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# THE REQUIRED CONDITIONS AND SUCCESS CRITERIA FOR CONTAINER-BASED SANITATION VIABILITY AND THE POTENTIAL FOR IMPLEMENTATION IN KATHMANDU, NEPAL

**by**

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A dissertation submitted in partial fulfilment of the requirements for the award of the degree of Master of Science of Loughborough University

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# Abstract

The impact of the relentless rise in population, compounded by rapid rates of urbanisation, is being felt across the globe, with ever increasing pressures placed on land availability and resources in many cities of the developing world. A consequence of these factors is the emergence of large, unplanned and disorganised high-density urban and peri-urban settlements, where the availability of adequate sanitation facilities is intolerably low, and the space required to provide improved facilities is in exceptionally short supply. Land tenure and ownership further complicate the situation leaving many residents of such settlements with very few options to improve their sanitation.

In recent years, a small number of container-based sanitation (CBS) services have been established in this type of environment, whereby human excreta are collected in sealable, portable containers or cartridges, which are subsequently collected and transported to treatment or disposal facilities. The organisations have developed reasonably independently of each other thus far, and therefore the processes by which they deliver their service are bespoke and specific to the contexts within which they operate. The reasons why variations in the operational methodologies exist are due to the developmental processes that the CBS organisations have been through to create their services. The effects of the physical characteristics of the settlements and the existence of localised influential cultural practices, have led to very context specific approaches, and varying degrees of expansion.

This research identifies and collates the numerous factors and influences that can affect the success and viability of CBS, based on the experiences of the existing organisations. Through the application of the identified factors, a weighted scoring matrix was developed to create a tool which could be used to evaluate any context with regard to the potential viability of CBS. Through the use of the matrix, the potential of CBS to provide a sanitation solution in any given area can be determined.

Following the identification of the required conditions and success criteria for CBS viability, and the development of the scoring matrix, the research applies the technique to the context of the squatter settlements of Kathmandu, in order to determine the potential of CBS technologies to provide these communities with an improved level of sanitation. It was determined that the potential of CBS within the squatter settlements of Kathmandu was low due to the widespread availability of existing sanitation, the low level of potential WTP and the universal practice of washing to anally cleanse following defecation.

**Keywords:** Container-based sanitation, CBS, Kathmandu, Squatter settlements, Urban sanitation

# Executive summary

## *Introduction*

Around the globe, cities in the developing world are expanding at a rapid rate, creating increasingly large and widespread urban and peri-urban settlements of very high-density within which the supply of essential services can be totally insufficient (UN 2014). The ensuing intense pressure on the availability of space hinders the establishment of adequate sanitation within such communities; often the inhabitants are forced to rely on inconvenient, unsafe and unhygienic public toilets, poorly functioning on-site sanitation or unsanitary shared toilets. These challenging conditions are often further compounded by land tenure and ownership issues, which discourage authorities from improving the level of services for fear of legitimising the communities. The settlements are frequently located in areas of little financial value and are often prone to flooding (UN Habitat 2016a). In general, the areas are not suitable for construction or habitation which is hence why the areas were hitherto uninhabited. These characteristics further affect the functionality and effectiveness of the limited on-site facilities available, leading to very poor levels of sanitation and consequentially high incidences of disease and ill health (UNICEF 2013). In order to tackle these issues, very few realistic options exist due to the space constraints and the tenure complications explained above.

In a handful of cities around the world, an innovative new technology is being developed and trialled to provide improved sanitation in just such environments through the provision of sealable, portable containers or cartridges, placed inside a toilet unit, into which the human excreta are accumulated. These containers are subsequently collected and transported to treatment or disposal facilities by the service provider. Many of the organisations subsequently utilise the collected faeces to create end-use products which are then sold to provide additional revenues to supplement that which is paid by the household toilet users in order to receive the service. Container-based sanitation (CBS) as it is known has been developed over recent years fairly independently by a small number of organisations, who have developed their systems and processes in response to the local conditions and obstacles that have been encountered. This has led to a variety of unique, but similar, approaches to the provision of improved sanitation through the utilisation of container-based systems.

The variety of different contexts and environments that the current CBS organisations work in have presented a large number of different barriers and influences during the evolution of their business models which have shaped the way in which the various organisations deliver their services. This research reviews the development and progress of these organisations, considering the various obstacles that have been faced, and the resulting solutions that have been devised to overcome the barriers encountered. By undertaking such investigations, the suitable conditions required for CBS to be considered as a potentially viable sanitation solution have been identified.

## *Aim and objectives*

The aim of this research is to undertake an analysis of CBS services that are currently being provided in urban communities, in order to identify the specific factors that have affected or contributed to the success or failure of each of the services studied. The acquired success criteria are then applied to squatter settlements of Kathmandu in order to determine the potential of CBS to provide an appropriate system of sanitation, and to establish possible forms that the service model might adopt.

In order to accomplish this overall research aim, five research objectives were set with the purpose of satisfying the requirements of the study, as follows:

1. Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work.
2. Investigate CBS services to determine and “distil” the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation.
3. Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any barriers that may affect the successful implementation of a CBS service.
4. Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements or for other applications within Kathmandu.
5. Establish criteria of the required conditions necessary for future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach.

## *Methodology*

A thorough literature review of CBS related material was undertaken alongside extensive semi-structured interviews conducted with many key members of the CBS community in order that a complete picture of the technology could be obtained. By doing so, a comprehensive array of barriers, hindrances, influences and conditions was developed in order that the success factors required for a CBS service to become viable option was established.

Once the required criteria for viability were determined, the results were used to develop the necessary materials which could then be used to establish the potential of CBS in other areas or regions. Squatter settlements of Kathmandu were selected as an environment within which suitable conditions might exist for CBS to be a potential sanitation option. These communities therefore formed the basis of a case study in order to evaluate the criteria that had been developed, and thus determine whether CBS would be appropriate in such circumstances.

A mixed methods approach was adopted to elicit the necessary data, and determine whether the conditions required for CBS viability were present or not. This was accomplished through a

combination of transect walks and observations, household questionnaires, semi-structured interviews and a focus group discussion.

The data obtained from the research undertaken in Kathmandu was analysed through the use of a weighted scoring matrix that was developed using the information and success criteria established during the initial phases of the research. By doing so, the suitability of CBS for use within the context of the selected squatter communities in Kathmandu could subsequently be determined, and thus final conclusions drawn with resulting recommendations made.

## *Results and analysis*

The attainment of the research results can be broken down into two distinct phases. An initial phase was undertaken whereby the required conditions for CBS viability were determined. A subsequent secondary phase was then undertaken in order to determine the suitability of CBS as a potential sanitation solution in the selected squatter settlements of Kathmandu.

The first phase of the research was undertaken by considering different aspects of the existing CBS organisations, their operational processes and the barriers and obstacles that they have encountered during their developmental process. In order to obtain the required information and details, the questioning was broken down into separate categories in order to deal with every aspect of the CBS process. The areas of discussion were broadly grouped into the following topics:

- **Selection and details of the operational area** – undertaken to understand more fully why the area of operation was selected initially and what was it about the area that made CBS a potentially suitable solution.
- **Initial conditions and sanitation practices in the operational area** – to understand the level of sanitation available within the area prior to the launch of CBS and to determine any traditions or practices which affected the implementation of the service.
- **Operating methodology** – a discussion to understand the different operating methodologies of the organisations and the reasons why the differences exist.
- **Toilet hardware considerations** – a comparison of the various toilet designs that are utilised by the various CBS organisations.
- **Reuse of end products** – clarification on the types of end products created, the reasons for the choice of products and their resulting financial performance.
- **Financial considerations** – a discussion of the commercial aspects of the respective business models, and the potential financial viability of the organisations.
- **Willingness and ability to pay** – to understand the respective levels of willingness and ability to pay that were encountered in the operational areas.
- **Learning opportunities** - to reveal any additional knowledge gained or other issues encountered as a result of the developmental processes of the CBS services.

As a result of this process, distinct categories of factors emerged that were then explored and expanded upon to provide a comprehensive criterion that could be used to establish the potential of CBS in any given context by considering the existence or impact of each individual factor. Following the identification of the required success criteria, the potential barriers to success and the circumstances that would provide favourable conditions for CBS to thrive, these combined factors were then considered with respect to the selected squatter settlements in Kathmandu.

Thorough research was undertaken to assess the suitability of the communities by identifying the presence, and ascertaining the level of impact, of each of the identified factors. Following a weighted scored matrix analysis of the findings, the main barriers to success and opportunities were identified and are shown in the table below.

| **Potential Barriers** | |
|---|---|
| **Factor Description** | **Implication** |
| Extent of payment for sanitation services historically by residents of community. | Very low familiarity with concept of paying for sanitation, which will affect potential paying customer base |
| Impact of anal cleansing practices on CBS implementation | Anal washing practiced universally. Impact on running costs of service and potential for use in public toilet context |
| Availability of private household or on-plot sanitation facilities | High level of availability of private facilities, therefore limited demand for CBS service |
| Availability of required space locally for treatment facility establishment | Densely populated area. Very limited scope for local establishment of treatment facility |
| Willingness to pay/current level of payment (e.g. pit emptying, public toilets, etc.) within the community for sanitation services | Current low level of acceptance to paying for a sanitation service; therefore, a cultural change would be required for widespread adoption of any scheme |
| **Potential Opportunities** | |
| **Factor Description** | **Implication** |
| Impact of the average housing size on the potential for CBS implementation (e.g. number of rooms, type of rooms, etc.) | Most houses have more than a single room with average dwelling size of 3.25 rooms per house, therefore minimising issues around the location of a toilet within the home |

## *Conclusions and recommendations*

Following the analysis of the data collected, it was determined that the potential of CBS within the context of the selected squatter settlements in Kathmandu was low and would therefore not be a suitable environment within which the technology could be employed. The main reasons for arriving at this conclusion are the widespread availability of existing sanitation, the low level of potential WTP and the universal practice of washing to anally cleanse following defecation. The use of CBS as a suitable technology to supplement the existing public toilets was also discounted due to the widespread practice of washing as a method of anal cleansing, and also due to the lack of enthusiasm and support that would be anticipated institutionally.

Recommendations for further research are suggested at the end of the report, with potential themes of consideration suggested as:

- Evaluation of the various CBS toilets currently in use to create a superior toilet design.
- Through the application of the factors determined by this study, research into the identification of new situations where suitable conditions exist should be undertaken.
- Exploration of the potential of PPPs, franchises or licencing to promote the use of CBS.

## *References*

UN, 2014. United Nations Population Division | Department of Economic and Social Affairs. Available at: http://www.un.org/en/development/desa/population/ [Accessed May 11, 2017].

UN Habitat, 2016a. Slums Almanac 2015-16. *Tracking Improvement in the Lives of Slum Dwellers. Nairobi*.

UNICEF, 2013. Children dying daily because of unsafe water supplies and poor sanitation and hygiene. *Release by Unicef Press Centre*.

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# Abbreviations and acronyms

| | |
|---|---|
| AD | Anaerobic Digestion |
| AHS | Annual Household Survey |
| ATP | Ability to Pay |
| CBS | Container-based sanitation |
| DWSS | Department of Water Supply and Sewerage |
| EAWAG | Swiss Federal Institute of Aquatic Science and Technology |
| ECOSAN | Ecological Sanitation |
| ENPHO | Environment and Public Health Organisation |
| FGD | Focus Group Discussion |
| FLT | Fresh Life Toilet |
| FS | Faecal Sludge |
| FSM | Faecal Sludge Management |
| GHS | Ghanaian Cedi |
| HPCIDBC | High Powered Committee for Integrated Development of the Bagmati Civilization |
| JMP | Joint Monitoring Programme |
| KES | Kenyan Shilling |
| KII | Key Informant Interview |
| KMC | Kathmandu Metropolitan City |
| KSWM | Kathmandu Solid Waste Management |
| KVWSIP | Kathmandu Valley Wastewater System Improvement Project |
| LMC | Lalitpur Metropolitan City |
| LPG | Liquid Petroleum Gas |
| MDG | Millennium Development Goal |
| MWSS | Ministry of Water Supply and Sanitation |
| NEC | Nepal Engineering College |
| NGO | Non-Government Organisation |

| | |
|---|---|
| NLSS | Nepal Living Standard Survey |
| NPR | Nepalese Rupees |
| OD | Open Defecation |
| PPP | Public Private Partnership |
| SanCoP | Sanitation Community of Practice |
| SDG | Sustainable Development Goal |
| SSC | Sanitation Service Chain |
| SSP | Sanitation Safety Plan |
| SuSanA | Sustainable Sanitation Alliance |
| UDDT | Urine Diverting Dry Toilets |
| UDWT | Urine Diverting Wet Toilets |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNICEF | United Nations Children's Fund |
| VDC | Village Development Committee |
| VIP | Ventilated Improved Pit |
| WASH | Water, Sanitation and Hygiene |
| WEDC | Water, Engineering and Development Centre |
| WHO | World Health Organisation |
| WSSCC | Water Supply & Sanitation Collaborative Council |
| WSUP | Water and Sanitation for the Urban Poor |
| WTP | Willingness to Pay |
| WWT | Waste Water Treatment |
| WWTP | Waste Water Treatment Plant |

# 1. Introduction

## *1.1. Context*

In many urban and peri-urban areas of modern cities in the developing the world, the level of sanitation available to the poorest sections of the population is often totally inadequate. Over recent years, populations in urban settlements have swelled, partly due to migration from rural to urban settings, but also due to rapid growth of the existing residential population. It is now estimated that a quarter of the urban population of the world now lives in slums (UN Habitat 2016b) The reasons for the migration to urban environments are manyfold but often it is for the promise of improved work prospects, better education and higher living standards. This increase in population has led to an intensified pressure on the availability of land, and subsequently the very poorest often find themselves living in slum areas or shanty towns, where conditions for human habitation can have a very significant impact on the health of the population (UN Habitat 2016a). The conditions generally experienced by the residents of these areas are ones of inadequate access to clean water and sanitation facilities, both of which lead to higher instances of premature death, disease and illness (Pruss-Ustun et al. 2008).

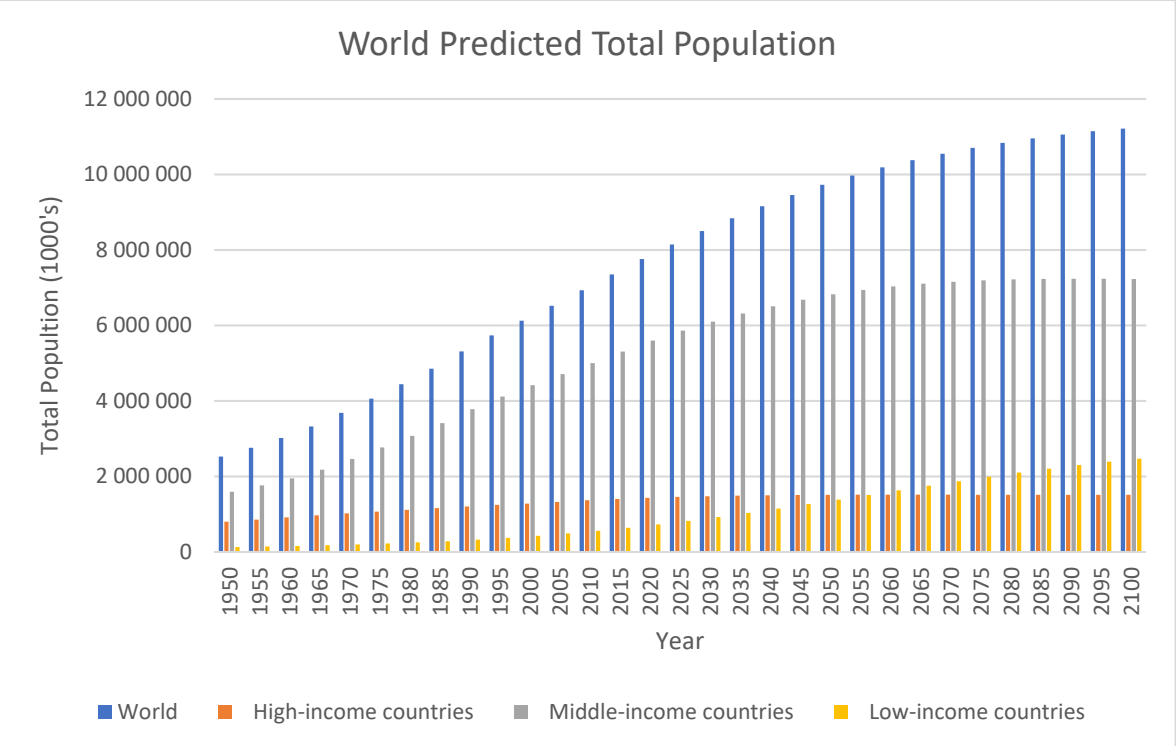


*Figure 1.1 World Population Predicted Growth 1950 - 2100*

*Source: (UN 2014)*

The population of low and middle-income countries is increasing faster than in high income ones, and this trend is set to increase over the course of the coming century. This can be seen

in Figure 1.1, where the total world population by 2100 is expected to exceed 11 billion people (UN 2014). One of the key features of this data is that predicted population of high income countries remains reasonable stable, where that of low and middle-income countries continues to rise as the century passes. This is especially true for low income countries, which exhibit continual growth, whereas the population growth in middle income countries does show signs of slowing down towards the end of the century.

When the effects of this data are combined with the predicted migration to urban areas, as shown in Figure 1.2, then the issues of land availability and increased urban population density, especially in low and middle-income countries, become even more acute. The percentage of the population living in urban areas across the globe is set to constantly increase according to the UN (UN 2014), for the foreseeable future, and this percentage is coupled with the increasing overall population, so the numbers living in urban environments will increase at a continually rapid rate.

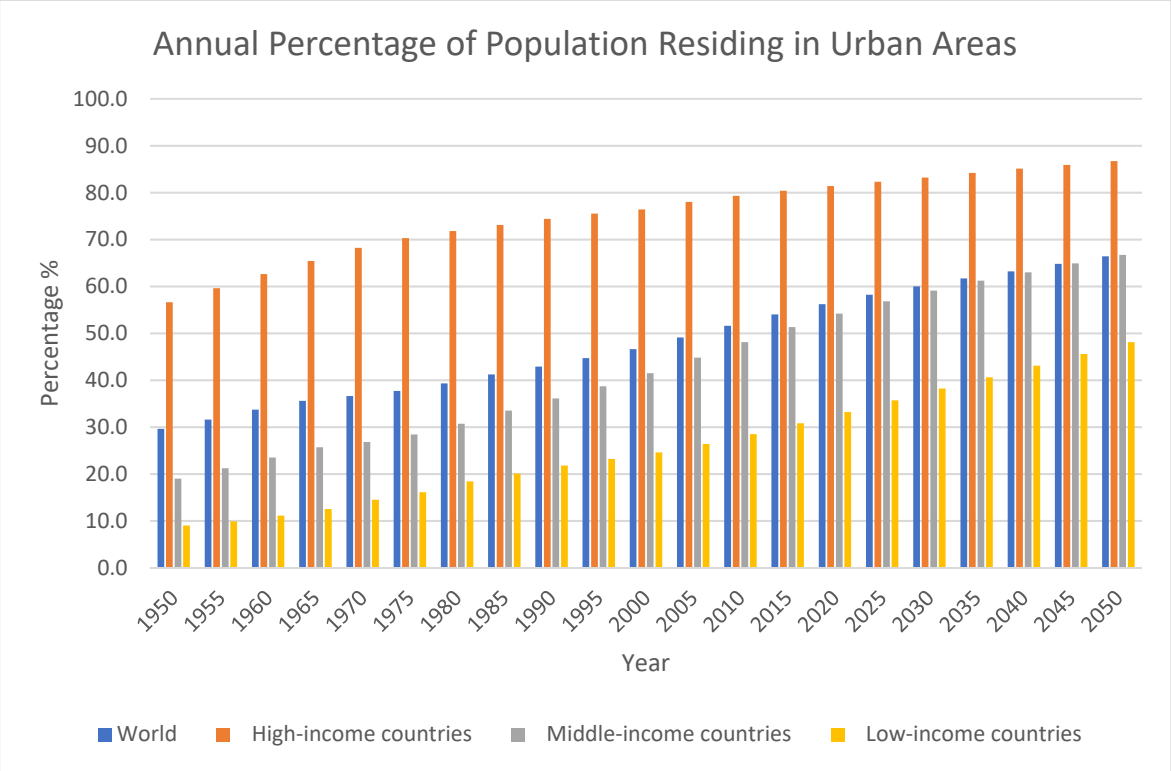


*Figure 1.2 Percentage Urban Population 1950 - 2050*

*Source: (UN 2014)*

On this basis, there is no reason to assume that the number of people living in slum or squatter settlements is likely to decrease, and will no doubt increase, as has been the case in many cities in low and middle-income countries, and therefore the resultant low level of sanitation provision and conditions is likely to also deteriorate without some form of intervention.

