V.17) included coverage of latrines per person, frequency of queues, distance between the dwelling and the latrine,

durability of the latrine, space inside the latrine, availability of water, water storage and dippers, availability of soap, perception of safety, cleanliness of the latrine, presence of odour and flies, and so on.

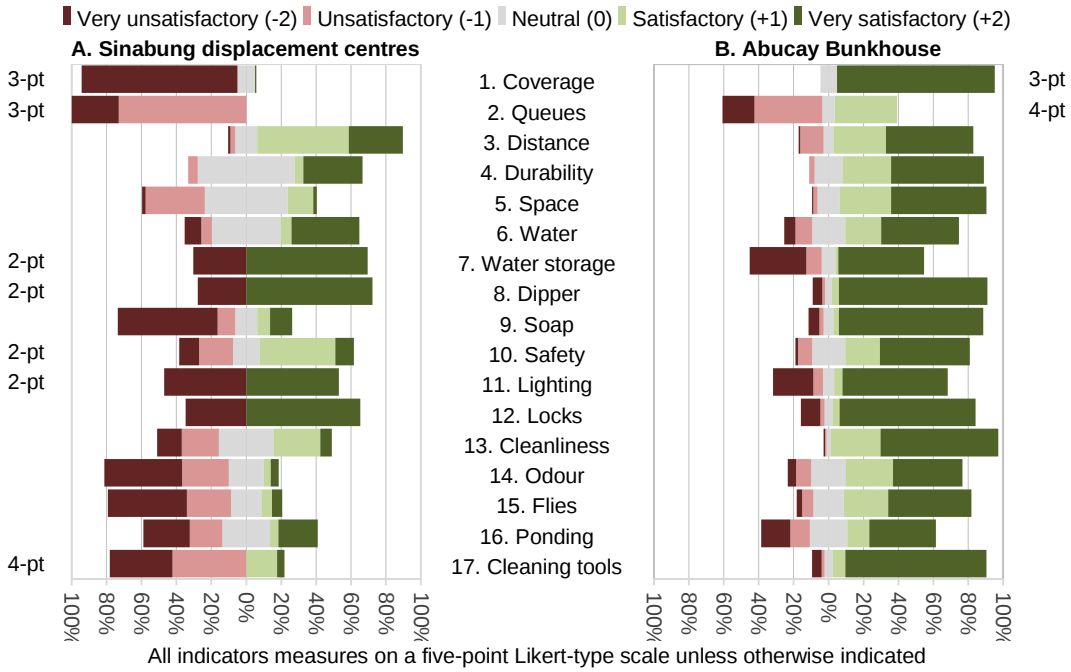


Figure V.17. Overview of sanitation conditions at the two study locations

Sanitation conditions appear to have been more satisfactory at Abucay Bunkhouse, with the exception of the frequency of queues (Table V.14, no. 2) and the availability of containers to store water (no. 7.). For distance (no. 3), availability of water (no. 6) and lighting (no. 11), there was no significant difference in conditions between the two study locations.

The remained of the subsection explores the indicators in greater detail. The Spearman's correlation (ρ) was used to determine, at 5% significance level, whether there were any statistically significant correlations between related variables for each study location.

Coverage and frequency of queues: Coverage of latrines at the Sinabung displacement centres ranged from 1:15 to 1:218. Only one of the thirteen

displacement centres met the Sphere standard of one latrine for a maximum of 20 people (Table V.15). In contrast, Abucay Bunkhouse had, officially, 52 latrines for its 867 residents – an overall coverage of 1:17. In reality, respondents estimated that between one and thirty people (up to nine families) used their household latrine. The low numbers could be due to the fact that many households had family members that did not actually stay at the bunkhouse, while the high numbers could be attributed to some latrines being shared with other households.

Table V.14 Overview of sanitation conditions at the two study locations

	A. Sinabung displacement centres					B. Abucay Bunkhouse						
	NS	S	1Q	M	3Q	NS	S	1Q	M	3Q	Better conditions	*p*
1. Coverage	89%	0.7%	-2	-2	-2	-	90%	+2	+2	+2	B	$\underline{2\times10^{-16}}$
2. Frequency of queues	17%	83%	+2	+2	+2	57%	43%	-1	0	+2	A	$\underline{9\times10^{-12}}$
3. Distance	4.0%	83%	+1	+1	+2	14%	80%	+1	+1.5	+2	-	0.057
4. Durability	5.6%	39%	0	0	+2	3.2%	81%	+1	+2	+2	B	$\underline{2\times10^{-7}}$
5. Space	36%	17%	-1	0	0	3.2%	84%	+1	+2	+2	B	$\underline{2\times10^{-7}}$
6. Availability of water	15%	45%	0	0	+2	16%	65%	0	+1	+2	-	0.072
7. Water storage	30%	70%	-2	+2	+2	41%	51%	-2	+1	+2	A	$\underline{2\times10^{-3}}$
8. Dipper	28%	72%	-2	+2	+2	7.1%	89%	+2	+2	+2	B	$\underline{6\times10^{-3}}$
9. Soap	67%	20%	-2	-2	0	8.7%	86%	+2	+2	+2	B	$\underline{2\times10^{-16}}$
10. Safety	31%	54%	-1	+1	+1	10%	71%	0	+2	+2	B	$\underline{3\times10^{-10}}$
11. Lighting	47%	53%	-2	+2	+2	29%	65%	-1	+2	+2	-	0.12
12. Locks	35%	65%	-2	+2	+2	13%	82%	+2	+2	+2	B	$\underline{0.012}$
13. Cleanliness	35%	33%	-1	0	+1	1.6%	96%	+1	+2	+2	B	$\underline{2\times10^{-16}}$
14. Odour	71%	8.7%	-2	-1	0	13%	67%	0	+1	+2	B	$\underline{2\times10^{-16}}$
15. Flies	71%	12%	-2	-1	0	10%	73%	0	+1	+2	B	$\underline{2\times10^{-16}}$
16. Ponding	45%	27%	-2	0	+1	28%	51%	-1	+1	+2	B	$\underline{3\times10^{-4}}$
17. Cleaning tools	78%	22%	-2	-1	-1	7.1%	88%	+2	+2	+2	B	$\underline{2\times10^{-16}}$

NS = % of responses that indicated very unsatisfactory or unsatisfactory conditions; S = % of responses that indicated very satisfactory or satisfactory responses; 1Q = 1st quartile; M = Median; 3Q = 3rd quartile; Better conditions = Which location has better conditions for that indicator based on the Wilcoxon rank sum test (based on *p*); *p* = two-tail Wilcoxon rank sum test for difference in mean ranks between the two locations. If $p < 0.05$, one location has better conditions for that indicator than the other location. The direction of the difference is determined from the descriptive statistics; Statistically significant values are underlined

Although coverage of latrines was much lower at the Sinabung displacement centres, only 17% of respondents experienced queues once or more per day compared to 57% of respondents at Abucay Bunkhouse (Table V.14 no. 2: column NS). These respondents were from centres 5, 8, 11 and 13. There was no statistically significant correlation between coverage and the frequency of queues

(Figure V.18A: p = 0.52) which at the bunkhouse is weak but statistically significant (B: ρ = -0.27, p = 2×10-3).

Table V.15 Coverage of latrines at the Sinabung displacement centres

Centre	10	2	5	8	6	7	9	13	11	4	1	12	3
IDPs	655	782	697	706	219	462	1,594	542	328	199	189	264	103
Latrines	3	4	4	5	2	5	23	8	6	4	4	6	7
- Male-Female	2-1	NA	2-2	1-4	NA	NA	9-14	4-4	3-3	2-2	2-2	3-3	3-4
Coverage	1:218	1:195	1:174	1:141	1:109	1:92	1:69	1:68	1:55	1:50	1:47	1:44	1:15
- Male	1:160	NA	ND	1:352	NA	NA	1:87	1:64	ND	1:54	ND	1:43	ND
- Female	1:347	NA	ND	1:90	NA	NA	1:58	1:72	ND	1:46	ND	1:45	ND

In order of increasing coverage; NA = not applicable; ND = no data

One explanation could be that, at the Sinabung displacement centres, residents could use alternative latrines if the one they normally used was occupied, either a latrine for males or a latrine at a nearby building. At Abucay Bunkhouse, residents could only use their own latrine. In addition, residents did not use their latrine to solely for urination and defecation, meaning that their latrine was often occupied. Respondents also used their latrine to bathe (79%), brush their teeth (37%), do laundry (27%), dry clothes (10%) and wash dishes (5%).

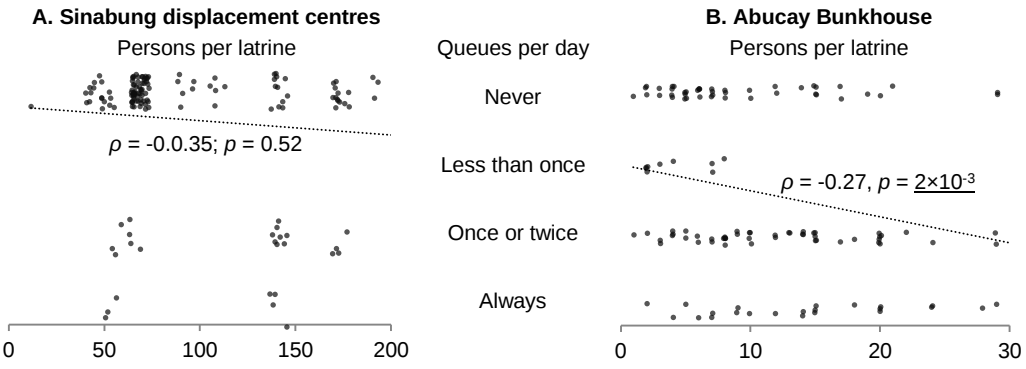
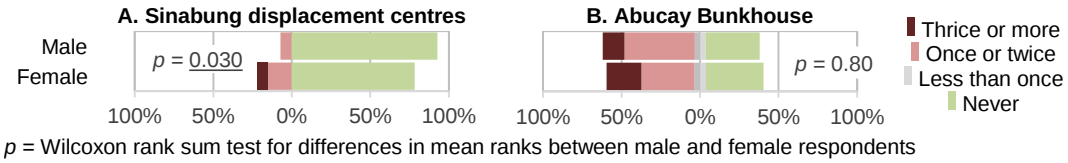


Figure V.18. Frequency of queues vs. coverage at both study locations

At the Sinabung displacement centres, female respondents experienced more queues than male respondents (Figure V.19A: p = 0.030). This could be due to the incorrect proportion of male-female latrines, which should be 1:3 according to the Sphere standards. However, only one centre met this standard (Table V.15 no. 8).



p = Wilcoxon rank sum test for differences in mean ranks between male and female respondents

Figure V.19. Frequency of queues experienced by male and female respondents

Distance: The Sphere standards recommend that latrines should be no more than 50 m away from dwellings. At the Sinabung displacement centres, 95% of survey respondents used latrines that met the Sphere standard (although it should be noted that the data was based on self-reported by the respondents, which may not be accurate) (Figure V.20i). At Abucay Bunkhouse, while only 46% of respondents used latrines that met this criteria (based on the actual time taken to walk from the dwelling to the latrine, assuming that walking speed is 0.8 m/s), a greater proportion (80%) felt that their latrine was close or very close. Among survey respondents from bunkhouse, there was no significant correlation between the perceived time taken for the respondent to walk from their dwelling to the latrine and whether the respondent felt that the latrine was close or not (ii: p = 0.26).

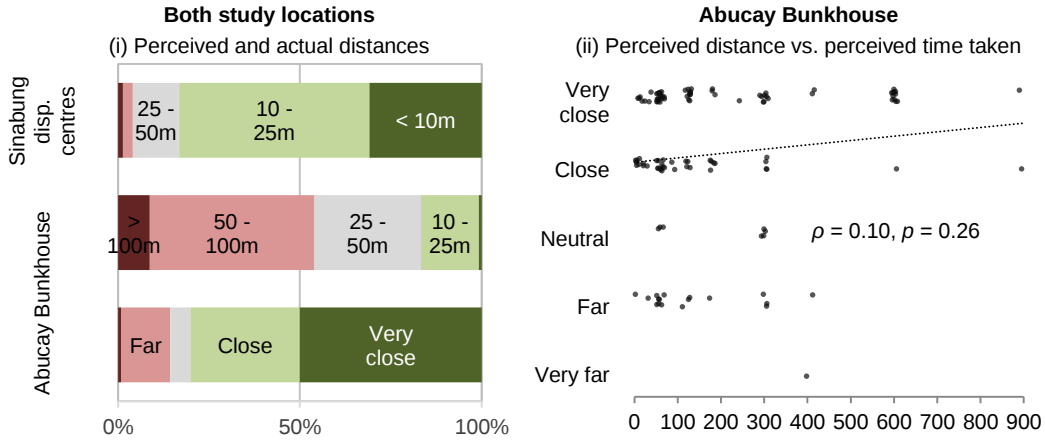


Figure V.20. Actual and perceived distances from the dwelling to latrine

The results suggest that there are other factors that influence end user opinions on distance. Further research is recommended to identify these factors and understand them in greater depth.

Durability: At the Sinabung displacement centres, only 5.4% and 8.2% of respondents had latrines with tarpaulin as their wall and door respectively. Other materials that were used at the displacement centres were wood and zinc, plastic as well as cement and brick, which were considered durable for the purposes of this survey. There are no standards prescribing the type of materials considered sufficiently durable for emergency situations. At Abucay Bunkhouse, all the latrines were made using timber for the frame and metal sheeting for the superstructure and roof. 81% of respondents agreed or strongly agreed that their latrine was durable (Table V.14 no. 4: B column S). 95% and 94% of respondents from the displacement centres and the bunkhouse respectively thought that durability was an important or very important factor.

Space: The Sphere standards do not provide guidance on the dimensions of a latrine, although a typical latrine slab is 0.8 m wide × 1.2 m long (Oxfam GB, 2015). At the Sinabung displacement centres, dimensions varied according to the design. 36% of respondents felt that their latrines were cramped or very cramped while 17% felt that they were spacious or very spacious. 47% were neutral (Table V.14 no. 5: A columns NS and S).

At Abucay Bunkhouse, latrines were approximately 1.3 m wide × 1.4 m deep × 1.8 m high (to the top of the wall not including the roof). 22% of respondents had even made their latrines twice as wide by tearing down the wall between the latrine and bathing cubicle (Figure V.21).

Figure V.21. Some families at Abucay Bunkhouse made their latrine bigger

Although there was no statistically significant correlation between respondents making their latrine bigger and whether they felt that it was spacious or cramped, none of the respondents who had a bigger latrine felt that it was cramped. Overall, it is no surprise that only 3.2% of respondents from the bunkhouse felt that their latrine was cramped or very cramped (Table V.14 no. 5: B column NS).

Water availability, storage and use: At both study locations, people almost exclusively used water for anal cleansing. All of the respondents at both locations used water in some way, while only five respondents from Abucay Bunkhouse used only toilet paper after urinating. Water was also required for flushing, handwashing and cleaning the latrines, although 19% of respondents from the Sinabung displacement centres and 5.6% of respondents from the bunkhouse admitted to not always flushing the latrine. At the bunkhouse, respondents used an average of 17.6 litres, and up to 70 litres, for cleansing, flushing and handwashing (Table V.16). This is higher than the 2 – 6 litres of water per person per day recommended by the Sphere standards for basic hygiene practices. Therefore, it is unsurprising that 15% and 85% of respondents from the Sinabung displacement centres as well as 20% and 78% from the bunkhouse felt that water was important and very important respectively.

Table V.16 Amount of water used for sanitation at both study locations

Dippers used (equivalent ℓ)	Flushing and handwashing	After urinating	After defecating	Flushing	Handwashing	Visits to latrine (previous day)	Water used
Range	0 – 20	0 – 10	1 – 10	0 – 20	1 – 10	0 – 10	0 – 140 (70ℓ)
Mean	8.0 (4.0ℓ)	2.5 (1.2ℓ)	3.8 (1.9ℓ)	8.8 (4.4ℓ)	2.6 (1.3ℓ)	2.5	35.2 (17.6ℓ)
Sample deviation	3.5	1.4	2.4	3.3	1.7	1.9	26.5

(1) Assumes that one dipper is 0.5ℓ; (2) Assumes that respondent defecated once and urinated for the remaining number of visits

At the Sinabung displacement centres, there were pre-existing but insufficient water supplies. Therefore, water trucks would deliver clean water every few days based on the location and population of the displacement centre. It was estimated that, at each centre, there was an average of 4.4 – 27.4 litres of clean water available to each person per day.

9.4% and 6.0% of respondents from the Sinabung displacement centres stated that water was never or rarely available respectively (Table V.14 no. 6: A column NS). Respondents who said that water was never or rarely available came only from two of the thirteen displacement centres survyed, suggesting that supply of water was uneven distributed. Nevertheless, interviews suggested that water was a more pressing issue that the survey results suggest. At GBKP Kota Kabanjahe, several persons did their laundry elsewhere because there was not even enough water available at the centre to clean themselves. In a tent settlement in Tiganderket district, residents collected water from irrigated plantations nearby to clean the latrines so that more clean water could be allocated for sanitation, bathing and washing.

At Abucay Bunkhouse, water was piped from a spring. Unfortunately, this was insufficient, especially during the study period because it was summer. The author observed very low inflow into the storage tanks. Therefore, it was not surprising that 26% of respondents also paid PHP 50 – 500 (USD 1.10 – 11.10) every month to neighbouring villagers to connect a private hose from the nearby stream. Some residents collected rainwater. The data indicates that there is a statistically significant correlation between the residents' source and availability of water (Figure V.22: p = 0.0.12). If clean water was not available, residents would just wait or go to the stream. Although only 16% of respondents stated that water was rarely or never available (Table V.14 no. 6: B column NS), interviews and observations indicated that residents spent a lot of time, money and effort to collect water.

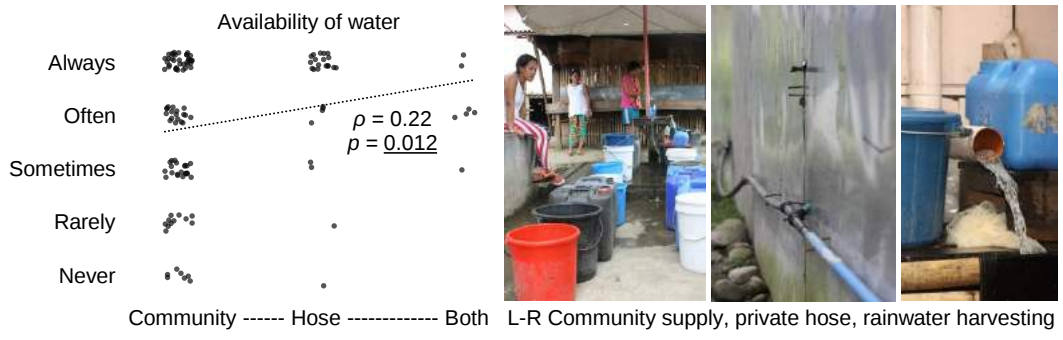


Figure V.22. Water source vs. availability of water at Abucay Bunkhouse

Data from both study locations clearly indicate that there is a statistically significant correlation between having containers to store water and the availability of water in latrines (Figure V.23). This is expected because having storage containers reduces the need for people to continuously collect water. For example, one Abucay Bunkhouse resident interviewed was considering buying another large drum so she could spend less time collecting water.

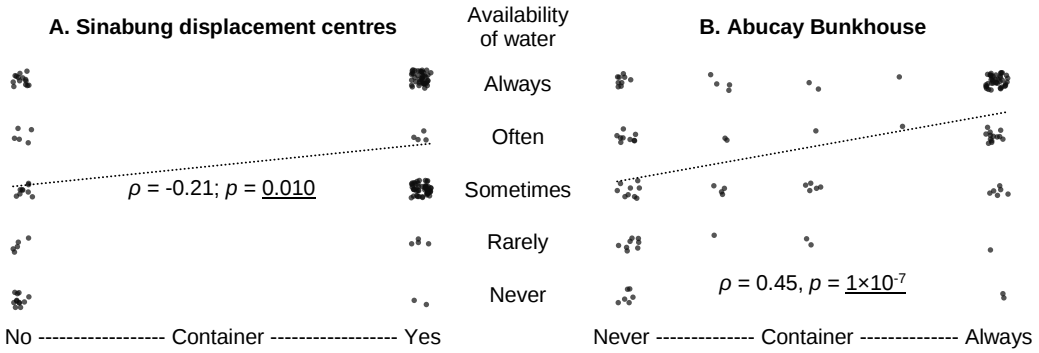


Figure V.23. Water storage vs. availability of water at both locations

Dippers were used for anal cleansing. At the Sinabung displacement centres, 28% of respondents used latrines without dippers. At Abucay Bunkhouse, only 7.1% of respondents' latrines never or rarely had dippers (Table V.14 no. 8: columns NS). Latrines with water storage were, unsurprisingly, more likely to have dippers (Figure V.24).

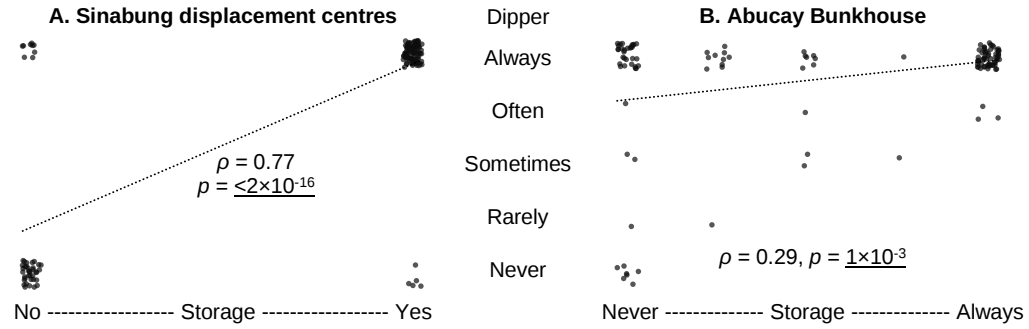


Figure V.24. Water storage vs. dippers of water at both locations

Soap: The Sphere standards state that users should have the means to wash their hands with soap (or an alternative) after using latrines. At the Sinabung

displacement centres, 67% of respondents rarely or never had soap, while at Abucay Bunkhouse, only 8.7% of respondents rarely or never had soap (Table V.14 no. 9: columns NS). At the same time, 98% and 97% of the respondents at the displacement centres and the bunkhouse respectively thought that soap was important or very important. One reason that the bunkhouse had more soap was that the supporting NGO provided such materials regularly. On the other hand, at the centres, soap was initially provided to the IDPs but after some time they were required to provide their own.

Safety and privacy: The Sphere standards state that women and girls should feel and are safe when using the latrines. At the Sinabung displacement centres, 31% of respondents felt unsafe or very unsafe. At Abucay Bunkhouse, only 10% of respondents felt unsafe or very unsafe (Table V.14 no. 10: columns NS). There was no statistically significant difference in mean ranks between male and female respondents at both study locations.

At both study locations, there was a statistically significant correlation between the distance (or perceived distance) from the dwelling to the latrine and safety (Figure V.25: $p = 2\times10^{-3}$ and $p = 6\times10^{-7}$ for the Sinabung displacement centres and Abucay Bunkhouse respectively). Lighting and locks also had a statistically significant correlation with safety at the displacement centres. At the centres, 47% and 35% of respondents respectively did not have lighting and locks at their latrines (Table V.14 no. 11 and 12: A column NS).

On the other hand, lighting and locks did not have a statistically significant correlation with safety at Abucay Bunkhouse, where 29% and 13% of respondents respectively rarely or never had lighting and locks at their latrines (B column NS). This suggests that the factors that impact safety may be complicated. For example, at the bunkhouse some respondents felt that the latrines were unsafe because the height of the wall was not completely covered, making it possible for someone to peek into the latrine. Other respondents were afraid of encountering snakes from the nearby forest. The protection committee that patrolled the bunkhouse at night

may have made the residents' feel safer. These were some factors raised that were not unrelated to distance, lighting or locks.

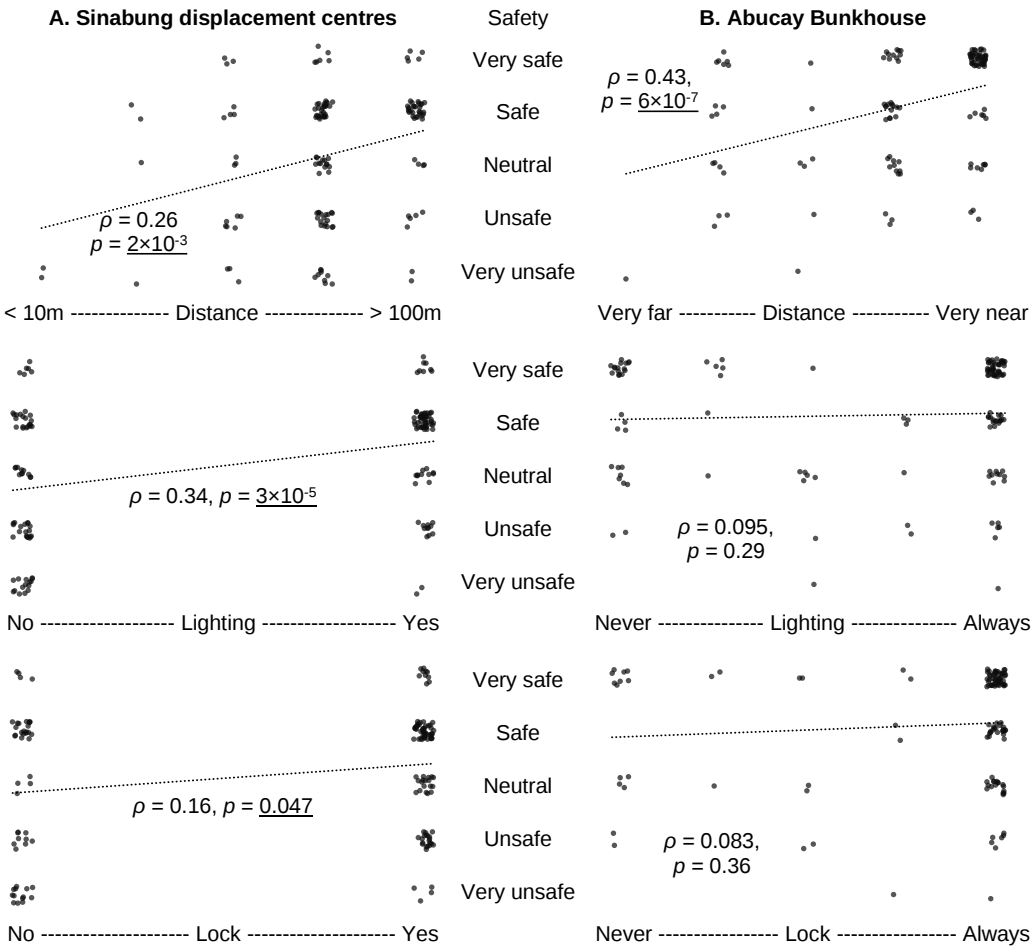


Figure V.25. Distance, lighting and locks vs. safety at both locations

Cleanliness: At the Sinabung displacement centres, only 33% of respondents felt that their latrines were clean or very clean (Table V.14 no. 13: A column S). The presence of odour, flies and ponding were also unsatisfactory, with 71%, 71% and 45% of respondents respectively stating that these issues were always or often present at the latrines (no. 14 – 16: columns NS). Observations at the centres showed that solid waste was strewn around the latrine cubicles, which could block drainage and lead to odour and ponding. At the displacement centres, all these three factors had statistically significant correlations with cleanliness (odour: ρ = 0.34, $p = 2\times10^{-5}$; flies: ρ = 0.31, $p = 1\times10^{-4}$; ponding: ρ = 0.40, $p = 3\times10^{-7}$).

At Abucay Bunkhouse, cleanliness was significantly better. 96% of respondents felt that their latrines were clean or very clean (Table V.14 no. 13: B column S). Interestingly, odour, flies and ponding did not have statistically significant correlations with cleanliness. One explanation could be that because families had ownership of their own latrines, they had adapted to the conditions of their latrines and were more accepting of any issues in cleanliness.

At the Sinabung displacement centres, there was a statistically significant correlation between the availability of cleaning tools and cleanliness (Figure V.26: $\rho = 0.39$, $p = 2\times10^{-6}$). Some residents interviewed felt that there was not enough water, hence brooms and other tools were needed. At Abucay Bunkhouse for example, in addition to water (98%), respondents used chlorine (92%), scrubs (87%), brooms (86%), detergent (65%), gloves (48%), soap (38%), cloth (15%) and plungers.

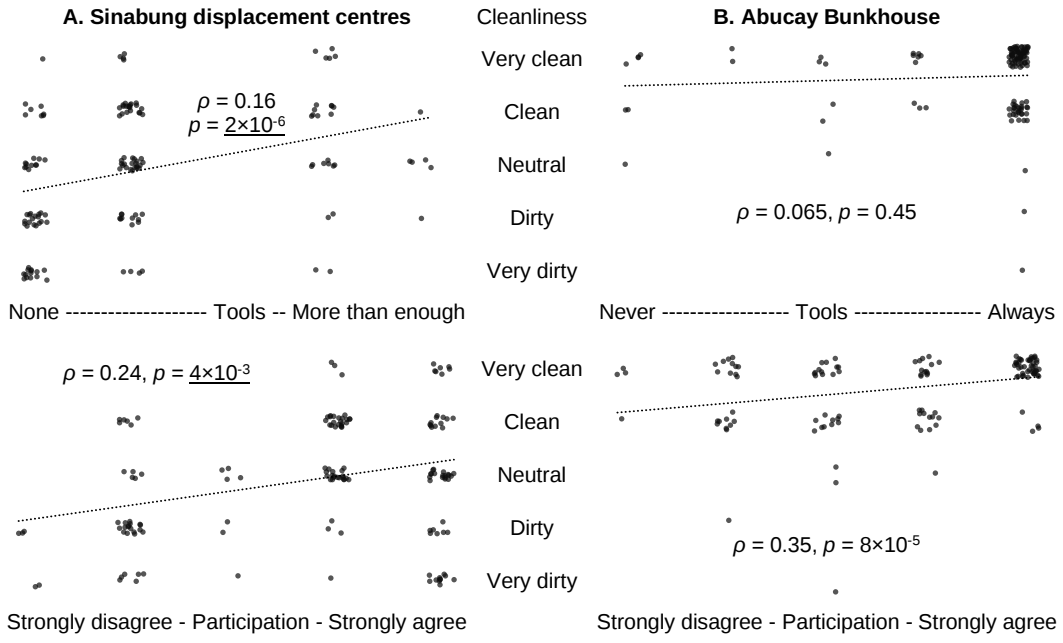


Figure V.26. Tools and participation in cleaning vs. cleanliness at both locations

At Abucay Bunkhouse, there was no statistically significant correlation between the availability of cleaning tools and cleanliness (Figure V.26: $p = 0.45$). This could be because the NGO regularly helped to provide cleaning materials,

therefore they were more regularly available. In addition, with families being responsible for specific latrines, there was a sense of ownership and impetus to invest in the necessary resources to keep their latrine clean. 66% and 40% of respondents even often or always had a container to throw rubbish and air fresheners respectively in their latrines. Therefore, availability of cleaning tools was not an issue at the bunkhouse.

At both study locations, there was a statistically significant correlation between participation in cleaning and cleanliness. At Abucay Bunkhouse, a few families had duty rosters. Other families had specific family members (typically the mother) who were responsible for cleaning. At the Sinabung displacement centres, 93% of respondents stated that everyone should help clean the latrines. At the bunkhouse, 87% of respondents agreed or strongly agreed with the aforementioned statement. However, only 70% and 37% of respondents at the centres and bunkhouse respectively agreed or strongly agreed that sanctions should be imposed on people who did not help to clean the latrines.

Factors affecting satisfaction towards sanitation facilities

There was greater satisfaction among respondents towards the sanitation facilities at Abucay Bunkhouse than at the Sinabung displacement centres (Figure V.27). 58% of respondents from the bunkhouse reported being satisfied or very satisfied with the facilities but only 27% of respondents from the displacement centres reported being satisfied or very satisfied.