Poor levels of access to adequate sanitation and hygiene are a major source of health issues across the globe. Diarrhoea, caused by the transmission and ingestion of pathogens, on its own results in 1.5 million deaths per year, most of whom are children, with 80% of cases of diarrhoea worldwide being directly attributed to unsafe water, inadequate sanitation or insufficient hygiene (Pruss-Ustun et al. 2008). It is estimated that 2,000 children under the age of five die every day from diarrhoeal diseases, and almost 90% of the child deaths are directly linked to contaminated water, lack of sanitation or hygiene (UNICEF 2013).

With the setting of the Millennium Development Goals (MDG's), good progress has been made into the provision of improved drinking water and sanitation. However, while the global MDG target for drinking water was met in 2010, the global MDG target for sanitation was missed by almost 700 million people (WHO/UNICEF 2015), and in 2015 2.4 billion people still lacked improved sanitation facilities. The vast majority of these people live in Southern Asia, Sub-Saharan and Eastern Asia, which are generally constituted of low and middle-income countries. Therefore, the expected population growth and urbanisation over the coming years will compound the sanitation challenges that are currently experienced in the poorest areas of the urban populations of these regions.

Without intervention, innovation or changes to the way in which WASH services are provided, then the outlook for the poorest sections of society living in slums and informal or squatter settlements in low and middle-income countries is not a positive one; innovative solutions need to be found that can overcome and address the many barriers and issues that lead to the poor levels of WASH services that are often encountered in such areas.

The reasons why the provision of improved sanitation in slums and squatter settlements is so low are wide ranging, and are often dependent upon the specific nature of the area in question. Traditional waterborne piped sewerage is generally not an option in these areas for a number of reasons. Firstly, the high capital expenditure of installing a piped network is prohibitive to local communities; however, in order for such a system to operate effectively, a reliable piped water supply is also required, which generally is also not present in slum or squatter settlements, and would also be prohibitively expensive to install. By 2015, provision of piped water in urban populations of the least developed countries stood at only 32% compared to that of developed countries where 98% of the urban population had access to piped water (WHO/UNICEF 2015). Another factor which prevents the installation of such infrastructure in such communities, regardless of the availability of financial resources, is the issue of land ownership and tenure; most slums or squatter communities are located on land that is not owned by the residents, and therefore investing in sanitation infrastructure is generally either not permitted by the land owners, or not seen as attractive investments by governments or institutions due to the often temporary or transient impression of the communities.

On-site sanitation options are generally therefore the adopted method for those living in urban poor households, often pit latrines or septic tanks. However, for those living in slum and squatter settlements, there are still barriers and issues with the use of these forms of sanitation. Often, these communities are located near rivers or in areas prone to flooding due to land pressures and the lack of available alternative areas (UN Habitat 2016a); the land is often the most hazardous and therefore unattractive to anyone other than the poorest and most vulnerable sections of the community. The siting of such communities can lead to issues around the practicalities and appropriateness of such sanitation options, such as the presence of high water tables, low infiltration rates or unstable ground leading to collapse; even the presence of rock, making hand excavation impossible, can be a deciding factor or barrier in the selection of a suitable on-site sanitation option.

Many other factors are present in slums and squatter communities, in addition to any geological or geographical ones mentioned above, which can also influence the ability for residents to achieve acceptable sanitation. For example, high population density, a lack of available space and limited plot sizes can prevent households from obtaining on-plot options. Furthermore, topographical issues such as very steep slopes or inadequate road access, including the tendency for the construction of very narrow access alleyways and irregular arrangements due to the high pressure on land availability, can prevent access by vehicles for emptying pits and tanks. If this is the case, the emptying is often completed manually, in unhealthy, insanitary and foul conditions, leading to considerable health risks to those individuals undertaking the emptying.

Usually, the only other option available to residents of slum settlements, if on-site sanitation is unfeasible or not possible, is to use public facilities. However, the use of public facilities comes with its own issues; facilities are often closed during overnight, and can be a long distance from resident's homes, leading to lengthy journeys required to and from the facilities, and the subsequent security risks that present themselves, especially for women and children, during such journeys. There is usually a cost incurred by the users of public toilets, which can be considerable to low-income families, which therefore can also be a deterrent from using the facilities.

The resultant effect of the issues above is that often, especially during the night, residents of slum and squatter communities either resort to open defecation, or to the use of flying toilets – generally a plastic bag used to collect faeces in the household - which is then discarded into the public environment. Both of these practices lead to the indiscriminate, unmanaged and uncontrolled disposal of faeces into the public environment and thus create a significant health issue to all of the residents within the community.

If the Sustainable Development Goals (SDG's) are to be met, and the sanitation practices currently used by residents within the poorest sections of society of low and middle-income

countries are to be improved, then new and innovative approaches will be required which addresses the issues highlighted above.

## 1.2. Sanitation service chain

The sanitation service chain (SSC) is a conceptual model which is widely used and recognised as a framework for the effective management of faecal sludge as shown in Figure 1.3.

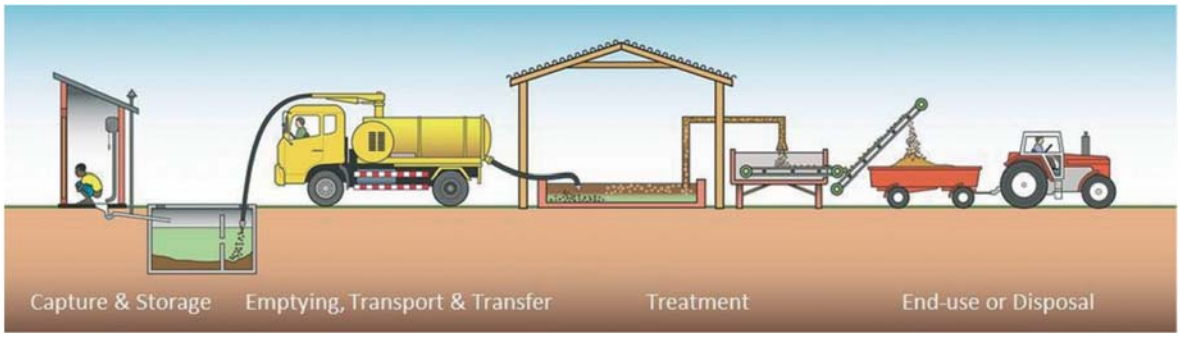


*Figure 1.3 The Sanitation Service Chain*

*Source: (Medland et al. 2016)*

The elements of the sanitation chain are all linked to each other and also follow on from one another in order that the entire process is managed. Therefore, if any of the links in the chain fail, or are not managed properly and sufficiently, then the faecal sludge within that part of the process can subsequently become a hazard to the health of the residents within the affected area. The chain itself covers the whole sequence of stages that faecal matter needs to go through, from initial collection and capture, via various emptying, transferral and transport processes until final treatment, which is either followed by disposal or preferably by transformation into a reusable end-product.

Therefore, for any new system or method of managing faecal sludge and sanitation to be successful, it needs to ensure that all the links of the chain are properly considered.

## 1.3. Container-based sanitation

Container-based sanitation (CBS) is a relatively new technology, which attempts to isolate human interaction with excreta throughout the whole sanitation service chain, in which wastes are captured in sealable, removable containers and transported to a treatment facility (Tilmans et al. 2015). CBS service providers generally distribute container-based toilets to households, usually in the form of a urine-diverting dry toilet (UDDT), in order to capture and store the faeces and urine separately at household level, and thus fulfil the first stage of the chain in a hygienic manner. The containers used are sealable and removeable, so can therefore be exchanged once filled for an empty container by the service provider, who then transports the filled containers, sometimes via a transfer station, to a treatment or disposal facility. Customers generally pay a monthly or weekly fee to the service provider to cover the cost of the provision of the toilet unit itself, and also towards the costs of collection and treatment. Many of the

providers currently operating CBS services subsequently process the collected faeces, in order to produce a resalable end product, and thus help in keeping the overall costs as low as possible.

CBS is relatively young in technological terms, but there is a risk that it can be associated with a previously used method of sanitation – the bucket latrine. The history of the bucket latrine goes back a long way; the use of buckets and outdoor privies were commonly used in England until the mid-nineteenth century, when the introduction of piped sewer networks started to be introduced. The collection of the human faeces was generally undertaken at night, and so the term “night soil” was used as a euphemism for the collected waste.

The key distinction between bucket latrines and modern-day CBS systems, is the fact that with CBS systems, each stage in the sanitation service chain is managed appropriately to prevent human contact with the waste, and that the waste is treated and disposed of or recycled safely. As can be seen in the early image from 18th century London in Figure 1.4 below, this was definitely not the case as two men struggle with an open bucket of excreta slung beneath a pole balanced precariously upon their shoulders. This distinction is an important one to make, in understanding how each of the stages of the sanitation service chain of collection, emptying, transport, treatment and disposal are undertaken; they are totally different for modern day CBS businesses as compared to those of bucket latrines, and therefore the two should not be in any way confused. The key point is that the stages of the chain are actually *managed* in CBS to prevent human contact with any excreta, and also to ensure that the material is treated and disposed of in a safe and appropriate manner. The collective driver of all CBS businesses is to manage the whole process in a safe, hygienic and conscientious manner.

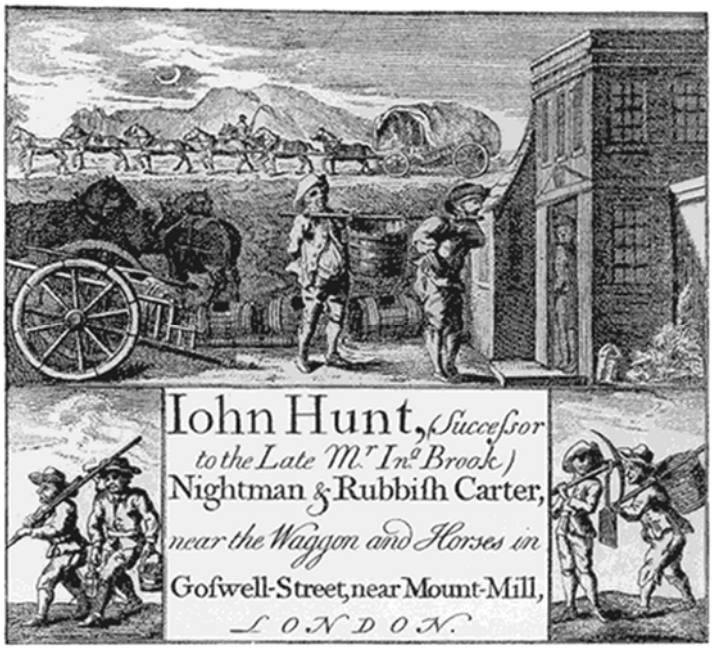


*Figure 1.4 Historical calling card of an 18th century night soil collector in London*
*Source: (Picard 2000)*

CBS addresses the issues associated with sanitation that are found in peri-urban, slum and squatter settlements, by managing each stage of the sanitation service chain and preventing human contact with excreta. The business models, processes, scale, treatment, transport, infrastructure and contexts within which the different services currently operate are extremely varied; they need to be understood and analysed to establish how well the different elements that make up their service models could be utilised or modified so that they could be incorporated for use in a CBS service in any given region, country or environment.

### *1.3.1. Currently operating container-based services*

There are a number of different organisations currently operating CBS services around the world. The processes by which the organisations operate and their business models all vary widely, depending upon the context within which they operate and the local conditions found there. Some of the main CBS businesses and organisations that are currently operating are listed in Table 1.1 below:

*Table 1.1. Current CBS Businesses and Organisations*

| Business/organisation name: | Operational Location: |
|---|---|
| Clean Team | Kumasi, Ghana |
| Loowatt | Antananarivo, Madagascar |
| Sanergy | Nairobi, Kenya |
| Sanitation First | Tamil Nadu, India |
| Sanivation | Naivasha, Kenya |
| SOIL | Port-au-Prince/Cap Haitien, Haiti |
| X-Runner | Lima, Peru |

The specifics of each organisation and the processes by which they operate have been developed according to the context and environment within which they work, and the multitude of factors and variables that present themselves as part of the complex web that makes up the societies and communities living within each area of CBS operation.

## *1.4. Kathmandu and Nepal*

Nepal is divided into 7 provinces, which are further subdivided into 75 separate districts, with a total overall population of approximately 30 million people (Central Bureau of Statistics 2012). Kathmandu, the capital city of Nepal, has suffered from rapid urbanisation and sharp population growth in recent years, and the subsequent establishment of many unplanned and illegal settlements have resulted in severe environmental and sanitary challenges now being faced by both the residents and authorities in the city (HPCIDBC 2011).

### *1.4.1. Current sanitation context*

In recent years, especially over the last decade, there have been improvements in the sanitation arrangements and provision within Nepal. By 2015, good progress had been made towards the

MDG target, with 43% of the population gaining access to improved sanitation since 1990 (WHO/UNICEF 2015).

The Kathmandu Valley is comprised of the three districts of Kathmandu, Bhaktapur and Lalitpur. In 2004, just over 90% of the population had access to toilet facilities (93% in Kathmandu, 91% in Bhaktapur and 81% in Lalitpur) (Gautam et al. 2004). However, by 2011 this figure had risen to over 98% (98.8% in Kathmandu, 97.0% in Bhaktapur and 95.7% in Lalitpur) according to the 2011 national census (Central Bureau of Statistics 2012). Despite the overall improvements in sanitation, the number of squatter settlements in the Kathmandu valley has increased rapidly over recent years from an estimated 17 in 1985 to over 45 by 2008 (Lumanti 2008), and in these communities the general living and sanitation conditions are much lower than those in conventional or legal settlements.

## *1.5. Identification of research problem*

In order to determine the suitability of CBS in any given area, an analysis of the current CBS service providers, the contexts within which they work and the processes undertaken by the organisations needs to be initially completed to determine the conditions under which CBS may have the potential to flourish and in which the technology might provide an appropriate sanitation solution. Once these criteria have been established, a scoring matrix can then be constructed and used to evaluate the potential for CBS implementation in any given environment.

Following the determination of the success criteria required for CBS to operate, specific areas and applications within Kathmandu will be evaluated in order to establish if conducive conditions exist that may lead to the potential implementation of a successful CBS solution

## *1.6. Research problem statement*

The problem statement of this research is to determine the required success criteria for CBS to operate successfully in any given area or environment, based on the experience and learning of current CBS services, and apply the knowledge gained during the development process to new locations and surroundings, using the specific case study of the squatter communities within the Kathmandu Valley.

## *1.7. Aim*

The aim of this research is to undertake an analysis of the CBS services that are currently being operated in urban communities, in order to identify the specific factors that have given rise to, contributed to or affected the success, failure or operating methodology of each of the services studied. The success criteria will then be applied to specific areas and communities living in the city of Kathmandu in order to determine the extent to which CBS would be an appropriate system for use there, and what form the service model might adopt.

## 1.8. Objectives

The main research objectives required in order to satisfy the research aim are:

1. Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work
2. Investigate CBS services to determine and “distil” the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation.
3. Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any barriers that may affect the successful implementation of a CBS service
4. Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements or for other applications within Kathmandu
5. Establish criteria of the required conditions necessary for future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach

## 1.9. Research questions

In order to satisfy each of the objectives above, questions need to be posed and answered in order to enable successful clarification, understanding and comprehensive conclusions to be drawn.

***Objective 1:***

- How do the current CBS services deal with each stage in the sanitation service chain in terms of their operating methodology?
- How do the business models and the financial arrangements of the CBS services compare?
- What does the actual toilet unit consist of and how is it operated for each of the CBS organisations?
- Are any end use products created from the collected waste and what is required to implement the production?

***Objective 2:***

- Why was the specific area of operation chosen and what was it about that area that made it suitable for the implementation of CBS?
- What cultural issues or practices were present in the operational area that influence the ongoing effectiveness, success or implementation methodology of the service?

- What other issues or problems were encountered during the development of the service, and are any ongoing issues still present affecting the success, uptake or performance of the service?

***Objective 3:***

- What are the current sanitation practices adopted by the residents living within the sample communities of Kathmandu?
- What alternative sanitation infrastructure currently exists within target areas of Kathmandu?
- What cultural barriers exist within the sample communities of Kathmandu which may affect the likelihood of successful implementation of a CBS system?
- What other barriers currently exist to prevent the implementation of any form of improved sanitation?

***Objective 4:***

- What would the response of the residents to utilising the different range of end-use products that can be produced from the faecal matter collected in CBS systems, or to the potential consumption of foodstuffs grown using fertiliser/compost produced as a result of CBS?
- What level of payment could be realistically expected in return for the provision of a CBS service within the sample communities of Kathmandu?
- How suitable or appropriate would CBS be for implementation in the target areas, and what would be the most appropriate model in terms of the individual stages of the sanitation service chain?
- How relevant or appropriate is CBS for any other contexts or sanitation applications in Kathmandu?

***Objective 5:***

- What are the cultural criteria that need to be satisfied in order for future CBS systems to be successfully implemented in other regions or countries?
- What physical, geographical or socio-economic factors need to be considered in order to establish the potential for success of any future CBS services?
- What are the financial considerations or implications for any future implementations of CBS based on the experience of the current CBS service providers?
- What other factors need to be considered in order to establish the appropriateness or success potential when evaluating any given area for the possible implementation of CBS?

- What are the current barriers to progress and foreseeable issues going forward for CBS to flourish as a successful and widely used method of sanitation globally in specific, appropriate contexts?

## *1.10. Scope*

The scope of this research will focus on the current CBS services that are operating around the world, in order to determine their operating methodology, the problems that they have faced during their development and the key success criteria that they have identified during their progression which are the essential conditions required for CBS to operate effectively.

A scoring matrix will subsequently be developed to enable an assessment of a given target area to be made as to how suitable CBS might be in that area, and in what form any implementation should take in order to maximise the potential for success.

The information gained from the initial stage and the scoring matrix with then be applied to the squatter areas within Kathmandu to determine the suitability of CBS as a solution to their current sanitation problems.

The research does not intend to investigate the potential of existing businesses or service providers within Kathmandu to deliver CBS as part of their respective business models. The research will also not investigate the details of the end-use product manufacture or processes by which the different products are generated or created, but potential markets and product types will be assessed.

## *1.11. Conclusions*

The structure of the study will comprise two distinct elements of research; the initial phase will determine the required success criteria for CBS to function in any given environment. This information and knowledge will then be applied in a subsequent case study, specifically to that of Kathmandu, in which the potential and likelihood of successful CBS deployment in that context is determined.

# 2. Literature review

## *2.1. Introduction*

In order to meet the research objectives, and thus the overall research aim, the research questions listed in section 1.8 above need to be investigated and addressed. In order to instigate this process a literature review was undertaken to gather as much relevant information as possible pertaining to the research questions, in order to determine any gaps in information that would subsequently need to be satisfied through independent research.

In essence, the literature review was undertaken to investigate the objectives and respective questions within the research framework (see Appendix A) as thoroughly as possible from any available published or unpublished literature, to develop understanding of the research topics, and therefore identify gaps in the available information and the knowledge. In order to accomplish this, initially investigation was undertaken into the specific operations of the currently operating CBS services, but also into the past, current and future issues that have been and are expected to be faced by the CBS service providers. Additionally, the current status of sanitation provision in Kathmandu, specifically in the squatter communities was investigated to obtain a better understanding of the level of sanitation provision and the current issues that exist within Kathmandu and Nepal as a whole.

### *2.1.1. Research objective 1*

- Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work.

In order to explore research objective 1, literature containing relevant information on the current CBS service providers was sought and reviewed in order to further understand the overall scale, area and scope of operation, operation methodology and business model of each of the services investigated. Any subsequent gaps in the required information needed to satisfy the objective following the literature review were covered by subsequent KIIs.

### *2.1.2. Research objective 2*

- Investigate CBS services to determine and “distil” the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation.

Research objective 2 was partly investigated by reviewing available relevant literature that describes the processes that have been implemented and the issues that have been encountered during the development of the individual CBS services. Again, any resultant gaps between the information available following the literature review and that required to fulfil the objective were bridged by the use of subsequent KIIs

#### *2.1.3. Research objective 3*

- Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any cultural barriers that may affect the successful implementation of a CBS service

To meet objective 3, relevant literature on the level of sanitation provision within Kathmandu, and specifically within the squatter communities located there, was reviewed. This information was further confirmed, expanded and developed through KIIs and additional research.

#### *2.1.4. Research objective 4*

- Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements or for other applications within Kathmandu

Objective 4 was met through the applying the knowledge and outputs produced during the fulfilment of objectives 1 – 3 whilst in the field.

#### *2.1.5. Research objective 5*

- Establish criteria of the required conditions necessary for future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach.

This objective was satisfied by initially reviewing relevant literature pertaining to the development of the current CBS services and the issues encountered by the organisations during that time. This information was supplemented by subsequent KIIs to obtain a complete evaluation of the required conditions required for viable CBS implementation, and also to understand more fully the future barriers and issues going forward that may prevent CBS from flourishing as a method of sanitation utilised globally in specific, appropriate contexts. The development of a mechanism for determining the likely potential for success of CBS in any given area or context was undertaken.

## *2.2. Literature review methodology*

Initially, documents relating to CBS were located through the WEDC Resources Centre, the WEDC Knowledge Base and also using the Loughborough University Library Catalogue Plus system. This information was further supplemented through the use of Google Scholar to locate specific relevant journal articles, reports and publications. The details and justification of using these sources and the approach subsequent results of the sources are given in Table 2.1.

Following the identification of initial documentation and awareness gained of the currently operating CBS service providers, the websites of the individual organisations were accessed in order to develop understanding of their operational methodologies and business models.

*Table 2.1 Literature Search Strategy*

| Source of Information | Reasoning and Methodology | Output |
|---|---|---|
| WEDC Resources Centre and Knowledge Base | The WEDC resources centre and Knowledge Base was an initial source of information, especially in the Nepal Country File, where some valuable sanitation reports and publications were identified pertaining to the specific context of Nepal and Kathmandu. | The quantity of information available on CBS in WEDC was limited, due to the small number of existing publications on the topic. However, the Nepal Country file yielded some reports and publications on various sanitation related topics. |
| Loughborough University Library/ Catalogue Plus | Key word searches were carried out using specific CBS related terms in order to locate any papers relating to the topic, for example “Contained Based Sanitation”, “Sanergy”, “Sanivation”, “Clean Team”, “Loowatt”, “Soil AND Sanitation”, “Sanitation First”, “Wherever the Need” and “X-runner”. Literature on the sanitation and settlements of Kathmandu was more forthcoming, and so more specific searches were undertaken such “Sanitation AND Kathmandu”, “Squatter AND Kathmandu” and “Faecal Sludge Management AND Kathmandu”. | A limited number of papers and journal articles on CBS were obtained through this means. However, significant resources and articles were obtained detailing current sanitation context of Kathmandu, FSM issues, historical sanitation improvement programs such as EcoSan and the status, scale characteristics of the squatter communities within the Kathmandu Valley. |
| CBS organisation websites | As a relatively new technology, the amount of information available on the details of the different organisations currently operating is restrictive. Therefore, the CBS websites were used to gain a greater understanding of the individual organisations themselves and their operations. | General details of the CBS organisations were obtained in varying quantities, pertaining to the history, location, scale, operational methodology and business models of the individual and specific services provided. |
| Google Scholar | Google Scholar and Google itself were utilised to locate and cite other relevant sources of information that were unavailable through either Catalogue Plus or WEDC. | Various publications, articles, reports and other published material was identified through Google Scholar using similar search terms to those used in Catalogue Plus. |
| Relevant institutional websites (e.g. WSUP, UN Habitat, WaterAid, GOAL, JMP-WHO/UNICEF, etc.) | Through the websites of relevant institutions and organisations, a large amount of information is available, including statistical data, reports and other high-level documents. | Limited literature was identified through these sources on CBS, apart from a small number of specific articles and reports available through WSUP and GOAL. However, significant data, statistics and information concerning the sanitation status of Nepal and Kathmandu was obtained through these sources. |

*Table 2.1 continues overleaf…*

*Table 2.1 continued…*

| | | |
|---|---|---|
| Nepalese Government department websites | The various departments and ministries of the Nepalese government all have their own websites (e.g. MWSS, DWSS, HPCIDBC, Central Bureau of Statistics, etc.), with downloadable documentation which is unavailable through other means or sources. | Numerous reports and documents containing data and information on many aspects of the sanitation, squatter settlement status, agricultural and employment statistics and other Kathmandu/Nepal specific literature were available for access. |
| NGOs (e.g. Lumanti, ENPHO, OXFAM, etc.) | NGOs operating within Kathmandu, specifically within the sanitation and squatter context were sources of unpublished, internal reports and grey literature. | The resource centre of Lumanti provided useful documentation on squatter settlements and sanitation, whilst ENPHO was helpful providing literature and reports on the status of FSM within Kathmandu. |
| Personal contacts | Personal contacts made through attending conferences, academic colleagues or contacts made during the fieldwork were sources of specific CBS, sanitation and Kathmandu/Nepalese documents. | Unpublished, internal organisation documentation, presentations and other forms of grey literature were obtained through personal contacts and relationships fostered during the research process. |
| Newspaper articles and publications | Sanitation and FSM in Kathmandu is a contentious topic, especially due to the pollution of the Bagmati, a holy river, and thus local publications and newspapers were searched for relevant articles and information. | Several relevant articles to the research were identified, especially on the topics of the lack of public toilet provision within the city, but also in connection with the use of mobile toilets across the Kathmandu Valley. |
| Conference proceedings | SanCoP and FSM4 conferences were both held prior to the start of the research, with both conferences having relevant speakers and presentations on CBS related topics. | The SanCoP and FSM4 conference materials and case study presentations were utilised to learn more about the current issues affecting CBS organisations and the future potential of the sector. |

Through personal contact with key individuals within the CBS organisations, additional unpublished material and reports were obtained and this was further complemented by obtained and reviewed conference proceedings (e.g. SanCoP, FSM4, etc.). Relevant reports and documents related to CBS were also obtained from institutions and NGOs involved with urban sanitation in developing countries, such as GOAL and WSUP.

However, due to the limited amount of time that CBS services have been operating, the quantity of literature available on the specific topic of CBS services and operations, especially that giving any indication towards potential viability or success criteria, was found to be limited.

Conversely, the volume of literature available on the status of sanitation, FSM and the squatter settlements of Kathmandu was far greater than that of CBS. Again, the WEDC Resource Centre was utilised, in particular, the country files for Nepal. The Loughborough University Library

Catalogue Plus system and Google Scholar were both employed to obtain relevant academic papers, publications, and reports. Additionally, the websites of relevant institutions such as UN Habitat, WHO, UNICEF, EAWAG and UN supplied data and documentation on various topics including sanitation, water and poverty implications within the country. More specific documents and reports were obtained from the websites of NGOs such as ENPHO, Mercy Corps and WaterAid, whilst some unpublished reports were obtained whilst in the field through personal contacts and during face-to-face meetings. The various Government departments and ministries of Nepal also provided both valuable statistical data and also some key reports and policies on sanitation related subjects. Personal contacts in the field were also forthcoming with papers and material that they had been involved with during their work in the WASH sector in country.

## 2.3. An overview of CBS organisations

This initial section attempts to satisfy research objective 1, as described in section 2.1.1 previously. A summary of the CBS organisations to be considered is given in Table 2.2.

*Table 2.2 CBS Organisations considered*

| Business/organisation name: | Operational Location: | Level of Provision: |
|---|---|---|
| Clean Team | Kumasi, Ghana | Household |
| Loowatt | Antananarivo, Madagascar | Household |
| Sanergy | Nairobi, Kenya | Household/Public |
| Sanitation First | Tamil Nadu, India | Shared Family |
| Sanivation | Naivasha, Kenya | Household |
| SOIL | Port-au-Prince/Cap Haitien, Haiti | Household |
| X-Runner | Lima, Peru | Household |

Literature on the currently operating CBS organisations was gathered and reviewed in order to determine their operating methodologies, business models and contexts within which they work. The quantity literature available on the various organisations varied significantly, so the resultant gaps in the available information for each organisation were of a conversely proportionate scale. The sanitation practices and initial reasons for the selection of the operational area were investigated where possible, in addition to categorising any success criteria or factors that may help to answer research objective 2.

### 2.3.1. Clean Team

#### 2.3.1.1. Context

Clean Team is a social enterprise in Kumasi, Ghana, that is operated to provide a CBS service to households within dense, low-income areas of the city (Huberts et al. 2016). Clean Team started operating in Kumasi in 2011, and by October 2016, was serving over 500 households (ibid.). The areas within which Clean Team operate are characterised by a high population density, compounded by poor sanitation infrastructure; it is estimated that of all the homes in

Kumasi, 43% have a toilet connected to a septic tank, 18% use a pit or VIP latrine, and 36% use fee-charging public toilets (ibid.). A reliance on fee-paying public toilets is not only inconvenient (often with inconvenient opening hours, or lengthy journeys required to visit them) and a security risk to women and children, particularly after dark, but also can be an expensive activity; the monthly cost for a family of four in Kumasi to use public toilets can be over GHS 80 (approx. $18) compared to the monthly household charge of GHS 38 (approx. $8.50) that Clean Team charge (Clean Team 2017).

#### *2.3.1.2. Operating methodology and business model*

Clean Team provide their customers with a free-standing, urine diverting chemical toilet , in which urine is diverted to either a drain or a storage vessel, and faeces are collected in a sealable, container within the toilet itself (Huberts et al. 2016). A cover material of sawdust is provided to customers to form a layer over the faeces after each use and reduce any smells or insect problems. The toilet unit is illustrated in Figure 2.1 below.

*Figure 2.1 The Clean Team Container-based free-standing toilet*

*Source: (Huberts et al. 2016)*

The waste containers are sealed, removed and exchanged with a fresh, clean container up to twice a week, with the containers of faeces taken off site and disposed of at a waste treatment facility (ibid.). The containers are subsequently cleaned and sterilised ready for reuse. In contrast to other CBS services, the treatment is not carried out by the CBS organisation itself, but by a facility managed by the municipality; therefore, the issues or potential costs and revenues associated with this element of other CBS business models is not considered with Clean Team. The overall business model for the Clean Team operation is shown in Figure 2.2.


*Figure 2.2 Clean Team CBS Business Model*

*Source: (Clean Team 2017)*

#### *2.3.1.3. Challenges and success criteria*

The main reasons for the success and uptake of CBS within the Clean Team customer base was a high WTP, as a result of the historic practice and level of payment for sanitation services within Kisumu (Renouf & Drabble 2017). Additionally, dissatisfaction with the smell and lack of cleanliness and convenience with their previous sanitation, were also contributory factors (Huberts et al. 2016). The design of the toilet, being of a pedestal type, was recognised as being more user friendly to elderly, sick, or those with mobility issues, due to the seating position, as opposed to the more traditional squatting method usually adopted (ibid.). The availability of a toilet within the home was cited as benefit to elderly users, due to the reduced distance required to access the facility, and also by women and children, who found the publicly available facilities unsafe, especially at night (ibid.).

Other potentially relevant insights for future CBS models are listed in Renouf & Drabble (2017) whereby most customers were found to be:

- Happy to clean their own toilet
- Happy to transport their own waste from the toilet to an on-plot bin
- Preferring a CBS toilet that did not obviously look like a toilet (especially with the toilet being located in-house)
- Responsive to training concerned with not putting solid waste into the toilet

The factors will need to be considered for the contexts of any potential future implementations of CBS.

### *2.3.2. Loowatt*

#### *2.3.2.1. Context*

Loowatt began to serve customers with a pilot CBS service in Antananarivo, Madagascar in 2012, incorporating a treatment system that produces biogas, energy and fertiliser from human waste (Loowatt 2017a). The unique aspect of the Loowatt design, is that the toilet unit incorporates a biodegradable film, which contains the waste and inhibits odours. The waste is stored in a container, which is subsequently emptied once filled, with polymer refills provided as required. The Loowatt toilet's hardware is shown in Figure 2.3 below.

One of the key differences of the Loowatt toilet compared with other CBS hardware is the fact that the urine is not diverted but is collected with the faeces within the polymer membrane in the internal container. However, the sealing mechanism separates the liquids and solids, providing a barrier to disease vectors and preventing odours (Purves & Gardiner 2012). The collection of both urine and faeces affects the speed with which the container fills, and thus the regularity with which the container needs to be emptied. By 2017, Loowatt had installed 100 household toilets, and were serving over 600 individual users (Gardiner et al. 2017).

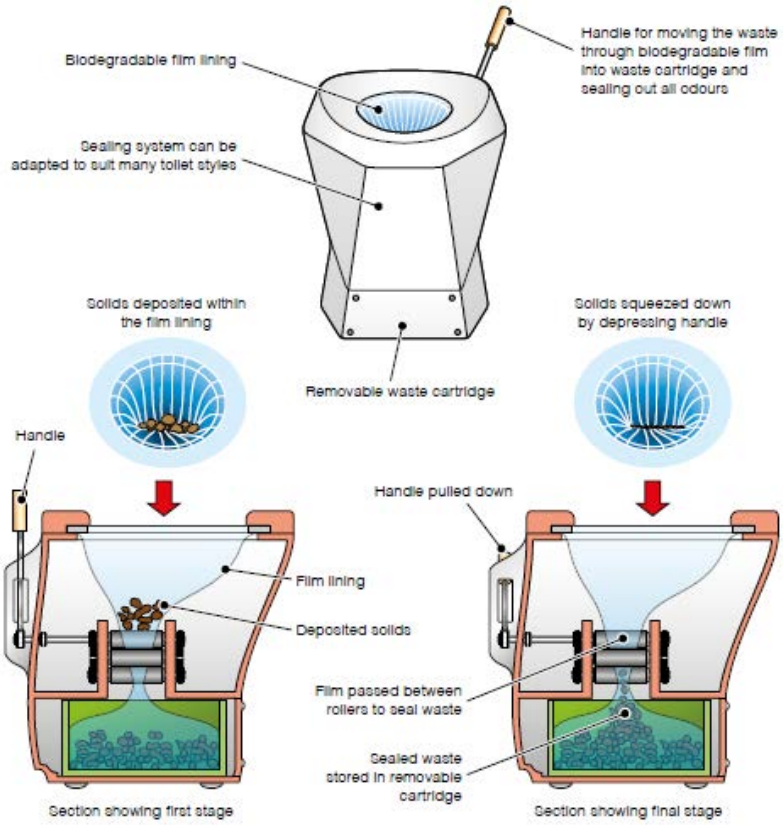


*Figure 2.3 The Loowatt Toilet*

*Source: (Shaw 2014)*

#### *2.3.2.2. Operating methodology and business model*

The Loowatt value chain addresses all the stages of their operational process from capture and storage using their bespoke toilet and polymer refills, weekly collection and transportation to the anaerobic digester, whereupon the waste is converted into by-products of compost and energy; this is summarised in Figure 2.4.

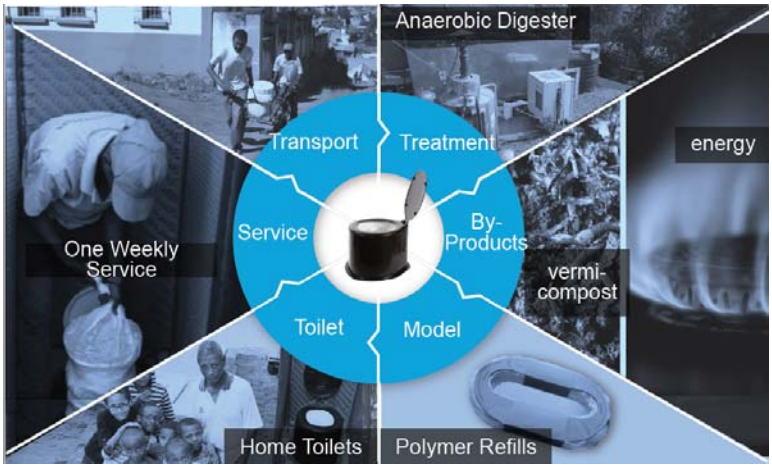


*Figure 2.4 The Loowatt Whole Value Chain Approach*

*Source: (Gardiner et al. 2017)*

Their approach to FSM has 4 fundamental stages (Purves & Gardiner 2012):

- FSM Stage 0 – The Loowatt Toilet (Capture and Storage)
- FSM Stage 1 – Mesophilic Anaerobic Digestion (AD)

  This stage converts the organic waste material into biogas and a nutrient-rich liquid digestate. A schematic of the digestion process is shown in Figure 2.5 below. The digestate is transferred to a compost factory, where it is converted into compost and sold to provide an additional source of revenue.