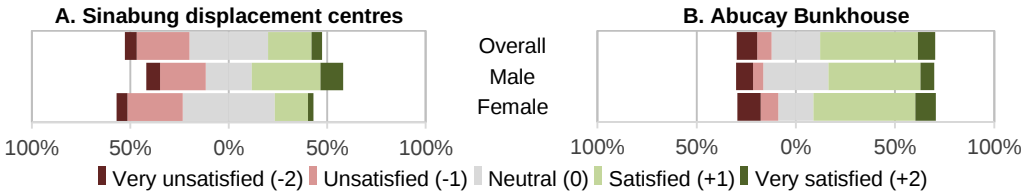


Figure V.27. Satisfaction towards sanitation facilities

Within the displacement centres, there was a statistically significant difference in satisfaction between male and female respondents (p = 0.036). 47% of male

respondents were satisfied or very satisfied with the facilities but only 20% of female respondents were satisfied or very satisfied. This suggests a greater need to improve female sanitation facilities at the centres.

Table V.17 Satisfaction towards sanitation facilities

	A. Sinabung displacement centres						B. Abucay Bunkhouse					
	NS	S	1Q	M	3Q	*p*	NS	S	1Q	M	3Q	*p*
Overall satisfaction	33%	27%	-1	0	+1	-	17%	58%	0	+1	+1	-
Among males	30%	47%	-1	0	+1	<u>0.036</u>	14%	53%	0	+1	+1	0.57
Among females	34%	20%	-1	0	0		21%	62%	0	+1	+1	

NS = % of respondents who were very unsatisfied or unsatisfied with the sanitation facilities; S = % of respondents who very satisfied or satisfied with the sanitation facilities; 1Q = 1st quartile; M = Median; 3Q = 3rd quartile; p = two-tail Wilcoxon rank sum test for difference in mean ranks between male and female respondents, if $p < 0.05$, males are more or less satisfied than females towards the sanitation facilities. The direction of the difference is determined from the descriptive statistics; Statistically significant values are <u>underlined</u>

The 17 indicators of sanitation conditions discussed previously were analysed for correlations with satisfaction, based on Spearman's correlation at 5% significance value.

At the Sinabung displacement centres, 15 of the 17 indicators had statistically significant correlations with satisfaction, the strongest being cleanliness (Table V.18 no. 13: $\rho = 0.51$), cleaning tools (no. 17: $\rho = 0.44$), odour (no. 14: $\rho = 0.41$) and lighting (no. 11: $\rho = 0.41$). This suggests that improvements to the latrines at the displacement centres should focus on improving cleanliness and providing lighting. At Abucay Bunkhouse, there were only two indicators that had statistically significantly correlations with satisfaction: flies (no. 15: $\rho = 0.59$) and lighting (no. 11: $\rho = 0.20$). However, not too much can be interpreted from these results because the homogeneity of the data makes it difficult for correlations to be detected.

Overall, none of the calculated correlations were strong or very strong. This suggests two possibilities. One, there are many factors that contribute to end user satisfaction. Two, the contribution of these factors to satisfaction differ from person to person.

Table V.18 Correlation of sanitation indicators with satisfaction

	Sinabung displacement centres				Abucay Bunkhouse			
	ρ	p	Classification	Rank	ρ	p	Classification	Rank
1. Coverage	0.28	5×10^{-4}	Weak	13	0.10	0.29	Very weak	8
2. Frequency of queues	-0.15	0.065	Very weak	16	0.12	0.20	Very weak	7
3. Distance	0.15	0.060	Very weak	16	6×10^{-3}	0.94	Very weak	17
4. Durability	0.31	2×10^{-4}	Weak	8	0.061	0.50	Very weak	13
5. Space	0.34	2×10^{-5}	Weak	6	0.021	0.82	Very weak	14
6. Availability of water	0.37	4×10^{-6}	Weak	5	0.087	0.33	Very weak	10
7. Water storage	0.28	5×10^{-4}	Weak	13	0.10	0.26	Very weak	8
8. Dipper	0.34	3×10^{-5}	Weak	6	0.077	0.39	Very weak	11
9. Soap	0.24	3×10^{-3}	Weak	15	0.16	0.065	Very weak	6
10. Safety	0.31	1×10^{-4}	Weak	8	0.17	0.055	Very weak	4
11. Lighting	0.41	3×10^{-7}	Moderate	3	0.20	0.023	Weak	3
12. Locks	0.31	1×10^{-4}	Weak	8	0.17	0.060	Very weak	4
13. Cleanliness	0.51	1×10^{-11}	Moderate	1	0.23	0.11	Weak	2
14. Odour	0.41	2×10^{-7}	Moderate	3	0.077	0.39	Very weak	11
15. Flies	0.31	1×10^{-4}	Weak	8	0.59	0.048	Moderate	1
16. Ponding	0.29	3×10^{-4}	Weak	12	-3×10^{-3}	0.95	Very weak	16
17. Cleaning tools	0.44	6×10^{-7}	Moderate	2	0.011	0.91	Very weak	15

ρ = Spearman's correlation; p-value = null hypothesis: $\rho = 0$; alternative hypothesis: $\rho \neq 0$; Rank = rank of the strongest correlations from highest to lowest ρ

V.3.2.4 Usefulness

The research on end users at the Sinabung displacement centres and Abucay Bunkhouse explored many issues that have yet to be investigated and published in the emergency sanitation literature. Many of these findings would be useful to suppliers and product developers, ranging from simple statistics on the amount of water used for sanitation to the key indicators that are correlated with end user satisfaction. The exploratory analysis provides a basis for investigating many of these factors in greater depth, such as the factors that contribute to safety and to determine causation rather than correlation between various factors. Comparing results from both study locations led to findings that would not have been identified if the studies had been conducted in isolation. The differences in the findings show that end users display different needs in different situations, and this highlights the importance of collecting data from different contexts. A better understanding of these factors would help suppliers and product developers design products that are more appropriate to end user needs. In conclusion, more and better data collection on end users would be very useful to product development.

V.3.3 Decision support tool for choosing a suitable product

Tools for selecting suitable emergency sanitation technologies exist. These are generally available as standards (i.e. the Sphere standards), technical briefs, technical books, decision trees and matrices (Zakaria et al., 2015). Akvo and WASTE (2015) are developing an online decision support tool. However, Zakaria et al. (2015) claim that the tool, at present, cannot be considered a complete system and therefore developed a computer-based DSS for selecting appropriate sanitation technologies during emergencies.

A decision support tool for choosing a suitable product as a means of promoting end products received a median usefulness of 'Somewhat large', which was significantly less useful than three other measures for promoting end products (Table V.5, 4c). The median ease of implementation was 'Somewhat easy' (Table V.6, 4c). Despite these less encouraging results, given that a decision support tool already exists, it was considered beneficial to understand its usefulness and ease of implementation. This was done by validating components of the DSS developed by Zakaria et al. (2015).

V.3.3.1 Overview of decision support system

The DSS was described in Zakaria et al. (2015). All information on the DSS is taken from the aforementioned reference. The DSS was developed by the authors to address the need for a system that considers the "complex scenarios commonly found in emergency settings". They assert that it is a "useful tool for selecting suitable sanitation... when an accurate decision has to be made in the shortest possible time". Sanitation options offered by the DSS are screened, built into a feasible sanitation chain and evaluated (Figure V.28). Each of the three stages will be explained in detail in the corresponding subsections.

V.3.3.2 Validation of decision support system

Each stage of the DSS process was validated: sanitation options offered by the DSS, screening criteria, compatibility matrix, and evaluation criteria (Figure V.28).

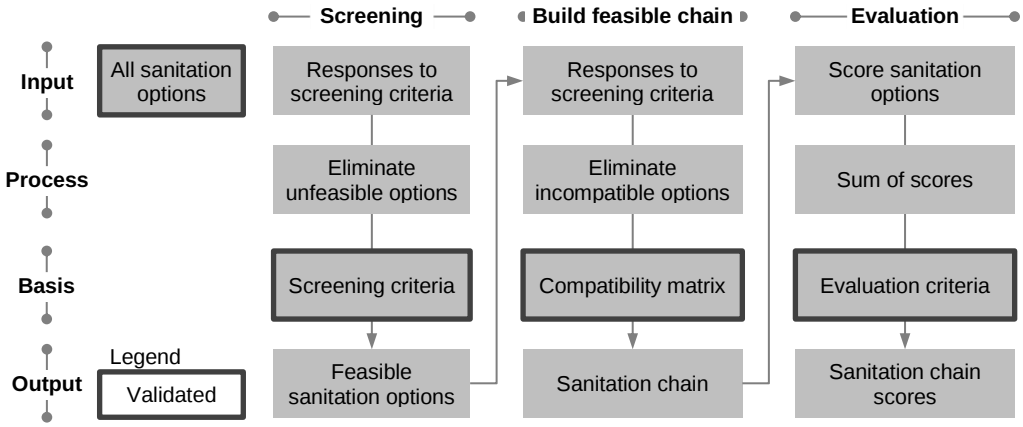


Diagram based on information from Zakaria et al. (2015) and author's own interpretation

Figure V.28. Decision support system process and components validated

Sanitation options

The DSS offers 49 sanitation options sorted into six stages (Table V.19). The developers selected these options based on proven technologies that had been used in emergencies or had the potential to be used. Technology definitions were mostly based on Tilley et al. (2014) but others were taken from humanitarian agency reports.

Comparison with case study findings: Sanitation options identified from the individual case study reports that were summarized in Subsection V.3.1.2 were compared to those in the DSS and compiled into 11 recommendations (Table V.20). The recommendations were generally related to ambiguity in the definitions of the sanitation options and scope for improving the advice provided by the DSS.

One challenge faced during the validation process was that many options offered by the DSS, particularly for treatment and disposal and reuse, were not found in the case studies. There is no evidence on the use of many of the options documented in the literature. At the same time, no details were provided by the DSS on why these unproven options would be suitable for emergencies. Thus, the author was unable to evaluate the developer's decision to include or exclude a particular option.

Table V.19 Sanitation options offered by decision support system

Component	Options
1. User interface	101: No user interface; 102: drop hole; 103: pour flush; 104: urine diversion, and; 105: urinal
2. Collection	201: Biodegradable bags; 202: buckets; 203: controlled open defecation; 204: shallow trench latrines; 205: deep trench latrines; 206: borehole latrines; 207: simple pit latrines; 208: ventilated improved pit latrines; 209: arborloo; 210: fossa alterna; 211: porta preta; 212: septic tank; 213: aerobic filtration; 214: anaerobic batch reactor; 215: aqua privies; 216: urine diversion dehydrated toilet; 217: urine diversion toilet; 218: floating latrines; 219: raised latrines; 220: urine jerrycan storage, and; 221: chemical toilet
3. Conveyance	301: No emptying / collection and transport; 302: human powered emptying / collection and transport; 303: human powered emptying / collection and motorised transport; 304: motorised emptying and manual transport; 305: motorised emptying and transport, and; 306: sewerage
4. Semi-centralised 1	401: No treatment; 402: co-composting; 403: planted drying beds; 404: unplanted drying beds; 405: sedimentation / thickening; 406: waste stabilisation pond, and; 407: surface flow constructed wetlands
5. Semi-centralised 2	501: No treatment; 502: trickling filters; 503: upflow anaerobic sludge blanket; 504: membrane bioreactor, and 505: conventional activated sludge
6. Disposal and reuse	601: Urine fertilizer; 602: sludge / dried faecal matter fertilizer; 603: burying / fill and cover onsite; 604: burying / fill cover offsite, and; 605: surface disposal / open dumping

Underlined options were those eliminated during screening for the test case

Table V.20 Recommendations on sanitation options

Recommendation	Supporting data from case studies or author's observation
1. Chemical toilet: Clarify whether they must include the use of chemicals	"Chemical toilets (with or without chemicals)"
2. Biodegradable bags: Expand to bag systems in general	"Locally available bags (grocery size)"
3. Disposal and reuse – missing sanitation option: Biogas	"Biogas toilets"
4. Include superstructure options	"Frame and plastic sheeting around the outside", "make-shift structures for privacy out of recycled materials", etc.
5. Incorporate the need to line pits	"Pits needed to be lined to prevent collapse", etc.
6. Incorporate strategic recommendations e.g. household versus communal approaches	"Block latrines", "communal latrines / toilets", "community toilet blocks / toilets / latrines", "public latrines" versus "family / household latrines / toilets"
7. Include rehabilitation as a strategic option	"In areas where latrine slabs remain, relief agencies would clean the septic tanks, pipes, and squat plates and will make minor repairs to latrines"
8. Incorporate solutions for vulnerable groups	"Latrines for persons with disabilities, including a folding seat and a ramp", "latrines with steps and handles to increase accessibility"
9. Explain how sanitation options can be realised	"Community latrines over a canal, with excreta channelled into pits"
10. Include available products within the options	"Mass sanitation module"
11. Include alternative and local names	"Barrel latrine", "Bayacou system of toilet clearance", "cesspits", etc.

Screening criteria

The DSS uses 13 screening criteria and 32 possible responses to those criteria to eliminate unfeasible sanitation options (Table V.21). The responses are input against the screening criteria and unfeasible options are made unavailable (highlighted in dark red) by the DSS (Figure V.29). In their paper, the developers list the options that are screened out by each response (Zakaria et al., 2015: Table 3) but do not explain how the criteria were identified, selected and defined. Thus, the author was unable to evaluate the options that are screened out by each response.

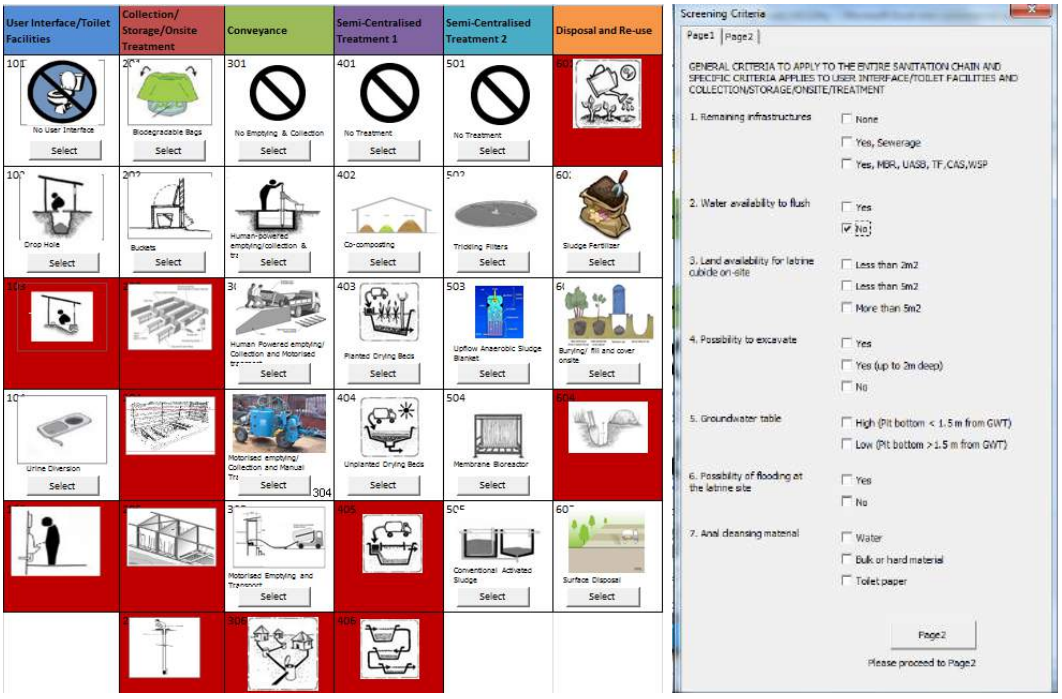
Table V.21 Screening criteria and corresponding response options

Screening criteria	Options
Remaining infrastructure	None; Yes: sewerage; Yes: MBR, UASB, TF, CAS, WSP
Water availability to flush	Yes; No
Land availability for latrine cubicle on-site	Less than 2 m^2; Less than 5 m^2; More than 5 m^2
Possibility to excavate	Yes; Yes (up to 2 m deep); No
Groundwater table (GWT)	High (pit bottom < 1.5 m from GWT); Low (pit bottom > 1.5 m from GWT)
Possibly of flooding at the latrine site	Yes; No
Anal cleansing material	Water; Bulky or hard material; Toilet paper
Accessibility to collection site by 4W vehicle	Yes; No
Type of waste stream (after collection)	Excreta; Blackwater; Urine
Energy availability to power desludging, transport and treatment	Yes; No fuel; No electricity; None
Land availability for off-site treatment	Less than 20 m^2; More than 20 m^2
Possibility to excavate at disposal site	Yes; No
Is land application / open dumping an option for final disposal (environmentally safe and permitted by local authority)?	Yes; No

Underlined options were those used for the test case

Comparison with case study findings: Design criteria identified from the case studies was compared to the screening criteria and compiled into 21 recommendations (Table V.22). In general, the recommendations relate to ambiguous or missing screening criteria. This raises some concerns as to the reliability of the screening process. Ambiguous screening criteria may lead to incorrect responses being input into the program, resulting in feasible options

being wrongly excluded or unfeasible options wrongly included. Missing screening criteria may result in unfeasible options being included. Ultimately, an incorrect set of sanitation options may be offered by the DSS and subsequently chosen by the user.



Unfeasible options are made unavailable and highlight in red

Figure V.29. Screening process

Results from test case: Data from the 2004 Indian Ocean earthquake and tsunami case study report (which summarised in Table V.11) was used as a basis for inputting responses to the screening criteria for the test case (Table V.21). Of the 49 sanitation options that were offered by the DSS, ten were screened out: one from user interface / toilet facilities, seven from collection / storage / on-site treatment, one from semi-centralised treatment 1, and one from disposal and reuse (Table V.19).

Compatibility chain

After screening, the user proceeds to build a sanitation feasible chain (Figure V.30).

Table V.22 Recommendations on screening criteria

Recommendation	Supporting data from case studies or author's observation
1. Remaining infrastructure: Must the infrastructure be in full working condition?	Damage to infrastructure is often partial and / or repairable e.g. " sewage disposal pipes choked or damaged"
2. Remaining infrastructure: Does sewerage refer to household systems in addition to centralised systems?	Repair of household systems can also form part of the emergency response
3. Remaining infrastructure: Incorporate capacity of remaining infrastructure	The capacity of the infrastructure from the conveyance component onwards will affect whether it is feasible
4. Land availability for latrine cubicle on-site: Is this per latrine or per person and is this for the settlement or only the area allocated to sanitation?	The criteria is ambiguous
5. Possibility to excavate: Is it in reference to soil type, groundwater table, permission to excavate, or all of the above?	Possibility to excavate can be due to a number of factors e.g. "groundwater table high therefore digging pits was a problem", "lack of authorization for digging pits", etc.
6. Groundwater table: Change to depth from earth surface rather than depth of pit bottom	Planners might not know depth of "pit bottom". It also partly depends on sanitation option chosen.
7. Anal cleansing material: Does this refer to availability or what the population uses?	The criteria is ambiguous
8. Type of waste stream (after collection): Remove and incorporate as part of "build sanitation chain"	The type of waste stream after collection depends on the user interface and collection options selected
9. Incorporate solid waste management practices into screening of conveyance options	Solid waste affects use of desludging trucks e.g. "people threw other waste into the pit latrines so desludging trucks could not suck slurry out"
10. Incorporate institutional issues and stakeholder preferences	Options may be rejected by institutions or end user needs e.g. "government did not want to allow a sense of permanence"
11. Incorporate design life rather than at evaluation	Longer-term options may be needed or expected e.g. "people planning to stay in settlements longer than expected"
12. Prioritise the rehabilitation or use of existing latrines when screening	DSS has an implicit bias towards new construction. However, there were many examples of existing latrines being used.
13. Incorporate privacy needs or clarify scope of sanitation options in terms of technology choice but not detailed design	Privacy issues exclude certain options or make certain design features necessary e.g. "women wanted roofs on latrines", etc.
14. Incorporate need for durability	Non-durable options may be unfeasible for the context e.g. "strong winds led to reinforcement of structures"
15. Incorporate land availability into screening of disposal options	Lack of land prevents certain disposal options from being feasible e.g. "lack of available landfill sites"
16. Incorporate logistical considerations	Some options difficult logistically, e.g. "lack of basic hand tools / shovels main obstacle to digging new latrines", etc.
17. Incorporate cost (rather than at scoring stage)	Some options financially unfeasible e.g. "difficult to pay for the operational costs of the gully suckers"
18. Incorporate displacement dynamics	Some options unfeasible due to people moving e.g. "possibility of people being relocated, therefore light superstructures used"
19. Explain how to use DSS for varying local contexts	Situations may vary locally in terms of collection / storage, but be centralised from the conveyance system onwards
20. Explain the acronyms (MBR, UASB, TF, etc.)	Users may not be familiar with the acronyms

An available sanitation option can be selected from any component of the sanitation chain. As the user selects from available options, incompatible options are made unavailable. At the end of the process, a feasible chain is formed (Figure V.30i). A feasible sanitation chain is based on a binary code matrix defining whether one option is compatible with another (ii). This matrix was determined by the developers based on the literature as well as their personal interpretation.

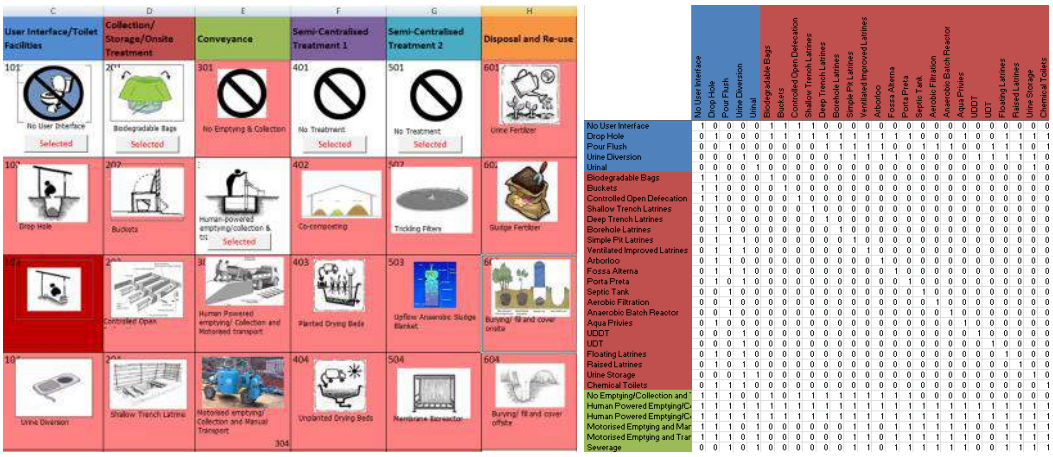


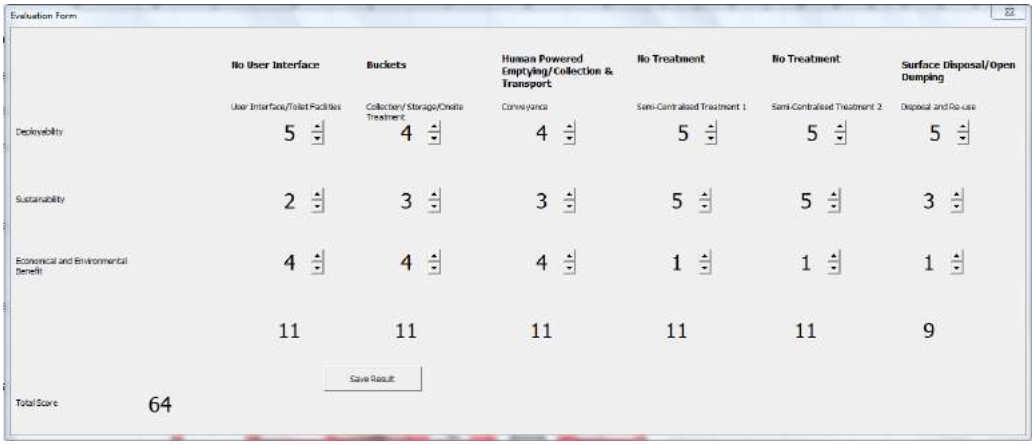
Figure V.30. (i) Building a sanitation chain (ii) Binary code matrix

Verification of compatibility chain logic: There are only two logical combinations of binary codes defining the compatibility of two options (Table III.4). Incorrect combinations lead to all options in one component of the chain being unfeasible, making it impossible to build a chain. Therefore, the first step verified whether the combinations in the matrix were correct. This step identified 131 incorrect combinations out of 2,401 total combinations, equivalent to a 5.5% error rate. Incorrect combinations were corrected based on the author's personal judgement.

Results from test case: After screening, there were 39 remaining options, from which 1,981 feasible sanitation chains could be built.

Evaluation criteria

After building one sanitation chain, the user proceeds to evaluate each option in the chain according to three categories (Figure V.31).



The minimum and maximum scores per category are zero and five respectively

Figure V.31. Evaluation of one of the sanitation chains from the test case

The criteria considered by the DSS deployability, sustainability, and economic and environmental sustainability. Each criteria has sub-criteria. For example, deployability includes: the time taken to deploy the option to the desired location; the use of local material, and; the need for special equipment and technical skill. The DSS provides a guide that helps users score each criteria (Table V.23).

Results from test case: Each option was scored based on data from the case study. If data from the case study was unavailable, the author's personal judgement of the local context was used (Figure V.32).

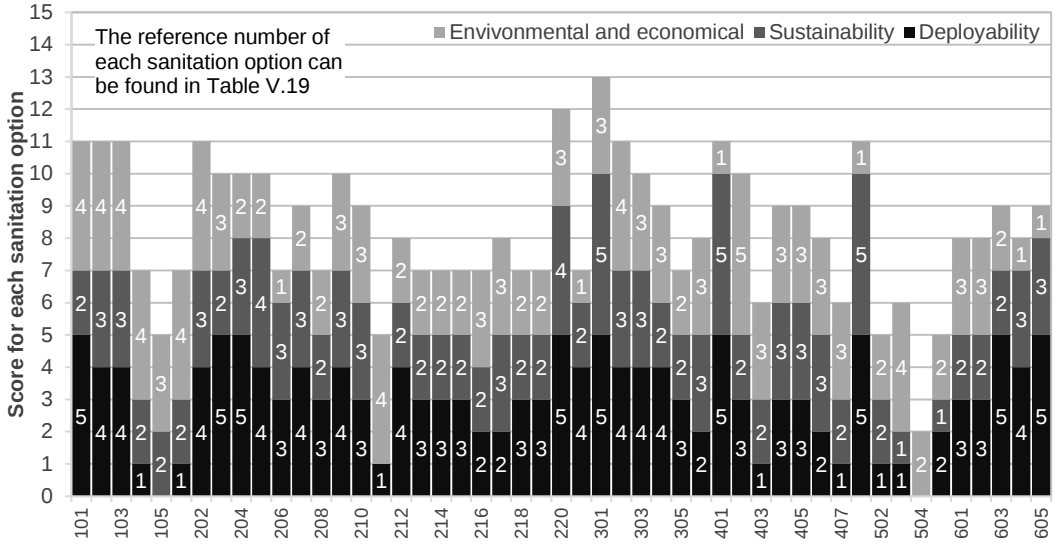


Figure V.32. Scoring of each sanitation option for test case

Table V.23 Scoring guide for evaluation criteria

	Deployability	Sustainability	Economic and environmental sustainability
0	• It takes a very long time and process to avail the option at the desired location • The option does not use local material • The option requires special equipment and technical skill to avail	• It is impossible to upgrade the option • The option has a very short life span. It continuously needs replacement and services. • The option is very complicated to operate and maintain	• The option is very costly to avail • The option benefits very few people • The option has negative environmental impact • There is no possibility of by-product reuse
1	• It takes quite a long time and process to avail the option at the desired location • The option uses almost no local material • The option requires a high degree of technical complexity (special equipment and technical complexities)	• It is remotely possible to upgrade the option • The option has a short life span. It continuously needs replacement and services. • The option is very complicated to operate and maintain	• The option is costly to avail • The option benefits few people • The option has negative environmental impact • There is limited possibility of by-product reuse
2	• It takes some time and process to avail the option at the desired location • The option uses little local material • The option requires some degree of technical complexity (special equipment and technical complexities)	• It is possible with some complications to upgrade the option • The option has a short life span. It continuously needs replacement and services. • The option is complicated to operate and maintain	• The option is somewhat costly to avail • The option benefits a limited number of people • The option has negative environmental impact • There is little possibility of by-product reuse
3	• It takes some time and process to avail the option at the desired location • The option uses some local material • The option requires some technical complexity (special equipment and technical complexities)	• It is quite possible to upgrade the option • The option has a considerably lengthy life span until it needs replacement and services. • The option is quite easy to operate and maintain	• The option is requires some cost to avail • The option benefits a considerable number of people • The option has some negative environmental impact • There is some possibility of by-product reuse
4	• It takes little time and process to avail the option at the desired location • The option uses mainly local material • The option requires little technical complexity (special equipment and technical complexities)	• It is possible to upgrade the option • The option has a long life span until it needs replacement and services. • The option is easy to operate and maintain	• The option is cheap to avail • The option benefits plenty people • The option has some negative environmental impact • There is some possibility of by-product reuse
5	• It takes no time and process to avail the option at the desired location • The option uses entirely local material • The option requires no technical complexity (special equipment and technical complexities)	• It is highly possible to upgrade the option • The option has a very long life span until it needs replacement and services. • The option is very easy to operate and maintain	• The option is very cheap to avail • The option benefits plenty people • The option has positive environmental impact • There is a high possibility of by-product reuse

The total score for the sanitation chains ranged from 41 to 64 out of a maximum possible score of 90. Most of the sanitation chains had a score between 48 and 51 (Figure V.33).

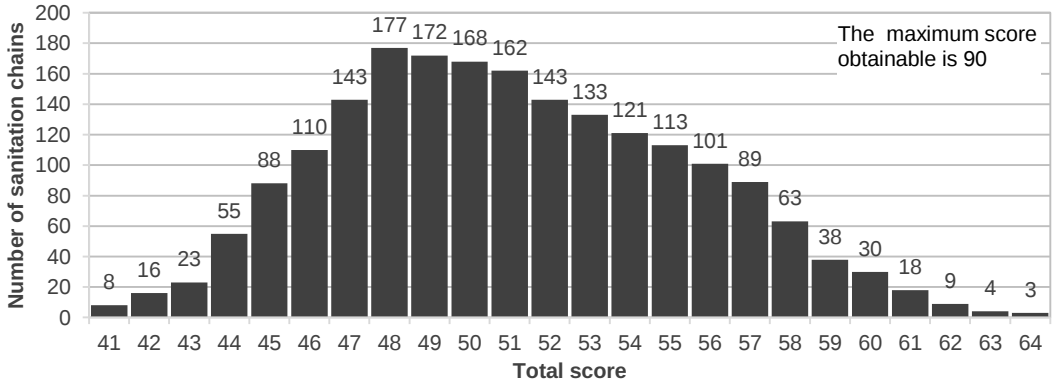


Figure V.33. Total scores obtained from the scoring of sanitation chains

Of the 1,981 feasible sanitation chains in the test case, three sanitation chains had the highest score of 64:

- No user interface (101) – Buckets (202) – Human-powered emptying / collection and transport (302) – No treatment (401 and 501) – Surface disposal (605)
- Drop hole (102) – Buckets (202) – Human-powered emptying / collection and transport (302) – No treatment (401 and 501) – Surface disposal (605)
- • Drop hole (102) – Fossa alterna (210) – No emptying and collection (301) – No treatment (401 and 501) – Burying / fill and cover onsite (603)

Because the user has to select his own sanitation chain based on his arbitrary judgement, assuming the selection was carried out randomly, the probability of the user building a chain with the highest score of 64 would be extremely small (3 ÷ 1,981 = 0.15%). The user would have 2.7 times more chance of building a chain with the lowest score of 41 (8 ÷ 1,981 = 0.40%) (Figure V.33). Therefore it may be argued that the DSS does not really help the user choose the most optimal sanitation chain, only screen out completely unfeasible options.

One way to address this shortcoming is to score the sanitation options before building the sanitation chains. This way, the user would know which options had the highest scores while building the chain. Alternatively, the software could be programmed to calculate which sanitation chains had the highest scores.

Moving on to consider the sanitation chains with the highest scores, it can be seen that the user interface and collection systems recommended (no user interface, drop hole, buckets, fossa alterna) involve dry systems that do not use water. However, it is evident from the test case data and in the literature that in most of Indonesia, pour-flush latrines are strongly preferred, with the majority of the population requiring water for anal cleansing. The screening criteria should include habits and preferences to ensure that end user needs are taken into account (as noted in Table V.22, no. 10).

The evaluation criteria has a number of issues. For example, the criteria give equal weightage to deployability, sustainability as well as economic and environmental sustainability. However, during the emergency phase, sustainability might be a significantly lower priority than deployability. (Although the developers claim that the DSS is a "flexible programme that can be easily modified", doing so requires programming knowledge and would be challenging under the pressure of an emergency situation.) Therefore, users should be given the option to prioritise certain criteria).

V.3.3.3 Usefulness and ease of implementation

As a concept, a DSS has merits because it helps to select the most suitable emergency sanitation solution for a given context. There are also secondary benefits: a supplier or product developer would be able to check whether their product would be feasible for a specific situation and explore how their product would fit in with other components of a sanitation chain (as demonstrated in Subsection VI.3.1.2). The application of the sanitation chain concept and use of evaluation criteria encourages users to consider all aspects of the solution, increasing the likelihood that a design would be technically feasible.

In practice, the DSS validated here has a number of shortcomings in its knowledge base and implementation. The numerous recommendations made and outputs from the test case suggest that there is much scope for improving the screening, building sanitation chain and evaluation process. In light of this, the

author has concerns about the validity of the options screened as feasible or unfeasible, as well as the options' corresponding scores.

V.3.4 Summary and discussion

This section evaluated in depth the usefulness and ease of implementation of three measures to improve product development in the emergency sanitation sector. The section demonstrated the different ways in which these measures could contribute to product development. Case studies on emergency scenarios and data collection on end users can provide useful information. On the other hand, a DSS is useful as a concept but needs to be developed further in order to be useful to product development. These findings reflected the poor evidence in the emergency sanitation sector, and the need to increase and improve the data that provides the foundation for making decisions during the product development process.

V.4 Conclusion

The previous chapter had found numerous areas where product development could be improved, such as in formulating design requirements. This chapter started by identifying 35 measures that could potentially to support product development. These were based on six approaches that included the capture, documentation and dissemination of knowledge and data (Figure V.34).

Next, results from the stakeholder survey showed clear agreement that the identified measures would be useful to suppliers and product developers for developing emergency sanitation products. In general, measures related to the documentation and dissemination of data about existing products and end users were considered useful throughout the stages of product development.

There was greater variation to survey responses on the ease of implementation of the identified measures. In addition, the findings demonstrated how factoring ease of implementation to usefulness could change a perspective on whether a measure was worth implementing.

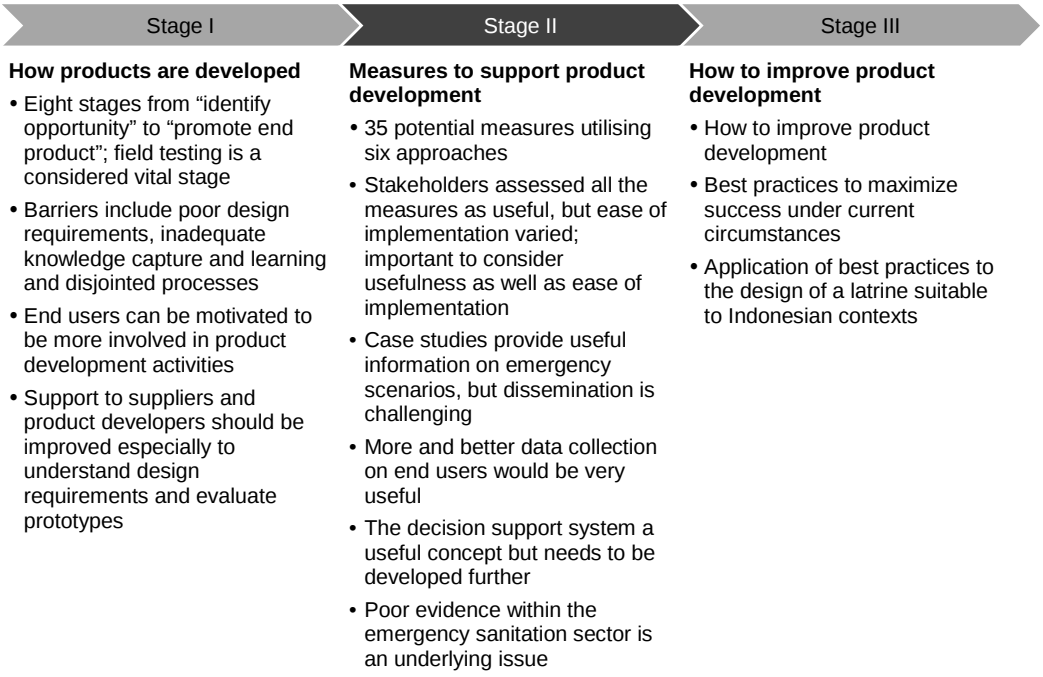


Figure V.34. Key findings from second stage of dissertation

Some measures were evaluated in greater depth. Case studies on emergency scenarios and data collection on end users can provide useful information. On the other hand, a DSS is useful as a concept but needs to be developed further in order to be useful to product development. These findings reflected the poor evidence in the emergency sanitation sector, and the need to increase and improve the data that provides the foundation for making decisions during the product development process.

The next chapter will bring together the findings from this and the previous chapter to propose a framework to improve product development in the emergency sanitation sector.

Chapter VI A recommended framework to improve the product development process

The previous two chapters explored the practices and challenges involved in developing emergency sanitation products, recognising that there were numerous areas that could be improved. One key barrier was poor design requirements. Potential measures to improve product development in the emergency sanitation sector were identified and evaluated. Based on the findings, this chapter proposes a framework for improving product development, focusing on improving design requirements (Section VI.1). The chapter also discusses what suppliers and product developers could do to maximise their chances of designing a successful product with respect to the design requirements, given the challenges of the current context (Section VI.2). Finally, the best practices are applied to the design of a latrine suitable to Indonesian contexts (Section VI.3) (Figure VI.1).

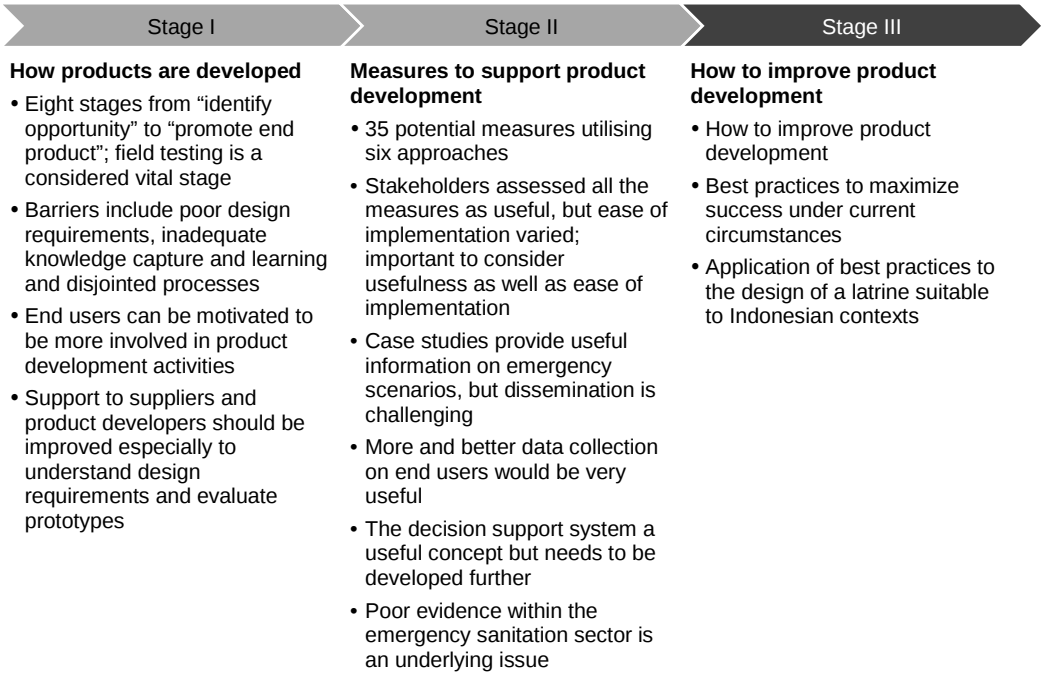


Figure VI.1. Aims and objectives of final stage of dissertation

Research findings suggest wide scope for improvement in how products are developed. In this dissertation, improving design requirements was chosen as the

focus of the framework. Design requirements is a major barrier to product development. In the stakeholder interviews, design requirements comprised 88 (or 22%) of the 445 observations related to barriers (Chapter IV, Figure IV.15). In the stakeholder survey, 99% of respondents agreed that there should be more support to suppliers and product developers in understanding design requirements, more so than evaluating product concepts, evaluating prototypes and promoting available products (Table IV.2). Issues faced in design requirements are also closely related to the other categories of barriers, including knowledge capture and learning, disjointed processes, and resources and capacity. Furthermore, it is an important stage of product development. In the stakeholder interviews, determining design requirements comprised 142 (or 23%) of the 613 observations related to stages of product development (Figure IV.5). As one of the earliest stages of product development, any improvements to understanding design requirements will have knock-on effects on later stages of product development.

VI.1 Framework to improve design requirements

The framework to improve design requirements was developed in three steps: problem analysis (Subsection VI.1.1), objective analysis (Subsection VI.1.2) and activities to achieve the objectives (Subsection VI.2).

VI.1.1 Problem analysis

Findings from Chapter IV were analysed for issues related to understanding design requirements. Key issues identified were structured into cause and effect relationships, allowing the focal problem, root causes and unavoidable constraints of design requirements to be established (Figure VI.2). Poor design requirements in the product development process lead to ideas that only satisfy part of the solution or do not reflect the actual needs and constraints of the stakeholders. As a result, ideas do not progress to an end product or fail during implementation. The problem poor design requirements is a consequence of three factors: overlooking aspects of the solution (Subsection VI.1.1.1), poor understanding of design requirements on the part of designers (supplier or product developer) (Subsection VI.1.1.2) and poor definition of design requirements (Subsection VI.1.1.3).

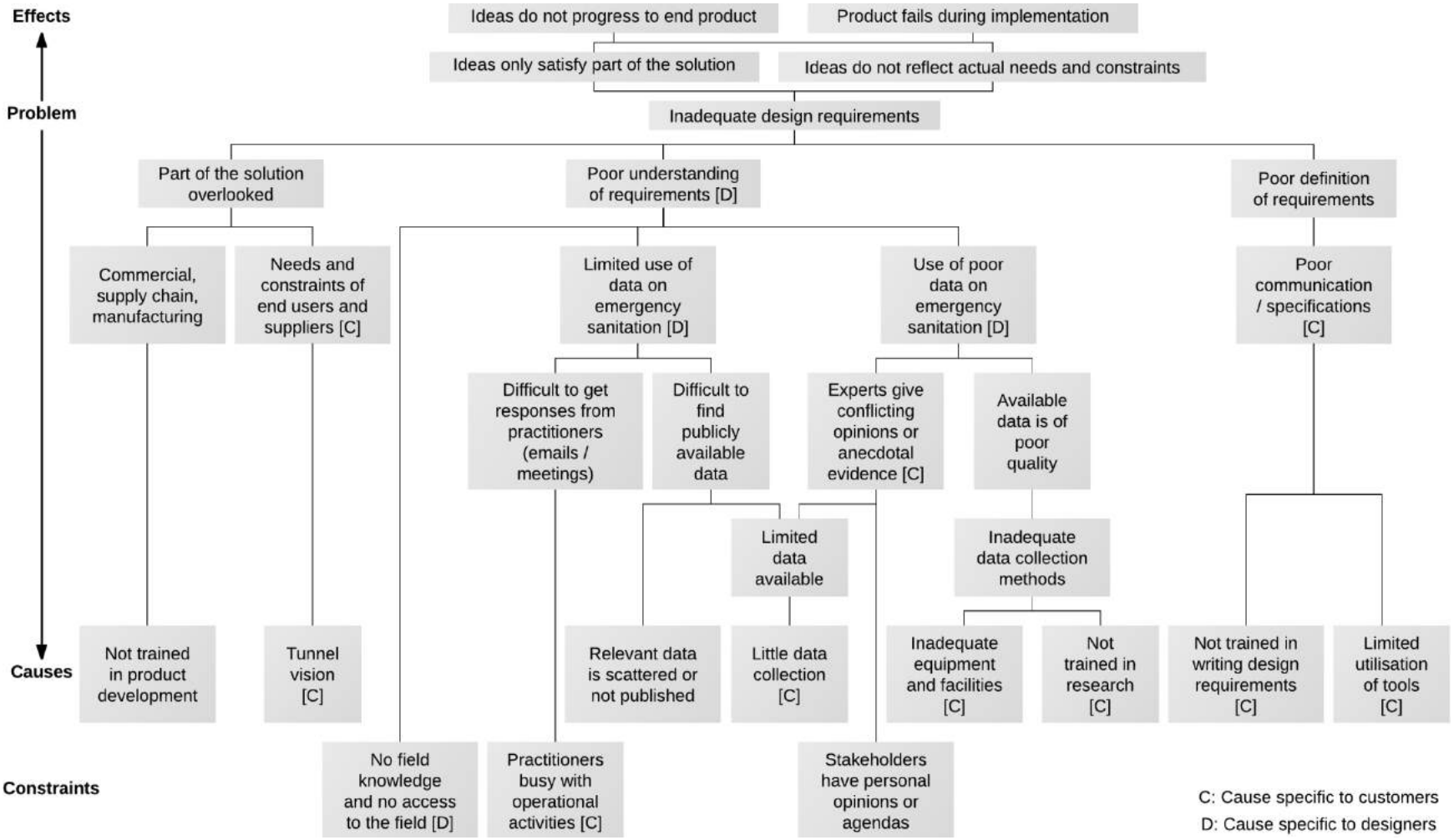


Figure VI.2. Problem analysis of inadequate design requirements

VI.1.1.1 Part of the solution overlooked

A successful product should address all aspects of the solution. However, the customer or designer is trained in a certain expertise (e.g. sanitation) and is therefore likely to overlook other aspects of the solution. These areas are typically in the area of commercial viability, supply chain or manufacturing. Because of this, an engineer, for example, might design something that is technically feasible but commercially not, or something that does not suit any particular manufacturer.

Stakeholders that are often overlooked are suppliers and end users. Instead, humanitarian sector needs tend to be emphasized. This is characterised in the framework as tunnel vision on the part of the humanitarian practitioners. Tunnel vision can be defined as "the tendency to focus exclusively on a single or limited objective or view" (Oxford University Press, 2015). The research findings suggests that practitioners who have been working in the sector for a long time are prone to fixate on the problems that they as an organisation face, rather than on the problems of the people that they serve (end users) or the people who serve them (suppliers). Practitioners think they already know the end user and that suppliers should fulfil whatever requests they have, which may not be feasible.

VI.1.1.2 Designers have a poor understanding of design requirements

Most designers do not have knowledge or experience in emergency sanitation and are not able to access disaster settings. Unfortunately, it is difficult to find relevant data because they are unpublished or scattered among diverse sources, and designers may not know where to look (e.g. the IFRC emergency items catalogue). More importantly, very little data has been collected on all aspects of emergency sanitation (scenarios, existing products, field testing, etc.). When data is collected, the methods are not robust due to inadequate equipment and facilities as well as inexperienced personnel. For example, data from field testing is typically informally collected from water, sanitation and hygiene (WASH) staff on site.

Designers usually approach humanitarian practitioners or experts for information and feedback, but practitioners may not reply or turn up to meetings. Furthermore,

experts give designers different, often conflicting, views because they have an agenda to pursue or they have personal opinions on what requirements are important (e.g. logisticians may prioritise speed of implementation over end user comfort).

As a result, designers rely on a small amount of poor-quality data to formulate design requirements. It is easy to imagine how these requirements subsequently may not reflect what stakeholders actually need.

VI.1.1.3 Requirements are poorly defined

Designers usually rely on customers for design requirements. Customers would talk designers through what they want as well as write design briefs or specifications. Designers may ask humanitarian practitioners questions or get feedback from practitioners about existing products. However, because customers are not trained to write design requirements, they do not know how requirements should be defined and communicated. For instance, products should have a specific design life. Stakeholders also do not make use of the many tools available to help people formulate design requirements.

VI.1.2 Objective analysis

Based on the problem analysis, objectives were formulated to address the root causes of the problem. By doing so, the objective analysis aims to improve design requirements so that ideas are more likely to address all aspects of the solution and reflect the actual needs and constraints of stakeholders (Figure VI.3).

VI.1.2.1 More aspects of the solution are considered

If customers and designers had basic knowledge of product development, they would be more likely to consider aspects of commercial viability, supply chain and manufacturing in their design requirements and, ideally, collaborate with stakeholders who have the relevant expertise. As a result, an engineer would be more likely to design something that is not only technically feasible, but also commercially viable and suitable for manufacture.

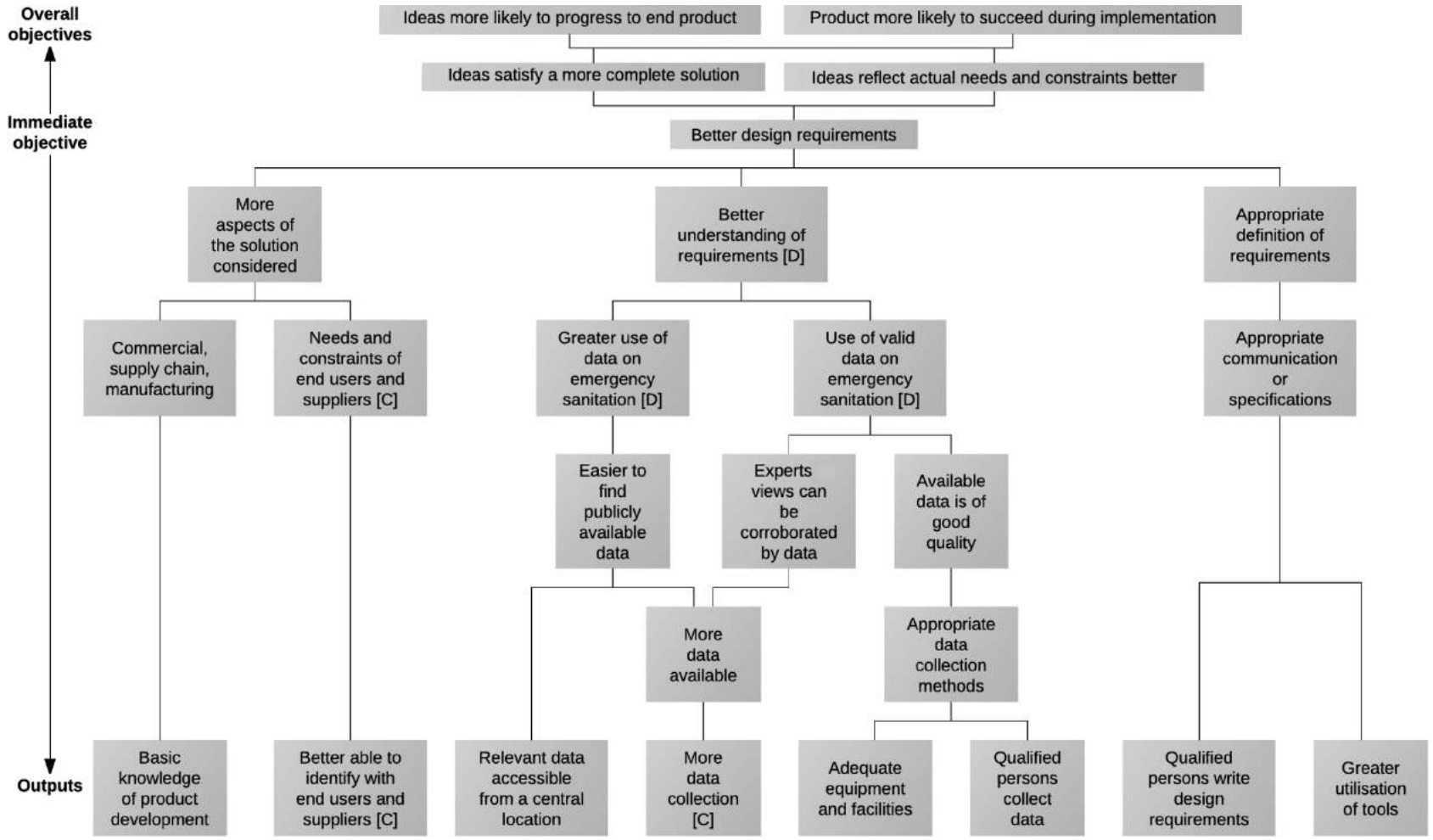


Figure VI.3. Objectives tree to improve design requirements

If customers could better identify with end users and suppliers, they would then be more likely to accord higher importance to the needs and constraints of the end users as well as the suppliers and place less emphasis on just the needs of humanitarian agencies. Customers would be more likely to consult end users and suppliers, and compromise with suppliers in order to come up with realistic design requirements.

VI.1.2.2 Designers have a better understanding of design requirements

The designers' lack of knowledge and experience working in the emergency sanitation sector, and lack of access to disaster settings, are unavoidable constraints. Fortunately, there are other measures that can be implemented to mitigate these constraints, for example, by: collecting more data on all aspects of emergency sanitation, using appropriate data collection methods that is supported by adequate equipment and facilities as well as trained personnel, and making the data collected accessible to other stakeholders. These measures would allow designers to tap into an abundant resource of good-quality data to formulate design requirements.

VI.1.2.3 Better-defined requirements

There are a number of ways for customers to write better-defined design requirements: customers could be trained on how to write design requirements; they could work with other people to write the requirements for them, or; they could make greater use of the many tools that are available to help develop such requirements. If requirements were better defined, designs would find it easier to come up with ideas that reflect the actual needs and constraints of stakeholders.

VI.1.3 Activities to achieve the objectives

The objectives tree proposes eight outputs that will contribute towards better design requirements for developing products in the emergency sanitation sector. For each output, a series of activities that could contribute to achieving the output is suggested, although it should be noted that this list is not exhaustive (Table VI.1).

Table VI.1 Suggested activities to improve design requirements

Output	Suggested activities
Customers and designers have basic knowledge of product development	• Develop a checklist for generating design requirements specific to the emergency sanitation context • Run introductory training workshops on product development for customers • Recommend that designers collaborate with people who have knowledge of product development • Provide resources communicating the importance of knowledge on product development and how it affects the development of products
Customers are better able to identify with end users and suppliers	• Provide design tools that allow stakeholders to analyse end users (e.g. product usage context) and supplier needs and constraints • Collect and disseminate examples of failed emergency sanitation products because end user or supplier needs and constraints were not met, and their impact • Organise regular discussion with suppliers • Encourage customers to engage closely with end users for a prolonged period
Relevant data is accessible from a central location	• Set up a website to store data and provide links to relevant resources (e.g. the Sustainable Sanitation Alliance [SuSanA] website) • Set up or appoint an organisation to curate data on emergency sanitation • Produce and distribute a resource pack with relevant data
More data collection (e.g. case studies, end user needs, field testing, product evaluations)	• Communicate the importance of data collection to humanitarian agencies • Obtain funding for data collection activities • Set up partnerships with appropriate organisations to collect data from all stages of the product development process, such as local universities • Set up student research projects
Adequate equipment and facilities for data collection	• Seek funding to purchase research equipment and facilities • Set up partnerships with organisations who have access to such resources, such as local universities • Set up an inter-agency initiative to share equipment and facilities among humanitarian agencies
Qualified persons collect data	• Collaborate with organisations who can collect data • Train a number of humanitarian practitioners on basic data collection methods • Recruit individuals who have expertise on data collection
Qualified persons write design requirements	• Run training workshops for customers on writing design requirements • Collaborate with qualified organisations to write design requirements
Greater utilisation of design tools	• Develop design tools specific to the emergency sanitation context (e.g. checklist for generating requirements) • Provide design tools to help stakeholders determine design requirements (e.g. process tree) • Run introductory training workshops on the use of design tools

These are only suggested activities based on findings from the research. The feasibility of these activities should be investigated further before they are implemented.

VI.2 Best practices to maximise success in current context

The recommendations in the previous section represent a long-term vision to improve the development of products in the emergency sanitation sector. This section takes another perspective and presents a checklist of best practices

designers can apply in the short term to increase the likelihood that their design requirements would satisfy a complete solution and reflect the actual needs and constraints of stakeholders, leading to ideas that would be developed to an end product and succeed during implementation.

Table VI.2 Best practices for developing better design requirements

Best practice	Recommended activities
Consider all aspects of the solution	• Make use of existing design tools (e.g. checklist for generating design requirements) • Get feedback from as many stakeholders as possible
Make use of as much data as possible	• Do a literature review. Good starting points are the SuSanA website. • Study the websites of humanitarian agencies (e.g. IFRC supply catalogue) • Study photos from disasters and of emergency sanitation (e.g. Flickr) • Get feedback from as many stakeholders as possible • Systematically analyse the data (e.g. using problem definition)
Define design requirements appropriately	• Consult existing guidelines for formulating design requirements (e.g. textbooks) • Collaborate with qualified persons to write design requirements

VI.3 Application of best practices to the design of a latrine for Indonesian contexts

This section demonstrates how the best practices from the product development framework could be used, by describing how they were applied to understanding the design requirements for developing a suitable emergency latrine for Indonesian contexts (Table VI.3).

Table VI.3 Application of best practices to latrine design for Indonesian contexts

Best practice	Application of best practice
Consider all aspects of the solution	• Tools: developed a process tree (see Subsection VI.3.1.1); utilised emergency sanitation decision support system (see Subsection VI.3.1.2); consulted design requirements checklist from Pugh (1991) • Examined case studies (e.g. from Table V.11), emergency sanitation literature (as described in Subsection V.3.1.1) and the Sphere standards (The Sphere Project, 2011) to understand the range of design issues involved
Make use of as much data as possible	• Examined desk-based case studies from Subsection V.3.1.2, especially data from the 2004 Indian Ocean earthquake and tsunami as well as 2006 Java earthquake, and research from the Sinabung displacement centres and Abucay Bunkhouse (see Subsection VI.3.1.3) • Utilised relevant data from other researchers (see Subsection VI.3.1.4) • Studied documents on the Indonesian disaster management context such as the National Plan for Disaster Management 2010 – 2014 (BNBP, 2010) and the Indonesia disaster management reference handbook (CME-DMHA, 2015)

First, examples of how the best practices were applied are described (Subsection VI.3.1). Next, the outcomes of applying these best practices are summarised (Subsection VI.3.2). Finally, the design concept resulting from these outcomes is presented (Subsection VI.3.3).

VI.3.1 Application of best practices

Four examples of how the best practices were applied to the design of a latrine suitable for Indonesian contexts are described in this subsection: developing a process tree for an emergency latrine product (Subsection VI.3.1.1), utilising the decision support system (DSS) that was validated in Subsection V.3.3 (Subsection VI.3.1.2), examining results of the end user research at the Sinabung displacement centres and in Abucay Bunkhouse that was presented in Subsection V.3.2 (Subsection VI.3.1.3), and utilising raw data from research that had been conducted by Hokkaido University and the Indonesian Institute of Sciences (LIPI) (Subsection VI.3.1.4).

VI.3.1.1 Process tree

A process tree provides a structured overview of the important processes that a product goes through during its life cycle from origination to disposal. By developing a process tree, the designer is forced to envisage the situations, places and activities that the product would encounter. From the process tree, the designer is able to identify appropriate design requirements by asking “which criteria must the product satisfy during the process of...?” In accordance with van Boeijen et al (2014), the process tree for an emergency latrine suitable to Indonesian contexts (Figure VI.4) was developed using the steps described in the following paragraphs.

First, the product was defined as a temporary latrine to be deployed in the aftermath of a natural disaster for displaced populations anywhere in Indonesia. Second, the stages of the product life cycle were identified. Third, the processes the product goes through during the identified stages were described. Fourth, the process tree was visualised.

Figure VI.4. Process tree for an emergency latrine in Indonesian contexts

The author used also data from Hokkaido University and LIPI on what end users from Indonesia do when they go to the toilet to urinate or defecate (Subsection VI.3.1.4). This helped to determine the sub-processes during the use of the latrine (Table VI.4 no. 5.3.1 and 5.3.2).

Table VI.4 Examples of design criteria derived from the process tree

Process		Product design criteria
1.	**Originate**	**N/A**
1.1	Study current situation	N/A
1.2	Develop product	N/A
1.3	Search for manufacturer	• Components should be easy to procure from Indonesia
2.	**Produce**	• **Latrine should be easy to manufacture in Indonesia**
2.1	Manufacture or procure components	• See 1.3
2.2	Check quality of components	• Determine tests to check quality of components
2.3	Assemble components into a package	• Resulting package should be easy to transport by air and truck
2.4	Store in supplier's warehouse	• Components will be manufactured and delivered on demand
3.	**Distribute package**	• **Target customer: National Disaster Management Agency (BNBP) or Ministry of Public Works (PU)**
3.1	Deliver to customer's warehouse	• Package will be stored in regional logistics warehouse[1]
3.2	Store package in warehouse	• Storage life of at least ten years
3.3	Deliver package to settlement	• Package should be easy to transport by truck in all road conditions
4.	**Install latrine(s)**	• **Latrine can be installed by unskilled adults supervised by BNBP / PU**
4.1	Determine location of latrine(s)	• BNBP / PU will determine location of latrine
4.2	Open package	• Package can be opened without any tools
4.3	Take out instruction manual	• Instructions are easily understood by adults with little education
4.4	Place foundation at appropriate location	• See 4.3
4.5	Join components together	• Include required installation tools in package
4.6	Construct collection system	• Collect excreta in a septic tank (see Subsection VI.3.1.2)
5.	**Use**	• **Latrine should correspond to users' habits**
5.1	Enter cubicle, close and lock door	• Provide an internal lock
5.2	Turn on light if dark	• Provide lighting
5.3	Urinate, defecate, bathe or change	• Latrine to be used for urinating, defecating and bathing
5.3.1	Urinate	• Latrine should minimise splash from urinating (→ urinal?)
5.3.2	Defecate	• Container should be within easy reach of user during use
5.3.3	Bathe	• Provide a hook
5.3.4	Change sanitary napkin	• Provide a rubbish bin for waste
5.4.	Unlock, open door, turn off light, leave	• Messaging to remind users to save electricity
6.	**Maintain latrine**	• **Latrine should be easy to maintain**
6.1	Cleaning after use	• User should be incentivised to clean latrine after use
6.1.1	Take cleaning tool	• Provide hook to cleaning tools
6.1.2	Scrub or mop dirt	• Provide cleaning tools
6.1.3	Return cleaning tool	• Provide funds for buying new cleaning tools
6.2.	Daily cleaning	• Paid attendant or families to be responsible for daily maintenance
6.2.1	Collect cleaning tools	• Provide storage for cleaning tools
6.2.2	Scrub and mop built up dirt	• Provide cleaning chemicals
6.2.3	Unclog latrines if needed	• Provide plunger
6.2.4	Return cleaning tools	• Assemble cleaning tools into an easy-to-transport package

(continued on next page)

Process		Product design criteria
	(continued from previous page)	
6.3	Repair broken components	• Spare parts of easily breakable components e.g. locks
6.4	Collection, desludging and treatment	• Recommend compatible sanitation chain technologies
7.	**Disassemble**	• **Latrine(s) should be disassembled by skilled persons**
7.1	Take components apart	• Disassembly teams should be trained
7.2	Deliver to warehouse	• See 3.3
8.	**Store**	• **Product should be reusable**
8.1	Clean components	• Equipment for cleaning and sterilising product after use
8.2	Assemble components into a package	• Instructions for packing components
8.3	Store in warehouse	• See 3.2

The process tree alone does not address all aspects of the problem or solution. For example, the process tree does not explicitly consider the safety and privacy of vulnerable groups such as women, children and the disabled. To ensure that other aspects of the design are covered, other literature should be consulted. For instance, the Sphere standards (The Sphere Project, 2011) provide guidance on which population groups latrines should cater to.