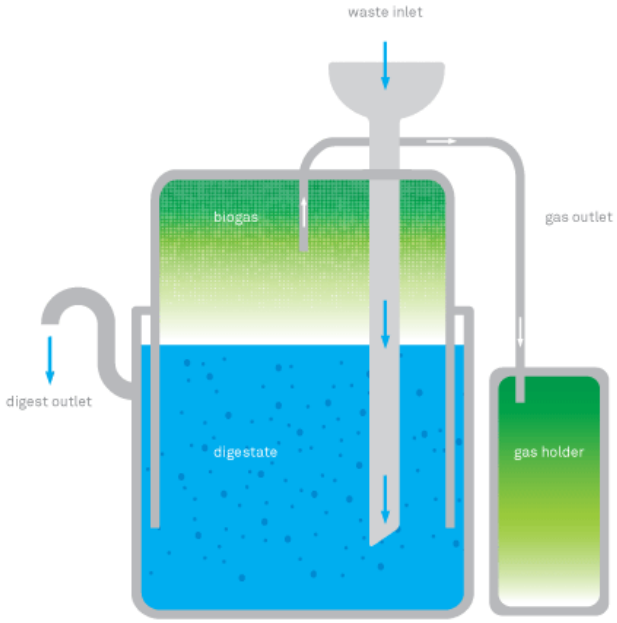


*Figure 2.5 The Loowatt Digester Process*

*Source: (Loowatt 2017b)*

The final two stages of the FSM process are undertaken at the composting factory.

- FSM Stage 2 – Aerobic Composting

  Digestate is combined with locally sourced dry organic matter, which then undergoes a thermophilic composting process to destroy any pathogens and convert the waste into compost.
- FSM Stage 3 – Vermicomposting

  The created compost is further upgraded through the use of Eisenia Foetida worms to produce vermicompost, which increases microbial activity, nutrient availability, water retention, mineral content and plant-pathogen suppression leading to increased crop yield. This process therefore increases the value of the compost and thus increase the potential revenues obtained from the sale of the by-product.

#### *2.3.2.3. Challenges and success criteria*

During the trial stage, Loowatt conducted research to determine cultural and other factor that may potentially affect the success of their operations. The research analysed many factors to consider their impacts and effects on the format of the business model and the by-products produced. The key factors that were assessed in the research were:

- The health of the community prior to the study (to ascertain the level of WASH related illness or diseases)
- Economic indicators, such as wage levels and expenses
- Mobile phone ownership levels to determine the potential for the use of Mobile Money and therefore facilitate the collection of customer fees
- The pre-existing sanitation facilities and the user's satisfaction with those facilities
- The type of toilet used (e.g. squatting or sitting) and the user's preference
- Location of sanitation facilities usually used (e.g. public toilets, shared household toilets, etc.)
- Willingness to pay for sanitation services
- Farmers attitudes towards using safe compost produced from human excreta
- Users attitudes towards purchasing vegetables, fruit or flowers grown using compost produced from human excreta
- Willingness of residents to use energy derived from human waste (e.g. biogas or electricity)

  (Mattens 2012)

Current challenges to the efficiency of their CBS operations have been identified at the FSM4 conference in 2017 as:

- Inefficient logistics leading to unsustainable collection costs.
- Increase in scale and density of the market to improve the margin generated
- Improvements to customer services to reduce customer churn.
- Increase the use of mobile networks for product and service uses; in 2016 Loowatt launched a mobile app that is hoped will help them to track each container and the waste through the treatment system, and make their collection service more efficient.

  (Gardiner et al. 2017)

### *2.3.3. Sanergy*

#### *2.3.3.1. Context*

Sanergy was founded in 2011 in Nairobi, Kenya. As of October 2015, they operated over 600 public toilets (known as their Fresh Life Toilet) in six informal settlements in the city serving approximately 32,000 people, with the high density of toilets allowing for lower waste transportation costs (O'Keefe et al. 2015). During the same period, Oxfam were developing an

in-home urine diverting toilet which could meet the needs of the millions of Kenyans living in slums (McSorley 2016). In 2011 the *Jitegemee*, the first prototype of an in-home portable toilet was trialled. In 2013, Oxfam began a partnership with Sanergy, and the following year the *iHud,* a fibreglass prototype toilet which separates the urine and faeces was launched (ibid.). This is now marketed as the Fresh Fit in-home toilet by Sanergy.

The slums of Nairobi have virtually no sewers whatsoever, so very few residents had toilets within their homes, with two thirds of the 3.5 million population of Nairobi without access to adequate sanitation facilities (Shields & Ruehle 2016). Therefore, slum dwellers often had to either use free public toilets a relatively long distance away, or pay to use insanitary and unhygienic privately-operated toilets, which were notoriously dangerous for women (ibid.). Many public toilets were closed at night requiring women to walk long distances and putting themselves at great risk of rape or assault (The Guardian 2012). Land tenure issues, a lack of regulation and enforcement of policies together also contribute to the situation in which over 2 million residents of Nairobi have no safe sanitation within a convenient distance from their home (McSorley 2016). The convenience of the location was also cited as one of the main two reasons along with cleanliness as reasons for choosing to pay to use a Sanergy toilet (O'Keefe et al. 2015).

#### *2.3.3.2. Operating methodology and business model*

The in-home section (Fresh Fit) of Sanergy's operations is currently much smaller than their public toilet service, so their business model is currently centred around the process of servicing and maintaining their franchised Fresh Life Toilets (FLTs). The franchising business model was developed through three distribution models: commercial, household and community institutions (Shields & Ruehle 2016). The commercial FLTs utilise local entrepreneurs who run communal pay-per-use solution in the form of a modular facility (London & Esper 2014) with the price set by the franchisee. The household toilets were established through partnerships with landlords to offer 24-hour access to hygienic and safe sanitation within their own compounds. The costs were included within the rents and tenants collaborated to maintain and clean the toilets (Shields & Ruehle 2016). Fresh Life also partnered with schools to provide hygienic sanitation with the costs being included within the school fees (ibid.). Toilets are also provided for churches and clinics to reach the most vulnerable parts of the communities (Sanergy 2017).

The Sanergy model is similar to other CBS services in that the entire sanitation chain is managed, albeit not all directly by Sanergy themselves, from collection and storage, through transport and removal to final treatment and reuse as shown below in Figure 2.6.

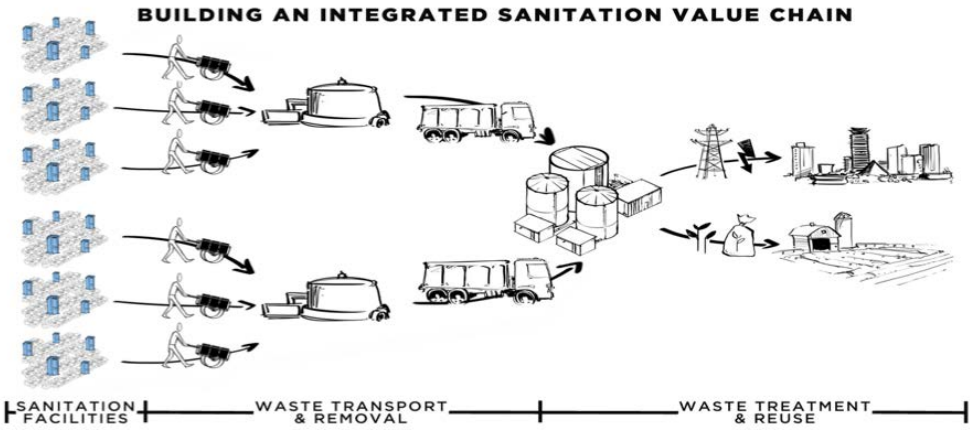


*Figure 2.6 The Sanergy model of the Sanitation Value Chain*

*Source: (Sanergy 2017)*

The Fresh Life Toilet is a low-cost, prefabricated toilet that is operated in informal settlements through a network of Fresh Life Operators – local entrepreneurs who purchase and operate the facilities (Sanergy 2017). The toilets are easy to maintain and compact in size making it possible for them to be installed near homes. The toilets are also equipped with toilet paper and hand-washing facilities, which are rarely provided in other public facilities within the vicinity (Shields & Ruehle 2016). The overall construction and layout of the FLT is given below in Figure 2.7.


*Figure 2.7 The Fresh Life Toilet*

*Source: (Sanergy 2017)*

The Franchisees are provided with training, ongoing operational and marketing support, a daily waste collection service and are even provided with access to finance (Sanergy 2017). Due to the franchise model, the demand for and cleanliness of the FLTs are ensured by the operators, as these factors have a direct effect on their own level of business.

The waste is collected on a daily basis by Fresh Life staff, who are equipped and trained to remove the filled containers and replace them with empty ones (Sanergy 2017). Due to the narrow, unpaved alleys required for access in the unformal settlements, wheelbarrows and handcarts are utilised to safely remove the waste from the community and transfer it to a treatment facility (ibid.). The waste is treated at a centralised facility where it is currently converted into end-products such as organic fertiliser (Sanergy's brand of compost called Evergrow), insect-based animal feed and renewable energy (ibid.). In order to produce the fertiliser, the waste is co-composted with a sawdust, other carbon sources and micro-organisms which eliminates the pathogens.

The production of the insect-based animal feed utilises a colony of Black Soldier flies, whose larvae consume the waste, thus removing the pathogens and converting the waste into protein (ibid.). The larvae are subsequently boiled and sun-dried to eliminate any residual pathogens, to produce a nutrient-rich feed for animals (ibid.). The urine is also reused as is the biogas produced by the waste which is captured to produce energy.

The overall business model of the public toilet franchise operations is shown in Figure 2.8 below; however, this diagram omits the animal feed aspect of the end-product section of the operations, as described above, which should also be included.

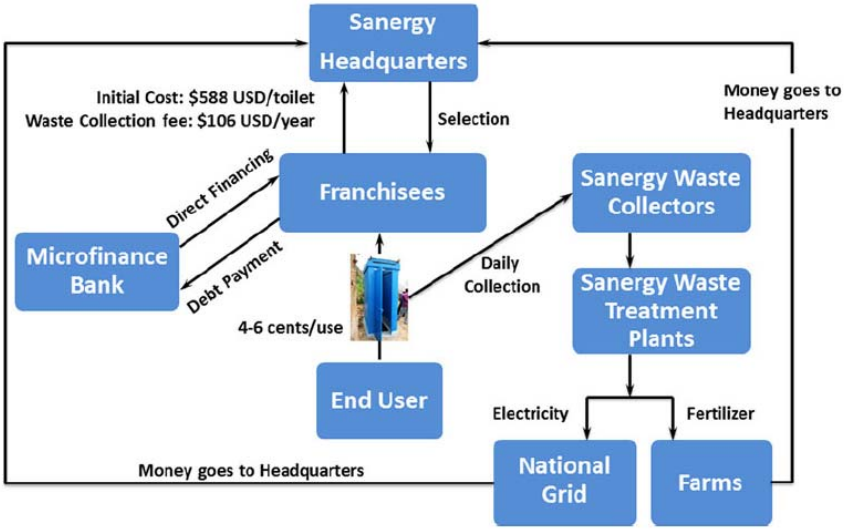


*Figure 2.8 Sanergy's public toilet business model*

*Source: (London & Esper 2014)*

#### *2.3.3.3. Challenges and success criteria*

Although the FLT side of Sanergy's business is successful, with over 32,000 being served by 2015 (Shields & Ruehle 2016), FLTs do not solve all the sanitation related issues. These are highlighted in the iHud project update (2016) which acknowledged that:

- "Commercial FLTs are not open 24 hours a day, leaving users without adequate sanitation at night
- Some landlords remain unwilling to install of an on-plot FLT

- Space constraints can make an FLT unfeasible in some plots
- Disabled, elderly and pregnant users have difficulty in squatting to use the FLT"

(Sanergy 2016)

Therefore, the market exists for an in-home toilet, which Sanergy provide in the form of their Fresh Fit toilet. In order to realise economies of scale, Sanergy have estimated that they need to provide at least 500 in-home toilets (ibid.). During the trial in 2016, 60 toilets were installed (ibid)., but by March 2017 only 30 toilets had been sold to households (SanCoP 2017). It can therefore be assumed that there is a need to increase the number of customers to improve the efficiency of the collection process, and to make the service financially viable. However, as the service was only launched recently, with the first bulk production run of the iHud only having been undertaken in Nairobi in December 2016 (ibid.), it is too early to assess the success of the in-home toilet service at the moment. The sales will no doubt increase over time to a more indicative level to allow for the establishment and awareness of the service to become more widespread.

#### *2.3.4. Sanitation first*

##### *2.3.4.1. Context*

Sanitation First was launched in 2016, through the renamed charity Wherever the Need, which was previously formed in1996, and now claim to be the largest provider of EcoSan toilets in India and Sierra Leone (Sanitation First 2017b). In India, approximately 100 GroSan toilets are managed in peri-urban areas of Cuddalore and Puducherry, with plans for a further 100 toilets to be installed in the slums of Chennai (Kirby-Garton 2017). Their GroSan toilets are based on urine diverting dry toilets (UDDT) which separate the liquids and solids at source allowing the waste to be safely contained and subsequently converted into compost which is then used as a fertiliser (Sanitation First 2017a). The reasons why CBS rather than more conventional forms of sanitation was identified as a potential option for the operational area were:

- Prohibitively large upfront capital investment of conventional sanitation not available
- Lack of availability of a reliable water and energy supply
- A shortage of established, professional and well managed existing utilities
- The fear of local authorities in conferring legitimacy to communities occupying land illegally

(Kirby-Garton 2017)

Therefore, CBS was introduced providing a system of safe containment and removal through the use of compact and portable units (ibid.).

##### *2.3.4.2. Operating methodology and business model*

One of the key differences of Sanitation First's program is the fact that the service is offered in the form of a free-at-the-point-of-use shared toilet service in slum areas (SanCoP 2017). This approach allows Sanitation First to reach the very poorest, as any potential affordability issues

do not need to be considered. Another unique aspect of the Sanitation First CBS system, was developed in response to the Manual Scavenging Act 2013 which exists in India. This act states that it is an offence to:

i. Construct or maintain an insanitary latrine; or
ii. Engage or employ a person to work as a Manual Scavenger
(SanCoP 2017)

This is a criminal act for which contravening is subject to fines or even prison sentences in an attempt to stop the practice of unprotected manual removal of human waste. In order to overcome this restriction, Sanitation First developed a system which incorporates a multiple container system on rollers, which remain on site for a further 3 weeks after being filled, prior to removal. This period allows the waste to be composted for a sufficient period for it to no longer be considered as untreated faecal waste (SanCoP 2017). This system is supplemented by a rigorous collection process incorporating a high level of operator PPE, specialised bespoke equipment for container handling and a thorough and hygienic container cleaning process (ibid.).

Due to the anal cleansing practices of washing in the communities within which the service is provided, Sanitation First also needed to provide a system that could manage and contain the resultant wash water that is produced. The overall process of Sanitation First's GroSan toilet system is shown in Figure 2.9 below.

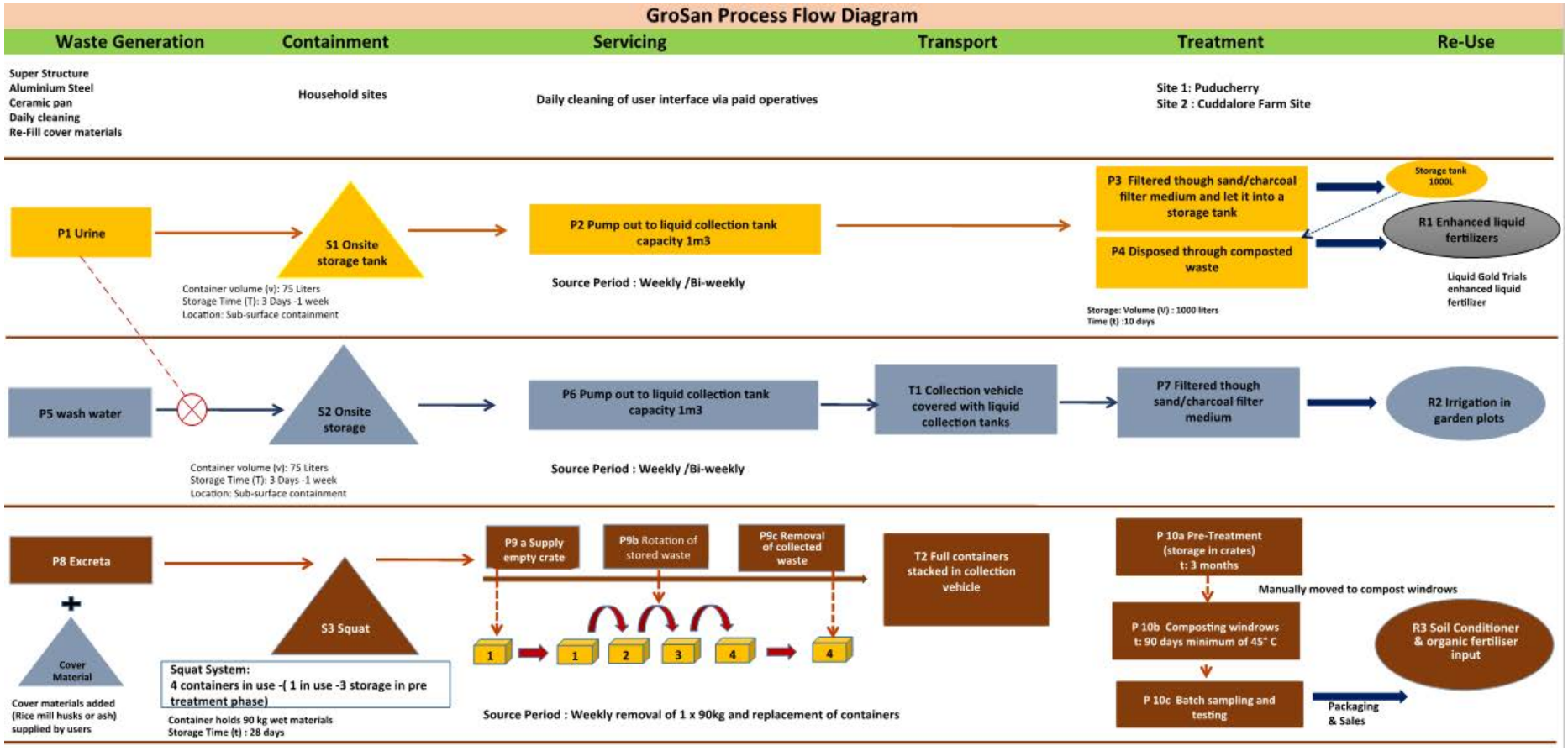


*Figure 2.9 Sanitation First's GroSan Process Flow Diagram*

*Source: (Kirby-Garton 2017)*

#### *2.3.4.3. Challenges and success criteria*

One of the main ongoing challenges for Sanitation First is still to overcome any existing perceptions of their operational process being regarded manual scavenging (Kirby-Garton 2017). Existing perceptions of a desirable toilet being of a white, ceramic, flushing type also need to be overcome (ibid.).

### ***2.3.5. Sanivation***

#### *2.3.5.1. Context*

Sanivation operate a household CBS service in Naivasha, Kenya, but also license out their model for operation in refugee camps (Sanivation 2017). Their business model is similar to other CBS organisations, in that they install CBS toilets free of charge into customers' homes, and then charge a monthly fee for the maintenance and emptying of the toilets. However, the unique aspect of the Sanivation model is through the production of clean burning charcoal briquettes from the collected waste, which are then sold to recover some of the costs of collection, transportation and treatment. By October 2016 Sanivation were producing 15 tons of briquettes per month and selling them for $200/ton (Berner et al. 2017b). The conditions within the target area are characterised by a high proportion (77% of the population) of shared/public latrine use; the latrines very rarely serviced, with most being covered and re-dug (Sanivation 2016). Similarly high statistics were obtained for the levels of rent-paying tenants and very low incomes (< KES 10K/month ≈ US$100/month) (ibid.). The main reasons identified by Sanivation in the uptake of their household service were generally connected with:

- Mobility challenges – associated with either long journeys to alternative facilities, or difficulties squatting on latrines, both of which are compounded for mobility-impaired users.
- Safety – concerns, especially of women and children, in using public latrines after dark.
- Convenience – being able to use a toilet within the home, especially at night or during periods of rain.
- Dissatisfaction with latrines – lack of cleanliness and odour leading to high levels of dissatisfaction, particularly amongst children.

  (Sanivation 2016)

The toilet unit is rented for 600 KES/month (≈US$6) which is installed and serviced twice a week by Sanivation. In servicing, the urine and faeces containers have lids fitted and the filled containers exchanged for empty ones. A desiccant cover material, usually ash supplied by the customer, is placed over fresh faeces after every use to prevent odours (Sanivation n.d.).

#### *2.3.5.2. Operating methodology and business model*

As mentioned above, the operating methodology of Sanivation is similar to that of other CBS organisations, with the key differences being that of the production of charcoal briquettes as an

innovative end-use product through the process of pyrolysis. Sanivation conducted their own research into the potential revenues of charcoal briquettes, compared with other faeces based fuel products and this, combined with high local demand for charcoal, led to their decision to produce briquettes (Berner et al. 2017b).

#### *2.3.5.3. Challenges and success criteria*

The main challenges affecting the potential uptake of the household operations of Sanivation currently are:

- Space – a large proportion (over 50%) of the residents live in 1-room houses where space is at a premium
- Privacy – difficulty in locating the toilet in a place where sufficient privacy is obtained in 1 or even 2-bedroom houses
- Smell – issues will smell emanating from the toilet after use which need to be kept away from living areas
- Price – due to the low wages of the average household, residents find 600 KSH difficult to afford

(Sanivation 2016)

### ***2.3.6. SOIL***

#### *2.3.6.1. Context*

SOIL is a US-based NGO working to promote EcoSan services in Haiti since 2006 (Remington et al. 2016). Initially, SOIL was established to provide public urine-diversion toilets in urban and rural settings, especially as a response to the earthquake in 2010 (ibid.). Their EkoLakay CBS toilet service was launched in Cap-Haïtien in early 2012, and then expanded to Port-au-Prince in 2015, to provide an alternative sanitation solution and reduce the occurrence of open defecation (OD) and flying toilets among the target communities. The reasons for the poor levels of sanitation within the areas of operation were due to the non-existence of a sewered network (and the unlikely deployment of such a system in the foreseeable future), and the lack of other suitable on-site sanitation options; high population density, irregular, narrow alley accesses, a high water table and flood-prone conditions existed in both communities (Russel et al. 2015), meaning that pit latrine and septic tank emptying was a hazardous and unhygienic operation due to the requirement for manual emptying (Tilmans et al. 2015). Other sanitation options such as shared communal or public facilities were located away from the communities, and were not open overnight, making the use of these types of facilities impractical and inconvenient (Russel et al. 2015). Other issues highlighted in Tilmans et al. (2015) are the reluctance of governments to invest in sanitation infrastructure in communities with uncertain or illegal tenure status, compounded by the lack of space and financial restrictions within individual households to provide their own sanitation facilities.

#### *2.3.6.2. Operating methodology and business model*

SOIL, through their EkoLakay brand, promotes the use of EcoSan, whereby the faeces from their container-based toilets is collected on a weekly basis, and processed into compost which is then sold to recover some of the costs of the waste treatment process (SOIL 2017) Customers of EkoLakay sign up for the service with their first monthly payment of between $4-5, which covers the installation of the toilet, weekly collection of the filled faeces container, provision of a weekly supply of a dry cover material (a mixture of sieved sugarcane bagasse and crushed peanut shells) and treatment at the composting waste treatment facility (Remington et al. 2016). The toilet unit houses a 20l container to store the excreta and a 3.8l container for capturing the urine, which is separated from the faeces through the use of a plastic funnel fitted in the seat (Tilmans et al. 2015) as shown in Figure 2.10 below.

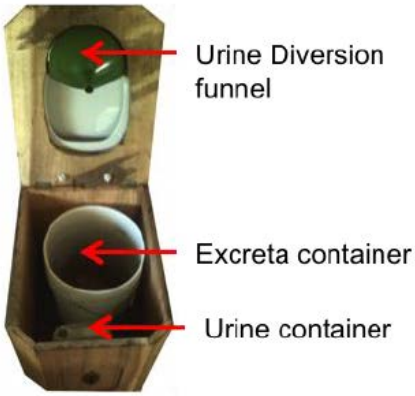


*Figure 2.10 EkoLakay Internal View*

*Source: (Remington et al. 2016)*

Households are responsible for emptying the urine container themselves as necessary, with two different models of the toilet available to customers; a wooden version with a production cost of US$50 and a ferro-cement model with a reduced cost of US$22 (ibid.). Both models are sourced and manufactured locally and are shown in figures Figure 2.11 and Figure 2.12 below.

SOIL employees visit potential customers within the specified service area to determine if sufficient space is available within the property for installation; if so a service contract is signed with the head of the household, the first month's payment is taken and the toilet is subsequently installed, with training on its use provided, and a GPS location taken for future identification by the collection team.

*Figure 2.11 Wooden EkoLakay*
*Source: (Remington et al. 2016)*

*Figure 2.12 Ferro-cement EkoLakay*
*Source: (Remington et al. 2016)*

The collection process as detailed in Remington et al. (2016) is summarised as:

- The filled and sealed containers are set aside weekly by the customers for collection, and these are exchanged for empty containers and an additional supply of cover material.
- Filled containers are transported to a centralised depot or pick-up point using modified wheelbarrows or 3-wheeled motorcycles.
- A flatbed truck transports the filled containers from depots and pick-up points to a centralised treatment facility.
- Payment collectors visit customers on a regularly using bicycles or motorcycles to collect the monthly fees.
- Customers who default on their payments by more than 2 months are cancelled and their toilets are removed.

By February 2016, SOIL had 721 customers of approx. 4000 individual users and had sold over 100 metric tonnes of compost.

#### *2.3.6.3. Challenges & success criteria*

The factors and challenges that have affected the success of SOIL and the ongoing challenges that they face are noteworthy for any future application of CBS. Issues considered by SOIL include understanding the willingness of the potential customers to handle their own urine, or assessing the potential for infiltration within the target area (Tilmans et al. 2015). Anal cleansing practices need to be considered, including the mechanism for dealing with grey water (ibid.). An assessment of WTP and ATP for such services also needs to established if the service is intended to be introduced as a potential business.

Door-to-door collections of the monthly fees can be time consuming, and therefore not very cost effective as often multiple visits are required (Remington et al. 2016). Cost effectiveness of collection is also significantly improved through higher densities of clients by minimising the

time, and thus cost, associated with each collection (ibid.). Due to the informal, often temporal and rapidly changing nature of the housing settlements, identification of the individual customers relies heavily on the memory, knowledge and intuition of the collection team, which can cause problems with staff changes or illnesses; this is partly overcome by the use of GPS location, but is a factor that still requires consideration (ibid.). A reliable and cost-effective source of organic material for use needs to be available locally, as both a cover material for the toilets, but also as a bulking agent in the composting process, especially if the service is planned to be scaled up; this factor needs to be established in any area where CBS is to be considered for potential use (ibid.). The available space within the individual homes also needs to be adequate in order to ensure that there is sufficient to room to acceptably accommodate a toilet unit without it impacting negatively on the lives of the residents (Russel et al. 2015).

### *2.3.7. X-runner*

#### *2.3.7.1. Context*

X-runner was founded in 2011 in Lima, Peru, where they supply a hygienic domestic sanitation service using portable dry toilets with a weekly pick-up service to a composting facility (Castizo & Buckland 2016). The main reason for adopting a dry toilet container system in this location was due to the water scarcity within the city; Lima is the 2nd driest capital in the world, so therefore a conventional water-based sewered system is not an option to serve the whole population of the city (X-runner 2017). Other forms of sanitation that are practiced in many of the illegally occupied peri-urban areas of the city include open defecation, and poorly maintained pit latrines or buckets, all of which have associated health problems and can lead to pollution of ground water supplies (Castizo & Buckland 2016). By July 2016, X-runner had supplied 530 toilets, with more than 2650 individual users, with a monthly household charge of US$ 14 per month per unit (ibid.).

#### *2.3.7.2. Operating methodology and business model*

The operating methodology of X-runner is similar to that of other CBS organisations which is illustrated in Figure 2.13 below.

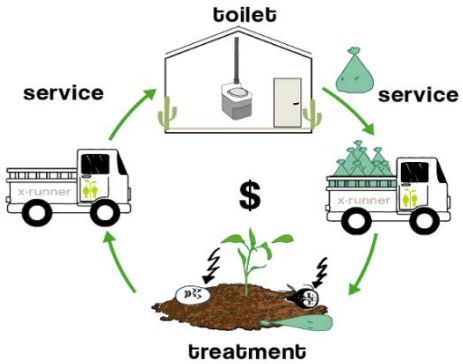


*Figure 2.13 The X-runner model*

*Source: (X-runner 2017)*

The toilet unit utilised by X-runner is waterless toilet manufactured by the Swedish company Separett (Separett 2017). Therefore X-runner have not experienced the developmental issues that other CBS organisation have had in designing and producing their own hardware. However, another unique feature of their operation is the way in which the collection service operates. The collection vehicle visits different areas each day on a weekly rota. As the collection route is followed, the truck plays a song through its PA system to announce that the collection vehicle is approaching. On hearing this, customers then transport their containers and filled bag of faeces to the vehicle where an X-runner operative removes the bag and exchanges it for a clean empty bag (Castizo & Buckland 2016). This method of collection minimises the collection costs, but also mitigates the issues of locating or recognising customers' houses, or issues of customers not being at home at the time of collection, as the onus is placed on the customer to be available on the day of collection, which are both issues experienced by other CBS organisations. The collected biodegradable bags of faeces are then transported to a treatment facility, where they are transformed into compost which is intended for sale to recoup some of the running costs of the organisation. However, currently there is no market for the compost due to a lack of regulation in Peru for fertilisers created from human waste (ibid.).

#### *2.3.7.3. Challenges and success criteria*

Finding a local producer of biodegradable bags rather than the currently used "Biobags" (Biobag 2017) which are currently imported from the US at 0.47 USD per bag would reduce costs; however, a system that does not require the use of bags at all would reduce the costs further and create a more effective pick-up service (Castizo & Buckland 2016). Finding clients willing to purchase compost produced from human waste, and also overcome the associated stigma of using the material, is another key challenge to the organisations business model (ibid.). Other innovations that X-runner are working on to improve their performance include:

- Maximising the use of local bank agent kiosks in existing shops in order to make the payment process as efficient as possible; this process places the responsibility for payment on the customer by visiting a bank agent, rather than having an X-runner employee visiting the home of the customer to collect their fees.
- Utilising efficient microorganisms to accelerate the composting process by adding them to sawdust provided to the customers as a cover material. By doing so, the composting process begins in the actual containers, thus starting the process a week before the waste arrives at the treatment plant
- Attaching NFC microchips (tags) to the toilet containers allows the service team to scan the tags, and thus provide the staff with real-time information on any issues with payment of the service or with the toilet itself.

  (Castizo & Buckland 2016)

### *2.3.8. Supplementary Identified Factors*

One of the main challenges identified during the first International Toilet Summit, organised and hosted jointly by Oxfam and Sanergy, is the fact that CBS is not widely recognised as an improved form of sanitation (McSorley 2016). This factor has implications globally as policy makers and governments would be more likely to recognise CBS as a potential option for addressing growing global sanitation issues, particularly in high density, peri-urban areas, if its' status as an improved form of sanitation were attained (ibid.).

Other challenges and issues identified during a workshop at the summit that are currently affecting the progress or success of CBS implementation include:

- A large bias by men against the use of CBS services, who see them as unnecessary (often having access to toilets at work, or seeing no practical need for the service) and also as potentially emasculating (reminding them of a potty)
- Reluctance of landlords to invest as they don't envisage a worthwhile return
- Controlling the odour and diverting the urine from the faeces in an ergonomic and efficient way
- High material costs, which could be lowered by product development standardisation and sharing of common parts between CBS organisations. This would also lead to economies of scale and greater purchasing power, in terms of developing contracts with suppliers, thus reducing the unit price and complexity of the supply chain
- Unmarked, difficult to recognise and frequently changing residency locations and appearances of the customers, making access and/or locating users a time consuming and inefficient process
- Difficulties in exchanging containers when customers are not at home
- Issues surrounding the separate collection and disposal of urine and faecal waste

  (Oxfam 2016)

As a result of the workshop, the top three challenges identified by the CBS organisations were:

- How to standardise the service and product designs across all the CBS providers
- How to improve the service model to a more integrated, safe, reliable and clean solution
- How to find solutions to the infrastructural and governmental barriers that currently affect CBS

  (Oxfam 2016)

To address these challenges, the workshop proposed that CBS organisations should:

- Collaborate on product development and arrive at a consensus on a universally shared range of parts

- Streamline their pickup services by trialling centralised drop off locations and new payment systems
- Form a CBS Alliance organisation, to unify the individual organisations, and to legitimise CBS as an appropriate and improved form of sanitation solution

  (Oxfam 2016)

In a recent report by WSUP and Ernst & Young into the viability of CBS as a potential solution to the global sanitation, the favourable market conditions required for CBS to be considered as an appropriate technology in a new market were investigated; an assessment tool was developed from this which could then be used in order to undertake an evaluation of an area or market and thus gauge the potential for any CBS implementation. An overview of the favourable market conditions considered by the assessment tool are shown in Figure 2.14 below.

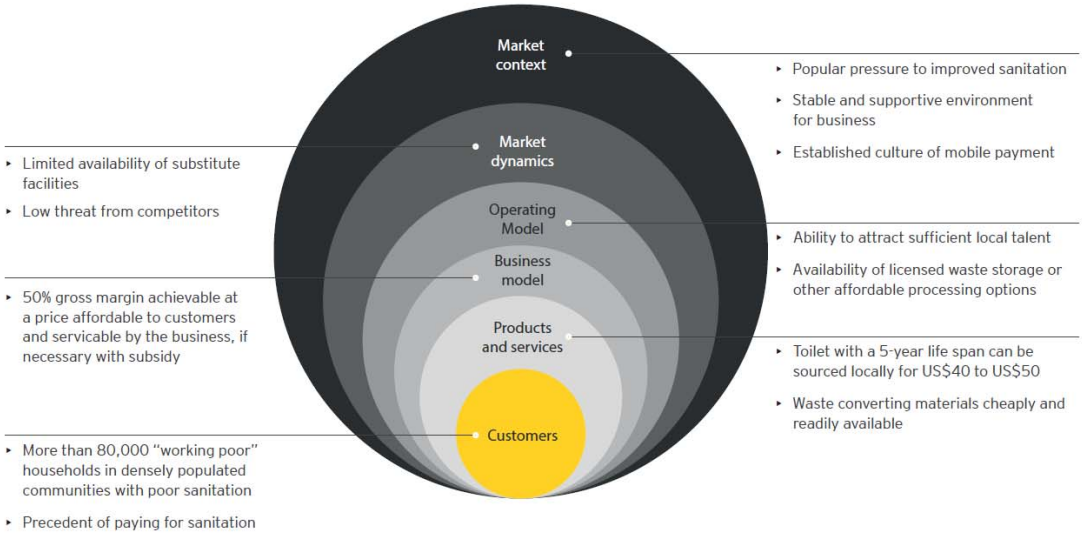


*Figure 2.14 Favourable market conditions for CBS*

*Source: (Mikhael et al. 2017)*

These factors identified through the development of the tool need to be included as part of any analysis or evaluation of a new market, in order to determine their implications on the potential viability of a CBS implementation. Other challenges and constraints on the implementation of urban sanitation are considered by Reade (2016), who suggests the biggest barriers in an urban context to the provision of conventional sanitation as:

- High population density
- Limited/lack of open space
- Inability to excavate, either because of permission issues, or because of hard surfacing (e.g. concrete)
- Insecurity in accessing toilets, particularly after dark, for women, children and even men
- Poor access for latrine emptying vehicles or equipment
- Land tenure issues

  (Reade 2016)

These factors are also supplemented by a number of other geological or physical constraints which may exist that impact on the ability to install some form of on-site sanitation (e.g. pit latrines, septic tanks. Examples of such conditions are:

- Areas where there is a risk of flooding
- High water table
- Low infiltration rates
- Rocky ground
- Collapsing or unstable ground

  (Reade 2016)

All these factors need to be considered for any given area to assess their impact on the selection of a sanitation option; if a combination of these constraints exist, a form of CBS may be the only appropriate sanitation solution, as CBS is generally unaffected by these issues.

#### *2.3.9. Summary of CBS literature*

The literature review of available relevant CBS material produced a large number of factors (e.g. population density, level of existing sanitation infrastructure, level of culture of paying for sanitation services, etc.) for consideration with regard to assessing the viability of any future CBS implementations. However, this information needs to be supplemented with more in-depth information from the CBS organisations themselves as to why the areas in which they operate were originally selected as suitable for CBS, what the existing sanitation practices were, the past, present and future cultural and implementation issues that have been encountered and any other learning opportunities that can be gained as a result of their experience. This information was obtained by undertaking KII with CBS organisations themselves, in order to establish a comprehensive list of factors and conditions required for potential CBS viability.

## *2.4. Sanitation in Nepal and Kathmandu city*

This section was compiled in response to research objective 3 in order to gain a clearer understanding of the current existing sanitation arrangements in place.

#### *2.4.1. Current sanitation provision*

By 2015, 46% of the population of Nepal had obtained access to improved sanitation (WHO/UNICEF 2015); this figure is further broken down into urban and rural categories, with 56% of urban residents using improved facilities whilst only 43% of rural residents have obtained access to similarly improved sanitation (ibid.). Figures produced by the Central Bureau of Statistics of Nepal in 2012 from a national census undertaken in 2011 broke the statistical data obtained on the types of toilet of the whole population down into the type of toilet used, as shown in below Table 2.3.

*Table 2.3 Nepalese households by types of toilet*

*Source: (Central Bureau of Statistics 2012)*

| Area | Total | Without toilet | Type of toilet used | | | Not stated |
|---|---|---|---|---|---|---|
| | | | Flush toilet (public sewerage) | Flush toilet (septic tank) | Ordinary toilet | |
| **Nepal** | **5,423,297** | **2,069,812** | **448,359** | **1,814,293** | **1,055,862** | **34,971** |
| **Urban/Rural** | | | | | | |
| Urban | 1,045,575 | 95,030 | 316,041 | 496,624 | 129,732 | 8,148 |
| Rural | 4,377,722 | 1,974,782 | 132,318 | 1,317,669 | 926,130 | 26,823 |

Table 2.3 shows that even though Nepal is making good progress in terms of sanitation, over a third of the households in the country are still without a toilet; most of these households are located in rural areas, but even in urban areas, only 30% of the households have access to a sewered system. This data was then further categorised into figures corresponding to the three districts which make up the Kathmandu Valley, Kathmandu, Lalitpur and Bhaktapur, and are given in Table 2.4 below.