VI.3.1.2 Decision support system

In the process tree, it can be seen that collecting, desludging and treatment is a sub-process of the emergency latrine life cycle (Table VI.4 no. 6.4). This design focuses on the latrine in order to address the challenges faced by end users as identified in Subsection V.3.2. However, this does not imply that that collection, desludging and treatment should be neglected. For the latrine design to be suitable, it should be compatible with appropriate collecting, desludging and treatment options. To achieve this, the author used the DSS validated in Subsection V.3.3, because the DSS uses the sanitation chain concept to ensure all components of the chain are considered. The purpose was to determine which options would be suitable with a pour-flush latrine (Figure VI.5).

First, ‘pour flush’ (103) was selected as the ‘User interface / toilet facilities’ option. At the ‘Collection / storage / onsite treatment’ stage, the ‘borehole latrine’ (206), ‘simple pit latrine’ (207), ‘ventilated improved pit latrine’ (208), ‘arborloo’ (209), ‘septic tank’ (213), ‘anaerobic filtration’ (214), ‘anaerobic baffled reactor’

(215), ‘raised latrine’ (220) and ‘chemical toilet’ (222) options were all compatible with ‘pour flush’ (103). ‘Septic tank’ (21) was selected as the ‘Collection / storage / onsite treatment’ option because it is common used in Indonesia. The only options eliminated at this step were ‘no emptying and treatment’ (301) at the ‘Conveyance’ stage, as well as ‘urine fertiliser’ (601) and ‘burying / fill and cover onsite’ (603).

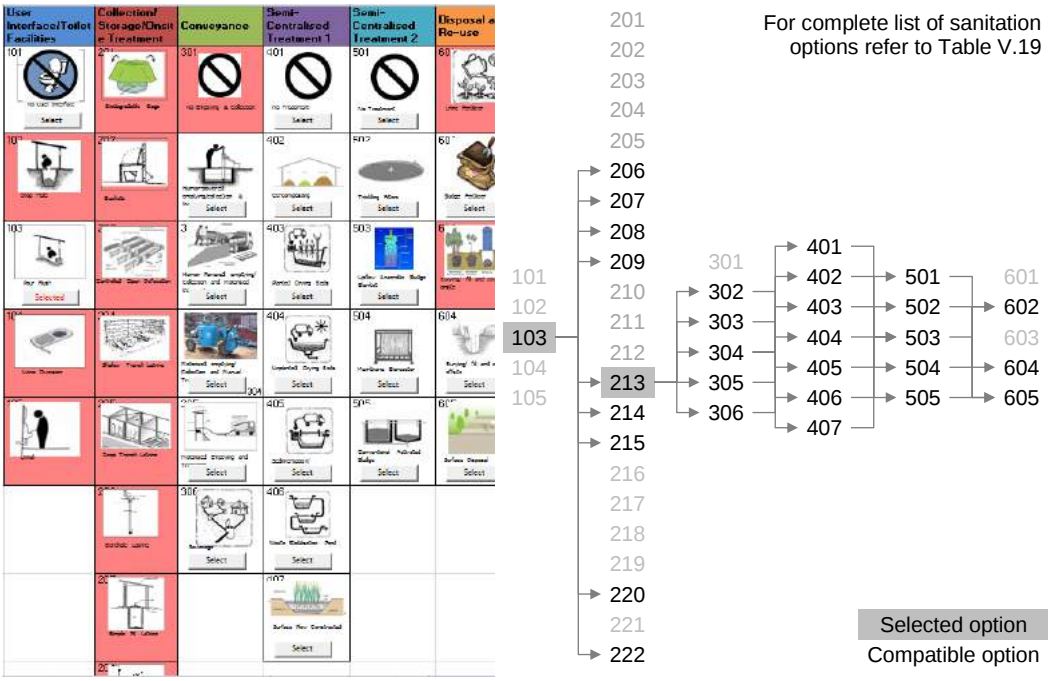


Figure VI.5. (a) DSS being used (b) Options compatible with pour-flush latrine and septic tank

Based on the outputs from the DSS it was concluded that designing a pour-flush latrine that would be connected to a septic tank would be compatible with a wide range of conveyance, treatment and disposal options and therefore flexible to different situations that would be encountered in Indonesian contexts.

VI.3.1.3 End user research from Indonesia and the Philippines

Results from the end user survey at the Sinabung displacement centres helped to determine the most important design criteria needed to satisfy end users. The survey found that cleanliness (ρ = 0.51), cleaning tools (ρ = 0.44), odour (ρ = 0.41) and lighting (ρ = 0.41) were the most strongly correlated with end user

satisfaction (Table V.18 no. 13, 17, 14 and 11 respectively). In addition, the availability of cleaning tools had a statistically significant, albeit weak, correlation with cleanliness (Figure V.26, ρ = 0.39). Therefore, this design focused on cleanliness as the most important criteria.

With regard to cleaning tools, the survey at Abucay Bunkhouse suggested that water was the most important cleaning tool because 98% of respondents used water to clean their latrines. At the Sinabung displacement centres, some residents interviewed felt that there was not enough water for cleaning. Furthermore, 15% and 85% of respondents from the displacement centres as well as 20% and 78% from the bunkhouse stated that water was important and very important respectively. Data from both locations demonstrated the importance of water for anal cleansing, flushing and handwashing. At the centres, respondents used an average of 4.0 litres of water daily for flushing and handwashing while at the bunkhouse, respondents used an average of 17.6 litres of water daily for anal cleansing, flushing and handwashing (Table V.16). Therefore, water was the second most important criteria in this design. The results of the surveys also provided inputs into the design features that would contribute to increasing the availability of water. For example, there was a statistically significant correlation between having containers to store water and the availability of water in the latrines (Figure V.23: ρ = 0.21 at the centres and ρ = 0.45 at the bunkhouse).

VI.3.1.4 Data from Hokkaido University and LIPI

The design process utilised data that had been collected by Hokkaido University and LIPI as part of a study by Ito et al. (2014) to develop a composting toilet. The authors of the study had conducted interviews with 15 people at LIPI. The interviews included simulations of the interviewees' sequences of actions when using different types of toilets. For example, the authors found that 11 people flushed before cleansing while three flushed after cleansing. Six of these simulations were kindly made available by Hokkaido University. The types of toilets included a squatting toilet with a dipper, a sitting toilet with a dipper and a sitting toilet with a washer.

Some relevant observations from the videos were:

- One interviewee squatted on a sitting toilet, suggesting that sitting toilets might be misused because many users from Indonesia have an instinct to squat. Hence, squatting toilets might be more appropriate in general.
- Most interviewees used a lot of water for anal cleansing, flushing and washing their hands and feet after urinating or defecating. Hence, the design should attempt to reduce water consumption.
- One interviewee washed themselves squatting on the floor rather than over the keyhole. Such behaviour would wet the floor and make it very easy for the toilet to become dirty. Hence, the design should attempt to keep the floor as dry as possible.

The interviewees' sequences of actions were also incorporated into the development of the process tree (Table VI.4 no. 5.3.1 and 5.3.2).

VI.3.2 Outcomes of applying best practices

Applying the best practices listed in Table VI.3 led to a better understanding of the design requirements for developing a suitable emergency latrine for Indonesian contexts. Four of these best practices were described in Subsection VI.3.1. Table VI.5 highlights how these four best practices contributed to the understanding of these design requirements.

Table VI.5 Contribution of best practices to understanding design requirements

Application of best practice	Contribution to understanding design requirements
Process tree	• Consideration of design criteria, throughout the life of the emergency latrine product, that might be overlooked if the process tree were not developed
Decision support system	• Determined the sanitation options from other components of the sanitation chain that were compatible with the emergency latrine
End user research	• Identified cleanliness and the availability of water as the two most important design criteria to satisfy end users in the Indonesian context
Data from Hokkaido University and LIPI	• Confirmed that squatting toilets were more appropriate • Identified keeping the floor dry and reducing water consumption as design features to support cleanliness and the availability of water respectively

VI.3.3 Design concept

Based on the understanding of the design requirements derived from the application of the best practices illustrated in the previous sections, a design concept was developed in collaboration with an architect. Figure VI.6 and Table VI.6 show the design features that facilitate cleanliness and ensure the availability of water.

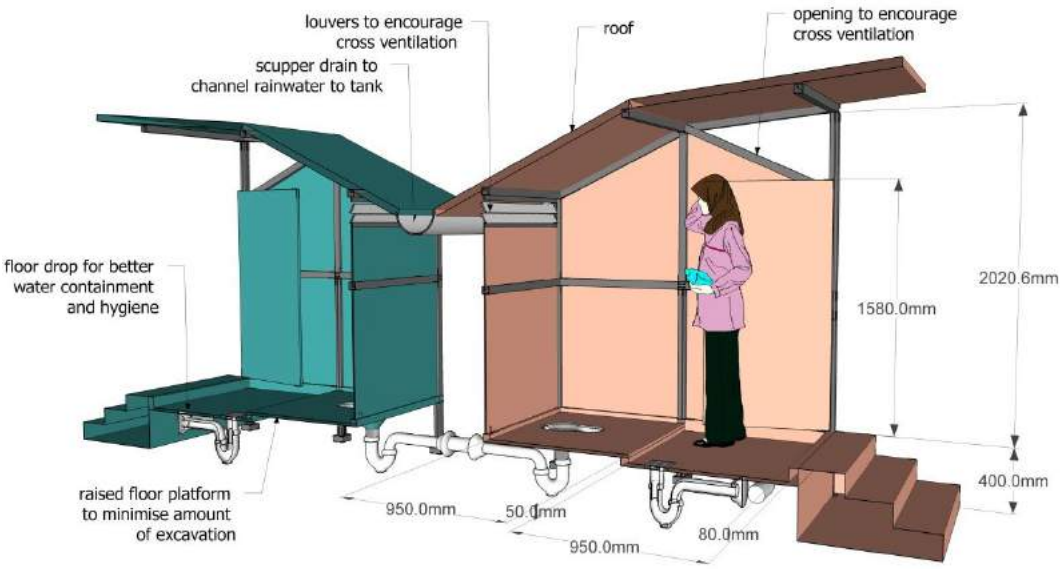


Figure VI.6. Design concept for an emergency latrine suitable to Indonesian contexts. Design by Regina Yeo

Table VI.6 Design features to facilitate cleanliness and the availability of water

Facilitate cleanliness	Ensure the availability of water
Provide cleaning tools inside the cubicle	Place a water drum inside the cubicle
Good drainage in the cubicle so that it remains as dry as possible	Rainwater harvesting to reduce dependence on water trucks
Provide ventilation so that the cubicle remains as dry as possible e.g. louvers and cross ventilation	Low flush squatting pan to reduce water use
	Messaging (e.g. posters) to encourage saving water

The design concept shown represents a product that is in the "generate and communicate ideas" stage of the emergency sanitation product development process (Figure VI.7). This is still in the very early stages of product development. The ideas used in the design concept must be evaluated and, if necessary, modified. Then, the design concept has to be iterated before being developed in

sufficient detail to manufacture one or more prototype(s) that must be tested and evaluated.

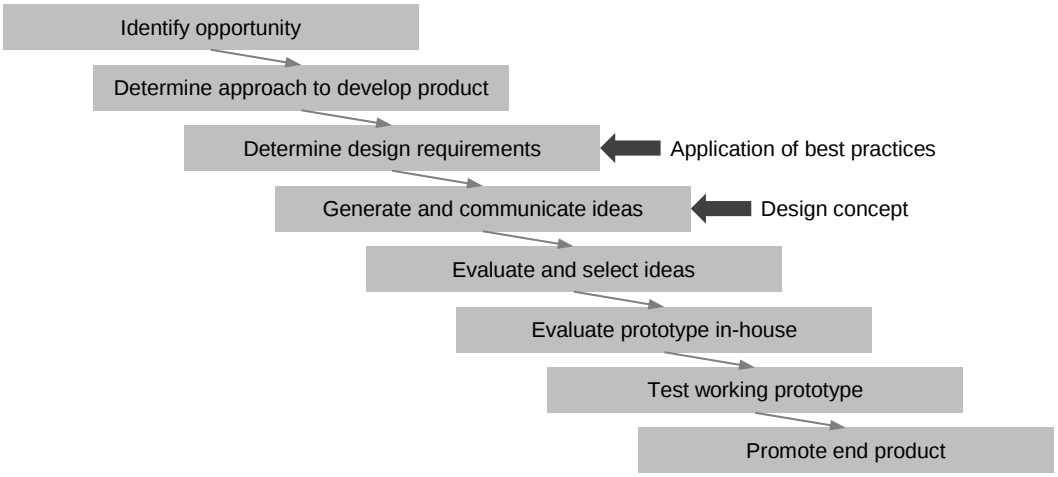


Figure VI.7. Stages of design concept in the product development process

VI.4 Summary

This chapter applied a problem and objective analysis for improving product development, focusing on improving design requirements because poor design requirements are a major barrier to product development in the emergency sanitation sector, with stakeholders agreeing that there should be more support to suppliers and product developers in understanding design requirements.

The problem analysis identified three causes of poor design requirements: part of the solution is overlooked, suppliers and product developers have a poor understanding of the requirements, and the requirements are poorly defined. To improve design requirements, the root causes should be addressed holistically. Based on the objectives tree, the emergency sanitation sector can determine appropriate strategies to address the problem of poor design requirements.

The chapter also discussed what suppliers and product developers could do to increase the likelihood that their design requirements would lead to a successful product given the constraints of the current circumstances. These best practices for improving design requirements were used in designing a latrine suitable for

Indonesian contexts. A number of tools and strategies allowed the design to consider all aspects of the solution and make use of as much data as possible. Four examples were described: developing a process tree for an emergency latrine product, utilising the DSS, examining results of the end user research at the Sinabung displacement centres and in Abucay Bunkhouse as well as utilising raw data from research that had been conducted by Hokkaido University and LIPI. These examples made positive contributions to the understanding of the design requirements by, for example, identifying cleanliness and the availability of water as the two most important design criteria to satisfy end users in the Indonesian context.

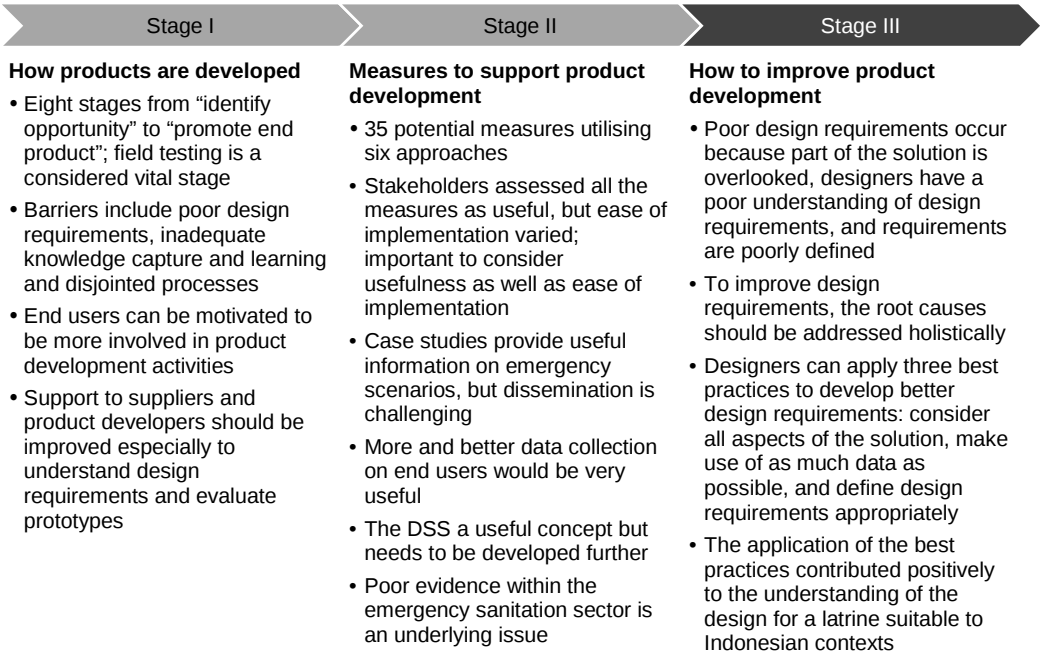


Figure VI.8. Key findings from final stage of dissertation

Chapter VII Conclusion

The final chapter beings with a summary of the research and its contributions. It ends with suggestions for further work on innovation in the emergency sanitation sector.

VII.1 Summary of research and its contributions

The dissertation was based on the problem statement that the limited understanding of the practices and challenges involved in developing products for the emergency sanitation sector prevented emergency sanitation products from being developed in an effective manner.

At the first stage of the research, stakeholder interviews, a case study at Abucay Bunkhouse and a stakeholder survey provided a detailed understanding of the product development process. The findings suggested much room for improving the development of emergency sanitation products. For instance, one of the barriers to product development in the emergency sanitation sector was poor design requirements.

At the second stage of the research, the dissertation demonstrated how a better understanding of product development in the emergency sanitation sector provided a valuable basis for identifying measures to improve product development in the emergency sanitation sector. The dissertation explored 35 measures that were identified to help suppliers and product developers, relying on one or a combination of six approaches, with clear agreement among stakeholders that the identified measures would be useful to suppliers and product developers in developing products. However, such measures should be evaluated in depth in order to understand its overall contribution to improving product development in the emergency sanitation sector. In this dissertation, desk-based case studies of previous disasters, data collection on end users, and a decision support system, were evaluated in-depth. A common thread underlying the findings is the lack of

good quality evidence in the emergency sanitation sector. Correspondingly, measures related to the documentation and dissemination of data are very beneficial to the product development process.

At the final stage of the research, a framework to improve design requirements was developed by systematically analysing the research findings to identify the root causes of the problem. The analysis showed that poor design requirements in the emergency sanitation sector was a consequence of three factors: overlooking aspects of the solution, poor understanding of the requirements on the part of suppliers and product developers, and poor definition of requirements. Recognising that the benefits of the abovementioned outputs would not be realised immediately, the dissertation also recommended four best practices stakeholders could apply under the present circumstances to maximise their chances of developing good design requirements: consider all aspects of the solution, make use of as much data as possible and define design requirements appropriately. These best practices were applied to the design of a latrine suitable to Indonesian contexts, demonstrating how applying the best practices could contribute positively to the understanding of design requirements.

VII.2 Suggestions for future research

This research is one of the first studies that focuses on the process of developing products in a specific sub-sector of humanitarian work. Because of this, the nature of the research was exploratory. This approach led to the identification of a wide range of recommendations for future research, as discussed in the following paragraphs.

Emergency sanitation innovation is advancing rapidly. There has been an increasing focus on sanitation rather than water in recent years (Rush and Marshall, 2015). For example, the Humanitarian Innovation Fund (HIF) has been employing a structured innovation process to address selected water, sanitation and hygiene (WASH) gaps (Bastable and Russell, 2013). It would be beneficial to examine whether these processes have influenced the way emergency sanitation

innovation operates. It would also be useful to compare whether some practices are better than others.

In the stakeholder interviews, only two local product developers and suppliers were interviewed out of 19 interviewees in total. Local stakeholders who design local products (e.g. in Indonesia) face particular contexts and challenges that differ from how international stakeholders (e.g. in UK) operate. There should be more in-depth research focusing on the specific processes and barriers for local stakeholders in different countries, including why there appears to be a lack of innovation among local stakeholders in the first place.

Finally, the dissertation identified an extensive list of potential measures to improve product development in the emergency sanitation sector. These measures should be investigated in-depth to determine their contribution to innovation in the sector. Interesting findings from the stakeholder survey merit further investigation. For example, it would be beneficial to interview product developers and suppliers to find out why, overall, product developers find the identified measures to improve product development more useful than suppliers.

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CURRICULUM VITAE

The author was born on 8 November 1986 in Singapore. She graduated from Raffles Junior College, Singapore, in 2004.

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From 2009 to 2010, she was an Engineer in the Building Research Institute at the Housing and Development Board, Singapore. From 2010 to 2012, she was an Assistant Development Manager in the Nanyang Environment and Water Research Institute at Nanyang Technological University, Singapore.

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Appendix 1 Stakeholder questionnaire

SURVEY ON SUPPORT FOR PRODUCT DEVELOPMENT IN THE EMERGENCY SANITATION SECTOR

What is this survey about? This survey explores how the emergency sanitation sector could support innovation by providing tools and guidelines for individuals and organisations supplying or developing products for emergency sanitation purposes. Results from the survey will lead to recommendations on tools and approaches for connecting suppliers and product developers with customers and end users.

Who is this survey for? The survey is intended for any individual that:

- Has had experience with, or been involved in, supplying or designing products for emergency sanitation, either directly or indirectly. This includes individuals and organisations that have participated in design contests, proposed ideas or products to potential customers, supported the testing of prototypes, funded product development activities, etc.
- Is considering or has considered supplying or designing products for emergency sanitation.

If you feel that the survey is not relevant to you, please inform us at yokepean@gmail.com.

Who will read the results? This survey is strictly confidential. Individual responses will not be made available to anyone. Only the research team can read your answers. If you wish to receive the results of the survey, please leave your contact details at the end of the survey.

For enquiries please contact Thye Yoke Pean (PhD researcher, Bandung Institute of Technology) at yokepean@gmail.com.

Please return this survey to yokepean@gmail.com. Please feel free to complete the survey on your computer or by hand.

THANK YOU FOR YOUR CO-OPERATION

1. BACKGROUND

This questionnaire seeks your opinion regarding product development within the emergency sanitation sector. The first part considers existing support to suppliers and product developers when developing new products. The second part considers how this support can be improved.

When completing the survey please keep in mind the following definitions:

- Emergency: the immediate or relief phase (not the recovery and reconstruction phase)
- Sanitation: excreta disposal (not solid waste, grey water or other forms of wastewater)
- Product development: the development of physical goods (rather than services, software or processes)

Background information

1.1. What is your:

a. Gender: ☐ Male ☐ Female

b. Nationality: _____

c. Age: _____ ☐ Prefer not to say

d. Highest degree obtained: ☐ Bachelor's ☐ Masters ☐ PhD ☐ None

☐ Other, please specify: _____

Involvement in product development

1.2. Have you ever been directly or indirectly involved in developing emergency sanitation products?

☐ Yes, I am currently involved

☐ Yes, I was previously involved. Year of most recent involvement: _____

☐ No, but I or my organisation have had the intention to do so

☐ No

1.3. If you answered 'Yes' to the previous question:

Please estimate the total duration of your involvement: _____ year(s) _____ month(s)

1.4. What best describes your main interest with regard to emergency sanitation products? (Please choose one)

☐ Customer: Your organisation purchases or implements emergency sanitation products

☐ Supplier: Your organisation supplies emergency sanitation products

☐ Potential supplier: Your organisation sells products that could be used for emergency sanitation or your organisation has / had the intention to supply emergency sanitation products

☐ Product developer: You or your organisation has designed emergency sanitation products (with no intention to supply the end product)

☐ Potential product developer: You or your organisation has / had the intention to design emergency sanitation products (with no intention to supply the end product)

☐ Intermediary: You or your organisation supports product development by providing expertise, through research, manufacturing prototypes, testing potential or existing products, funding product development, etc.

☐ Other, please specify: _____

1.5. Which product type(s) do you or your organisation have an interest in? (Please choose all that apply)

- [ ] Latrine facilities (as a package)
- [ ] Latrine superstructure
- [x] Latrine slab
- [ ] Non-toilet options (e.g. bag systems)
- [ ] Desludging
- [ ] Faecal sludge treatment
- [ ] Other, please specify: _____

1.6. Which market do you or your organisation have an interest in? (Please choose one)

- [ ] Local or national
- [ ] Regional
- [ ] International

1.7. What is your organisation's main motivation for participating in product development? If you are involved in product development as an individual, please answer as an individual. (Please choose one)

- [ ] Accountability to beneficiaries
- [ ] Personal motivation e.g. give something back, fun, etc.
- [ ] Profit
- [ ] Other, please specify: _____

CONTINUE TO NEXT SECTION

2. SUPPORT TO SUPPLIERS AND PRODUCT DEVELOPERS

This section seeks your opinion on existing support to suppliers and product developers when developing new products for emergency excreta disposal.

Overall

2.1. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. Suppliers and product developers receive adequate guidance when developing new products	☐	☐	☐	☐	☐	☐	☐	☐
b. There should be more support to suppliers and product developers in:								
i. Understanding design requirements	☐	☐	☐	☐	☐	☐	☐	☐
ii. Evaluating product concepts	☐	☐	☐	☐	☐	☐	☐	☐
iii. Evaluating prototypes	☐	☐	☐	☐	☐	☐	☐	☐
iv. Promoting available products	☐	☐	☐	☐	☐	☐	☐	☐

Understanding design requirements

2.2. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. Design requirements are clearly communicated to suppliers and product developers	☐	☐	☐	☐	☐	☐	☐	☐
b. Suppliers and product developers understand:								
i. Challenges faced during emergencies	☐	☐	☐	☐	☐	☐	☐	☐
ii. The requirements of implementing agencies	☐	☐	☐	☐	☐	☐	☐	☐
iii. End user requirements	☐	☐	☐	☐	☐	☐	☐	☐
c. Suppliers and product developers have sufficient access to:								
i. Implementing agencies	☐	☐	☐	☐	☐	☐	☐	☐
ii. End users	☐	☐	☐	☐	☐	☐	☐	☐
iii. Emergency settings	☐	☐	☐	☐	☐	☐	☐	☐

Understanding design requirements: Design criteria 2.3. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. Design criteria should:								
i. Be specific	☐	☐	☐	☐	☐	☐	☐	☐
ii. Be able to be evaluated	☐	☐	☐	☐	☐	☐	☐	☐
iii. Allow for creative solutions	☐	☐	☐	☐	☐	☐	☐	☐
iv. Be categorised by customer and end user needs	☐	☐	☐	☐	☐	☐	☐	☐
b. Design criteria should be prioritised by:								
i. Identifying critical parameters	☐	☐	☐	☐	☐	☐	☐	☐
ii. "Must-meet" and "should-meet" criteria	☐	☐	☐	☐	☐	☐	☐	☐
iii. "Essential", "important" and "optional" criteria	☐	☐	☐	☐	☐	☐	☐	☐
iv. Relative numerical weights	☐	☐	☐	☐	☐	☐	☐	☐

Evaluation of product concepts 2.4. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. Evaluating concepts is an important stage of product development	☐	☐	☐	☐	☐	☐	☐	☐
b. Suppliers and product developers:								
i. Have the means to evaluate proposed concepts	☐	☐	☐	☐	☐	☐	☐	☐
ii. Can easily obtain feedback on proposed concepts	☐	☐	☐	☐	☐	☐	☐	☐
c. Implementing agencies:								
i. Have the means to evaluate proposed concepts	☐	☐	☐	☐	☐	☐	☐	☐
ii. Are receptive to unfamiliar concepts	☐	☐	☐	☐	☐	☐	☐	☐

Evaluation of prototypes

2.5. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. Evaluating prototypes is an important stage of product development	☐	☐	☐	☐	☐	☐	☐	☐
b. Suppliers and product developers:								
i. Have the means to evaluate prototypes	☐	☐	☐	☐	☐	☐	☐	☐
ii. Can easily obtain feedback on prototypes	☐	☐	☐	☐	☐	☐	☐	☐
c. Implementing agencies:								
i. Have the means to evaluate prototypes	☐	☐	☐	☐	☐	☐	☐	☐
ii. Are receptive to unfamiliar products	☐	☐	☐	☐	☐	☐	☐	☐

Promoting available products

2.6. To what extent do you agree with the following statements:	Strongly disagree -3	Disagree -2	Somewhat disagree -1	Neutral 0	Somewhat agree +1	Agree +2	Strongly agree +3	Don't know
a. I am aware of the products available on the market	☐	☐	☐	☐	☐	☐	☐	☐
b. It is easy to:								
i. Introduce new products to potential customers	☐	☐	☐	☐	☐	☐	☐	☐
ii. Learn about new products	☐	☐	☐	☐	☐	☐	☐	☐
iii. Compare competing products	☐	☐	☐	☐	☐	☐	☐	☐
iv. Choose an appropriate product to purchase	☐	☐	☐	☐	☐	☐	☐	☐

CONTINUE TO NEXT SECTION

3. IMPROVING SUPPORT FOR PRODUCT DEVELOPMENT

We have identified some measures that could potentially help suppliers and developers in developing more successful products. This section seeks your opinion on these measures. If you wish to comment on any of the following measures there is space for comments on the final page.

Understanding design requirements	Very small -3	Small -2	Somewhat small -1	Neutral 0	Somewhat large +1	Large +2	Very large +3	Don't know	Very difficult -3	Difficult -2	Somewhat difficult -1	Neutral 0	Somewhat easy +1	Easy +2	Very easy +3	Don't know
3.1. To what extent would the following measures:	A. Help suppliers and product developers design products								B. Be easy to implement							
a. Documenting and disseminating:																
i. Typical emergency scenarios and corresponding design criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Challenges faced by implementing agencies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iii. Challenges faced by end users	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iv. The performance of existing products in emergencies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. Developing:																
i. A common standard for describing design criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Indicators for evaluating individual design criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. Creating a design tool that includes:																
i. Typical contexts of use for a specified product type	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Design criteria for a specified emergency scenario	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iii. Design requirements and product components which fulfil them	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iv. Relationships between various design requirements and product components	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
v. A corresponding tool for evaluating product concepts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
vi. Corresponding guidelines for evaluating prototypes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Evaluating product concepts	Very small -3	Small -2	Somewhat small -1	Neutral 0	Somewhat large +1	Large +2	Very large +3	Don't know	Very difficult -3	Difficult -2	Somewhat difficult -1	Neutral 0	Somewhat easy +1	Easy +2	Very easy +3	Don't know
3.2. To what extent would the following measures:	A. Help suppliers and product developers choose concepts to develop further								B. Be easy to implement							
a. Checklist of design requirements	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. Matrix to guide concept screening (non-weighted)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. Matrix to guide concept scoring (weighted)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. Documentation of results from the evaluation of similar products	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. A system where concepts can be reviewed by experts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Evaluating prototypes	Very small -3	Small -2	Somewhat small -1	Neutral 0	Somewhat large +1	Large +2	Very large +3	Don't know	Very difficult -3	Difficult -2	Somewhat difficult -1	Neutral 0	Somewhat easy +1	Easy +2	Very easy +3	Don't know
3.3. To what extent would the following measures:	A. Help suppliers and product developers evaluate product prototypes								B. Be easy to implement							
a. Documenting and disseminating examples of how prototypes of various product types were evaluated	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. Developing guidelines that include:																
i. General methods for evaluating prototypes (see 3.4 for examples)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
ii. Tests for evaluating individual design criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. Providing:																
i. A system where prototypes can be reviewed by experts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Facilities or locations for evaluating prototypes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Evaluating prototypes: methods	Very small -3	Small -2	Somewhat small -1	Neutral 0	Somewhat large +1	Large +2	Very large +3	Don't know	Very difficult -3	Difficult -2	Somewhat difficult -1	Neutral 0	Somewhat easy +1	Easy +2	Very easy +3	Don't know
3.4. To what extent would the following methods:	A. Be useful for evaluating prototypes								B. Be easy to implement							
a. Checking of product specifications against design requirements	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. Inspection of prototypes by experts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. Laboratory-based tests or experiments	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. Field testing under non-emergency settings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. Field testing under emergency settings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f. Benchmarking against existing products	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Promoting end products	Very small -3	Small -2	Somewhat small -1	Neutral 0	Somewhat large +1	Large +2	Very large +3	Don't know	Very difficult -3	Difficult -2	Somewhat difficult -1	Neutral 0	Somewhat easy +1	Easy +2	Very easy +3	Don't know
3.5. To what extent would the following measures:	A. Support the dissemination of end products								B. Be easy to implement							
a. Documenting and disseminating:																
i. A list of available products	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Product specifications of available products	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iii. The performance of available products during testing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
iv. The performance of available products in emergencies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. Enforcing:																
i. A common standard for presenting product specifications	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ii. Product testing with associated protocols	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. Creating a decision support tool for choosing a suitable product	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

CONTINUE TO FINAL SECTION

COMMENTS

Do you have any other comments on supporting product development in the emergency sanitation sector?

WRAP UP

If you would like to receive a copy of the results please provide your email address: _____

We plan to conduct interviews to gain a deeper understanding of product development in the emergency sanitation sector. If you are interested in taking part in an interview supplementary to the questions in this survey, please provide your contact details:

Name: _____

Organisation: _____

Email: _____

Telephone: _____

Address: _____

Can you recommend anyone to take part in this survey? If so, please provide their names and contact information:

THANK YOU FOR YOUR CO-OPERATION

Appendix 2 Stakeholder survey responses

1. Individual responses (1.1a – 2.1a)

No.	1.1a	1.1b	1.1c	1.1d	1.2	1.3	1.4	1.5	1.6	1.7	2.1a
1	2	6	0	3	1	23	6	1	1	4	4
2	1	11	2	3	1	30	4	6	1	3	5
3	1	6	2	2	1	39	3	1	2	4	2
4	1	2	0	3	1	15	1	1-6	1	4	6
5	1	8	4	3	1	168	7	1,6	1	3	8
6	1	1	0	4	1	60	4	1,4-6	1	4	1
7	1	2	1	3	2	1	5	3	1	3	3
8	1	2	1	3	1	18	6	1,5-6	1	4	2
9	1	2	5	3	1	48	6	1-3,6	1	3	3
10	2	2	2	2	1	75	2	2,5-6	1	2	5
11	1	1	1	1	2	4	4	7	1	3	6
12	2	4	1	2	2	3	4	7	1	4	2
13	1	9	2	2	2	3	4	1-4	1	4	3
14	2	2	3	3	1	36	2	4	1	1	1
15	1	1	4	1	1	24	3	1-2	1	2	4
16	1	8	5	2	1	312	3	7	1	2	4
17	1	1	4	4	1	36	2	1,3-4	1	2	6
18	1	8	5	3	1	48	2	1,6	3	4	3
19	1	2	4	5	1	60	3	1,3,6	1	3	2
20	2	8	1	3	3	0	6	1,4,6-7	1	4	1
21	1	1	3	3	3	0	1	1,3-5	3	1	7
22	2	1	3	3	4	0	6	1,6-7	1	4	3
23	2	3	2	3	1	120	7	1-3,5-6	1	1	5
24	1	8	3	3	1	60	1	1-6	1	1	5
25	1	2	4	2	1	120	4	1-2,7	1	4	3
26	1	10	1	2	4	0	5	3,6	1	1	5
27	1	7	2	3	4	0	7	1,4	1	1	5
28	1	2	4	3	1	6	3	7	1	3	6
29	2	1	1	3	1	12	3	7	1	3	3
30	2	1	2	3	4	0	6	7	1	1	3
31	1	8	3	3	1	60	2	1-2,6	1	4	3
32	1	1	5	4	1	240	2	1-2,5-6	1	0	6
33	1	7	2	2	1	120	6	1-7	1	1	6
34	2	3	3	3	3	0	2	1-2	1	2	5
35	1	1	2	4	3	0	1	1,4-6	1	1	3
36	2	2	1	3	2	3	4	4	1	4	4
37	2	5	1	2	2	2	4	1	1	3	6
38	1	1	4	2	1	36	4	7	1	2	5
39	1	8	2	3	1	48	1	5-6	1	1	5
40	1	7	4	5	2	12	6	1-6	1	1	6
41	2	1	4	3	3	0	6	5-6	1	4	4
42	2	1	1	3	1	36	4	6	1	1	4
43	1	1	2	5	3	0	3	1,5-6	1	1	2
44	1	1	3	3	1	24	2	1-6	1	4	6
45	1	1	2	4	2	18	6	1-3,5-6	1	4	2
46	1	1	3	5	2	6	6	6-7	1	1	6
47	1	1	2	4	1	48	6	2	1	4	5
48	1	2	5	2	1	102	2	2-3	1	2	1
49	1	1	1	2	1	16	2	1-2,4	1	3	3
50	1	1	5	1	1	300	3	1	1	2	4
51	2	2	1	3	2	60	5	1-3	1	4	2
52	2	2	3	3	2	24	6	1-7	1	1	3
53	1	6	3	2	1	18	6	7	1	1	7
54	2	2	3	3	1	66	2	2-4	1	4	3
55	1	1	1	2	1	24	2	5-7	1	2	3
56	2	1	2	2	1	24	4	1-6	1	1	2

No.	1.1a	1.1b	1.1c	1.1d	1.2	1.3	1.4	1.5	1.6	1.7	2.1a
57	2	6	1	2	3	0	5	1,5	3	3	7
58	2	6	1	1	1	3	6	1,5-6	3	3	3
59	1	1	2	4	1	32	4	1-2	1	4	2
60	1	1	2	3	2	60	4	1,4	1	2	2
61	2	2	4	2	1	18	4	1-3,7	1	3	5
62	2	1	4	4	3	0	1	1-5	2	4	6
63	1	7	4	2	3	0	3	3	3	1	6
64	1	7	4	2	3	0	3	1	3	1	7
65	1	7	5	4	3	0	6	1	2	1	7
66	1	7	1	3	1	14	4	1-6	1	1	7
67	2	6	1	3	1	12	6	1-6	1	3	3

2. Sum of responses (1.1a – 2.1a)

Code	1.1a	1.1b	1.1c	1.1d	1.2	1.3	1.4	1.5	1.6	1.7	2.1a
[0]			3			15					
[1]	44	25	17	3	40	9	6	44	58	21	4
[2]	23	15	17	19	12	16	12	27	3	14	10
[3]		2	12	32	11	17	10	24	6	10	16
[4]		1	12	8	4	10	15	22		21	7
[5]		1	6	5			4	24			11
[6]		6					17	32			12
[7]		7					3	16			6
[8]		7									1
[9]		1									
[10]		1									
[11]		1									

3. Codes (1.1a – 2.1a)

1.1a [1] Male [2] Female; **1.1b** [1] Western Europe [2] Northern Europe [3] Southern Europe [4] Eastern Europe [5] Eastern Asia [6] South-Eastern Asia [7] Southern Asia [8] Northern America [9] Central America [10] Caribbean [11] Eastern Africa; **1.1c** [0] Prefer not to say [1] 21 – 30 [2] 31 – 40 [3] 41 – 50 [4] 51 – 60 [5] > 60; **1.1d** [1] None [2] Bachelor's [3] Masters [4] PhD [5] Other; **1.2** [1] Currently involved [2] Previously involved [3] Intend to get involved [4] Not involved; **1.3** (months) [0] NA [1] ⩽ 6 [2] 1 – 2 years [3] >2 – 5 [4] >5; **1.4** [1] Customer [2] Supplier [3] Potential supplier [4] Product developer [5] Potential product developer [6] Intermediary [7] Other; **1.5** [1] Latrine facilities [2] Superstructure [3] Slab [4] Non-toilet options [5] Desludging [6] Treatment [7] Other; **1.6** [1] International [2] Regional [3] Local or national; **1.7** [0] Invalid response [1] Accountability [2] Personal motivation [3] Profit [4]; **2.1a** [1] Strongly disagree [2] Disagree [3] Somewhat disagree [4] Neutral [5] Somewhat agree [6] Agree [7] Strongly agree [8] Don't know

1. Individual responses (2.1bi – 2.2ciii)

No.	2.1bi	2.1bii	2.1biii	2.1biv	2.2a	2.2bi	2.2bii	2.2bii	2.2ci	2.2cii	2.2ciii
1	6	6	6	6	4	3	3	3	3	2	3
2	7	8	8	8	6	6	6	5	6	4	4
3	5	4	6	4	4	6	6	6	5	5	5
4	5	4	4	2	6	6	6	6	6	4	4
5	7	7	7	7	8	8	8	8	8	8	8
6	7	6	6	4	1	1	1	1	2	2	1
7	7	7	7	7	8	2	2	5	4	2	1
8	6	7	7	5	2	3	3	2	3	4	3
9	6	7	7	6	2	3	2	2	3	3	5
10	6	6	6	6	5	5	3	3	4	2	2
11	6	4	4	4	4	2	3	5	4	2	2
12	6	6	6	8	1	3	3	1	6	1	1
13	6	7	6	4	3	5	5	5	3	2	1
14	7	7	7	5	1	5	5	7	2	7	1
15	6	7	7	7	2	4	3	3	3	2	2
16	6	6	6	4	2	2	2	2	2	2	2
17	6	6	7	4	5	4	3	3	3	3	3
18	6	4	6	7	6	6	6	6	6	2	5
19	7	6	6	6	2	5	3	6	3	3	3

No.	2.1bi	2.1bii	2.1biii	2.1biv	2.2a	2.2bi	2.2bii	2.2bii	2.2ci	2.2cii	2.2ciii
20	7	7	7	7	1	2	2	2	8	8	8
21	7	7	6	5	6	7	7	8	4	8	2
22	6	6	6	8	5	2	4	3	8	2	8
23	6	6	6	6	3	3	3	3	4	2	2
24	6	6	4	2	4	3	2	3	5	3	2
25	7	7	7	5	5	3	3	2	2	1	2
26	7	6	5	7	3	4	7	7	8	4	2
27	7	7	7	7	5	6	5	6	5	5	5
28	6	6	6	6	5	5	5	5	3	3	3
29	6	7	7	7	5	3	3	5	3	2	2
30	6	6	6	4	2	4	4	2	4	1	4
31	7	6	7	6	2	3	3	1	3	1	1
32	5	5	6	6	6	6	6	6	5	5	6
33	7	7	7	4	6	5	6	5	7	6	5
34	6	6	6	6	3	5	5	5	5	5	5
35	6	5	5	5	2	3	3	4	3	5	2
36	7	7	7	7	5	5	4	5	3	3	3
37	7	7	7	7	6	5	5	4	4	4	5
38	6	6	6	6	3	6	3	4	2	3	2
39	6	6	6	5	5	2	2	2	5	3	2
40	7	7	7	7	6	5	5	5	6	6	6
41	7	4	5	6	8	4	5	2	8	1	3
42	7	7	7	6	1	5	1	3	5	1	1
43	7	7	7	7	2	2	4	1	2	1	2
44	5	6	5	5	5	5	4	5	6	5	6
45	7	7	7	7	1	5	3	5	2	5	3
46	6	6	6	6	6	6	6	6	5	4	5
47	5	5	7	7	2	5	3	3	2	2	2
48	6	5	5	6	2	3	3	4	2	4	4
49	7	6	5	4	3	6	6	5	3	1	3
50	5	5	5	5	6	6	6	6	4	3	3
51	7	6	5	4	2	3	3	3	3	3	3
52	6	6	6	6	2	3	3	2	3	2	3
53	7	7	7	7	7	7	7	7	6	6	7
54	5	5	5	5	3	2	1	1	2	1	1
55	5	6	6	5	4	5	5	5	4	4	3
56	7	7	7	7	1	1	1	2	3	1	1
57	6	6	6	7	7	7	6	6	7	6	6
58	7	7	7	7	3	5	8	3	3	5	8
59	7	6	6	4	2	2	2	3	2	1	1
60	6	6	6	6	2	2	2	2	2	2	2
61	6	7	7	7	3	6	3	5	3	3	3
62	4	6	6	6	6	3	3	6	8	8	8
63	6	7	6	7	7	6	6	6	6	6	7
64	6	6	7	3	6	7	7	6	6	6	7
65	7	7	6	6	7	4	4	3	6	4	3
66	7	7	7	7	5	6	7	7	7	7	7
67	6	5	6	6	3	3	2	5	2	1	1

2. Sum of responses

Code	2.1bi	2.1bii	2.1biii	2.1biv	2.2a	2.2bi	2.2bii	2.2bii	2.2ci	2.2cii	2.2ciii
[1]					7	2	4	5		12	11
[2]				2	15	10	9	11	13	15	16
[3]				1	10	15	21	13	18	11	15
[4]	1	5	3	11	5	6	6	4	9	9	4
[5]	8	7	9	10	11	16	9	16	8	8	8
[6]	30	28	28	19	12	13	11	12	10	6	4
[7]	28	26	26	21	4	4	5	4	3	2	4
[8]		1	1	3	3	1	2	2	6	4	5

3. Codes (2.1bi – 2.2ciii)

2.1bi – 2.2ciii [1] Strongly disagree [2] Disagree [3] Somewhat disagree [4] Neutral [5] Somewhat agree [6] Agree [7] Strongly agree [8] Don't know

1. Individual responses (2.3ai – 2.4bii)

No.	2.3ai	2.3aii	2.3aiii	2.3aiv	2.3bi	2.3bii	2.3biii	2.3biv	2.4a	2.4bi	2.4bii
1	6	7	7	6	6	5	5	5	6	4	4
2	7	7	7	7	7	5	7	6	7	5	8
3	4	5	7	5	5	6	5	4	5	5	5
4	2	2	6	2	6	2	2	2	6	5	5
5	7	7	7	7	7	7	7	7	7	7	7
6	7	7	7	5	7	7	7	4	7	2	2
7	7	7	7	7	7	5	6	7	7	3	3
8	5	7	5	6	8	7	5	8	7	8	3
9	4	6	6	6	6	6	6	6	7	5	2
10	6	6	4	6	6	7	6	4	6	6	2
11	6	5	4	6	6	4	4	4	7	5	5
12	7	7	6	6	7	6	6	5	7	6	5
13	5	7	7	6	7	7	7	6	7	2	1
14	3	7	7	7	6	6	6	2	7	3	3
15	6	6	7	6	5	6	6	5	6	5	4
16	6	6	6	6	6	6	6	6	6	5	5
17	6	6	6	6	6	5	6	4	6	3	3
18	5	7	6	6	7	6	7	6	7	2	6
19	7	6	6	6	4	5	7	4	7	3	4
20	6	7	7	6	4	6	4	4	7	8	8
21	7	7	7	7	7	7	7	7	6	6	6
22	7	7	7	6	6	6	6	6	7	6	7
23	6	7	7	6	6	5	6	6	7	3	5
24	6	6	6	6	5	5	5	4	6	3	5
25	7	7	5	6	7	6	6	5	7	7	7
26	7	7	6	7	7	6	4	6	7	6	6
27	7	7	7	7	6	6	7	7	7	7	6
28	5	5	5	5	5	5	5	5	7	4	4
29	3	5	7	7	7	6	6	2	7	3	3
30	4	4	6	7	6	4	4	8	6	8	8
31	5	5	7	4	4	5	5	4	6	4	3
32	7	6	6	7	6	6	6	6	8	6	6
33	6	6	6	7	6	7	5	6	6	7	7
34	7	7	7	7	7	7	7	6	7	5	5
35	7	7	7	5	5	5	6	8	7	8	6
36	6	6	7	7	7	6	6	5	6	7	7
37	6	4	5	5	4	5	6	7	6	3	5
38	7	5	6	6	7	6	6	4	7	3	3
39	4	6	6	6	5	5	6	5	5	4	2
40	7	7	7	7	7	7	7	7	7	7	7
41	7	7	6	7	7	7	3	6	5	3	3
42	7	7	7	7	7	7	7	5	7	5	1
43	5	7	7	7	7	7	6	5	7	2	2
44	6	6	5	6	6	8	8	4	6	5	6
45	7	7	7	5	7	7	7	5	7	2	3
46	6	6	6	6	6	6	6	5	6	6	5
47	5	7	7	7	6	2	6	4	7	5	2
48	6	6	6	6	6	6	6	6	7	6	7
49	6	6	7	6	6	6	7	6	7	5	5
50	6	6	6	6	6	6	6	6	6	6	6
51	7	7	7	7	7	7	7	7	7	5	3
52	6	6	6	6	6	6	6	6	4	3	3
53	7	7	7	7	7	7	7	7	7	7	7
54	6	6	7	6	6	6	6	5	7	2	1
55	4	4	6	5	5	5	7	4	6	4	4
56	7	7	2	7	7	7	3	5	7	3	1

No.	2.3ai	2.3aii	2.3aiii	2.3aiv	2.3bi	2.3bii	2.3biii	2.3biv	2.4a	2.4bi	2.4bii
57	7	7	6	6	7	6	5	6	6	5	6
58	4	7	7	6	6	4	5	5	6	6	4
59	7	7	7	6	7	7	6	4	7	6	2
60	6	6	5	6	6	6	6	2	7	3	2
61	2	7	7	2	6	6	5	4	7	2	2
62	8	7	4	8	5	4	4	6	6	8	8
63	7	7	6	6	7	6	6	6	7	7	7
64	7	7	7	6	7	6	6	6	7	7	7
65	7	7	7	6	7	7	7	6	7	6	6
66	5	6	7	7	7	7	7	5	7	7	7
67	7	7	7	2	5	5	7	2	6	3	8

2. Sum of responses (2.3ai – 2.4bii)

Code	2.3ai	2.3aii	2.3aiii	2.3aiv	2.3bi	2.3bii	2.3biii	2.3biv	2.4a	2.4bi	2.4bii
[1]											4
[2]	2	1		3		2	1	5		7	9
[3]	3		1				2			14	11
[4]	6	3	3	1	4	4	5	15	1	5	6
[5]	8	6	6	7	9	14	10	15	3	14	11
[6]	20	20	22	33	25	27	29	21	21	12	10
[7]	27	37	35	22	28	19	19	8	41	10	11
[8]	1			1	1	1	1	3	1	5	5

3. Codes (2.3ai – 2.4bii)

2.3ai – 2.4bii [1] Strongly disagree [2] Disagree [3] Somewhat disagree [4] Neutral [5] Somewhat agree [6] Agree [7] Strongly agree [8] Don't know

1. Individual responses (2.4ci – 2.6biii)

No.	2.4ci	2.4cii	2.5a	2.5bi	2.5bii	2.5ci	2.5cii	2.6a	2.6bi	2.6bii	2.6biii
1	8	8	7	3	3	6	3	5	4	8	8
2	8	8	7	8	8	5	8	6	5	5	5
3	5	5	7	6	5	5	6	6	4	4	3
4	5	6	6	5	5	5	6	7	3	6	6
5	7	8	7	7	7	7	8	6	6	6	6
6	2	2	7	4	2	2	2	6	1	2	1
7	5	4	7	5	5	5	5	5	6	6	6
8	2	3	7	8	3	3	3	5	2	3	1
9	5	3	7	5	3	5	3	5	3	5	5
10	7	3	7	6	3	7	5	6	6	6	5
11	6	4	5	6	6	6	4	4	3	4	3
12	5	5	7	6	6	7	5	6	3	5	5
13	4	2	7	5	5	4	3	6	2	2	6
14	6	1	7	5	5	7	1	5	2	5	6
15	6	2	6	6	6	6	6	5	2	2	2
16	8	8	6	4	3	3	8	4	2	2	5
17	5	3	6	3	3	6	4	4	3	4	3
18	6	2	7	5	5	7	5	3	6	2	6
19	3	2	7	3	3	6	3	5	3	5	5
20	6	8	7	8	8	6	8	5	1	5	3
21	7	7	7	5	3	7	7	4	4	4	4
22	8	8	7	6	7	8	8	5	2	3	3
23	3	5	7	6	3	6	5	5	3	5	3
24	6	6	6	3	3	5	5	5	4	5	5
25	7	7	7	7	7	7	7	3	2	3	2
26	7	4	7	5	4	4	5	5	4	5	7
27	6	7	7	7	7	6	6	6	4	3	3
28	5	4	7	5	3	6	5	3	4	4	4
29	3	1	7	3	2	5	7	5	3	3	3
30	6	5	7	8	8	6	5	6	4	3	3
31	3	2	6	6	5	6	2	3	3	5	5
32	7	5	7	6	7	7	5	6	3	4	5

No.	2.4ci	2.4cii	2.5a	2.5bi	2.5bii	2.5ci	2.5cii	2.6a	2.6bi	2.6bii	2.6biii
33	7	6	7	7	6	7	7	6	2	6	6
34	7	5	7	5	5	7	5	0	3	5	5
35	7	6	7	8	6	6	6	3	8	6	5
36	7	7	7	7	7	5	4	6	3	3	3
37	4	6	3	4	5	3	6	6	5	5	7
38	3	3	7	5	5	7	7	6	2	5	4
39	3	5	6	3	3	3	5	5	4	5	5
40	6	6	7	7	7	7	7	6		5	5
41	4	8	8	8	8	8	8	5	2	5	3
42	7	2	7	5	1	7	2	5	2	5	5
43	7	3	7	6	2	7	3	8	2	3	2
44	6	5	7	6	6	7	8	6	6	6	5
45	6	2	7	5	3	5	2	6	2	2	2
46	6	4	6	6	6	6	4	5	4	4	4
47	6	5	7	1	1	6	5	5	3	5	8
48	6	3	7	6	7	6	3	5	2	3	3
49	7	5	7	6	5	7	5	6	2	3	5
50	4	3	7	6	6	5	5	7	3	4	5
51	3	2	7	5	5	3	3	5	3	4	3
52	3	3	4	4	4	4	4	2	8	8	8
53	7	7	7	7	7	7	7	7	7	7	7
54	2	2	7	1	1	5	2	5	4	4	3
55	4	4	6	4	4	4	4	5	3	3	4
56	5	5	7	5	1	6	5	7		7	7
57	6	5	7	6	6	6	4	6	3	5	6
58	6	8	6	6	6	6	6	2	8	5	8
59	3	2	7	6	3	3	3	6	3	5	5
60	6	2	7	2	2	6	2	6	2	3	3
61	2	3	7	3	2	2	3	6	2	2	3
62	2	2	7	8	8	2	2	6	2	5	4
63	7	6	7	6	6	7	6	7	7	7	7
64	7	6	6	6	6	6	6	7	7	7	7
65	6	5	7	3	4	3	3	6	4	5	6
66	6	7	6	6	7	7	7	7	7	7	7
67	4	4	7	3	3	8	4	6	2	1	1

2. Sum of responses (2.4ci – 2.6biii)

Code	2.4ci	2.4cii	2.5a	2.5bi	2.5bii	2.5ci	2.5cii	2.6a	2.6bi	2.6bii	2.6biii
[1]		2		2	4		1		3	1	3
[2]	5	13		1	5	3	7	2	19	7	4
[3]	9	10	1	9	15	7	11	5	18	12	16
[4]	6	7	1	5	4	4	8	4	12	10	6
[5]	8	13	1	15	12	11	16	22	3	22	18
[6]	19	8	12	21	12	20	9	25	5	8	9
[7]	16	6	51	7	10	19	8	7	4	5	7
[8]	4	8	1	7	5	3	7	1	3	2	4

3. Codes (2.4ci – 2.6biii)

2.4ci – 2.6biii [1] Strongly disagree [2] Disagree [3] Somewhat disagree [4] Neutral [5] Somewhat agree [6] Agree [7] Strongly agree [8] Don't know

1. Individual responses (2.6biv – 3.1Aciv)

No.	2.6biv	3.1Aai	3.1Aaii	3.1Aaiii	3.1Aaiv	3.1Abi	3.1Abii	3.1Aci	3.1Acii	3.1Aciii	3.1Aciv
1	8	6	6	6	6	5	5	6	6	6	6
2	5	7	7	7	7	7	7	7	7	7	7
3	4	5	4	4	4	7	6	6	6	6	5
4	6	6	6	6	6	2	2	4	8	8	8
5	4	7	7	7	7	5	7	7	7	7	7
6	1	6	6	6	6	6	6	2	2	2	2
7	8	7	7	7	7	7	7	7	7	7	7
8	3	5	6	6	6	4	6	6	5	8	6

No.	2.6biv	3.1Aai	3.1Aaii	3.1Aaiii	3.1Aaiv	3.1Abi	3.1Abii	3.1Aci	3.1Acii	3.1Aciii	3.1Aciv
9	5	6	6	6	6	5	6	6	6	6	6
10	5	5	6	6	7	3	3	5	5	5	5
11	4	6	4	6	6	7	3	5	5	6	4
12	3	7	7	7	7	3	3	7	7	5	5
13	5	6	6	7	7	6	6	6	6	6	6
14	8	6	7	7	6	3	3	2	8	8	8
15	3	4	4	4	4	5	6	6	6	6	6
16	4	5	5	5	5	5	5	8	8	5	5
17	8	5	5	6	6	6	6	6	6	5	5
18	3	2	4	5	6	5	5	8	8	8	8
19	3	6	6	7	5	4	4	5	6	6	6
20	3	6	6	8	7	6	6	6	6	6	6
21	3	6	6	6	6	5	4	7	7	7	7
22	8	6	8	6	7	3	3	7	7	6	6
23	4	6	6	6	6	5	6	6	6	6	6
24	5	4	6	6	5	2	3	3	3	3	3
25	3	7	7	7	7	5	6	6	5	5	8
26	7	3	8	5	6	4	5	6	7	7	6
27	3	6	7	6	6	6	6	6	7	6	6
28	4	5	6	6	6	3	3	5	6	6	6
29	2	7	5	7	7	6	6	6	7	5	5
30	4	4	6	7	6	6	6	6	6	6	6
31	5	5	3	5	6	5	8	5	6	4	3
32	4	0	0	0	0	0	0	0	0	0	0
33	6	6	6	6	6	6	6	6	6	8	6
34	5	6	6	6	6	6	6	6	6	6	6
35	3	8	8	8	8	8	8	8	8	8	8
36	3	7	7	7	7	6	6	6	7	7	7
37	6	5	4	6	7	6	6	5	6	7	7
38	5	6	5	6	6	6	6	5	5	5	5
39	5	6	6	6	6	3	3	3	5	5	5
40	5	6	7	6	6	7	6	7	6	7	6
41	2	7	7	7	7	8	8	8	8	8	8
42	2	7	7	7	7	7	6	7	7	7	7
43	2	5	6	7	7	5	5	7	6	6	6
44	5	5	6	5	5	5	5	6	5	6	5
45	2	7	7	7	7	6	7	7	7	7	7
46	4	6	5	6	5	6	5	5	5	5	5
47	8	5	6	6	6	4	5	6	5	5	5
48	4	5	5	5	6	4	4	4	4	4	4
49	3	6	6	6	6	6	6	6	6	6	6
50	4	4	3	4	4	4	4	4	4	4	4
51	3	5	6	6	7	2	6	5	5	5	5
52	8	7	7	7	7	8	8	8	8	8	8
53	7	6	6	6	6	6	6	6	6	6	6
54	8	2	2	2	4	2	2	1	1	1	1
55	4	5	5	6	6	5	5	5	5	4	4
56	7	7	6	7	6	1	1	8	1	5	3
57	6	6	6	6		7	6		6	6	6
58	5	7	7	7	7	7	7	7	7	7	7
59	5	7	7	7	7	7	7	6	6	6	7
60	3	6	6	6	6	6	5	5	6	6	6
61	8	5	6	7	6	1	3	3	3	2	3
62	3	8	8	8	8	8	8	8	8	8	8
63	7	2	6	6	1	1	2	1	2	3	5
64	7	3	6	6	1	1	2	1	2	3	5
65	7	7	6	7	6	7	7	8	3	6	7
66	7	6	7	7	7	7	7	7	6	7	7
67	3	6	6	5	6	6	7	6	6	5	5

2. Sum of responses (2.6biv – 3.1Aciv)

Code	2.6biv	3.1Aai	3.1Aaii	3.1Aaiii	3.1Aaiv	3.1Abi	3.1Abii	3.1Aci	3.1Acii	3.1Aciii	3.1Aciv
[0]		1	1	1	1	1	1	1	1	1	1
[1]	1				2	4	1	3	2	1	1
[2]	5	3	1	1		4	4	2	3	2	1
[3]	16	2	2			6	9	3	3	3	4
[4]	12	4	5	3	4	6	4	3	2	4	4
[5]	13	15	7	7	6	13	10	12	11	13	15
[6]	3	25	31	30	31	18	24	23	24	22	21
[7]	7	15	16	23	21	11	9	12	13	12	12
[8]	10	2	4	2	2	4	5	8	8	9	8

3. Codes (2.4ci – 2.6biii)

2.6biv [1] Strongly disagree [2] Disagree [3] Somewhat disagree [4] Neutral [5] Somewhat agree [6] Agree [7] Strongly agree [8] Don't know; **3.1Aai – 3.1Aciv** [0] No response [1] Very small [2] Small [3] Somewhat small [4] Neutral [5] Somewhat large [6] Large [7] Very large [8]

1. Individual responses (3.1Acv – 3.3Aci)

No.	3.1Acv	3.1Acvi	3.2Aa	3.2Ab	3.2Ac	3.2Ad	3.2Ae	3.3Aa	3.3Abi	3.3Abii	3.3Aci
1	5	5	5	4	4	6	6	6	5	6	6
2	7	7	7	7	7	7	7	7	7	7	7
3	5	5	2	5	4	5	3	4	5	4	4
4	2	2	6	2	2	6	6	2	2	2	6
5	7	7	7	7	7	7	7	7	7	7	7
6	2	2	6	4	4	6	4	6	6	6	6
7	7	7	6	6	7	7	7	6	7	7	7
8	6	6	6	5	6	6	6	7	5	5	6
9	6	6	6	6	6	6	6	6	6	6	6
10	5	5	5	4	4	6	5	4	5	4	5
11	3	3	6	4	5	8	4	8	5	4	4
12	5	6	6	5	7	6	7	5	6	6	7
13	6	6	6	6	6	6	6	6	6	6	6
14	8	7	8	8	8	8	8	6	7	7	6
15	6	6	6	5	6	6	6	6	6	6	6
16	5	5	6	6	6	6	6	6	6	6	6
17	5	6	6	4	5	6	5	6	5	4	5
18	8	8	8	8	8	8	8	6	6	6	5
19	5	6	3	3	3	6	6	6	6	5	6
20	6	6	7	8	8	7	7	5	5	5	6
21	7	7	7	6	6	7	6	6	6	6	6
22	7	7	6	6	7	6	7	6	6	7	7
23	6	7	6	5	5	7	6	7	7	7	7
24	5	5	2	2	2	5	5	6	6	6	6
25	4	4	7	8	5	4	7	6	6	7	7
26	6	6	7	5	5	6	6	6	5	5	5
27	7	7	7	6	7	7	7	7	7	7	7
28	6	6	5	5	5	5	5	4	4	4	4
29	5	5	6	6	6	7	7	6	6	7	7
30	6	6	5	8	8	6	6	6	6	6	4
31	3	5	6	8	8	4	6	8	8	5	5
32	0	0	5	5	4	6	6	6	5	5	6
33	6	6	6	6	6	6	6	6	6	6	6
34	6	6	6	6	6	6	6	6	6	6	6
35	8	8	8	8	8	8	8	8	8	8	8
36	7	7	6	6	6	6	7	7	6	6	7
37	7	5	6	5	7	7	6	5	4	7	5
38	5	5	6	6	6	6	7	6	6	4	6
39	3	5	5	2	2	7	5	7	5	6	5
40	6	6	6	6	6	6	6	6	5	5	5
41	8	8	8	8	8	8	8	8	8	8	8
42	7	7	7	7	7	7	7	7	7	7	7
43	6	5	7	5	5	7	7	7	6	7	7

No.	3.1Acv	3.1Acvi	3.2Aa	3.2Ab	3.2Ac	3.2Ad	3.2Ae	3.3Aa	3.3Abi	3.3Abii	3.3Aci
44	5	4	4	8	8	5	5	4	6	5	5
45	7	7	7	6	6	7	6	7	6	6	6
46	6	6	6	4	4	6	5	5	5	5	5
47	6	6	6	5	6	5	4	5	5	5	6
48	4	4	5	5	5	5	5	4	4	4	5
49	6	6	6	6	6	6	7	6	6	6	6
50	4	4	4	4	4	4	4	4	4	4	4
51	6	6	6	5	6	6	6	6	4	4	5
52	8	8	6	8	8	8	8	8	8	8	8
53	6	6	6	6	6	6	6	7	7	7	7
54	1	1	6	7	7	7	6	7	7	7	7
55	4	5	5	4	5	4	6	6	4	5	5
56	3	3	7	2	2	2	6	1	8	7	7
57	6	6	6	5	6	7	6	6	6	6	5
58	7	7	7	7	7	7	7	7	7	7	7
59	6	6	7	6	6	7	6	6	7	7	6
60	6	6	5	5	5	7	6	6	6	6	7
61	3	5	4	5	5	6	7	5		5	7
62	8	8	8	8	8	8	8	8	8	8	8
63	3	5	1	2	6	7	6	6	6	5	2
64	3	5	3	3	6	7	6	6	6	7	2
65	7	7	7	6	6	6	7	6	6	7	7
66	7	6	7	6	7	7	7	6	7	7	7
67	7	7	7	5	5	6	6	5	7	7	5