*Table 2.4 Households by types of toilet in the Kathmandu Valley*

*Source: (Central Bureau of Statistics 2012)*

| Area | Total | Without toilet | Type of toilet used | | | Not stated |
|---|---|---|---|---|---|---|
| | | | Flush toilet (public sewerage) | Flush toilet (septic tank) | Ordinary toilet | |
| Lalitpur | 109,505 | 4,735 | 49,045 | 42,492 | 12,139 | 1,094 |
| Bhaktapur | 68,557 | 2,079 | 33,019 | 26,109 | 6,913 | 437 |
| Kathmandu | 435,544 | 5,034 | 300,014 | 85,728 | 41,301 | 3,467 |

Table 2.3 shows that even though Nepal is making good progress in terms of sanitation, over a third of the households in the country are still without a toilet; most of these households are located in rural areas, but even in urban areas, only 30% of the households have access to a sewered system. This data was then further categorised into figures corresponding to the three districts which make up the Kathmandu Valley, Kathmandu, Lalitpur and Bhaktapur, and are given in Table 2.4 below.

Table 2.4 shows that the level of toilet provision within the Kathmandu Valley is much higher than that for the rest of the country, with less than 2% having no toilet. However, the level of sewer provision for the valley as a whole is still only 62%, which leaves 38% with either no facilities or on-site sanitation facilities.

These figures are confirmed by a further survey conducted in 2014/15 by the Central Bureau of Statistics in which it found that 22% of the population still had no toilet, with 10% of urban and 28% of rural households without their own toilet (Central Bureau of Statistics 2016). Statistical data from 4 different surveys undertaken in Nepal is shown in Table 2.5 below. NLSS was carried out in 2010/11, AHS II in 2013/14 and AHS III in 2014/15.

*Table 2.5 Summary of toilet facility statistics in percentage terms*

*Source: (Central Bureau of Statistics 2016)*

| Household facilities | Facilities | Region | AHS III | AHS II | NLSS III | Census 2011 |
|---|---|---|---|---|---|---|
| Toilet facility | Flush toilet | Nepal | 50.3 | 51.4 | 42 | |
| | | Urban | 68.5 | 81 | | |
| | | Rural | 41.2 | 44.4 | | |
| | No toilet | Nepal | 22 | 25.7 | 44.0 | 38.2 |
| | | Urban | 10.4 | 0.2 | | |
| | | Rural | 27.8 | 0.6 | | |

The same survey also conducted research into the type of toilet used by households and also the type of sanitation management methods, which are shown in Table 2.6 and Table 2.7 respectively, and which also break the data down further into income quintiles. There appears to be a discrepancy in the figures for flush toilets to public drainage between Table 2.3 and Table 2.6, with the former showing higher values of public sewer connection. However, one of the key features of Table 2.6 is that over 50% of the poorest quintile have no toilet.

*Table 2.6 Distribution of households by type of toilet in percentage terms*

*Source: (Central Bureau of Statistics 2016)*

| | Flush (public drainage) | Flush (septic tank) | Ordinary toilet | Communal toilet | No toilet | Total |
|---|---|---|---|---|---|---|
| **Urban/Rural** | | | | | | |
| Urban | 13.4 | 55.1 | 20.7 | 0.4 | 10.4 | 100.0 |
| Rural | 1.7 | 39.5 | 30.2 | 0.8 | 27.8 | 100.0 |
| **Consumption Quintiles** | | | | | | |
| First Quintile (Poorest) | 0.2 | 21.7 | 25.1 | 1.1 | 51.9 | 100.0 |
| Second Quintile | 0.3 | 29.6 | 35.9 | 0.9 | 33.3 | 100.0 |
| Third Quintile | 1.1 | 40.7 | 32.8 | 0.7 | 24.7 | 100.0 |
| Fourth Quintile | 3.6 | 53.8 | 29.0 | 0.6 | 12.9 | 100.0 |
| Fifth Quintile (Richest) | 17.3 | 63.7 | 16.0 | 0.3 | 2.6 | 100.0 |
| **Nepal** | **5.6** | **44.7** | **27.0** | **0.7** | **22.0** | **100.0** |

Table 2.7 demonstrates the low levels of sanitation management undertaken across Nepal as a whole, with 83.5% of rural, and nearly 50% of urban households having no facilities for managing the sewage produced by the members of the household.

From this data, it can be seen there are still many challenges faced by Nepal in improving the levels and provision of adequate sanitation, not only in the rural context, but also from an urban perspective, particularly for the poorest sections of the society.

*Table 2.7 Distribution of households by sanitation management method of sewage*

*Source: (Central Bureau of Statistics 2016)*

| | Underground drain | Open drain | Soak pit | No facilities | Total |
|---|---|---|---|---|---|
| **Urban/Rural** | | | | | |
| Urban | 18.9 | 16.1 | 15.2 | 49.8 | 100.0 |
| Rural | 2.0 | 8.9 | 5.6 | 83.5 | 100.0 |
| **Consumption Quintiles** | | | | | |
| First Quintile (Poorest) | 0.2 | 8.5 | 4.4 | 86.9 | 100.0 |
| Second Quintile | 0.9 | 7.4 | 5.5 | 86.1 | 100.0 |
| Third Quintile | 1.9 | 8.8 | 6.1 | 83.2 | 100.0 |
| Fourth Quintile | 4.1 | 13.7 | 9.5 | 72.8 | 100.0 |
| Fifth Quintile (Richest) | 23.7 | 15.5 | 15.1 | 45.8 | 100.0 |
| **Nepal** | **7.6** | **11.3** | **8.8** | **72.3** | **100.0** |

### *2.4.2. Wastewater treatment and faecal sludge management in Kathmandu*

Presently there is only one large scale WWTP in the whole of Kathmandu that is partially operational, which treats less than 5% of the total wastewater generated (HPCIDBC 2011). Apart from a small trial FS treatment plant set up by a Nepalese public health organisation (ENPHO 2017) in Lubhu which was established to manage FS generated by emergency toilets during the response to the earthquake in 2015 (ENPHO 2016), there are no other FS disposal and treatment sites in the Kathmandu Valley; however this small plant only treats 9m³ of sludge per week. A previous treatment facility was operated by KMC in Teku between 1998 and 2004, but due to operational and technical problems, the facility has remained out of service since this time (HPCIDBC 2011). Therefore, all mechanically collected FS is disposed of illegally into sewers or drains, which ultimately ends up in the rivers (ibid.). The lack of WWTPs and FSM is highlighted as one of the main sources of pollution of the Bagmati river, and therefore establishment of additional WWTPs and FSM systems are identified as some of the main activities to improve the river water quality in the Bagmati Action Plan (HPCIDBC 2009). The lack of any formal FSM system could impact on the approach that any CBS business would adopt; this lack of any existing FS treatment facility would mean that the treatment would need to be considered by the CBS organisation itself, as there are currently no other options.

With regard to the total population of the Kathmandu Valley who have access to toilets, approximately 74% of the population discharge wastewater from toilets directly into the sewer network, whilst 21% use septic tanks and 4% use pit latrines (HPCIDBC 2011). In terms of the type of sanitation facility used at household level, the majority utilise pour-flush systems as shown in Figure 2.15 below.

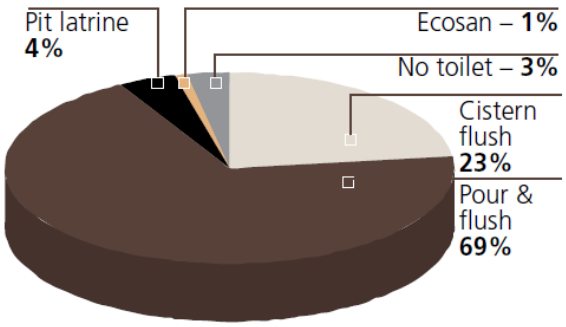


*Figure 2.15 Types of sanitation facilities in households of the Kathmandu Valley*
*Source: (HPCIDBC 2011)*

In April 2017, a Faecal Sludge Regulatory Framework for the cities of Nepal was approved by the MWSS. This document sets out the roles and responsibilities of different organisations for the effective management of FS, and also for the planning, execution and monitoring of FSM. This document also states that "provision of appropriate manpower and budget for the effective implementation and monitoring of FSM" is undertaken (MWSS 2017).

The realisation of this statement would have an effect on the potential viability of CBS, particularly if the sale of end-use products were not found to be an option. However, two key points on this subject mentioned in the same document state that:

- "Local levels can cooperate with Ministry or Department of Agriculture for the safe use and marketing of organic fertilisers produced by faecal sludge treatment system.
- Local bodies can collaborate with private sectors, NGOs', research organizations for reuse and marketing of organic fertilisers."
  (MWSS 2017, Section 4.5)

The references to the potential for reuse or sale of organic fertilisers produced from FS is a good indication to the level of support or cooperation that might be expected from institutions, as it aligns with the current policy and framework of the MWSS towards FSM going forwards.

### *2.4.3. Squatter settlements of the Kathmandu Valley*

Rural-urban migration has led to the rapid growth of squatter settlements in Kathmandu, driven by low socio-economic growth, a poor land administration system and inadequate capacity to deal with the housing needs (Shrestha 2013). A study conducted by Lumanti, a Nepalese support group for the provision of shelter (Lumanti 2017), in 2008 surveyed 45 settlements, 40 of which were classed as squatter settlements (Lumanti 2008). The 40 surveyed squatter settlements were generally located along the river banks of the Bagmati, Bishnumati, Hanumante, Dhobikhola and Tukucha rivers, and are shown in Appendix K, Figure 8.1 (ibid.). Also included in the same appendix are tables detailing the population (see Table 8.1) and toilet provision (see Table 8.2) of the individual settlements. It can be seen that in 2008 there were a total of 12,726 people or 2,735 households living in the 40 settlements, an average of approx. 320 people or 68 households per settlement. Therefore, although the total number of residents

of the squatter settlements is reasonably high and continues to grow, the population of each individual settlement is actually fairly low.

The sanitation provision of the settlements in the report shows that 84% of the households studied have a household toilet. This percentage can be broken down into 17% using a pour-flush toilet, 19% using pit latrines and 48% using toilets that discharge straight to the river (ibid.). Of the remaining 16% of households who have no access to a toilet, 10.3% are stated as defecating on the river banks whilst the other 5.4% of households rely on using open space (ibid.). The relatively high level of toilet availability indicated in this survey might impact on the potential viability of CBS, as the potential for payment of a sanitation service would be an added expense to the already poor residents who don't currently pay for sanitation and who have access to an existing toilet. The level and quality of sanitation provision in the squatter settlements would need to be further assessed prior to the introduction of any potential CBS service.

The level of sanitation provision within the squatter communities was also assessed in 2012 by Mercy Corps who found that 100% of the residents that they interviewed had access to a toilet (Little 2012). This study was based on a total of 16 households in 4 different settlements, so the data set is very limited; however, the apparently high level of access to toilets concurs with the Lumanti study, and therefore needs to be considered and investigated in determining the viability of CBS from a purely business perspective.

Also included in the Lumanti study is data on the cooking fuel used by the residents of the settlements. The study shows that the main fuel used for cooking in the settlements is LPG, at 41% of households.

#### *2.4.4. EcoSan toilets*

Historically, the re-use of human excreta and organic waste as a fertiliser has been practiced by many communities in Nepal, although it's use is in decline due to the adoption of modern systems of sanitation and changes in livelihood and employment away from subsistence farming (WaterAid Nepal 2008). In Newari communities, the traditional inhabitants of the Kathmandu Valley, the concepts of 'Nauga' and 'Saaga' were utilised to create compost from waste and excreta for use in Agriculture (ibid.). Nauga, which means 'ash pit', is system whereby the area under the stairs on the ground floor is used to store ash from the kitchen along with urine and other agricultural residue, such as straw, to produce compost for use in the fields (ibid.). Saaga, which means 'compost pit', was an area next to the house where waste was composted and harvested every six months for use in the fields (ibid.). This historic use of human waste and compost for use as a fertiliser would bode well for the potential reuse of products created from the treatment of human waste collected by CBS. What is also encouraging is a historic practice of the Newaris whereby households sold their excreta to farmers in tins containing approximately

20l, indicating that the Newari people recognised that their waste not only had a value as a fertiliser, but also a monetary value (Nepali 1965).

The concept and various types of EcoSan was introduced in Nepal in 2002, and by the end of 2006, 517 EcoSan toilets had been constructed, most of which were located in the Kathmandu Valley (WaterAid Nepal 2008). There are two types of EcoSan toilets that have been introduced into Nepal; the Urine Diverting Wet Toilet (UDWT), also known as the Urine Diverting Pour Flush Toilet, and the Urine Diverting Dry Toilet (UDDT) (Adhikari 2015). There are various types of UDDT's that have been constructed such as double vault urine diversion (DVUD) toilets, two-vault solar EcoSan toilets and single vault moveable container toilets.

The moveable container type of toilets is particularly relevant as it incorporates a plastic container mounted on a metal frame below the squatting pan, which is replaced by an empty container when it has been filled with faeces (WaterAid Nepal 2008). The toilet itself is a moveable unit designed for indoor use with separate tanks for urine collection and anal cleansing water, and is ideal for households with limited available space. However, only very few of these toilets were ever produced, and are limited to the Siddhipur region (ibid.).

The main additive material used in EcoSan toilets in Nepal is ash (>90%), due to the high use of firewood or other burning materials for cooking, although rice husks (9%) and sawdust (<1%) are also used (ibid.). However, the use of LPG for cooking is increasing rapidly, so the availability of ash is therefore decreasing; the availability of an organic additive, or cover material, needs to be seriously considered as a factor when assessing the viability of any CBS service.

In their 2008 assessment of EcoSan in Nepal, WaterAid surveyed 440 families in order understand the perceptions of not only the users, but also of the neighbours and surrounding community. In general, the users provided positive feedback regarding the production of a free source of fertiliser. However, reservations were expressed about the process of carrying the urine and its smell, removal of the vault content, and also the consumption of vegetables grown through the use of human urine. The reaction of most neighbours was also positive towards the use of EcoSan (98%), with limited comments made on the odour and smell, particularly during the emptying process (ibid.).

#### *2.4.5. Public and mobile toilets*

In 2009, the press in Kathmandu published numerous articles on the rise of mobile public toilets in Nepal to supplement the limited number of static permanent public toilets available. Two toilets were identified by the UNDP as being used in Dhulikhel, at the Eastern edge of the Kathmandu Valley, one in the bus station and one for residents who did not have toilets in their homes (UNDP 2009). Another article describes the first mobile toilet set up in Kathmandu, servicing nearly 800 people daily at a cost of 3NPR (The Himalayan Times 2009). The unit contained separate 500l tanks for the collection and separation of urine and faeces, which were

subsequently taken to a KMC treatment facility. However, the article also describes the desire of the Kathmandu Solid Waste Management Service (KSWM) to recycle the waste into compost and to produce biogas, following the identification of a suitable site (ibid.). Another consideration made by KSWM was the proposed introduction of toilet paper use instead of water in an effort to reduce the quantity of water required for the facility to operate. At the time of writing, KSWM were planning to extend the service to 9 more locations within 10 months. LMC was also operating a mobile unit at Gwarko Chowk (to the east of Patan adjacent to the ring road in the district of Lalitpur) which was serving 600 people daily, with the collected waste being used to produce biogas (ibid.). The unit had been previously moved from Patan Durbar Square, the palace square of Patan in the district of Lalitpur, due to complaints received about the smell from the facility.

However, by 2011, the plans of KMC had not come to fruition, with only 3 portable toilets in operation rather than the 10 originally planned (Shahi 2011). The reasons cited by KMC included objections by local people and authorities, lack of available space and traffic congestion. Another reason may be the lack of a suitable treatment facility for the sludge, as the former solitary working facility in Teku became non-functioning in 2004 (HPCIDBC 2011). The lack of a treatment plant is cited by Shahi (2011) as a major problem in the operation of the mobile toilets; earlier plans by KMC to use a treatment plant had been thwarted by local protests against the establishment of a plant, and the closure of the existing earlier plant at Teku. At this time only 32 public toilets were operated in Kathmandu, many of which were in a dire state of repair due to lack of management and maintenance, which implies that a large market exists for new public toilets (Shahi 2011).

A more recent article describes plans by the current Mayor of Kathmandu to increase the number of public toilets from the 10 existing facilities managed by KMC to around 300 within the ring road area, to be constructed at 200-300m intervals across the city (The Kathmandu Post 2017). According to KMC, tendering for the works had already begun, with 30 million NPR allocated for the project (ibid.).

#### *2.4.6. Agriculture and employment*

In 2011, the percentage of agriculturally employed households with land living in Nepal was 73.9% (Central Bureau of Statistics 2011). This figure had fallen from 83.1% in 1996 and is expected to continue to fall due to changes in lifestyle and rural-urban migration. Even so, in 2011 over 56% of men and over 70% of women were employed in the agricultural sector, with the vast majority of these being self-employed (ibid.). Therefore, it would appear that the market for compost sales should be a healthy one. When you consider the figures for urban residents of the Kathmandu Valley however, the level of employment in agriculture falls to just 3.3%.

The commercial floriculture sector could be a potential market for compost produced through CBS, and previous studies by Loowatt (Mattens 2012) have shown generally higher acceptance

to the purchase of plants and flowers grown in human excreta derived compost than for fruit and vegetables. Additionally, the majority of the potential market customers are located in the three districts making up the Kathmandu Valley with over 61% of the 561 floriculture farms of Nepal located within this area (Central Bureau of Statistics 2014).

## 2.5. Key learning and identified knowledge gaps

When the average size of squatter settlement is considered in conjunction with the map of the settlements, shown in Figure 8.1 in Appendix K, it can be seen that the settlements themselves are relatively spread out across the city. This information could have a serious impact on the potential cost effectiveness of the collection and transportation element of any CBS service; the time taken for collections and the potential for a high density of customers will be affected by the geographical spread of the settlements, if these are to be the only envisaged customers of any proposed CBS service. Additionally, the ability and feasibility of servicing the settlements by a single FS treatment plant, may require the establishment of a number of transfer stations to minimise the operating costs, so areas for these would also need to be considered; however, as many of the settlements are within the urban area of the city, the availability of suitable land may be scarce, especially due to the intended purpose of the sites and the likely resistance from local residents to that land use as a result.

The level of LPG usage as a cooking fuel would indicate that there may be a significant market for gas produced as part of the treatment process of the waste collected from a CBS business; the cultural reaction to using such a fuel required further assessment during the research period spent in Nepal to ensure acceptability, and this should be further extended prior to any large-scale implementation.

The anal cleansing habits of the Nepalese is an area that requires further consideration prior to any potential CBS implementation, as this liquid needs to be contained, managed and kept separate from the faeces and the urine.

The historic use of fertiliser derived from human waste, and the recent successful implementation of EcoSan toilets, is a useful indicator into the potential market for any end-use products from a CBS service, but also into the cultural perspective on handling containers of urine or faeces, which have been issues in other CBS implementations.

The demand and desire for improved and proliferated public toilet coverage in Kathmandu exists; CBS may be a viable solution to help bridge the gap in public toilet provision, especially due to the lack of existing treatment facilities; the potential for recovering some of the operational costs through the resale of end-use products could also be a useful revenue stream for KMC due to the limited funds available, and the high capital cost of the whole public toilet expansion project.