2. Sum of responses (3.1Acv – 3.3Aci)

Code	3.1Acv	3.1Acvi	3.2Aa	3.2Ab	3.2Ac	3.2Ad	3.2Ae	3.3Aa	3.3Abi	3.3Abii	3.3Aci
[0]	1	1									
[1]	1	1	1					1			
[2]	2	2	2	5	4	1		1	1	1	2
[3]	7	2	2	2	1		1		1		
[4]	4	4	3	8	7	4	4	6	6	10	5
[5]	11	15	9	17	12	6	8	7	13	14	15
[6]	21	23	29	19	22	28	30	33	27	19	21
[7]	14	14	16	5	11	21	18	13	13	19	20
[8]	6	5	5	11	10	7	6	6	6	4	4

3. Codes (3.1Acv – 3.3Aci)

3.1Acv – 3.3Aci [0] No response [1] Very small [2] Small [3] Somewhat small [4] Neutral [5] Somewhat large [6] Large [7] Very large [8]

1. Individual responses (3.3Acii – 3.5Aaiv)

No.	3.3Acii	3.4Aa	3.4Ab	3.4Ac	3.4Ad	3.4Ae	3.4Af	3.5Aai	3.5Aaii	3.5Aaiii	3.5Aaiv
1	6	6	6	6	5	6	6	5	5	5	6
2	7	7	7	7	4	7	7	7	7	7	7
3	5	4	4	6	6	7	6	5	5	6	5
4	6	2	5	3	4	7	2	6	6	6	6
5	7	7	7	7	7	7	8	7	7	7	7
6	6	6	6	6	6	6	6	6	6	6	6
7	7	6	7	7	7	7	6	7	7	7	7
8	5	5	5	6	3	6	6	3	3	5	6
9	6	6	6	6	6	7	7	6	6	6	6
10	5	6	6	6	3	7	4	7	7	4	7
11	5	4	5	6	6	6	5	4	5	3	6
12	6	6	7	6	5	7	6	6	7	5	7
13	6	6	6	6	6	7	7	7	7	7	7
14	7	5	5	7	7	7	3	7	7	6	7
15	7	6	7	6	7	7	6	6	6	6	6
16	6	6	6	6	6	6	6	6	6	6	6
17	5	6	6	4	6	6	4	6	5	6	6
18	5	3	6	3	6	7	7	4	5	6	6

No.	3.3Acii	3.4Aa	3.4Ab	3.4Ac	3.4Ad	3.4Ae	3.4Af	3.5Aai	3.5Aaii	3.5Aaiii	3.5Aaiv
19	6	6	6	4	5	6	6	6	6	6	6
20	6	6	6	6	6	6	6	6	7	7	7
21	6	6	6	6	6	6	6	7	7	7	7
22	7	6	6	7	6	7	5	5	5	6	7
23	6	6	6	6	7	7	6	7	7	7	7
24	5	5	6	5	5	6	5	5	5	5	6
25	7	6	7	7	6	7	6	7	7	6	6
26	7	6	6	5	6	6	5	7	5	7	7
27	7	6	6	6	7	7	7	7	7	7	7
28	4	5	5	5	5	5	5	4	4	5	5
29	7	4	6	4	3	7	6	7	7	7	7
30	6	6	4	2	6	6	5	6	6	6	6
31	7	5	6	5	7	7	6	6	6	6	7
32	6	6	6	6	6	7	5	5	5	6	6
33	6	6	6	6	6	6	6	6	6	6	6
34	6	6	6	6	6	6	6	6	6	6	6
35	8	8	8	8	8	8	8	8	8	8	8
36	7	7	7	7	7	7	7	7	7	7	7
37	7	6	4	7	6	5	6	5	7	5	7
38	7	6	6	6	6	7	3	6	6	5	6
39	6	4	5	5	6	6	6	6	6	6	6
40	5	6	6	6	6	6	5	5	6	6	6
41	8	8	8	8	8	8	8	8	8	8	8
42	7	7	7	7	7	7	7	7	7	7	7
43	7	7	7	5	6	7	5	6	6	6	7
44	5	5	5	5	5	5	5	4	5	5	5
45	6	7	5	5	5	7	7	7	7	7	7
46	4	5	4	5	6	6	5	4	5	5	5
47	5	4	5	5	6	6	4	5	5	6	7
48	5	5	5	4	5	5	5	5	5	5	5
49	6	7	7	7	6	7	5	7	6	7	7
50	4	4	4	4	4	4	4	4	4	4	4
51	7	6	6	6	7	7	5	6	6	6	6
52	8	5	4	4	5	7	5	5	4	5	6
53	7	7	7	7	7	7	7	6	6	6	7
54	7	7	7	5	5	7	7	4	4	7	7
55	5	5	5	5	6	7	5	5	5	5	6
56	2	5	7	5	6	7	5	1	1	1	5
57	6	5	5	5	6	7	4	6	7	7	7
58	7	7	7	7	7	7	7	7	7	7	7
59	6	7	7	6	6	7	7	6	6	1	5
60	7	5	7	5	7	7	5	4	4	5	7
61	7	6	7	2	7	7	4	7	7	7	7
62	8	4	6	5	4	7	5	5	5	5	7
63	1	1	2	1	5	1	2	1	2	1	1
64	1	1	2	1	5	1	2	2	2	1	1
65	5	7	7	6	6	4	7	7	7	7	6
66	6	7	7	7	5	7	7	7	7	7	7
67	6	6	4	5	5	7	6	6	6	6	7

2. Sum of responses (3.3Acii – 3.5Aaiv)

Code	3.3Acii	3.4Aa	3.4Ab	3.4Ac	3.4Ad	3.4Ae	3.4Af	3.5Aai	3.5Aaii	3.5Aaiii	3.5Aaiv
[1]	2	2		2		2		3	1	4	2
[2]	1	1	2	2			3		2		
[3]		1		2	3		2	1	1	1	
[4]	3	7	8	6	4	2	5	9	5	2	1
[5]	13	13	12	17	14	4	18	11	15	14	7
[6]	22	28	25	23	30	18	22	21	19	24	24
[7]	22	13	19	13	14	39	14	20	22	20	31
[8]	4	2	2	2	2	2	3	2	2	2	2

3. Codes (3.3Acii – 3.5Aaiv)

3.3Acii – 3.5Aaiv [0] No response [1] Very small [2] Small [3] Somewhat small [4] Neutral [5] Somewhat large [6] Large [7] Very large [8]

1. Individual responses (3.5Abi – 3.1Bcii)

No.	3.5Abi	3.5Abii	3.5Ac	3.1Bai	3.1Baii	3.1Baiii	3.1Baiv	3.1Bbi	3.1Bbii	3.1Bci	3.1Bcii
1	4	4	4	3	3	3	3	1	2	3	3
2	7	7	7	3	6	6	5	2	2	5	4
3	6	6	5	4	4	4	4	4	4	4	4
4	2	5	2	5	5	5	4	1	1	6	2
5	4	7	6	6	6	6	6	4	7	6	6
6	6	6	4	2	2	2	2	2	2	2	2
7	7	7	7	7	7	7	7	7	7	7	7
8	6	6	5	6	5	3	3	1	3	3	5
9	6	6	6	6	6	6	6	6	6	6	6
10	4	4	5	4	4	4	5	3	5	5	5
11	4	2	5	6	6	6	4	4	4	5	5
12	6	6	5	2	6	5	3	2	1	3	3
13	6	6	7	5	5	6	3	2	2	3	3
14	5	7	8	7	7	7	6	6	8	8	8
15	6	6	6	4	4	4	4	3	3	5	5
16	6	6	6	1	2	2	2	4	4	5	4
17	5	5	4	6	6	6	6	6	5	5	5
18	4	2	4	1	5	5	4	5	5	8	8
19	5	5	6	3	3	5	5	2	2	5	5
20	4	5	7	8	5	5	4	4	5	8	5
21	7	7	7	2	2	2	2	2	2	4	4
22	5	6	4	3	8	3	2	1	2	2	3
23	6	6	5	5	3	3	5	3	5	5	5
24	2	5	2	4	3	2	3	2	3	4	3
25	4	6	6	5	5	5	2	2	2	3	3
26	7	5	7	4	4	8	5	4	7	7	7
27	6	6	7	6	6	6	7	5	6	6	5
28	4	4	4	5	5	5	5	3	3	5	5
29	6	5	4	4	7	6	7	5	5	6	4
30	8	8	7	2	6	5	2	6	6	5	5
31	4	3	4	2	4	3	3	2	3	4	3
32	4	5	4	0	0	0	0	0	0	0	0
33	6	6	5	6	6	5	6	6	6	6	6
34	6	6	6	6	6	6	6	6	6	6	6
35	8	8	8	5	5	3	3	2	1	8	8
36	6	7	7	2	6	2	6	3	4	3	3
37	5	7	4	6	4	7	7	6	7	7	7
38	6	5	6	6	5	6	6	6	6	5	5
39	3	3	2	5	5	5	5	2	2	2	2
40	6	5	5	6	6	6	6	6	6	6	6
41	8	8	8	8	8	8	8	8	8	8	8
42	7	7	7	6	5	5	3	1	1	6	6
43	7	5	7	4	3	2	3	4	4	4	4
44	5	5	5	5	4	5	6	3	4	5	5
45	7	6	6	5	5	5	5	6	6	6	6
46	5	4	4	5	5	5	5	5	4	5	6
47	5	6	4	4	2	3	5	2	2	5	4
48	5	5	4	4	4	4	4	3	3	5	5
49	7	6	7	4	3	3	5	5	5	5	5
50	4	4	4	4	1	4	4	4	4	4	4
51	7	7	7	3	2	2	6	3	3	6	6
52	6	6	5	2	2	2	2	8	8	8	8
53	6	6	6	7	7	7	7	7	7	7	7
54	3	3	5	2	1	1	5	1	1	3	2
55	5	5	6	5	2	2	6	5	4	5	5

No.	3.5Abi	3.5Abii	3.5Ac	3.1Bai	3.1Baii	3.1Baiii	3.1Baiv	3.1Bbi	3.1Bbii	3.1Bci	3.1Bcii
56	1	2	5	7	1	1	5	7	7	8	1
57	6	6	7	4	2	2	5	2	2	5	3
58	6	7	6	4	5	4	5	3	3	3	3
59	6	6	6	2	5	5	6	6	6	3	3
60	3	4	2	2	1	2	2	2	2	2	2
61	4	3	3	3	5	5	3	1	2	5	5
62	4	4	7	5	2	5	6	2	2	5	5
63	2	3	1	2	1	2	1	6	2	1	6
64	2	3	1	2	1	2	1	6	2	1	6
65	7	6	6	7	7	7	6	7	7	7	7
66	7	7	7	2	2	2	6	5	5	3	3
67	7	5	6	4	2	5	3	2	3	5	2

2. Sum of responses (3.5Abi – 3.1Bcii)

Code	3.5Abi	3.5Abii	3.5Ac	3.1Bai	3.1Baii	3.1Baiii	3.1Baiv	3.1Bbi	3.1Bbii	3.1Bci	3.1Bcii
[0]				1	1	1	1	1	1	1	1
[1]	1		2	2	6	2	2	7	5	2	1
[2]	4	3	4	12	4	10	8	16	16	4	6
[3]	3	6	1	6	6	8	11	9	9	10	12
[4]	13	7	14	14	8	6	8	8	9	6	8
[5]	10	15	12	12	16	18	15	7	8	21	18
[6]	21	22	15	13	19	15	16	12	9	11	12
[7]	12	11	16	5	5	5	5	4	7	5	4
[8]	3	3	3	2	2	2	1	3	3	7	5

3. Codes (3.5Abi – 3.1Bcii)

3.5Abi – 3.5Ac [0] No response [1] Very small [2] Small [3] Somewhat small [4] Neutral [5] Somewhat large [6] Large [7] Very large [8]; **3.1Bai – 3.1Bcii** [0] No response [1] Very difficult [2] Difficult [3] Somewhat difficult [4] Neutral [5] Somewhat easy [6] Easy [7] Very easy [8] Don't know

1. Individual responses (3.1Bciii – 3.3Bbi)

No.	3.1Bciii	3.1Bciv	3.1Bcv	3.1Bcvi	3.2Ba	3.2Bb	3.2Bc	3.2Bd	3.2Be	3.3Ba	3.3Bbi
1	3	3	3	3	5	4	4	4	4	4	4
2	6	6	6	5	7	3	3	6	6	5	5
3	4	4	4	4	4	4	4	4	4	4	4
4	2	2	2	2	6	2	2	5	2	4	3
5	6	6	6	6	7	6	6	6	5	7	7
6	2	2	2	2	1	2	2	2	4	2	2
7	7	7	7	7	7	6	7	7	7	6	6
8	8	6	3	3	7	7	3	6	6	2	3
9	6	6	6	6	5	5	5	5	5	5	5
10	4	4	5	5	5	4	4	5	5	4	5
11	5	2	2	4	7	4	2	3	3	0	3
12	2	2	5	5	5	5	2	3	1	3	5
13	4	3	3	3	6	6	6	6	6	5	4
14	8	8	8	8	8	8	8	8	8	8	8
15	5	5	5	5	5	4	5	6	5	5	5
16	3	3	2	2	4	4	4	2	2	4	3
17	6	4	4	4	6	6	5	6	4	6	5
18	8	8	8	8	8	8	8	8	8	3	6
19	6	6	4	7	3	3	3	6	6	6	5
20	5	3	3	3	5	8	8	5	5	4	8
21	4	4	4	4	4	4	4	4	4	4	4
22	4	4	5	5	5	3	3	5	2	2	4
23	5	5	5	5	5	5	5	5	3	5	5
24	3	3	5	5	3	2	3	5	4	4	5
25	3	8	3	3	6	8	4	3	5	5	5
26	6	7	5	4	7	6	5	6	6	6	6
27	6	5	6	6	6	6	6	6	6	6	6
28	5	5	5	5	5	5	5	5	5	5	5
29	4	4	4	4	7	4	4	6	6	5	4

No.	3.1Bciii	3.1Bciv	3.1Bcv	3.1Bcvi	3.2Ba	3.2Bb	3.2Bc	3.2Bd	3.2Be	3.3Ba	3.3Bbi
30	4	3	3	3	5	8	8	6	4	6	6
31	8	2	3	5	5	8	8	5	3	8	8
32	0	0	0	0	5	5	5	5	5	5	5
33	8	6	6	6	6	6	6	6	6	5	6
34	6	6	6	6	6	6	6	6	6	6	6
35	8	8	8	8	5	3	3	5	2	3	2
36	2	3	3	3	5	5	3	5	3	5	5
37	7	6	6	7	6	7	4	6	5	5	7
38	5	5	5	5	5	5	3	3	4	4	6
39	5	2	2	3	3	1	1	3	2	3	3
40	5	5	6	6	6	6	6	6	6	7	6
41	8	8	8	8	8	8	8	8	8	8	8
42	6	3	6	3	7	7	7	7	7	7	7
43	4	4	3	4	4	4	4	3	3	4	4
44	5	3	5	4	6	6	6	5	5	6	5
45	6	6	6	6	6	6	6	6	6	6	6
46	6	5	6	6	5	4	4	5	5	5	5
47	2	8	8	8	6	3	2	3	4	3	1
48	5	5	5	5	5	4	4	4	4	4	4
49	5	3	4	3	6	5	5	6	3	3	3
50	4	4	4	4	4	4	4	4	4	4	4
51	6	6	6	6	6	6	6	5	2	3	3
52	8	8	8	8	4	8	8	8	8	8	8
53	7	7	7	7	7	7	7	7	7	7	7
54	2	1	3	3	2	3	3	2	2	2	2
55	4	6	5	5	5	4	5	6	4	5	4
56	7	2	6	6	7	2	2	2	6	7	8
57	3	3	2	3	3	3	2	5	2	5	3
58	3	3	3	3	3	3	3	5	5	5	3
59	3	3	3	3	6	6	6	6	6	5	5
60	2	2	2	2	2	2	2	2	3	2	2
61	6	6	6	6	6	6	6	5	2	3	6
62	5	5	5	3	5	5	5	5	5	4	3
63	5	3	2	2	6	2	1	1	1	1	2
64	5	3	2	2	6	2	1	1	1	1	2
65	7	6	6	7	3	2	2	4	5	3	3
66	5	3	3	6	6	5	3	7	6	4	5
67	5	5	3	1	6	4	3	2	1	4	2

2. Sum of responses (3.1Bciii – 3.3Bbi)

Code	3.1Bciii	3.1Bciv	3.1Bcv	3.1Bcvi	3.2Ba	3.2Bb	3.2Bc	3.2Bd	3.2Be	3.3Ba	3.3Bbi
[0]	1	1	1	1							
[1]		1		1	1	1	3	2	4	2	1
[2]	7	8	9	6	2	8	9	6	9	5	7
[3]	7	16	13	14	6	8	12	7	7	9	11
[4]	10	8	8	10	6	14	12	5	12	15	10
[5]	16	10	13	12	19	10	10	20	14	17	17
[6]	13	13	15	12	20	14	11	19	14	9	11
[7]	5	3	2	5	10	4	3	4	3	5	4
[8]	8	7	6	6	3	8	7	4	4	5	6

3. Codes (3.1Bciii – 3.3Bbi)

3.1Bciii – 3.3Bbi [0] No response [1] Very difficult [2] Difficult [3] Somewhat difficult [4] Neutral [5] Somewhat easy [6] Easy [7] Very easy [8] Don't know

1. Individual responses (3.1Bbii – 3.5Baii)

No.	3.3Bbii	3.3Bci	3.3Bcii	3.4Ba	3.4Bb	3.4Bc	3.4Bd	3.4Be	3.4Bf	3.5Bai	3.5Baii
1	4	4	3	5	3	2	4	3	3	5	5
2	5	5	5	5	6	6	6	5	6	5	3
3	4	4	4	4	4	4	4	4	4	4	4
4	3	3	3	6	5	4	5	2	8	4	4

No.	3.3Bbii	3.3Bci	3.3Bcii	3.4Ba	3.4Bb	3.4Bc	3.4Bd	3.4Be	3.4Bf	3.5Bai	3.5Baii
5	7	5	5	7	5	5	5	5	8	7	7
6	2	1	1	2	2	2	2	2	2	2	2
7	7	6	3	7	6	6	4	2	7	7	7
8	3	3	2	6	3	3	3	7	2	5	5
9	5	5	5	5	5	5	5	5	5	6	6
10	4	5	5	4	4	4	3	1	4	7	7
11	2	3	3	6	4	5	5	2	2	5	3
12	3	1	2	6	1	6	5	1	6	7	6
13	3	3	2	6	3	3	3	2	1	6	6
14	8	8	8	8	8	8	8	8	8	8	8
15	5	6	6	5	6	5	6	6	5	5	6
16	3	2	2	4	2	2	2	1	2	4	2
17	3	6	4	4	4	6	4	2	5	6	6
18	6	1	1	3	2	2	5	5	5	5	5
19	5	6	6	7	6	5	7	6	5	6	6
20	8	5	8	6	5	5	6	3	5	5	5
21	4	4	4	5	5	5	5	5	5	4	4
22	3	4	4	5	4	3	2	2	4	5	3
23	5	5	3	5	5	5	5	2	5	5	5
24	5	3	3	5	4	5	5	2	5	5	5
25	5	4	4	6	5	3	3	2	3	4	3
26	5	7	5	6	5	5	3	5	3	7	5
27	6	6	6	5	6	5	6	6	6	6	6
28	5	5	5	5	5	5	5	5	5	5	5
29	6	6	4	5	6	5	6	3	5	7	7
30	8	8	8	6	4	2	6	2	4	6	6
31	3	4	3	5	5	6	4	2	3	7	6
32	5	4	5	0	0	0	0	0	0	5	5
33	0	0	5	6	6	6	6	5	7	6	6
34	6	6	6	6	6	6	6	6	6	6	6
35	1	2	2	6	3	2	5	1	1	8	8
36	5	3	3	5	3	5	5	2	7	6	6
37	6	6	7	2	7	5	6	6	7	7	6
38	4	5	5	6	6	6	5	5	4	6	6
39	3	3	5	3	3	3	3	3	3	3	3
40	6	5	5	6	6	6	7	6	6	5	5
41	8	8	8	8	8	8	8	8	8	8	8
42	7	5	5	7	7	7	7	7	7	5	5
43	3	1	1	6	2	7	4	2	3	4	4
44	5	6	5	5	5	3	6	3	6	6	5
45	6	6	6	6	5	5	6	7	7	6	6
46	5	5	4	5	4	5	6	6	5	4	5
47	2	2	4	5	5	5	3	1	3	5	5
48	4	4	4	5	5	4	5	5	5	4	4
49	3	3	2	2	2	2	5	2	3	5	5
50	4	4	4	4	4	4	4	4	4	4	4
51	3	1	1	6	3	5	5	2	6	7	7
52	8	8	8	4	4	4	4	3	4	6	5
53	7	7	7	7	7	7	7	7	7	7	7
54	2	4	4	4	4	3	4	5	4	3	4
55	5	4	5	4	5	4	6	7	4	4	3
56	3	1	1	7	1	1	5	7	2	1	1
57	3	4	4	6	6	5	5	3	4	6	6
58	3	5	3	6	5	5	6	3	5	6	6
59	5	3	2	6	6	3	5	2	6	6	6
60	2	2	2	5	4	7	2	1	2	5	5
61	5	2	3	6	6	3	3	2	4	5	4
62	3	2	2	4	2	6	6	1	4	5	5
63	3	3	1	2	3	1	3	2	2	3	2
64	3	3	1	2	3	1	3	2	2	3	2

No.	3.3Bbii	3.3Bci	3.3Bcii	3.4Ba	3.4Bb	3.4Bc	3.4Bd	3.4Be	3.4Bf	3.5Bai	3.5Baii
65	4	3	6	3	4	3	5	2	5	5	4
66	3	6	5	6	7	5	4	2	6	7	7
67	1	3	1	6	3	3	4	2	4	7	7

2. Sum of responses (3.1Bbii – 3.5Baii)

Code	3.3Bbii	3.3Bci	3.3Bcii	3.4Ba	3.4Bb	3.4Bc	3.4Bd	3.4Be	3.4Bf	3.5Bai	3.5Baii
[0]	1	1		1	1	1	1	1	1		
[1]	2	6	8		2	3		7	2	1	1
[2]	5	6	9	5	6	7	4	23	8	1	4
[3]	19	13	10	3	10	11	10	8	8	4	6
[4]	8	12	12	9	13	7	11	2	13	10	9
[5]	16	12	15	18	16	22	20	11	15	20	18
[6]	7	11	6	23	13	10	15	7	9	16	18
[7]	4	2	2	6	4	4	4	6	7	12	8
[8]	5	4	5	2	2	2	2	2	4	3	3

3. Codes (3.1Bbii – 3.5Baii)

3.1Bbii – 3.5Baii [0] No response [1] Very difficult [2] Difficult [3] Somewhat difficult [4] Neutral [5] Somewhat easy [6] Easy [7] Very easy [8] Don't know

1. Individual responses (3.5Baiii – 3.5Bc)

No.	3.5Baiii	3.5Baiv	3.5Bbi	3.5Bbii	3.5Bc
1	3	3	8	8	4
2	5	6	5	5	3
3	4	4	4	4	4
4	3	3	1	3	3
5	6	6	1	4	5
6	2	2	3	3	4
7	5	3	1	6	6
8	4	3	1	2	8
9	6	6	6	6	6
10	4	7	4	4	5
11	2	2	4	2	2
12	5	1	3	1	2
13	5	5	3	3	3
14	8	8	8	8	8
15	5	5	5	5	5
16	3	1	2	2	3
17	5	3	4	3	3
18	5	5	1	1	4
19	6	5	7	6	4
20	5	3	3	3	5
21	4	4	4	4	4
22	2	2	3	4	5
23	5	3	5	5	3
24	4	3	4	4	4
25	3	2	2	2	2
26	7	6	7	5	7
27	6	6	4	4	7
28	5	5	5	5	5
29	7	7	6	4	3
30	6	3	8	8	1
31	6	4	4	2	5
32	3	3	2	2	2
33	6	6	6	6	5
34	6	6	6	6	6
35	8	8	2	2	2
36	5	2	5	5	3
37	4	6	5	5	4
38	5	6	6	5	6
39	3	3	2	2	2

No.	3.5Baiii	3.5Baiv	3.5Bbi	3.5Bbii	3.5Bc
40	5	5	5	5	5
41	8	8	8	8	8
42	5	5	5	5	5
43	3	1	3	2	3
44	5	3	5	5	5
45	6	6	6	6	6
46	5	5	5	4	4
47	3	2	2	4	2
48	4	4	4	4	4
49	2	3	3	3	3
50	4	4	4	4	4
51	5	5	6	6	6
52	5	3	4	3	3
53	6	7	7	7	7
54	4	4	2	2	4
55	4	5	5	5	6
56	1	5	4	1	3
57	5	5	3	3	3
58	6	5	4	3	3
59	1	3	3	2	3
60	2	1	5	5	5
61	3	2	3	3	3
62	5	1	4	4	5
63	2	2	3	3	2
64	2	2	3	3	2
65	5	5	3	3	3
66	7	5	1	2	2
67	2	2	3	1	3

2. Sum of responses (3.5Baiii – 3.5Bc)

Code	3.5Baiii	3.5Baiv	3.5Bbi	3.5Bbii	3.5Bc
[1]	2	5	5	4	1
[2]	8	10	7	13	11
[3]	9	15	14	12	17
[4]	10	6	14	13	12
[5]	21	15	12	13	13
[6]	11	10	7	7	7
[7]	3	3	4	1	3
[8]	3	3	4	4	3

3. Codes (3.5Baiii – 3.5Bc)

3.5Baiii – 3.5Bc [0] No response [1] Very difficult [2] Difficult [3] Somewhat difficult [4] Neutral [5] Somewhat easy [6] Easy [7] Very easy [8] Don't know

Appendix 3 Abucay Bunkhouse end user questionnaire (translated)

The end user questionnaire for Abucay Bunkhouse was first drafted in English and translated into Tagalog by volunteers at the bunkhouse. Here the English version of the questionnaire is presented.

Volunteer: A / J / M / Date: _____ Checked for completeness: ☐ Ref: _____

Dear Sir / Ma'am! Good day! My name is Yoke, I am a student from the UNESCO-IHE team. I would like to ask about what you think of your comfort room or bathroom. I would appreciate it if you could spend a little time to answer the questions below. There are no right or wrong answers and your responses will be kept confidential. If there are any questions that you are not comfortable answer, you may skip them. If you need some help to answer the questions, please approach our volunteers. Thank you very much!

1 ABOUT YOU

1.1 (a) Name (optional): _____ Gender: ☐ Male ☐ Female (b) Age: _____ years

1.2 What is the highest education level that you have obtained?
☐ None ☐ Elementary school ☐ High school
☐ College (Bachelor's) ☐ Masters, Doctoral or Supplemental

1.3 Before Typhoon Yolanda,

(a) Occupation:
☐ Permanent employment or business
☐ Seasonal work ☐ Casual, daily or weekly work
☐ Unemployed / student / housework / retired

(b) Annul household income:
☐ Less than ₱40,000 ☐ ₱40,000 – 59,999 ☐ ₱60,000 – 99,999
☐ ₱100,000 – 249,000 ☐ ₱250,000 or more ☐ Don't know

(c) Type of toilet facility used by the household: ☐ Sitting ☐ Squatting ☐ No toilet

(d) What did you use to clean yourself after:

	Dipper	Hose	Tissue	None
- Urinating	☐	☐	☐	☐
- Defecating	☐	☐	☐	☐

1.4 Current situation:

(a) When did you move to Abucay Bunkhouse? _____ month _____ year

(b) Building # _____, Room # _____

(c) Number of members in the household: _____ total, including you
_____ under 5 years old
_____ 65 years or older

2 SOURCE OF WATER

2.1 Source of drinking water:
☐ Community water system

☐ Private hose used alone or shared with other households
- Cost: ₱_____ per month
- Shared by _____ families

2.2 What do you do when there is no water? _____

3 ABOUT YOUR CR

3.1 How many minutes does it take to walk to your CR? _____ minuto

3.2 How many families / people use your CR? _____ families, _____ people

3.3 How similar is the CR now compared to the CR you used before Typhoon Yolanda?
☐ Very similar ☐ Similar ☐ Neutral ☐ Different ☐ Very different

3.4 Did you remove the wall between the CR and the bathroom so that it becomes more spacious? ☐ Yes ☐ No

3.5 What do you do at the CR? Tick all that apply. ☐ Urinate ☐ Defecate ☐ Bathe ☐ Brush ☐ Wash clothes ☐ Dry clothes ☐ Wash dishes

3.6 Yesterday, how many times did you go to the CR to urinate or defecate? _____ ilang beses

3.7 In the CR, there is:	Always	Often	Sometimes	Rarely	Never
(a) Water	☐	☐	☐	☐	☐
(b) Drum to store water	☐	☐	☐	☐	☐
(c) Dipper	☐	☐	☐	☐	☐
(d) Tissue	☐	☐	☐	☐	☐
(e) Soap	☐	☐	☐	☐	☐
(f) Lock	☐	☐	☐	☐	☐
(g) Light	☐	☐	☐	☐	☐
(h) A place to store rubbish	☐	☐	☐	☐	☐
(i) Air freshener	☐	☐	☐	☐	☐
(j) Cleaning tools	☐	☐	☐	☐	☐

3.8 What do you use to clean the CR? Tick all that apply.

☐ Water ☐ Chlorine (e.g. Domex) ☐ Detergent ☐ Soap ☐ Broom
☐ Scrub ☐ Gloves ☐ Cloth ☐ Others, please specify: _____

3.9 How many times is the toilet cleaned? (Answer only one)

_____ times per week _____ times per day

3.10 I do this after...

(a) Urinating:	Always	Often	Sometimes	Rarely	Never
- Flush	☐	☐	☐	☐	☐
- Wash my hands	☐	☐	☐	☐	☐
- Use soap	☐	☐	☐	☐	☐
(b) Defecating:					
- Flush	☐	☐	☐	☐	☐
- Wash my hands	☐	☐	☐	☐	☐
- Use soap	☐	☐	☐	☐	☐

3.11 Number of dippers of water used for:

(a) Cleansing yourself after urinating: _____ tabo ☐ Refuse to answer
(b) Cleansing yourself after defecating: _____ tabo ☐ Refuse to answer
(c) Flushing: _____ tabo
(d) Washing your hands: _____ tabo

3.12 Where do(es):

(a) Excreta go to: _____ ☐ Don't know
(b) The sludge collected go to: _____ ☐ Don't know

4 CONDITIONS OF YOUR CR

4.1 How often do you have to queue (wait for more than 15 minutes) to use the CR per day?

☐ Never ☐ Less than once a day ☐ Once a day ☐ Twice a day ☐ Three or more times a day

4.2 In and around your CR, there is:	Always	Often	Sometimes	Rarely	Never
(a) Clogging	☐	☐	☐	☐	☐
(b) Bad smell	☐	☐	☐	☐	☐
(c) Flies	☐	☐	☐	☐	☐
(d) Ponding	☐	☐	☐	☐	☐

4.3 Do you have any other comments about the CRs? _____

5 SATISFACTION TOWARDS YOUR CR

5.1 How satisfied are you with your CR? ☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

5.2 In which position are you comfortable using your CR? ☐ Sit ☐ Squat

5.3 Please indicate your degree of agreement or disagreement towards the following statements:

(a) My CR is:	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
- Close to my building	☐	☐	☐	☐	☐
- Spacious	☐	☐	☐	☐	☐
- Clean	☐	☐	☐	☐	☐
- Cool in temperature	☐	☐	☐	☐	☐
- Safe to use at night	☐	☐	☐	☐	☐
- Durable	☐	☐	☐	☐	☐
(b) If I needed to urinate and defecate, I would still use the CR if:					
- It was far	☐	☐	☐	☐	☐
- I needed to wait more than 15 minutes	☐	☐	☐	☐	☐
(c) Everyone helps to keep the CRs clean	☐	☐	☐	☐	☐
(d) Everyone should help to clean the CRs	☐	☐	☐	☐	☐
(e) People who do not help to keep the CRs clean should be fined	☐	☐	☐	☐	☐

5.4 How important are the following?	Very important	Important	Neutral	Unimportant	Very unimportant
(a) CRs assigned to families, rather than communal for everyone	☐	☐	☐	☐	☐
(b) Separation between male and female CRs	☐	☐	☐	☐	☐
(c) Durability	☐	☐	☐	☐	☐
(d) Lockable from the inside	☐	☐	☐	☐	☐
(e) Water in the CR	☐	☐	☐	☐	☐
(f) Tissue	☐	☐	☐	☐	☐
(g) Soap	☐	☐	☐	☐	☐
(h) Drainage	☐	☐	☐	☐	☐
(i) Knowing where the excreta goes to	☐	☐	☐	☐	☐
(j) Regular collection of sludge from the septic tank	☐	☐	☐	☐	☐

5.5 Do you have any suggestions to improve the CRs? _____

_____

_____

_____

_____

5.6 Would you be willing to participate in further research so that we can better understand your experience with and opinions towards the CRs? ☐ Yes ☐ No

6 ESOS TOILET (HI-TECH CR)

6.1 What do you think about the eSOS toilet (hi-tech CR), even if you haven't used it? _____

_____

_____

_____

_____

Thank you for taking the time to complete the questionnaire!