Due to the relatively low levels of employment within the agricultural sector in the Kathmandu Valley compared to that of Nepal as a whole, in order to sell compost produced as an end-product of CBS either self-employed agricultural workers outside the urban area of the Kathmandu Valley would need to be targeted or other markets would need to be developed.

As mentioned in section 2.3.9 above, the success criteria and conditions for CBS to become a viable sanitation option are further expanded and explored through KII with existing CBS businesses to determine the past, present and future potential issues that have been encountered in their development. Once these factors were collated, further research was undertaken in Kathmandu to supplement the information attained from this literature review to determine the potential for CBS implementation in some form in a Nepalese context. This research attempts to determine the viability of CBS in the squatter settlements of Kathmandu, but also to assess other markets such as public toilets. Additionally, the research determines the potential for the sale and reuse of any end-use products created during the CBS treatment process (e.g. compost/fertiliser, biogas, etc.), as well as the extent to which any possible cultural barriers exist which may affect the viability of CBS.

# 3. Methodology

## *3.1. Introduction*

The research questions that this study aims to answer are given in section 1.9 above to address the research objectives which are given below:

1. Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work.
2. Investigate CBS services to determine and "distil" the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation.
3. Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any cultural barriers that may affect the successful implementation of a CBS service.
4. Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements of Kathmandu.
5. Establish criteria of the required conditions necessary for future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach.

The full scope of the research questions is also given in Appendix A - Research framework, which gives an overview of the method of research undertaken and also the target groups and key informants associated with satisfying each respective objective.

## *3.2. Methods of data collection*

In order to answer research questions 1 and 2, apart from undertaking a literature review of relevant material, semi-structured interviews were conducted with key informants and stakeholders with experience and knowledge of CBS. These interviews were utilised in order to supplement the information gained from the literature review, by gaining more in-depth details on how their specific, individual experiences of the development of CBS could be applied to other situations or contexts.

Questions 3 and 4 were answered following the establishment of answers to questions 1 and 2. Initial data on current sanitation arrangements collected from the literature review, was supplemented by semi-structured and unstructured interviews in Kathmandu with key informants and stakeholders. These interviews included obtaining data on the history and status of sanitation in the region as well as considering the potential of CBS in Kathmandu from the perspective of the key informants and stakeholders. Additionally, transect walks and observations within sample communities were undertaken to assess the physical conditions that are present, both from an existing sanitation perspective, but also to assess the impact of the physical characteristics of each settlement on the potential for any CBS implementation.

Resident questionnaire surveys and focus group discussions (FGDs) were also conducted to ascertain the opinions of the community towards the acceptability of CBS and to determine the impact level of any significant cultural, financial or infrastructural factors.

Question 5 was answered by a combination of the findings of the literature review, but also through semi-structured and unstructured interviews with key informants and stakeholders, to determine what constraints need to be satisfied in order for CBS to be implemented on a larger scale worldwide in a wider variety of different countries and contexts than those few within which the existing services are currently operating.

In summary, the research process was effectively undertaken in two stages; firstly, the key success factors were identified in an initial phase through a combination of the literature review and KIIs. A subsequent second phase was then undertaken to apply the knowledge and understanding gained from the first phase to a case study location for which Kathmandu was selected. The findings and data obtained from the case study were then used to populate a weighted scoring matrix which was developed from the findings of the first phase of the research, which can be found in Appendix G – CBS scoring matrix. The overall methodology is summarised below in Figure 3.1.

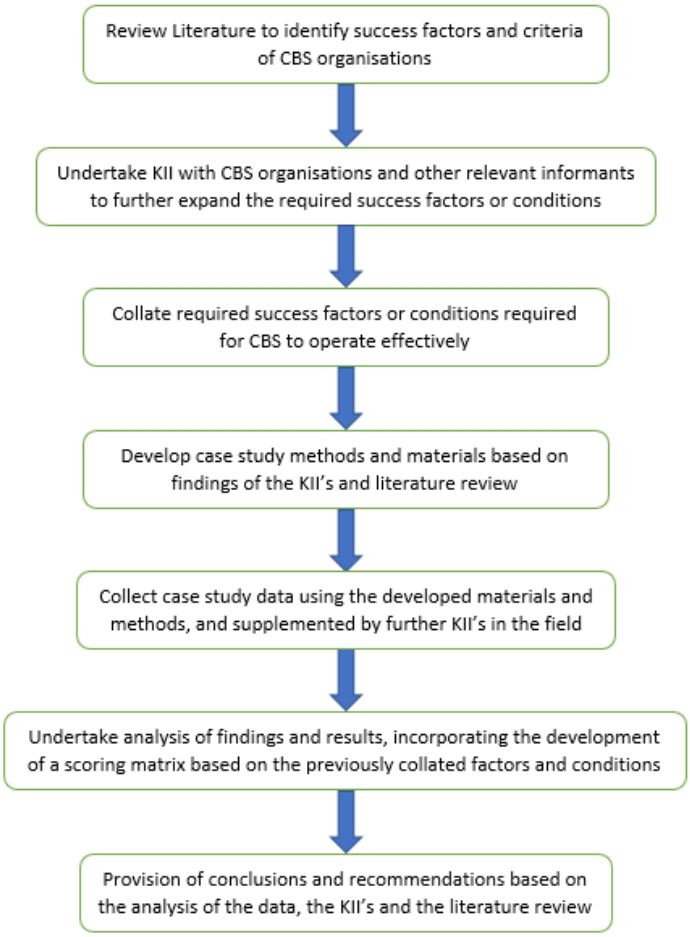


*Figure 3.1 Research Methodology overview*

## 3.3. Research philosophy

A mixed methods approach was adopted to undertake this research, due to the fact that the data sources identified fall into distinct categories, whilst also having different but clear-cut perspectives on the subject. The data obtained from the current CBS service providers is based on their actual experience of implementing CBS, and so a less structured approach was required, in order to allow the interviewee to elaborate on a wide range of issues, thus enabling the interviewer to obtain more in depth and specific qualitative data. This is compared to the data obtained from members of the communities in Kathmandu, whereby larger numbers of respondents were needed in order to determine the general opinions, statistical data on the current sanitation status and the potential acceptance or not of any CBS implementation.

A mixed methods approach and the different perspectives that this brings also allows for the opportunity to triangulate the data, corroborating the findings and enhancing the validity of the information (Denscombe 2014). The methods adopted for this research are given below, followed by the reasoning behind the specific requirement for each particular source, and an explanation of the data that was to be attained:

1. Semi-structured Key Informant Interviews
2. Unstructured Key Informant Interviews
3. Household/Individual Questionnaires
4. Focus Group Discussions
5. Transect Walks/Observations

### 3.3.1. Semi-structured key informant interviews

Semi-structured interviews were chosen as the best method of gaining more in-depth information from key informants that have been involved with establishing the current CBS services. The information gained during the literature review pertaining to CBS was limited, partly due to the youth of the technology, but also due to the type of information that is available within the publicly accessible material. Factual information was available in terms of subjects such as the processes undertaken by the various services to manage the SSC, the areas where the services operate, the end-use products that are produced and other related data. However, in order to understand the issues that the different CBS services had encountered during their development, a flexible method of obtaining data needed to be used which provided the interviewee with the freedom to elaborate on key topics, whilst still focusing on areas of interest to the interviewer; semi-structured interviews allowed for this level of freedom for the interviewee, whilst still allowing the interviewer the ability to direct the line of the questioning to meet the objectives of the interview and to elicit the exact required information. Therefore, as the interviewer needed to know more about the interviewees thoughts, experiences and knowledge of the development of the various services, semi structured interviews allowed the interviewee to develop ideas and speak more widely on the issues raised (Denscombe 2014).

The interviews were generally carried out over the internet due to the geographical spread of the interviewees. Following the literature review, a set of subject areas emerged that required further investigation that could not be satisfied by the literature itself. For each subject area, a list of possible unknowns and queries were developed in order to form the basis of the semi structured interviews. These unknowns and subject areas were collated into a single document (see Appendix B – CBS service provider semi-structured interview) that was provided to the interviewee prior to the interview actually taking place to allow them to understand the type of information that sought by the interviewer during the process.

The main subject areas that were identified as requiring further investigation are summarised below:

1. **Selection and details of the operational area** – This section attempted to understand why the operational area was originally chosen, what was it about the area that made it appear suitable for CBS implementation initially, what the initial level of sanitation infrastructure was prior to the introduction of CBS and whether any other factors (e.g. topography, housing density, socio-economic, geographical, geological, etc.) influenced the implementation or the initial decision to establish CBS in the first place.
2. **Initial conditions and sanitation practices in the operational area** – The questioning in this section was developed to understand what sanitation practices were used by the residents prior to the introduction of CBS, but also more importantly, whether any cultural traditions or community issues had emerged during the development of the implementation, that were not envisaged prior to the start of the service.
3. **Operating Methodology** – Much of the operating methodology information was gained during the literature review. However, gaps in the knowledge of the processes used by some of the service providers still remained following the literature review, for which questioning was devised in order to obtain a complete understanding.
4. **Toilet unit/hardware considerations** – This section posed questions aimed at providing further information about the actual toilet unit itself and its manufacturing, lifespan and installation details.
5. **Reuse of end products** – This section was discussed to consider the details of any end use products created and the level of revenues generated through their resale.
6. **Financial considerations** – This section attempted to delve in more detail into the method by which the service is paid for, how much is actually paid by customers, any issues surrounding payment and to what extent are the operating costs of the service are covered by the revenues generated.
7. **Willingness and ability to pay** – To determine the level to which the residents of the operational area were both willing to pay (WTP), but also had the required ability to pay (ATP) for the CBS service; additionally, whether there was a previous history of paying for sanitation services was established and at what level.

8. **Learning opportunities** – A key section of questioning, in order to establish any other issues of a historical or ongoing nature that affected the progress or implementation of the service, and to identify any knowledge that had been gained as a result of the development of the service that would affect how the organisation might implement a similar service in future.
9. **Other issues** – Identification of any other key documents or factors that may impact on the potential success of a CBS service in a different region or context.

Semi-structured interviews with the seven CBS service providers listed in Table 1.1 were carried out in the UK prior to visiting Kathmandu. The resulting information and data was utilised to develop the materials required to undertake the various research methods that were used for collecting data in Nepal; this ensured that adequate and sufficient data was obtained in Kathmandu which enabled definite conclusions to be reached.

Additional semi-structured interviews were conducted in Kathmandu with key informants from various institutions which were arranged through Sabitri Tripathi, of Nepal Engineering College (NEC), who has worked extensively in the city for many years. Sabitri therefore has widespread contacts across the city, but was also able to provide translation when required. The nature of the questioning of these individuals was more specific to their particular role and experience in order to ascertain their views on the potential for CBS implementation. Another goal of the semi-structured interviews undertaken in Kathmandu was to gain more insight into the current level of sanitation in the city. This was approached both from a historical perspective, to understand how the politics and institutional arrangements had affected the progress and implementation of the sanitation, but also how the plans for the sanitation of Kathmandu might affect the future provision of the city.

#### *3.3.2. Unstructured key informant interviews*

Unstructured interviews were also carried out with key informants who have been involved with CBS over many years, and who have extensive knowledge of the technology and its progress, albeit not through the specific involvement with any one particular organisation. These informants were able to provide a more impartial and general view of the whole sector, and were able to provide their own opinions on the potential success criteria and required conditions for CBS to operate, based on their experience with many different service providers and not just a single entity for whom they had worked. Unstructured interviews afforded these respondents the ability to talk from their involvement about issues that have in the past, and still do affect the whole CBS community. Respondents were also able to elaborate on their views on the future potential of CBS, and what major issues might exist that could prevent the proliferation of CBS to a global scale over the forthcoming years.

A number of unstructured interviews were also arranged in Kathmandu through Sabitri Tripathi. These interviews were generally with key informants who had a knowledge of the history and

status of the sanitation of the city and country of Nepal as a whole. During these interviews, the researcher gave an overview of CBS technology and described the operating methodology and business models of the current service providers, in order that the interviewee could understand the overall concept. Once this information was imparted, the interviewee was then able to give their opinion on the potential for CBS implementation in the context of Kathmandu and Nepal. This method of interview was particularly useful in allowing the interviewee the freedom and opportunity to explain in detail certain aspects of the sanitation of Kathmandu, and to provide explanations based on their own experience as to the potential of CBS in different circumstances or situations within Kathmandu. More importantly, the unstructured nature of the interviews allowed the interviewee the freedom to elaborate and expand much more on the actual motivations reinforcing their opinions on the potential for CBS in Kathmandu. Unstructured interviews also afforded interviewees the opportunity to explain the historical and contextual intricacies of the specific aspects of sanitation in the country and how these might impact on the potential success of any CBS implementation.

#### *3.3.3. Household/Individual questionnaires*

Following the establishment of key factors and criteria that might affect the potential of CBS implementation in any given context, a household questionnaire was developed for use as the primary method of data collection from the residents of the study communities, and an example of the questionnaire is given in Appendix C – Household questionnaire. The main purpose of the questionnaire was to determine the specifics of the current sanitation arrangements within the communities, and the extent of satisfaction with the facilities. Additionally, any potential cultural or physical barriers to the potential success of a CBS service or to any of the end-use products as well as details of the household characteristics and relevant socio-economic information was acquired.

The main subject areas covered by the questioning are summarised below:

1. **Identity Data** – Base data to establish the characteristics of the respondents.
2. **Household Characteristics** – Questioning designed to establish how the size and nature of the dwelling and its surroundings may affect the success of CBS.
3. **Socio-Economic Information** – This section probes into the health, wealth and status of the respondents in terms of employment/schooling, size of family, levels of illness and mobile phone/bank account usage in order to understand the potential WTP, options for the method of any payments and also to identify any patterns of health issues as a potential result of the existing sanitation facilities.
4. **Water, Sanitation Practices and Infrastructure** – The questioning of this section aimed to understand the level of drinking water provision, but also to determine what type of sanitation facilities were used by the respondents. Additionally, any cultural practices that are followed which may affect a CBS implementation were identified. This

section also endeavoured to establish whether a history of paying for sanitation services existed, and what level of willingness to pay (WTP) might be expected. The use of public toilets and general level of satisfaction with the currently used toilets was also queried, in order to obtain further clarity on the potential demand for an alternative sanitation service.

5. **Cultural Issues** – Based on information gained from the CBS interviews, the main cultural issues encountered by existing services, such as the potential acceptance of locating a CBS toilet within the home or handling containers of urine or faeces, were explored to determine their significance in the context of the study communities. As part of this process, the concept of CBS was explained more fully through the use of large colour pictures and diagrams illustrating the actual toilets themselves, but also the operating method through which the service is provided.
6. **End-use Products** – From issues experienced by the existing CBS services, questions relating to the potential level of acceptability of various end-use products derived from the different treatment methods of the human waste collected during the CBS process. Currently used fuel types and expenditure were also ascertained as part of this section.

The household questionnaire was developed in the UK, but was revised several times after arrival in Kathmandu, due to the actual conditions that were encountered in the communities after arriving in Nepal. For example, certain sections of the questionnaire were written dealing with the use of public toilets; however, on arrival in Kathmandu, it soon became apparent that the lack of public toilet facilities in the city meant that in reality, none of the residents ever used public toilets as a form of sanitation.

Overall 20 questionnaires were conducted in 4 different communities in Kathmandu with households selected at random and utilising the service of an interpreter to facilitate the process by translating the questions and corresponding answers.

#### *3.3.4. Focus group discussions*

Focus groups discussions (FGDs) were planned (see Appendix D – Focus group discussion) in order to supplement the data obtained from the household questionnaires, through a more interactive and open medium that allowed the respondents within a community to expand on their views and thoughts of the current sanitation arrangements within their community. As suggested by Laws et al. (2013), a FGD provides “in-depth information about how people think about an issue – their reasoning about why things are as they are, and why they hold the views that they do”. The FGD was also employed to obtain the residents’ thoughts and opinions on CBS and also to discuss their personal views and impressions on the potential for CBS within their community. Therefore, the questions were broken down into two sections; firstly, a conversation was encouraged into opinions on the current sanitation practices and then subsequently a discussion on the potential demand for and implementation of future sanitation

improvements, including CBS, was held. The FGD was designed to allow residents more flexibility to express their views and opinions than that afforded by the household questionnaires by encouraging conversation and discussion between the residents and to enable them to express their thoughts and opinions on a variety of relevant topics.

The FGD was written prior to visiting Nepal, based on the findings from the literature review and CBS interviews. However, the actual FGD plan was amended several times prior to its actual use, as it became apparent that some of the sections and question areas included in the original document, such as questions relating to the prevalence of public toilets, were not relevant in the context of the squatter communities of Kathmandu. Some content was also removed from the FGD discussion plan, as there was an overlap foreseen between the FGD and the household questionnaire on certain sensitive issues (e.g. anal cleansing methods, sitting or squatting preference when using the toilet, etc.), and these were deemed to be more suitable for a face-to-face interview rather than in a group context.

It was originally planned to complete a FGD in all the communities that were studied. However, after undertaking transect walks and household questionnaires in two of the four communities, it became apparent that there would be little to be gained from conducting FGDs there. In the third community, it was felt that a constructive FGD could not be held following the household questionnaires, due to high levels of suspicion and animosity experienced towards the translator and interviewer during the interviews. Therefore, it was decided that a FGD would not produce a constructive discussion on the questions of interest, and so a discussion in that community was not arranged. A FGD was successfully arranged and carried out with the assistance of Sabitri Tripathi, who also provided translation of the participants' responses; the FGD was attended by 6 residents, utilising a local school as the venue for the discussion.

#### *3.3.5. Transect walks/observations*

A transect walk record sheet was developed (see Appendix E – Transect walk record sheet) based on that of a previous World Bank report format (Ross et al. 2016), prior to conducting any questionnaires, interviews or FGDs in the communities, in order make and record an assessment of the current level of sanitation facilities within the communities. Transect walks were also used to assess the potential impact of physical aspects and characteristics of the communities that might affect the possibility of successful CBS implementation. During the transect walks, physical features of the communities were assessed to determine their potential impact on CBS implementation, such as the size, shape and housing density of the community. Additionally, factors such as the ease of access into the community for potential collection of CBS containers, plot sizes and availability of public space, as well as existing standards of sanitation were all assessed to ascertain their potential impact on a CBS service.

Transect walks were undertaken in each of the target communities to get an initial understanding of the permanence of the settlement in addition to the existing level of sanitation provision,

cleanliness and quality within the area. The squatter settlements of the Kathmandu Valley are generally located along the river banks of the Bagmati and its tributaries, and this was the case with all the target communities chosen for the study. Due to the riverside locations of the communities, the overall shape of the settlements tended to be of a linear nature. Therefore, the routes undertaken for the transect walks were generally in two passes parallel to the river to ensure that the entirety of each settlement was covered. A photographic record of each community was made during each transect walk, and the overall dimensions of the settlements were subsequently obtained using Google Maps.

## *3.4. Triangulation*

Triangulation of data is a concept whereby data from several different sources or methods of collection are used in order to obtain fuller data on a particular topic. The theory is that by seeing things from a different perspective, the opportunity afforded to corroborate the findings can enhance the validity of the data (Denscombe 2014). By collecting information in different ways, greater confidence in the trustworthiness of the research can also be attained (Laws et al. 2013).