Input into Excel ☐ Data complete ☐ Comments translated ☐ Interview questions prepared ☐ Interview done ☐

Appendix 4 Abucay Bunkhouse end user survey responses

1. Individual responses (1.1b – 1.4cii)

No.	1.1b	1.1c	1.2	1.3a	1.3ci	1.3cii	1.3ciii	1.3d	1.3e	1.3fi	1.3fii	1.4bi	1.4ci	1.4cii
1	1	4	1	2	1	1	1	1	-2	2	2	5	2	0
2	2	2	3	0	1	1	1	1	-2	2	1,3	7	9	3
3	2	2	1	0	1	1	1	1	-2	1,2	2,3	4	9	2
4	2	3	3	3	0	0	0	0	2	1	1	2	5	0
5	2	2	4	1	0	0	1	1	2	2	1	5	5	1
6	1	2	4	0	1	1	1	1	-2	1	1	6	8	0
7	2	2	1	3	1	1	1	1	-2	3	3	3	4	2
8	1	1	1	0	1	1	1	1	-2	2	2	4	6	0
9	2	4	4	1	0	0	1	1	2	1	1	6	4	0
10	2	4	1	1	0	0	1	1	2	1	1	5	4	0
11	2	3	3	0	0	0	1	1	2	1	1	1	3	0
12	2	3	3	0	0	0	0	0	2	1,3	1,3	1	4	0
13	2	2	3	0	0	0	0	0	2	1,3	1,3	1	8	5
14	1	3	3	3	0	0	0	0	2	1	1	5	1	0
15	1	1	3	2	0	0	0	0	2	1	1	8	7	2
16	2	2	3	0	0	0	0	0	2	1	1	1	4	1
17	1	1	1	3	0	0	0	0	2	1	1	8	6	1
18	1	2	1	3	0	0	0	0	2	1	1	4	4	0
19	1	2	1	3	0	0	0	0	2	2	2	4	4	1
20	1	1	1	0	1	1	1	1	-2	1	1	2	3	0
21	2	2	4	0	1	1	1	1	-2	1	1	6	8	0
22	2	1	3	0	1	1	1	1	-2	1	1	6	4	0
23	2	3	4	1	1	1	1	1	-2	1,3	1,3	8	8	4
24	2	4	1	1	1	1	1	1	-2	1,3	1,3	5	7	0
25	2	2	4	0	0	0	0	0	2	1,3	1	7	3	0
26	2	1	1	0	1	1	1	1	-2	2	2	4	8	0
27	1	2	4	0	1	1	1	1	-2	1,3	2,3	6	8	0
28	1	1	1	1	0	0	0	0	2	1	1	6	6	0
29	1	2	1	1	0	0	0	0	2	1	1	6	7	0
30	1	2	4	0	0	0	1	1	2	1,3	1,3	6	7	0
31	2	2	1	1	0	0	1	1	2	1	1	1	4	1
32	1	2	4	1	0	0	1	1	2	1	1	6	5	2
33	2	2	4	1	0	0	1	1	2	3	2	7	3	0
34	2	2	4	2	0	0	1	1	2	1,3	1,3	7	2	0
35	2	2	3	0	0	0	1	1	2	1	2	1	6	2
36	2	3	3	1	1	1	1	1	-2	1	1	7	9	2
37	1	2	1	3	0	0	1	1	2	1	1	7	3	1
38	1	4	1	0	0	0	0	0	2	1	1	7	4	0
39	2	2	1	1	1	1	1	1	-2	1	1	1	6	2
40	2	2	1	0	1	1	1	1	-2	1,3	1,3	7	5	3
41	2	2	4	1	0	0	0	0	2	1	1	8	6	1
42	2	2	1	0	1	1	1	1	-2	1	1	5	2	0
43	2	3	4	0	0	0	1	0	2	1	1	6	8	0
44	2	2	3	1	0	0	1	0	2	1	1	8	6	1
45	1	1	3	1	1	1	1	1	-2	1	1	8	6	0
46	1	2	4	2	0	0	1	1	2	1	1	8	5	0
47	2	2	4	0	0	0	1	1	2	1	1	8	5	2
48	2	2	4	0	0	0	1	1	2	1	1	8	4	2
49	2	2	3	1	0	0	1	1	2	1,3	1,3	1	3	1
50	1	2	1	2	0	0	1	1	2	1	1,2	5	3	0
51	2	4	3	3	0	0	0	0	2	1	1	5	3	0
52	2	3	4	0	0	0	0	0	2	1	1	6	6	0
53	2	3	3	3	0	0	0	0	2	1	1	5	3	0
54	1	2	3	0	0	0	0	0	2	1	1	3	9	0
55	1	2	3	3	0	0	0	0	2	1	1	7	5	1
56	1	3	3	1	0	0	1	11	2	3	1	7	1	0

No.	1.1b	1.1c	1.2	1.3a	1.3ci	1.3cii	1.3ciii	1.3d	1.3e	1.3fi	1.3fii	1.4bi	1.4ci	1.4cii
57	2	2	3	0	0	0	0	1	2	1	1,3	5	5	1
58	1	3	3	1	0	0	0	1	2	1	1	5	6	1
59	2	3	4	1	1	1	1	1	-2	1	1	2	7	0
60	1	1	1	0	0	0	1	1	2	1	1	4	6	0
61	1	2	4	2	0	0	1	1	2	1	1,3	3	3	1
62	2	2	4	0	0	0	1	1	2	1,3	1,3	3	4	0
63	1	2	1	1	0	0	1	1	2	1	1	3	8	2
64	2	4	3	2	0	0	1	1	2	1	1	4	3	0
65	2	2	1	0	0	0	0	0	2	3	1	3	8	2
66	1	2	3	3	0	0	0	0	2	1	1	3	13	4
67	1	2	1	2	0	0	0	0	2	3	1,3	4	6	2
68	1	3	3	1	1	1	1	0	-2	1	1	2	3	0
69	2	3	4	2	1	1	1	0	-2	1,3	1,3	1	8	1
70	1	2	3	1	0	0	0	0	2	1	1	2	4	2
71	2	4	1	1	0	0	0	0	2	1	1	4	4	0
72	2	2	1	0	0	0	0	0	2	1	1	4	7	0
73	1	1	1	0	0	0	0	0	2	1	1	8	4	0
74	1	1	3	0	0	0	0	0	2	1,3	1,3	8	7	1
75	2	1	3	3	0	0	0	0	2	1,3	1,3	1	7	0
76	2	4	1	1	0	0	1	1	2	1	1	4	7	0
77	2	1	1	3	0	0	1	1	2	1	1	5	8	0
78	1	1	3	2	1	1	1	1	-2	1,3	1,3	6	7	0
79	2	4	1	3	0	0	0	0	2	2	2	8	4	0
80	1	2	4	1	0	0	0	0	2	1	1	7	2	0
81	1	2	3	3	1	1	1	1	-2	1	1	5	3	1
82	2	1	1	0	1	1	1	1	-2	1	1	5	10	1
83	1	2	3	3	1	1	1	1	-2	1	1	5	5	1
84	2	3	4	2	1	1	1	1	-2	1	1	9	3	0
85	2	3	4	1	0	0	0	0	2	1,3	1,3	2	4	0
86	2	2	1	2	1	1	1	1	-2	1	1	2	8	1
87	2	1	3	0	0	0	0	0	2	1	1	9	7	1
88	2	4	3	0	1	1	1	1	-2	1	1	2	8	1
89	1	2	3	2	1	1	1	1	-2	2	2	7	7	2
90	1	2	4	1	1	1	1	1	-2	1,3	1,3	8	3	1
91	2	3	4	3	1	1	1	1	-2	1	1	8	7	1
92	2	2	1	0	1	1	1	1	-2	1	1	9	5	0
93	2	2	1	0	1	1	1	1	-2	1	1	9	5	1
94	2	1	1	0	0	0	0	0	2	1	1	8	8	1
95	2	5	3	1	1	1	1	1	-2	1	1,3	4	2	0
96	2	2	1	0	0	0	1	1	2	1	1	5	3	0
97	2	1	4	0	0	0	1	1	2	1,3	1,3	4	3	0
98	2	2	3	0	0	0	1	1	2	1	1	6	3	1
99	2	1	1	0	1	1	1	1	-2	1	1	6	5	1
100	2	4	3	3	0	0	0	0	2	1,3	1,3	4	2	0
101	1	2	1	2	1	1	1	1	-2	1	1	1	5	3
102	1	3	0	2	1	1	1	1	-2	1	1	1	7	0
103	1	4	1	1	1	1	1	1	-2	1	1	2	6	1
104	1	3	3	1	1	1	1	1	-2	1	1	1	3	0
105	1	2	3	1	1	1	1	1	-2	1	1	1	6	1
106	1	3	3	2	1	1	1	1	-2	1	1	2	3	0
107	2	2	4	0	1	1	1	1	-2	1	1	7	6	2
108	2	2	3	0	0	0	0	0	2	1	2	7	7	2
109	2	2	1	0	1	1	0	0	2	1,3	1,3	7	6	4
110	1	2	1	2	1	1	1	1	-2	1	1	1	7	0
111	1	3	3	2	1	1	0	0	2	1	1	3	4	0
112	1	2	4	0	1	1	1	1	-2	1	1,3	2	5	0
113	1	3	3	2	1	1	1	1	-2	1	1	7	2	0
114	2	2	3	0	1	1	1	1	-2	1	1	3	7	0
115	2	2	4	3	1	0	1	1	-2	1	1	9	5	0
116	1	4	1	3	1	1	1	1	-2	1	2	3	9	0

No.	1.1b	1.1c	1.2	1.3a	1.3ci	1.3cii	1.3ciii	1.3d	1.3e	1.3fi	1.3fii	1.4bi	1.4ci	1.4cii
117	1	3	1	3	1	1	1	1	-2	1,3	1,3	3	7	0
118	1	4	1	3	1	1	1	0	2	2	1	3	3	0
119	1	5	1	3	1	1	1	1	-2	1	1	5	7	2
120	2	5	4	1	1	1	1	1	-2	1	1	4	5	1
121	1	3	1	2	1	1	1	1	-2	2	1	3	8	0
122	1	4	1	3	1	1	1	1	-2	2	1	5	8	0
123	1	4	4	1	1	1	1	1	-2	1	1	5	4	1
124	1	4	1	1	1	1	1	1	-2	1	1	7	4	0
125	1	1	3	1	1	1	1	1	-2	1	1	1	3	0
126	1	3	4	3	1	1	1	1	2	1	1	2	3	0

2. Sum of responses (1.1b – 1.4cii)

Code	1.1b	1.1c	1.2	1.3a	1.3ci	1.3cii	1.3ciii	1.3d	1.3e	1.3fi	1.3fii	1.4bi	1.4ci	1.4cii
[-2]									55					
[-1]														
[0]			1	46	66	67	39	42						71
[1]	58	20	48	35	60	48	37	84		109	113	16	2	31
[2]	68	60	0	20					71	12	12	12	7	17
[3]		25	44	25						27	27	13	23	3
[4]		18	33									15	20	3
[5]		3										19	16	1
[6]												14	16	
[7]												17	19	
[8]												15	16	
[9]												5	24	

3. Codes (1.1b – 1.4cii)
1.1b [1] Male [2] Female;
1.1c [1] ⩽ 17 [2] 18 – 35 [3] 36 – 51 [4] 52 – 64 [5] ⩾ 65 years old;
1.2 [0] None [1] Elementary [2] High school [4] College;
1.3a [0] None [2] Permanent [3] Seasonal [3] Casual;
1.3ci – 1.3d [0] No [1] Yes;
1.3e [-2] Before [2] Now;
1.3fi – 1.3fii [0] Nothing [1] Dipper [2] Washer [3] Tissue;
1.4bi – 1.4cii [9] 9 or more;

1. Individual responses (1.4ciii – 3.8c)

No.	1.4ciii	2.1	2.1i	2.1ii	3.1	3.2i	3.2ii	3.3	3.4	3.5	3.6	3.8a	3.8b	3.8c
1	0	2	130	1	903	1	2	-2	0	1-2	1	2	2	1
2	0	2	200	4	90	4	17	1	0	1-3	1	2	2	1
3	0	1			130.2	9	2	1	0	1-6	1	1	-2	2
4	0	1			180	6	29	-2	0	1	1	2	2	2
5	0	2	210	5	390	5	15	-2	0	2	1	2	-2	-2
6	0	1			60	4	20	-1	0	1-3	1	1	2	2
7	0	1			300	5	10	-1	0	1-2	1	0	0	2
8	0	1			90	1	5	-1	0	1-3	1	1	-2	1
9	0	2	300	4	60	4	12	1	1	1-5,7	1	1	2	1
10	0	1			120	2	4	1	0	1,3	1	-2	-2	2
11	0	2	100	1	30	3	14	-1	0	1-3	1	0	-2	2
12	0	1			30	3	14	-1	0	1-3	1	2	2	2
13	0	1			30	7	30	-1	0	1-3	1	2	2	2
14	0	1			300	4	15	1	1	1-3	1	2	2	2
15	0	1			600	1	6	-1	0	1-4	1	1	-1	2
16	0	1			600	3	10	-1	0	1-3	1	2	-2	2
17	0	1			300	1	6	-1	1	3,5	1	2	1	0
18	1	1			120	1	4	-1	1	1,3-7	1	1	-2	2
19	1	2	200	2	600	1	4	-2	1	1,3-4	1	-1	0	1
20	0	1			60	5	29	-1	0	1-4,6	1	2	2	2
21	0	1,2	200	5	180	4	20	-1	0	1-3,5	1	1	2	2
22	0	1,2	300	5	300	4	20	-1	0	1-3,5	1	1	2	2
23	0	1,2	200	2	120	2	8	-1	0	1-3,5-6	1	2	2	2

No.	1.4ciii	2.1	2.1i	2.1ii	3.1	3.2i	3.2ii	3.3	3.4	3.5	3.6	3.8a	3.8b	3.8c
24	0	1			180	1	7	-1	1	1-4	1	2	2	2
25	0	1,2	100	1	180	5	20	-1	0	1-3,5	1	1	2	2
26	0	1			120	1	8	0	0	1-6	1	0	-2	2
27	0	2	200	5	60	5	24	-1	0	1-3	1	2	2	2
28	1	1			420	1	2	-1	0	1-4	1	1	-2	2
29	0	2	300	2	60	5	15	1	1	1-5	1	2	2	2
30	0	2	200	1	60	5	15	-1	1	1-5,7	1	2	2	2
31	0	1			60	5	20	0	0	1-3	1	0	-2	-2
32	0	2	300	7	120	5	15	1	1	1-7	1	2	2	2
33	0	3	200	3	300	3	7	-1	0	1-3,5	1	1	2	2
34	0	1			60	4	8	1	0	1-5	1	0	2	2
35	0	1			900	1	6	-2	0	1	1	1	2	2
36	0	2	200	4	120	4	17	1	0	1-5	1	1	2	2
37	0	1			300	2	5	-2	1	1-4	1	1	1	2
38	0	1			300	1	4	-1	0	1-4	1	2	-2	2
39	0	1			300	6	12	-1	0	1-4	1	2	-1	2
40	0	1			60	3	7	1	0	1-2	0	0	-2	2
41	0	1			60	5	21	1	0	1-4	1	2	2	2
42	0	2			420	1	2	0	0	1-4	1	-2	2	2
43	0	2	300	5	420	5	24	-1	0	1-3,5	1	1	2	2
44	0	1			300	5	20	-1	0	1-3	1	-1	0	2
45	0	1			60	1	6	0	0	1-4	1	2	0	2
46	0	1			1.2	3	10	1	0	1-3	1	2	2	2
47	0	1			10.2	4	22	-1	0	1-3	1	-1	-2	-1
48	0	1			10.2	4	12	1	1	1-3	1	-2	-2	0
49	0	1			300	1	2	-2	1	1-2	1	2	2	2
50	0	2	100	1	60	2	7	-2	0	1-3,5	1	2	2	2
51	1	1			300	5	15	-1	0	1-5	0	2	2	2
52	0	2	200	5	60	5	24	-1	0	1-3,5	0	2	2	2
53	0	1			180	1	3	-1	0	1-6	1	2	-1	2
54	0	1			120	3	14	-1	1	1-5	1	2	2	2
55	0	1			30	4	17	-1	0	1-3	1	1	2	2
56	0	1			300	5	8	-1	0	2	1	2	2	2
57	0	1			60	1	5	-1	0	1-6	0	2	2	2
58	2	1			60	3	15	-1	0	1-4	1	1	-1	2
59	0	1			120	5	7	-2	0	1-4	0	1	0	2
60	0	1			600	1	6	-1	0	1-3,5	NA	2	0	2
61	0	1			300	5	10	-1	0	1-3	1	0	-1	2
62	0	1			300	5	20	-1	0	1,3-7	1	0	2	2
63	0	1			600	5	7	-1	1	1	0	0	-2	2
64	0	1			120	5	4	-2	0	1	0	-1	2	2
65	0	1			600	3	3	-2	0	1	1	0	0	0
66	2	1			180	4	13	1	0	2	1	0	-1	2
67	0	1			60	3	3	-2	0	1-2	1	2	-2	2
68	1	1			60	5	28	-2	0	1-2	1	-1	-2	2
69	0	1			60	3	8	-1	0	1-3	1	2	-2	2
70	0	1			120	5	15	-1	0	1-2	1	-1	-2	2
71	0	1			30	2	7	-1	0	1-2	1	1	-2	2
72	1	1			10.2	2	7	-2	0	1-4	1	-1	-2	2
73	0	1			120	1	4	-1	1	1,3	1	-2	-2	-2
74	0	1			120	1	7	-1	1	1,3	1	1	-2	2
75	0	1			240	2	14	-1	0	1-4	1	2	-2	2
76	0	1			600	1	2	1	1	1-4	1	1	2	2
77	0	1			120	5	8	-2	0	1-4	1	0	0	0
78	0	1			900	2	6	-1	0	1-5	1	2	2	2
79	0	1			10.2	5	15	1	0	1-2	1	-1	-2	-2
80	0	1			120	1	2	-1	0	1-3	1	1	-2	-2
81	0	1			60	1	2	-1	0	1	1	1	-2	2
82	0	1			120	2	12	0	1	1-3	1	0	-2	2
83	0	1			600	3	10	2	0	1	1	2	-2	2

No.	1.4ciii	2.1	2.1i	2.1ii	3.1	3.2i	3.2ii	3.3	3.4	3.5	3.6	3.8a	3.8b	3.8c
84	0	1,2	250	5	300	2	8	-1	0	1-3	1	2	2	2
85	0	1			60	2	4	-1	0	1-3	0	2	2	2
86	1	1			60	2	4	-1	0	1-4	0	0	2	2
87	0	1			300	4	1	-1	0	1-5	NA	2	2	2
88	0	2	240	2	60	2	8	-1	0	1-4	0	2	-1	2
89	0	1			15	0	3	-2	0	1-3	1	1	-2	2
90	1	1			60	8	20	-1	0	1-2	NA	-1	-1	-1
91	1	2	250	1	60	8	20	1	0	1-2	NA	2	2	2
92	0	2	500	5	4.8	2	10	-1	0	1-5	1	2	-1	2
93	0	2	50	1	60	2	10	-1	0	1-4	1	2	2	2
94	1	2	365	2	12	4	18	-1	0	1-4	0	2	-2	2
95	1	1			60	2	3	1	0	1	0	0	-2	2
96	0	1			60	2	5	-1	0	1-3	0	0	-1	2
97	0	1			300	3	4	-1	0	1-2	1	-1	-2	2
98	0	1			19.8	2	5	-1	1	1-3	1	0	2	2
99	0	1			300	1	5	-1	0	1-3	1	2	2	2
100	0	1			60	2	4	-1	0	1	1	-2	-2	2
101	0	1			180	6	29	-1	0	1-3	1	-1	-2	-2
102	0	1			60	6	29	-1	0	1-3	1	2	2	2
103	0	1			600	3	7	-2	0	1-3	1	2	2	2
104	0	1			60	3	14	-1	0	1-3	1	0	0	2
105	0	2	150	1	180	4	15	-1	1	1-3	1	2	2	2
106	0	1			60	4	14	-2	0	1-3	1	-1	-2	0
107	1	2	150	1	300	2	6	-1	0	1-3,5-6	0	2	-2	2
108	0	1			15	2	9	-2	1	1-4	1	0	2	2
109	0	1			60	6	6	0	1	1-2	1	2	2	2
110	0	1			600	6	29	-1	0	1-3	0	2	2	2
111	0	1			600	4	13	-2	0	1-3	1	0	-2	2
112	0	1			120	5	20	0	0	1-2	1	1	2	2
113	1	2	200	2	60	1	2	-1	0	1-3,5-6	1	1	2	2
114	0	1			60	3	9	-1	1	1-3,5	1	2	2	2
115	0	2	50	5	10.2	2	8	-2	0	1-3	1	2	2	2
116	0	1			60	3	18	-1	1	1-5	1	2	2	2
117	0	1			60	3	9	-1	1	1-3,5	1	2	2	2
118	0	1			10.2	4	15	-1	0	1-4	1	0	-2	2
119	2	2	100	7	60	3	9	-1	0	1-4	1	0	-1	2
120	1	2	250	3	600	2	5	-2	1	1-3,5	1	2	2	2
121	0	1			60	2	12	-1	1	2-3	1	0	2	2
122	0	1			120	1	8	-1	1	1-5	1	-2	2	2
123	0	1			60	2	5	1	0	1-4	1	-2	-2	2
124	0	1,2	300	5	19.8	5	19	1	0	1-4,5-6	1	0	0	2
125	0	1			34.8	1	1	-1	0	1-3	1	2	2	2
126	1	1			180	5	15	-1	0	1-4	1	-2	-2	-2

2. Sum of responses (1.4ciii – 3.8c)

Code	1.4ciii	2.1	2.1i	2.1ii	3.1	3.2i	3.2ii	3.3	3.4	3.5	3.6	3.8a	3.8b	3.8c
[-2]								22				8	41	7
[-1]								76			15	12	11	2
[0]	108					1		7	98	121	107	24	10	5
[1]	15	100				26		20	28	110		26	2	5
[2]	3	33				25		1		100		56	62	107
[3]						19				46				
[4]						18				34				
[5]						27				12				
[6]						6				6				
[7]						1								
[8]						2								
[9]						1								

3. Codes (1.4ciii – 3.8c)

1.4ciii [9] 9 or more;

2.1 [1] Communal system [2] Hose;
3.3 [-2] Very different [-1] Different [0] Neutral [1] Similar [2] Very similar;
3.4 [0] No [1] Yes;
3.5 [1] Defecate [2] Urinate [3] Bathe [4] Brush [5] Laundry [6] Dry clothes [7] Wash dishes;
3.6 [0] No [2] Yes [NA] No response;
3.8a – 3.8c [-2] Never [-1] Rarely [0] Sometimes [1] Often [2] Always;

1. Individual responses (3.8d – 3.11bi)

No.	3.8d	3.8e	3.8f	3.8g	3.8h	3.8i	3.8j	3.9	3.10	3.11ai	3.11aii	3.11aiii	3.11bi
1	1	2	2	1	1	2	2	1,3-6	3	2	2	2	2
2	0	2	1	2	2	2	2	1-3,6	7	2	2	2	2
3	-2	2	2	-2	2	-1	1	1-3,6	1	2	2	2	2
4	-2	2	2	-2	-2	-2	2	1-4,6	1	2	2	2	2
5	-2	2	2	2	2	2	2	2	7	2	2	2	2
6	-1	2	2	2	2	2	2	1-3,6	1	2	2	2	2
7	0	1	2	1	-1	1	0	1-6	3	2	2	2	2
8	-1	0	-1	-1	-1	-1	1	1,3-5	2	2	0	2	2
9	0	2	1	2	2	1	2	1-8	21	2	2	2	2
10	-2	2	-2	2	2	1	2	1-5,7	1	2	2	2	2
11	-2	2	2	2	2	-1	2	1-7	1	2	2	2	2
12	2	2	2	2	2	2	2	1-7	5	2	2	2	2
13	2	2	2	2	2	2	2	2-7	5	2	2	2	2
14	0	2	2	2	2	0	1	1-4	1	2	2	2	2
15	-2	2	-2	2	-2	-2	2	1-6	3	2	2	2	2
16	-2	2	-2	2	-2	-2	2	1-2,4-5	3	2	2	2	2
17	2	-2	0	1	1	2	-2	1-3	2	-2	1	1	1
18	0	2	2	-2	2	2	2	1,3,5	2	2	2	2	2
19	1	2	2	2	2	1	2	1-2,7	14	2	2	2	2
20	-2	2	2	-2	-2	2	2	1-7	1	2	2	2	2
21	0	2	2	2	2	1	2	1-8	7	2	2	2	2
22	0	2	2	2	2	1	2	1-8	7	2	2	2	2
23	1	2	2	1	2	-2	2	1-3,5-8	7	2	2	2	2
24	2	2	2	2	2	2	2	1-3	3	2	2	2	2
25	-2	2	2	2	2	-1	0	1-6	14	2	2	2	2
26	-2	2	2	-2	-2	-2	-2	1-5,8	7	2	2	2	2
27	2	2	2	2	2	2	2	1-5,7	1	2	2	2	2
28	-2	2	2	-2	-2	2	2	1-5,7-8	7	2	2	2	2
29	-2	2	2	2	2	2	2	1-5,7	14	2	2	2	2
30	2	2	2	2	2	0	2	1-8	3	2	2	2	2
31	-2	-2	-2	-1	-2	-2	-1	1-2,4-5	1	2	2	2	1
32	-2	2	2	2	2	2	2	1-8	14	2	2	2	2
33	-1	2	2	2	2	2	2	1,3-5,7	2	2	2	2	2
34	-1	2	2	2	2	-1	2	1-5,7	3	2	2	2	2
35	-2	2	2	2	2	0	1	1-5	2	2	2	2	2
36	-1	2	2	2	2	1	2	1-3,6	7	2	2	2	2
37	-1	2	2	2	2	-1	2	1-2,4,7	1	2	2	2	-1
38	-2	2	2	2	-1	-2	2	1-7	3	2	2	2	2
39	-2	2	2	2	2	-2	2	1-6	7	2	2	2	2
40	2	2	2	2	2	-2	2	1,3-5,7	1	2	2	2	2
41	2	2	2	2	2	2	2	1-4,7	14	0	2	2	2
42	-2	2	2	-2	-2	-2	2	1-7	7	2	2	2	2
43	-1	2	2	2	2	2	2	1-5,7	7	2	2	2	2
44	-1	2	1	0	1	-1	2	1-6	3	2	0	1	2
45	-2	2	1	-2	1	1	2	1-7	1	2	2	2	2
46	-2	2	2	2	0	0	2	1-6,8	1	2	2	2	2
47	-2	0	1	-2	-2	-1	2	1-5	1	2	2	2	2
48	-2	2	2	2	-1	-2	2	1-5,7	2	2	2	2	2
49	-2	2	-2	2	2	2	2	1-4,6-8	3	2	2	2	2
50	2	2	2	2	2	2	2	1-5,7-8	7	2	2	2	2
51	2	2	2	2	2	2	2	1-7	2	2	2	2	2
52	1	2	2	2	2	-1	2	1-4,7	7	2	2	2	2
53	2	2	2	2	2	2	2	1-3,6	7	2	2	2	2

No.	3.8d	3.8e	3.8f	3.8g	3.8h	3.8i	3.8j	3.9	3.10	3.11ai	3.11aii	3.11aiii	3.11bi
54	2	2	2	2	2	2	2	1-3,6	2	2	2	2	2
55	-2	2	2	2	2	2	2	1-5	7	2	2	2	2
56	2	2	2	2	2	2	2	1-2,7	1	2	2	2	1
57	-1	2	-1	-1	-1	-1	2	1-7	7	2	2	2	2
58	-2	2	2	2	-1	2	2	1-4,7	7	2	2	2	2
59	-2	2	2	-2	0	2	2	1-7	14	2	2	2	1
60	-2	2	2	2	-1	-2	2	1-7	7	2	2	2	2
61	-2	0	-2	0	0	-2	0	1-6	7	2	2	2	2
62	2	2	2	2	2	-1	2	1-2	3	2	2	2	2
63	-2	2	0	0	-2	-2	0	1-4	2	2	2	2	2
64	2	2	2	2	2	-2	2	1-2,4	28	2	2	2	2
65	0	0	0	0	0	0	0	1-3	2	2	2	2	2
66	0	0	2	-1	-1	-1	2	1-4,7	4	2	2	2	2
67	2	2	2	2	2	2	2	1-3	14	2	2	2	2
68	-2	-2	-2	-2	-2	-1	2	1-6	7	2	2	2	2
69	2	2	2	-2	-2	2	2	1-6	7	2	2	2	2
70	-2	-1	2	2	-2	-1	2	1-4	1	2	2	2	2
71	-2	2	0	-2	2	-2	2	1-4,6	4	2	2	2	2
72	-2	-2	-2	2	2	-2	2	1-6,8	7	2	2	2	2
73	-2	2	-2	-2	-2	-2	-2	1,4-5	1	2	1	2	2
74	-2	2	2	-2	-2	-2	-2	1,3-5	2	2	2	2	2
75	-2	2	2	2	2	2	2	1-6	4	2	2	2	2
76	-2	2	2	2	2	-2	2	1-6	1	2	2	2	2
77	-1	-1	2	2	1	-2	1	1-2,4-6,8	5	2	2	2	2
78	-1	2	2	2	2	-1	2	1-6	7	2	2	2	2
79	-2	2	-2	-2	-1	-2	2	1-4,7	7	2	2	2	2
80	-2	-2	2	2	-2	-2	-2	1,4	2	2	2	2	2
81	-2	-2	2	1	0	-2	1	1-6	2	2	2	2	2
82	-2	2	2	-2	-2	-2	2	1-5	3	2	2	2	2
83	2	2	2	2	2	2	2	1-2	2	2	2	2	2
84	-2	2	2	2	2	-2	2	1-5	7	2	2	2	2
85	2	0	2	2	1	2	2	1-5,7	2	2	2	2	1
86	-1	2	2	-2	2	-2	2	1-5	7	2	2	2	2
87	1	2	2	2	2	-1	2	1-6	7	2	2	2	2
88	-2	2	2	-2	2	-2	2	1-5	2	2	2	2	2
89	1	2	2	1	0	-1	2	1-4,6	7	2	2	2	2
90	-1	-1	-1	-1	-1	-1	-1	1-2,4	2	2	2	2	2
91	2	2	2	2	2	2	2	1,4	2	2	2	2	2
92	-2	2	-2	-2	2	-2	2	1-5	10	2	2	2	2
93	-2	2	0	-2	2	-2	2	1-5,7	1	2	2	2	2
94	-2	2	0	0	-2	-2	1	1-4	1	2	2	2	2
95	2	2	2	0	2	-2	2	1-5,7	7	2	2	2	2
96	-2	2	2	-2	2	2	2	1-5,7	14	2	2	2	2
97	-2	1	2	-2	-2	-2	-2	1-2,5	7	2	2	2	2
98	-2	2	2	2	2	0	2	1-7	1	2	2	2	2
99	-1	2	2	2	2	-2	2	1-5	7	2	2	2	2
100	2	2	2	0	0	-2	2	1-5	7	2	2	2	2
101	-2	-2	-2	-2	-2	-2	-2	1,3-4	1	2	2	2	2
102	-2	2	2	2	2	-2	2	1-2,4-5	2	2	2	2	2
103	-1	2	2	2	2	-1	2	1-5	7	2	2	2	2
104	-2	2	2	2	2	0	2	1-5	7	2	2	2	2
105	-1	2	2	0	2	2	2	1-5	7	2	2	2	2
106	-2	0	2	-2	2	-2	2	1-7	3	2	2	2	2
107	-2	2	2	2	2	0	0	1-5	7	2	2	2	2
108	0	2	2	-1	0	0	1	1-4,6	7	2	2	2	2
109	2	2	2	2	2	2	2	1-8	7	2	2	2	2
110	-2	2	2	2	2	-2	2	1-5	1	2	2	2	2
111	-2	2	2	-2	-2	2	2	1-4,8	1	2	2	2	2
112	2	1	2	-1	-1	-1	1	1-6	7	2	2	2	2
113	-1	2	2	2	2	-1	2	1-5,7	7	2	2	2	0

No.	3.8d	3.8e	3.8f	3.8g	3.8h	3.8i	3.8j	3.9	3.10	3.11ai	3.11aii	3.11aiii	3.11bi
114	1	1	2	2	2	2	2	1-4,6	2	2	2	2	2
115	-2	2	-2	2	2	-2	2	1-4,7	1	2	2	2	2
116	2	2	2	2	2	2	2	1-4,6	2	2	2	2	2
117	2	2	2	2	2	0	2	1-4,6	1	2	2	2	2
118	2	2	2	-2	-2	2	2	1-4,6	7	2	2	2	2
119	-2	2	2	-2	2	-2	2	1-8	2	2	2	2	2
120	-2	2	2	2	2	2	2	1-6	3	2	2	2	2
121	2	2	2	2	2	2	2	1-4,6	14	2	2	2	2
122	2	2	2	2	2	2	2	1-4,6	14	2	2	2	2
123	-2	2	2	2	2	0	2	1-5,7	7	2	2	2	2
124	-2	2	2	2	-1	-1	2	1-7	7	2	2	2	2
125	-2	2	2	2	2	-1	2	1-2,4-5	1	2	2	2	2
126	-2	-2	-2	-2	-2	-2	2	1-4,6	1	2	2	2	2

2. Sum of responses (3.8d – 3.11bi)

Code	3.8d	3.8e	3.8f	3.8g	3.8h	3.8i	3.8j	3.9	3.10	3.11ai	3.11aii	3.11aiii	3.11bi
[-2]	63	8	14	29	23	42	7			1	0	0	0
[-1]	17	3	3	7	12	23	2			0	0	0	1
[0]	10	7	6	8	8	11	6			1	2	0	1
[1]	7	4	5	6	6	8	9	124		0	2	2	5
[2]	29	104	98	76	77	42	102	116		124	122	124	119
[3]								109					
[4]								108					
[5]								82					
[6]								60					
[7]								48					
[8]								19					

3. Codes (3.8d – 3.11bi)
3.8d – 3.8j [-2] Never [-1] Rarely [0] Sometimes [1] Often [2] Always
3.9 [1] Water [2] Chlorine [3] Scrub [4] Broom [5] Detergent [6] Gloves [7] Soap [8] Cloth;
3.11ai – 3.11bi [-2] Never [-1] Rarely [0] Sometimes [1] Often [2] Always; 3.12a – 3.12d [NA] Refused to answer;

1. Individual responses (3.11bii – 5.3ai)

No.	3.11bii	3.11biii	3.12a	3.12b	3.12c	3.12d	4.1	4.2a	4.2b	4.2c	4.2d	5.1	5.2	5.3ai
1	2	2	3	4	4	4	1	-1	0	-1	-1	2	1	1
2	2	2	3	3	3	3	2	2	1	2	2	1	1	1
3	2	2	2	2	10	2	2	-1	-1	2	-1	2	1	2
4	2	2	4	3	10	2	-2	2	2	2	2	-2	1	1
5	2	2	4	2	8	2	-2	2	2	2	2	1	1	-2
6	2	2	3	3	7	2	-1	0	0	0	0	1	1	1
7	2	2	5	5	10	5	-1	1	1	1	1	1	1	0
8	1	2	4	3	4	3	-2	-1	0	1	0	1	1	1
9	2	2	10	5	10	8	-1	-2	1	2	0	-1	1	2
10	2	2	2	2	10	1	2	2	2	1	1	1	1	2
11	2	2	3	1	10	2	-2	2	2	-2	2	-2	1	2
12	2	2	2	1	10	2	-2	2	1	1	1	-2	1	1
13	2	2	2	1	10	2	2	2	1	1	1	-2	1	1
14	2	2	2	NA	NA	NA	2	2	1	0	-2	1	1	-1
15	2	2	5	3	10	2	2	2	-2	2	-2	0	1	2
16	2	2	2	1	10	1	-1	2	2	2	0	2	1	2
17	0	2	1	1	1	1	-2	-2	-1	0	-2	1	2	2
18	2	2	10	2	1	3	-1	2	1	2	2	0	1	1
19	2	2	3	3	10	10	-1	1	0	-1	0	1	1	2
20	2	2	NA	NA	10	10	2	1	1	2	2	1	2	2
21	2	2	4	3	5	3	-2	-1	-1	-1	-1	-1	1	2
22	2	2	3	3	10	3	-2	-1	-1	-1	-1	-1	1	2
23	2	2	4	3	10	2	2	1	1	1	0	1	1	1
24	2	2	10	10	5	5	1	2	2	2	2	1	1	1
25	2	2	5	3	6	2	2	1	0	1	-2	1	1	1

No.	3.11bii	3.11biii	3.12a	3.12b	3.12c	3.12d	4.1	4.2a	4.2b	4.2c	4.2d	5.1	5.2	5.3ai
26	0	2	2	1	10	2	-1	1	2	0	-1	0	1	-1
27	2	2	5	3	10	3	-1	1	0	2	0	1	1	2
28	2	2	4	3	5	6	-2	0	0	0	2	1	1	2
29	2	2	5	4	7	4	-2	2	1	1	2	0	1	1
30	2	2	8	7	10	5	-1	1	2	1	0	1	1	2
31	2	1	3	1	6	2	-1	-1	1	0	-1	0	1	2
32	2	2	3	7	10	10	-1	2	1	1	-2	0	1	2
33	2	2	2	2	10	2	2	1	2	2	2	1	1	1
34	2	2	3	1	6	2	2	1	2	2	0	1	1	2
35	2	2	2	1	7	2	-1	1	-1	0	-2	1	1	1
36	2	2	5	2	4	2	2	0	0	1	-1	1	1	1
37	1	2	2	3	10	2	2	1	0	0	0	1	1	0
38	2	2	2	3	5	2	2	2	1	1	1	0	1	1
39	2	2	2	3	10	2	2	2	2	2	2	0	1	1
40	2	2	2	1	3	1	1	1	1	1	1	1	1	1
41	2	2	6	6	5	3	2	1	2	2	2	1	1	2
42	2	2	5	3	10	5	1	2	2	2	0	0	1	-1
43	2	2	3	3	10	3	-2	-1	2	2	0	1	1	2
44	0	-2	NA	NA	10	5	-1	-1	0	-1	2	-1	2	0
45	2	2	NA	NA	10	2	2	0	1	2	0	0	1	1
46	2	2	3	1	10	3	2	1	2	2	2	1	1	2
47	2	2	2	1	7	2	-1	0	1	0	-1	1	1	1
48	2	2	10	5	20	5	-2	2	1	1	0	1	1	1
49	2	2	2	2	7	1	1	0	2	2	2	2	1	2
50	2	2	10	3	20	3	-1	0	1	1	0	1	1	-1
51	2	2	5	2	10	2	-1	0	2	1	0	1	1	-1
52	2	2	3	2	10	2	-2	-2	2	0	1	1	1	-1
53	2	2	3	2	10	2	-1	2	2	2	2	-1	1	-1
54	2	2	4	4	10	5	2	0	0	0	-1	2	1	2
55	2	2	6	3	10	3	-1	0	0	1	-2	1	1	-1
56	2	2	2	1	10	2	1	1	1	2	2	1	1	-1
57	2	2	3	2	10	3	2	2	2	1	2	-1	1	2
58	2	2	1	2	10	1	2	-1	2	2	2	1	1	-1
59	1	2	3	2	10	2	2	0	2	2	2	1	1	2
60	2	2	3	2	10	2	2	2	0	1	0	1	1	2
61	2	2	3	2	10	2	2	2	1	1	2	-1	1	0
62	2	2	NA	2	NA	NA	-1	0	0	1	1	1	2	2
63	2	2	3	3	10	1	2	0	0	0	0	-1	1	2
64	2	2	3	3	10	1	1	1	2	1	0	1	1	2
65	2	2	2	3	10	1	2	-1	-1	-1	-1	0	1	2
66	2	2	2	1	6	1	-1	2	1	1	2	0	1	2
67	2	2	3	2	10	2	-1	1	0	2	2	0	1	0
68	2	2	2	2	1	2	-2	1	1	2	-2	0	1	0
69	2	2	2	1	5	2	-1	0	1	2	2	1	1	2
70	2	2	5	1	5	1	-1	0	0	2	-2	0	1	2
71	2	2	7	2	10	1	2	2	-1	-1	2	1	1	2
72	2	2	10	2	10	2	-2	-1	2	2	2	1	1	2
73	2	2	10	3	10	2	-1	2	2	2	-2	1	1	-1
74	1	2	10	3	10	2	-2	2	2	2	-2	1	1	-1
75	2	2	3	4	10	2	-1	0	0	0	-1	2	2	2
76	2	2	3	3	10	1	-1	1	1	1	0	1	1	2
77	1	1	2	1	6	1	-1	0	1	1	1	1	1	2
78	2	2	3	2	10	2	2	2	2	2	2	1	1	2
79	2	2	2	1	10	2	-2	2	2	2	0	0	1	2
80	2	2	4	3	6	3	1	2	1	1	-1	0	2	2
81	2	2	3	2	5	3	2	2	2	2	1	1	1	-1
82	2	2	1	3	10	2	2	2	2	2	2	2	1	2
83	2	2	10	NA	10	2	-1	-1	-1	-1	-1	-1	1	2
84	2	2	3	2	5	4	-1	-2	2	2	2	0	1	2
85	2	2	4	2	10	1	-2	2	-2	2	2	0	1	2

No.	3.11bii	3.11biii	3.12a	3.12b	3.12c	3.12d	4.1	4.2a	4.2b	4.2c	4.2d	5.1	5.2	5.3ai
86	2	2	3	3	10	3	2	0	1	2	2	0	1	2
87	2	2	3	3	10	2	2	2	2	2	2	1	1	2
88	2	2	1	2	10	2	2	1	2	2	2	1	1	1
89	2	1	5	3	6	5	1	1	2	0	-1	0	1	1
90	2	2	2	0	0	2	-1	1	1	1	1	0	1	2
91	2	2	2	2	2	2	-2	1	1	1	1	0	1	2
92	2	2	10	1	10	1	-1	2	2	2	1	2	1	1
93	2	2	10	3	10	1	-2	-2	2	2	2	-2	1	2
94	2	2	2	2	5	2	-2	2	0	0	2	0	1	1
95	2	2	NA	2	10	2	2	0	2	2	2	-2	2	1
96	2	2	2	2	10	2	2	2	2	2	2	-2	1	2
97	2	2	4	2	6	2	2	0	1	2	0	1	2	2
98	2	2	5	2	10	2	-1	2	2	2	1	2	1	2
99	2	2	3	2	10	2	-1	2	2	1	1	1	1	2
100	2	2	2	2	20	2	2	2	2	2	2	1	2	1
101	2	2	4	4	10	2	-1	0	0	2	-2	-2	1	1
102	2	2	3	2	10	2	2	1	1	2	-2	0	1	1
103	2	2	3	3	10	2	-1	0	1	1	1	1	1	2
104	2	2	2	2	10	2	-1	1	2	2	2	0	1	1
105	2	2	3	2	10	2	2	2	0	0	2	0	1	1
106	2	2	3	2	6	2	-1	1	-1	0	-2	-2	1	0
107	2	2	3	2	6	2	-1	2	-2	0	0	1	1	1
108	2	2	1	2	6	2	-1	2	-2	2	0	1	1	1
109	2	2	2	2	10	1	2	2	2	2	2	1	1	2
110	2	2	3	2	10	2	-1	0	1	1	2	0	1	1
111	2	2	5	3	10	2	-1	2	0	0	2	0	1	2
112	2	2	3	3	10	2	-1	1	1	1	0	0	1	2
113	0	0	2	1	10	1	2	2	-2	2	-2	-2	1	1
114	2	2	3	3	10	3	-1	-2	-2	-2	-2	1	1	2
115	2	2	10	2	10	2	-1	0	2	2	-2	-2	1	2
116	2	2	4	4	10	4	-1	0	0	2	2	1	1	-1
117	2	2	3	4	10	2	-2	-2	-1	0	-2	1	1	-1
118	2	2	3	1	10	3	2	2	2	2	0	-2	1	-1
119	2	2	3	2	10	2	-2	1	0	-2	-2	1	1	2
120	2	2	5	3	10	3	2	2	2	2	2	0	1	2
121	2	2	4	2	10	4	-1	2	2	2	2	1	1	-1
122	2	2	4	4	10	4	-1	2	2	2	2	2	1	1
123	2	2	5	0	20	3	2	2	2	2	2	1	1	1
124	2	2	2	2	10	2	2	0	0	0	0	2	1	1
125	2	2	3	1	10	2	-1	0	2	0	-2	1	1	2
126	2	2	4	2	5	2	-1	0	-1	-2	-2	-2	1	2

2. Sum of responses (3.11bii – 5.3ai)

Code	3.11bii	3.11biii	3.12a	3.12b	3.12c	3.12d	4.1	4.2a	4.2b	4.2c	4.2d	5.1	5.2	5.3ai
[-2]	0	1					23	7	6	4	21	13		1
[-1]	0	0					49	12	11	8	14	9		17
[0]	4	1					0	28	25	22	27	31		7
[1]	5	3					9	29	34	32	16	62	117	38
[2]	117	121					45	50	50	60	48	11	9	63

3. Codes (3.11bii – 5.3ai)
3.11bii – 3.11biii [-2] Never [-1] Rarely [0] Sometimes [1] Often [2] Always;
3.12a – 3.12d [NA] Refused to answer;
4.1 [-2] Never [-1] Less than once per day [0] Once per day [1] Twice per day [2] Thrice or more;
4.2a – 4.2d [-2] Never [-1] Rarely [0] Sometimes [1] Often [2] Always;
5.1 [-2] Very unsatisfied [-1] Unsatisfied [0] Neutral [1] Satisfied [2] Very satisfied;
5.3ai [-2] Strongly disagree [-1] Disagree [0] Neutral [1] Agree [2] Strongly agree

1. Individual responses (5.3aii – 5.4d)

No.	5.3aii	5.3aiii	5.3aiv	5.3av	5.3avi	5.3bi	5.3bii	5.3c	5.3d	5.3e	5.4a	5.4b	5.4c	5.4d
1	0	1	1	1	1	1	-1	-1	-1	-1	-1	2	1	1

No.	5.3aii	5.3aiii	5.3aiv	5.3av	5.3avi	5.3bi	5.3bii	5.3c	5.3d	5.3e	5.4a	5.4b	5.4c	5.4d
2	1	-2	1	1	0	-1	-1	0	0	-1	-1	1	-1	1
3	2	2	1	1	1	-1	-1	2	2	0	2	2	2	2
4	1	1	1	1	0	-1	-1	-1	1	-1	1	2	-1	1
5	-2	1	-2	-2	2	-2	-2	-2	-2	-2	2	-2	1	1
6	1	2	1	2	1	-1	-1	1	2	0	1	1	2	2
7	1	1	0	1	1	1	1	0	0	-1	2	2	2	2
8	0	2	0	0	0	-1	-1	2	2	-1	2	0	1	1
9	2	2	0	2	2	-1	-1	-1	2	1	2	2	2	2
10	2	2	0	2	2	0	2	2	2	-1	-1	2	2	2
11	2	2	2	2	2	-1	-2	2	2	-1	2	1	2	2
12	1	1	1	1	1	-1	-1	1	1	-1	1	2	1	1
13	1	1	1	1	1	-1	-1	1	1	-1	1	1	1	1
14	0	1	1	1	1	0	-1	1	2	1	1	2	2	2
15	0	2	0	0	2	-1	-1	-1	2	-1	2	2	2	2
16	0	2	2	2	2	2	0	0	2	0	2	2	2	2
17	2	1	-2	-1	2	1	1	0	-2	2	2	2	1	-2
18	1	1	1	0	1	-1	1	1	1	-1	1	1	1	1
19	1	1	1	0	0	-1	-1	-1	1	1	2	2	1	1
20	2	2	0	2	2	-1	-1	2	-1	-1	2	2	2	2
21	2	2	0	2	2	-1	-1	2	1	1	2	2	2	2
22	2	2	0	2	2	-1	-1	2	1	1	2	2	2	2
23	1	1	0	0	0	-1	-2	2	2	0	1	2	2	2
24	1	1	1	1	1	-1	-1	-1	1	-1	2	2	2	2
25	2	2	0	2	2	0	0	0	2	0	2	2	2	2
26	0	0	-1	-1	-1	0	0	1	2	0	-2	0	-1	2
27	2	2	1	2	2	-1	-1	1	1	1	2	2	2	2
28	2	2	2	2	2	1	-1	-1	2	-1	2	2	2	2
29	2	2	0	2	2	-1	-1	2	2	-1	-1	2	2	2
30	2	2	2	2	2	2	0	2	2	-1	2	2	2	2
31	2	2	2	2	2	-1	-1	-2	2	2	1	2	2	2
32	2	2	0	2	2	-1	-1	2	2	-1	-1	2	2	2
33	1	1	1	0	1	0	-1	-1	1	1	2	0	2	1
34	2	2	1	1	1	0	-1	1	1	-2	1	2	1	1
35	1	2	0	2	1	-1	-1	1	1	0	1	1	1	1
36	1	1	1	0	1	-1	-1	0	1	1	-1	1	1	1
37	2	2	0	0	0	-1	-1	1	2	-1	0	0	0	2
38	1	2	0	1	2	-1	-1	1	1	0	2	2	1	1
39	1	1	-1	-1	1	-1	-1	-1	0	-1	-1	1	1	1
40	0	1	1	1	1	1	-2	1	1	-2	1	1	1	2
41	2	2	2	2	2	-1	-2	1	1	-1	-1	1	2	2
42	2	2	0	0	0	-1	-2	2	2	-1	2	2	2	2
43	2	2	2	2	2	-1	-1	2	2	-1	2	2	2	2
44	-1	2	1	-2	0	-2	0	-2	2	-1	0	2	-1	2
45	1	1	1	1	2	0	0	1	0	-2	2	1	1	1
46	2	2	2	2	2	-2	-2	-1	2	2	2	2	2	2
47	1	2	2	2	2	-2	-1	0	2	0	1	2	2	2
48	2	2	0	2	2	-1	-1	2	2	-1	2	2	2	2
49	2	2	2	2	2	-2	-2	2	2	2	2	2	2	2
50	2	2	0	2	2	-1	-1	1	2	-1	2	2	2	2
51	2	2	2	2	2	-1	-1	2	2	-1	2	2	2	2
52	2	2	1	0	2	-1	-1	2	1	1	2	1	1	1
53	1	1	-1	-1	2	-2	-2	2	1	-1	2	1	2	1
54	2	2	2	2	2	-1	-1	2	2	2	2	2	2	2
55	2	2	1	1	1	-1	-1	0	0	-1	-1	1	1	1
56	0	2	0	2	1	-1	-1	1	1	2	2	2	2	2
57	2	2	1	2	2	-1	-1	2	2	2	2	2	2	2
58	-1	2	2	2	2	-1	-1	0	-1	2	2	2	2	2
59	1	2	1	2	2	-1	-2	-1	2	-2	2	1	2	2
60	0	2	-1	1	1	-1	-1	-1	1	-1	2	1	2	2
61	-1	0	1	0	0	-1	-1	0	1	-1	1	1	1	1

No.	5.3aii	5.3aiii	5.3aiv	5.3av	5.3avi	5.3bi	5.3bii	5.3c	5.3d	5.3e	5.4a	5.4b	5.4c	5.4d
62	2	2	2	2	2	-1	-1	0	-1	0	2	2	2	2
63	2	2	0	0	0	-1	-1	0	2	2	2	2	2	2
64	2	2	0	2	2	2	2	2	2	2	2	2	2	2
65	2	2	0	0	0	2	0	2	2	2	2	2	2	2
66	2	2	2	2	2	-2	-2	2	2	2	2	2	2	2
67	1	-1	0	-1	-1	-1	-1	-1	-1	2	1	2	-1	1
68	0	0	0	0	0	-1	-1	0	1	1	2	0	2	2
69	1	2	1	0	0	-2	-2	2	2	2	1	2	1	2
70	2	2	2	2	2	-2	-2	0	1	-1	1	2	2	2
71	2	2	2	2	2	-1	-1	-1	2	2	2	2	2	2
72	2	2	2	2	2	-1	-1	2	2	-1	-1	2	2	2
73	2	2	-1	0	1	1	1	2	2	1	1	1	1	1
74	2	2	-1	0	1	1	1	2	2	1	1	1	1	1
75	2	2	0	2	2	0	-1	2	2	1	2	2	2	2
76	0	2	-1	2	2	2	2	2	2	2	2	2	1	2
77	2	2	2	2	2	0	0	0	0	0	2	2	2	2
78	2	2	2	2	2	2	2	2	2	2	2	2	2	2
79	2	2	2	2	0	-1	-1	0	2	-1	-1	2	2	2
80	2	2	1	2	2	-2	-2	2	2	-1	-2	1	2	2
81	1	1	0	-1	1	1	-1	0	2	-1	2	1	2	2
82	2	2	2	2	2	-1	-1	-1	-1	-1	1	0	1	1
83	2	2	2	2	2	2	2	2	2	2	2	2	2	2
84	0	1	0	-1	-1	-1	-1	-1	-1	-1	2	2	2	2
85	2	2	-1	2	2	2	2	2	2	2	2	2	2	2
86	0	2	-1	2	2	2	2	2	2	2	2	2	2	2
87	0	2	1	1	1	-1	-1	2	2	-1	2	2	2	2
88	1	1	0	0	0	-1	-1	0	1	-1	1	1	2	2
89	1	1	1	1	1	-2	-2	0	1	-1	2	0	2	2
90	2	2	2	2	2	0	0	0	0	0	2	2	2	2
91	2	2	2	2	2	0	0	0	0	0	2	2	2	2
92	2	2	2	2	0	-1	-1	2	2	-1	2	2	2	2
93	2	2	1	2	2	-1	-1	2	2	0	2	2	2	2
94	2	2	-1	-1	-1	2	2	-1	2	-1	2	-1	2	2
95	2	2	0	0	2	-1	-1	2	2	1	2	2	2	2
96	2	2	2	2	2	-1	-1	2	2	-1	2	2	2	2
97	2	2	1	2	2	-2	-2	1	2	0	2	2	2	2
98	2	2	2	2	2	0	0	2	2	-2	-1	2	2	2
99	0	2	0	0	0	-1	-1	1	1	-1	2	2	2	2
100	2	2	2	2	2	-2	-2	-2	2	-1	2	2	2	2
101	0	1	0	-1	1	-1	-1	1	1	-1	2	1	2	2
102	1	1	0	1	0	-1	-1	0	1	1	1	1	1	1
103	2	2	2	2	2	-1	-1	1	1	1	1	1	1	1
104	1	1	0	0	1	-1	-1	1	1	-1	2	1	1	2
105	1	1	0	0	1	-1	-1	1	1	-1	2	1	2	1
106	2	2	2	2	2	-1	-2	-1	1	0	2	1	2	2
107	1	1	1	1	1	-1	-1	-1	1	-1	-1	1	1	1
108	1	1	1	1	1	-1	-1	0	1	-1	1	1	1	1
109	2	2	2	2	2	-1	-1	2	2	-1	2	2	2	2
110	1	1	0	0	1	-1	-1	1	1	-1	2	2	1	2
111	1	1	0	1	1	-1	-1	0	1	1	1	2	1	2
112	2	2	2	2	2	-2	-2	0	1	-1	1	2	2	2
113	2	2	2	2	2	-2	-2	1	1	1	2	2	2	2
114	2	1	1	1	1	2	1	2	2	2	2	2	2	2
115	1	1	1	-1	0	1	-1	2	2	-1	2	2	1	2
116	1	1	1	1	1	-1	-1	1	1	1	2	2	2	2
117	1	1	1	1	1	-1	-1	0	2	1	1	1	2	2
118	2	2	2	2	2	-1	-1	2	2	2	2	-1	2	2
119	2	2	2	2	2	2	2	2	2	-1	-1	1	1	2
120	1	2	0	0	0	-1	0	2	2	-1	2	2	0	2
121	2	2	2	2	2	-1	-1	2	2	2	2	-1	2	2

No.	5.3aii	5.3aiii	5.3aiv	5.3av	5.3avi	5.3bi	5.3bii	5.3c	5.3d	5.3e	5.4a	5.4b	5.4c	5.4d
122	2	2	2	2	2	-1	-1	2	2	2	2	1	2	2
123	2	2	2	2	2	-1	-1	2	2	2	-1	2	2	2
124	1	1	1	1	1	-1	-1	-1	1	-1	2	2	2	2
125	1	1	2	2	1	-1	-1	1	1	0	2	2	1	1
126	2	2	2	2	2	-1	-1	-1	2	2	2	2	2	2

2. Sum of responses (5.3aii – 5.4d)

Code	5.3aii	5.3aiii	5.3aiv	5.3av	5.3avi	5.3bi	5.3bii	5.3c	5.3d	5.3e	5.4a	5.4b	5.4c	5.4d
[-2]	1	1	2	2	0	15	20	4	2	6	1	2	0	1
[-1]	3	1	10	10	4	78	79	21	7	57	3	15	5	0
[0]	16	3	37	24	20	12	12	26	8	17	7	2	2	0
[1]	37	36	36	25	35	9	6	26	41	20	33	26	33	30
[2]	69	85	41	65	67	12	9	49	68	26	82	81	86	95

3. Codes (5.3aii – 5.4d)

5.3aii – 5.4d [-2] Strongly disagree [-1] Disagree [0] Neutral [1] Agree [2] Strongly agree

1. Individual responses (5.3aii – 5.4d)

No.	5.4e	5.4f	5.4g	5.4h	5.4i	5.4j
1	1	2	1	-1	-1	1
2	1	2	2	2	2	1
3	2	2	2	2	2	2
4	2	1	2	1	2	1
5	2	2	2	2	-1	2
6	2	-1	2	0	0	0
7	2	-1	2	2	1	2
8	2	2	2	1	1	2
9	2	2	2	2	2	2
10	2	-1	2	2	-1	2
11	2	2	2	2	2	2
12	1	1	1	2	1	1
13	1	1	1	2	1	1
14	2	-1	2	2	2	2
15	-1	2	-1	2	2	2
16	1	-1	2	2	1	2
17	-2	0	0	1	2	2
18	1	-1	1	-1	0	1
19	1	1	2	2	2	1
20	2	2	2	2	2	2
21	2	2	2	2	2	2
22	2	2	2	2	2	2
23	2	1	2	2	1	2
24	2	2	2	2	2	2
25	2	1	2	2	1	2
26	2	-2	2	-1	-2	1
27	2	2	2	2	2	1
28	2	-1	2	2	2	2
29	2	-1	2	2	2	2
30	2	2	2	2	2	2
31	2	2	2	2	-1	2
32	2	2	2	2	2	2
33	2	1	2	2	0	1
34	2	2	2	1	1	2
35	1	-1	2	2	2	1
36	2	1	2	1	2	2
37	0	2	2	2	0	1
38	2	2	2	0	1	2
39	1	1	1	1	1	1
40	2	1	1	1	2	2
41	2	2	2	2	2	2
42	2	-1	2	2	2	2

No.	5.4e	5.4f	5.4g	5.4h	5.4i	5.4j
43	2	-1	2	2	2	2
44	2	2	1	2	-2	-2
45	1	1	1	2	1	1
46	2	-1	2	2	2	2
47	2	2	2	2	2	2
48	2	2	2	2	2	0
49	2	2	2	2	2	2
50	2	2	2	2	2	2
51	2	2	2	2	2	2
52	1	1	1	1	1	1
53	1	2	2	2	2	2
54	2	2	2	2	2	2
55	2	2	2	2	1	2
56	2	2	2	2	2	2
57	2	2	2	2	2	2
58	2	-1	2	2	2	2
59	2	-1	2	-2	-1	2
60	2	2	2	2	2	2
61	1	1	1	1	1	1
62	2	2	2	2	-1	-1
63	2	2	2	2	2	2
64	2	2	2	2	2	2
65	2	2	2	2	2	2
66	2	2	2	2	2	2
67	1	2	1	1	-1	1
68	2	2	2	2	1	2
69	2	2	2	2	2	1
70	2	2	2	2	2	2
71	2	-1	2	2	2	2
72	2	2	2	2	2	2
73	1	1	1	1	1	1
74	1	1	1	1	1	1
75	2	1	2	2	2	1
76	2	1	2	2	2	2
77	2	-1	2	1	1	-1
78	2	2	2	2	2	2
79	2	-1	2	2	2	2
80	2	2	2	2	2	1
81	2	2	2	2	1	2
82	1	1	1	1	1	1
83	2	2	2	2	2	2
84	2	2	2	2	2	2
85	2	2	2	2	2	2
86	2	0	2	2	2	2
87	2	2	2	2	2	2
88	2	-1	2	2	2	2
89	1	1	1	1	1	2
90	2	2	2	2	2	2
91	2	2	2	2	2	2
92	2	-1	2	2	2	2
93	2	2	2	2	2	2
94	2	-1	2	-1	2	2
95	2	2	2	2	2	2
96	2	2	2	2	2	2
97	2	2	2	2	2	2
98	2	-1	2	2	2	2
99	2	-1	2	2	2	2
100	2	2	2	2	2	2
101	2	-1	2	2	2	2
102	1	-1	1	1	2	2

No.	5.4e	5.4f	5.4g	5.4h	5.4i	5.4j
103	1	-1	1	1	1	1
104	1	0	1	2	2	2
105	1	-1	1	1	2	2
106	2	2	2	2	2	2
107	1	1	1	1	1	1
108	1	1	1	1	1	2
109	2	2	2	2	2	2
110	2	-1	2	2	2	2
111	2	-1	2	1	1	1
112	2	2	2	2	1	1
113	2	2	2	2	2	2
114	2	2	2	2	2	2
115	2	2	2	2	2	2
116	2	2	2	2	2	2
117	2	2	2	2	2	2
118	2	-1	2	2	2	2
119	2	-1	2	2	2	2
120	2	-1	2	2	1	1
121	2	2	2	2	2	2
122	2	2	2	2	2	2
123	2	-1	2	2	2	2
124	2	-1	2	2	2	2
125	1	1	1	2	1	2
126	2	2	2	2	2	2

2. Sum of responses (5.4e – 5.4j)

Code	5.4e	5.4f	5.4g	5.4h	5.4i	5.4j
[-2]	1	1	0	1	3	1
[-1]	1	33	1	4	7	2
[0]	1	3	1	2	4	2
[1]	25	22	22	21	28	28
[2]	98	67	102	98	84	93

3. Codes (5.4e – 5.4j)

5.4e – 5.4j [-2] Strongly disagree [-1] Disagree [0] Neutral [1] Agree [2] Strongly agree