The research undertaken into the current CBS models was undertaken through KIIs with the individual CBS organisations themselves. However, other practitioners from outside any one specific CBS business were also interviewed in order to obtain an overall view of the sector and to obtain a balanced understanding of the current performance and future prospects of the technology.

Likewise, whilst in Kathmandu besides the interviews, observations and FGDs undertaken within the communities, many other interviews were undertaken with NGOs, government/municipal officials, independent consultants and private business employees; each respondent was able to contribute from their own individual experience and perspective on the current status of sanitation and FSM, in both the context of the squatter settlements, but also in the city and the country as a whole. This variation from respondents led to a high level of triangulation and a more complete picture of the issues that exist.

## *3.5. Data collection*

The majority of the semi-structured interviews with CBS organisations were carried out over the internet during May 2017 prior to the field visit to Kathmandu in June 2017. Interviews conducted over the internet, and KIIs with English-speaking interviewees were recorded, either using bespoke recording software in the case of internet interviews, or through the use of a voice recorder for face-to-face interviews; this allowed for the interviews to progress more naturally and rapidly, and for the detail of the conversations to be documented for subsequent review and reference.

A diary is given in Appendix H – Research diary, which details the order in which the data collection activities were undertaken whilst in Kathmandu. Appendix I – CBS key informant

interview record gives an overall schedule of all the KIIs undertaken for the CBS specific elements of the project, while Appendix J – Kathmandu key informant interview record, provides a listing of the KIIs conducted in Nepal.

## 3.6. Ethical considerations

In order to conduct the research in a responsible and ethical manner three guiding principles, as described by Denscombe (2014), were followed throughout the data collection phase of the project:

Principle 1: The interest of the participants should be protected.

Principle 2: The researcher should avoid deception or misrepresentation.

Principle 3: Participants should give informed consent.

Prior to conducting any data collection, an Ethical Checklist was drafted and approved by Loughborough University Ethics Committee. Participant Information and an Informed Consent forms were created, which were subsequently provided to each respondent prior to conducting any interviews or questionnaires. If the interviews were carried out online, the Participant Information and an Informed Consent forms were provided in advance to allow the interviewee to read through them and either query or agree to them prior to the interview commencing. At the same time, the interviewee was made aware of the desire to audio record the interview for future transcription, and thus approval was also attained at the same time for recording to take place.

In the case of face-to-face interviews or questionnaires, the Participant Information and an Informed Consent forms were reviews with the respondent prior to the interview or questionnaire commencing. The forms were translated as necessary dependent upon the lingual ability of the respondents. During the household interviews and FGD, a female interpreter was present, due to the personal nature of the questions and discussion topics to ensure that female respondents were made as comfortable as possible in talking about any sensitive or personal subjects.

## 3.7. Limitations of research

The research based in the squatter communities of Kathmandu was focused on only 4 of the individual settlements. However, there are over 40 such settlements currently inhabited within the Kathmandu Valley and the sizes, circumstances, characteristics and longevity of each of the settlements varies widely depending upon a wide range of different factors. The number of questionnaires conducted in each of the study areas was limited due to time restrictions. The data obtained within any given community was quite consistent within each specific area, and so it was deemed that little additional information would be gained by undertaking a significantly larger quantity of questionnaires; the time required to complete such a survey would have been prohibitive in any case due to the limited availability of translation resources.

Originally it was proposed that FGDs would be undertaken in each of the target communities. However, in reality only one FGD was conducted during the research period. Two of the selected communities in which research was undertaken produced little evidence, if any, to indicate that CBS could be a potentially useful technology to the population. Of the remaining two communities, the level of resistance and suspicion towards the interpreter and researcher encountered in one of the settlements was such that it was deemed that a FGD would be a fruitless proposition in any attempt to hold a constructive discussion or conversation; the cause of the resistance encountered in the settlement was assumed to be due to the recent eviction of the residents from the settlement and thus a general suspicion of any perceived prying newcomers. During the one FGD that was successfully held, all participants were female, as the group was conducted during the day. Additionally, the level of contribution of the individual participants varied significantly within the group, with some of the younger group members having a much lower level of input than the older participants.

During the semi-structured interviews, a large volume of questions was developed for discussion (See Appendix B for full questionnaire), and depending upon the available time for the interview, not all the individual questions were fully answered by every interviewee. However, all sections of each questionnaire were covered to some degree, the extent to which was determined by the time available, to ensure that the key topics of interest were explored.

# 4. Results and analysis

Following the literature review, the research was broadly broken down into 2 stages. The first stage was undertaken to build on the information obtained from the literature review relating to CBS by conducting KIIs with individuals from relevant organisations and other professionals within the field in order to satisfy research objective 2. From this, the conditions required for CBS viability were obtained, which were then utilised to create the research materials and tools that could be applied to the case study areas in Kathmandu; this would form the second stage of the research and would meet research objective 4.

## *4.1. Determining the conditions required for CBS viability*

During the literature review, it became apparent that the different factors, characteristics and reasons for certain aspects of the operating methodology of the various CBS organisations could be grouped into clear categories, which were subsequently developed into the different subject areas for KIIs, as illustrated in Appendix B. The schedule of the CBS specific KIIs is provided in Appendix I, and the findings of these interviews provided the basis of section 4.1. The broad areas of discussion during the semi-structured KIIs are summarised below, as identified earlier in section 3.3.1:

1. **Selection and details of the operational area** – this section was to understand more fully why the area of operation was selected initially and what was it about the area that made CBS a potentially suitable solution, in addition to any other geographical, geological or socio-economics factors which influenced the decision to implement CBS.
2. **Initial conditions and sanitation practices in the operational area** – explored to understand the level of sanitation available within the area prior to the launch of CBS, to determine any cultural traditions or practices which affected the implementation and to ascertain the reaction of the community to the introduction of the CBS service.
3. **Operating methodology** – discussed to understand the different operating methodologies of the organisations, and the reasons for the variations in their approaches to the provision of a CBS service.
4. **Toilet hardware considerations** – a comparison of the various toilets utilised by CBS organisations, including details of the manufacturing and the specifics of the toilet units themselves.
5. **Reuse of end products** – clarification on the types of end products generated, the reasons for the choice of products and the financial implications of the end product creation and subsequent sale.
6. **Financial considerations** – a discussion of the financial aspects of the respective business models, and the potential for financial viability of the organisations.

7. **Willingness and ability to pay** – explored to understand the respective levels of WTP and ATP that were encountered in the operational areas, and the extent to which these were known prior to the introduction of CBS.
8. **Learning opportunities** - a final section of questioning to discuss further knowledge gained and issues encountered during the development of the CBS services.

#### *4.1.1. Selection and details of the operational area*

From the KIIs with CBS organisations, there were some recurring conditions that were found within the operational areas prior to the launch of the services. Every CBS KII reported that the areas within which they operate are very densely populated urban or peri-urban areas with very high levels of poverty. Levels of existing sanitation infrastructure and coverage are another common theme within the operational areas; low or non-existent sewer coverage exists in the areas served, leading to a reliance on other forms of sanitation such as public toilets or on-site sanitation (e.g. pit latrines, septic tanks, etc.). However, other factors often conspire against the potential success and functionality of the other available sanitation options. The high population density encountered in these areas can lead to a network of narrow passageways and alleys, precluding access for vacuum tankers to empty on-site sanitation facilities, thus necessitating the requirement for the manual desludging of pits and tanks.

A lack of open space was another common theme within the areas where CBS services are currently provided; this factor restricts the ability of the community to install adequate on-site sanitation facilities, or causes issues once existing pits become filled. The lack of space severely restricts the options available to residents in terms of their ability to provide some form of sanitation facility for themselves, as traditional forms of on-site sanitation require sufficient space for their installation (e.g. for a tank or a pit) which is difficult to attain in such densely populated areas.

In areas where residents were previously reliant on shared or public toilets, security, particularly at night and for women and children, was a significant factor in the consideration of an in-home or on-plot solution.

A more specific factor exhibited in certain areas was a high level of renting, particularly by SOIL, Sanergy, Clean Team and Sanivation. Due to the implicit nature of renting, residents were generally unwilling to invest in any form of sanitation infrastructure due to the unknown duration in occupation of their homes. A complex mix of renters, landlords and co-landlords experienced by Clean Team in Kumasi, whereby multiple landlords own properties in a single compound meant that establishing and maintaining shared facilities was problematic due to difficulties encountered in reaching agreement between the different stakeholders (Mikhael, KII, 26/5/17). Complex land tenure issues with multiple barriers to resolution were also identified by Oxfam as a consideration in the selection of CBS in Nairobi (McSorley, KII, 25/5/17). Another issue highlighted, also connected with the high level of renting, was the reluctance of many landlords

to provide and maintain adequate sanitation; for example, in Kumasi many tenants suffer from difficulties in getting compound pit latrines emptied by their landlords (Mikhael, KII, 26/5/17). Similar issues were also encountered by SOIL in Haiti where the compliance of landlords with their legal responsibility to provide a toilet was often not met (Kramer, KII, 22/5/17).

Water scarcity in Lima was a major factor considered by X-runner in their choice of CBS as a suitable sanitation solution, as the limited water availability, and thus its intrinsic value and high cost, meant that a waterless solution was key driver in the selection of CBS as a potential solution (Medem, KII, 10/7/17). The lack of a piped water supply in many of the areas was an indication that a sewered network would not become a reality at any point in the near future. Other factors which influenced X-runner in their decision to implement CBS specifically within their identified areas of operation was a general absence of any religious or cultural barriers, combined with an existing familiarity with the concept of using a cover material following defecation.

Key influences for Clean Team in selecting CBS were the high-density existing, privately run network of public toilets in Kumasi (Mikhael, KII, 26/5/17). 60% of low income families, and 40% of the whole city of Kumasi are reliant on the use of paid public toilets, and so the concept of regularly paying for sanitation was not envisaged to be a cultural barrier. Additionally, an institutional memory of the concept of nightsoil, only outlawed 20 years prior to the commencement of the service was thought to provide an initial familiarity with the concept of a container-based form of sanitation (Narracott, KII, 6/6/17). Another reason for the specific selection of Kumasi, was the existence of an official waste disposal facility, run by a cooperative waste management department, thus allowing Clean Team to complete the SSC in a straightforward manner (ibid.).

A reliance on on-site sanitation requires that whatever type of facility is utilised, the conditions within that context need to be favourable for the service to function effectively. However, in many cases, multiple factors were present which prevented the existing on-site sanitation facilities from functioning adequately. The presence of a high water table and a proneness to flooding were a recurring factor identified by most of the CBS organisations, as the land where the communities served reside is generally vacant or available for specific reasons. For example, many of the settlements are located along river banks or on river flood plains which are not generally chosen for permanent habitation due to the persistent threat of inundation. Under these conditions, the functionality of on-site sanitation is very limited, as pits and tanks fill rapidly, with groundwater or during flooding, and subsequently remain so due to the inherently low ground infiltration rates associated with such conditions. These circumstances lead to the requirement for increased frequency of emptying, which is not only costly, but also logistically challenging, as explained previously. Therefore, with no sewer network available, and very unfavourable conditions for on-site sanitation, residents are left with few other options for

sanitation other than open defecation or flying toilets. Due to the lack of alternative sanitation options, the development of CBS services emerged, owing to the ability of the system to provide an acceptable standard of sanitation in such challenging and restrictive conditions.

#### *4.1.2. Initial conditions and sanitation practices in the operational area*

The existing sanitation practices found within the operational areas of the CBS services generally consisted of a reliance on shared or compound pit latrines or public toilets. For example, in Port-Au-Prince household pit latrines provided coverage of approximately 30% of the population, with the remaining 70% either being reliant on public toilets or on the use of their neighbours' pit. A reliance on limited and often dysfunctional pits or public toilets was identified by Clean Team, Loowatt, Sanergy, Sanivation and X-runner. On the contrary, the practice adopted by the residents of the area in which Sanitation First operate was almost exclusively open defecation; no sanitation infrastructure existed, with the nearest available public toilets being a considerable distance away (Kirby-Garton, KII, 24/5/17).

The awareness of specific cultural traditions and practices, often unique to the areas of operation, became apparent during the development of many of the services. For example, in Kenya, Sanivation originally provided ash for use as a cover material, until they became aware that for one of the major tribes in the country, the practice of throwing of ash onto another person's faeces is used as a way of placing a curse on someone (Woods, KII, 22/5/17).

The actual act of defecating within the home was found to be a cultural barrier in certain areas. This was found to be particularly prevalent where the dwellings were limited to a single room. In such circumstances, Oxfam found that some customers tried to improvise by subdividing their room with a curtain, but generally few of their customers who had such limited space would keep the toilet in their home (McSorley, KII, 25/5/17). The experience of Sanivation is similar, whereby the high number of single room dwellings and very restricted outdoor space has severely impacted on the speed of uptake of their service (Woods, KII, 22/5/17). By contrast, the experience of Clean Team found that between 70-90% of their customers utilised a separate shower room to locate their toilet. The existence of separate shower rooms also facilitated in addressing another potential issue; 70% of Clean Teams customers are Muslim, and therefore prefer to wash to cleanse themselves anally. This can cause problems with a UDDT which needs to be dry by nature. Therefore, the availability of a shower within the room where the toilet was located allowed the users to wash after defecation without affecting the function of the toilet. This experience highlights the need to consider the anal cleansing practices within any community and the potential impacts that those practices may have on any CBS service.

An aversion to handling containers of excreta by some members of society was encountered by Clean Team in Kumasi, and Oxfam in Nairobi during their early stages of development. The concept of paying for a sanitation service, and also understanding the method of using the new technology were identified by SOIL as cultural barriers that required consideration. In connection

with this, a concern of all the service providers during their development was the local preference of either squatting or sitting to use the toilet; most CBS systems use a sitting posture, especially the in-home types which essentially consist of a portable unit that is simply placed on the ground. Therefore, if an in-home service is to be provided, the reaction of residents who normally squat to the prospect of sitting needs to be assessed.

Limited resistance from local groups or sections of society has been experienced by CBS organisations thus far to the introductions of their services. This may be due to the small scale at which most of the services are currently running, and therefore the size of the threat to existing pit emptier's or other potentially affected parties is low. However, Loowatt have experienced some resistance from local residents during the identification of potential sites to locate treatment facility (Roach, KII, 18/5/17). This is an issue that needs to be considered, particularly if existing treatment facilities with sufficient capacity do not exist, and if the area of operation has a high density residential population.

The experience of all the CBS services, in terms of the most receptive sections of the societies within which they work, indicate that women and children are far more interested and enthusiastic about the prospect of CBS. This was found especially in areas where a reliance was placed on the use of public toilets, and the inherent safety and security risks that exist for women and children as a result. However, elderly or disabled customers were also identified as very keen users, due to the increased convenience of having a toilet actually in the home, but also due to the ease of use of a sitting toilet compared to that of a squatting variety.

Certain political drivers and constraints have been encountered by some CBS organisations that have influenced the implementation or success of the services. This is especially true for Sanitation First, who had to design their whole collection process to comply with the Manual Scavenging Law in India, but also to prevent any association of the system with manual scavenging by the users, which is a massively sensitive issue in the country, and one which could have had serious implications on the level of adoption of the service.

Sanergy's work in Kenya has led to an acknowledgment within Kenyan national policy of CBS as an improved form of sanitation. This is a key achievement in terms of acceptance by the government, as it will provide CBS with increased credibility and thus should encourage other countries to consider the technology as a potential option for use in similar contexts. It is hoped that with this recognition by the Kenyan government, and the development of standard operating procedures in line with Sanitation Safety Plans (SSPs) currently being developed by WHO (SanCoP 2017), it can be shown that measures are in place to safeguard and mitigate against any risks, and thus promote the case for using CBS in other countries and regions.

These cultural aspects highlight the need to undertake thorough research in any potential area prior to the implementation of service to understand the intricacies and specifics that exist which

may impact on either the method of implementation or the potential appropriateness and success of the venture.

#### *4.1.3. Operating methodology*

The different characteristics of the individual operating methodologies of the CBS services have developed as a result of the conditions and contexts within which the organisations operate. The different methods adopted and the local conditions encountered all influence the cost-effectiveness and efficiency with which the service is provided, which is the key issue in creating a sustainable business.

The collection frequency of all the in-home services is either once or twice weekly. Obviously, if only one collection per week is offered, then this is more cost effective than if two are supplied; however, some of the services have experienced issues with odour when collections are made on a weekly basis. Sanergy provide daily collections for their FLTs due to the sheer quantity of waste deposited in their public toilets every day. Sanitation First collect their shared household toilet containers on a weekly basis also, albeit with a delay of 3 weeks as described previously in section 2.3.4.2.

Apart from Loowatt, CBS services use urine diverting systems. The collection of urine and faeces within one vessel by Loowatt does add to both the bulk and the weight of the collected material, but it prevents the users from having to deal with the emptying of a urine container, or having to find a location for the urine to drain to. Additionally, their membrane cartridge system also minimises odours without the need of a cover material, which reduces the bulk and weight of the collected material, so the net difference may not be significant. Sanergy, Sanivation and, in some cases Sanitation First, also collect and dispose of the urine. This process obviously has additional costs and risks (due to the liquid nature of the urine), but in certain areas disposal of the urine by the users, or to a soakaway/ground may not be a feasible or acceptable option.

The use of an organic cover material by most CBS services requires that, for whatever material is utilised, a sufficiently economic and sustainable supply of the material to meet the demand must exist. The issue of identifying a cheap and readily available material for use as a cover material was recognised by Laura Kwong during her research into the potential for CBS in Bangladesh. Difficulties in sourcing adequate quantities of sawdust, and the relatively high value and limited supply of ash proved to be a key factor in her final conclusion that the technology was unsuitable for use in the city of Khulna in Bangladesh (Kwong, KII, 31/1/17).

X-runner incorporate the use of biodegradable bags in their containers; this process was introduced to remove the requirement for users to exchange their entire container. This led to efficiencies in their processes, as the total number of containers required to operate the service was reduced, the capacity of the collection vehicles was increased and the requirement to clean

and sterilise the containers after each use was removed. The efficiency savings however are slightly offset by the additional cost of providing the biodegradable bags.

The various levels of housing density and topography encountered by the different CBS services affects the collection mechanism of many of the organisations. The often narrow, muddy or inaccessible lanes and alleyways within the communities prevents the access of large collection vehicles, and thus necessitates the use of a two-stage collection process. The initial collection from the customers generally utilises small vehicles such as hand carts or tuk-tuks, which can navigate restricted or tight passageways. Depending on the location of the final treatment plant, and the overall scale of the operation, a transfer station may be incorporated into the process from which larger vehicles can operate, and transport substantial quantities of containers to improve the overall efficiency of the operation.

X-runners' innovative approach using a "jingle" to notify residents of their arrival has enabled them to undertake their collections from the narrow alleyways without the need for a separate collection process or bespoke smaller vehicles to access the customers houses, as the customers carry their own containers to the collection vehicle. This method allows a single, large collection vehicle to be utilised for the entire collection process, which improves efficiency, whilst circumnavigating the access issues of the steep and narrow accesses.

Other issues encountered by the service providers include the identification and location of the customers' homes, as maps of the areas of operation generally don't exist, and the areas are in a constant state of change. The appearance of, and access to, homes in many of the settlements changes regularly leading to issues for collectors in recognising and finding their customers. The X-runner collection method avoids this problem, but the other organisations have needed to find solutions to this issue. SOIL use a system of GPS, photographs and identification panels on their client's properties in order to locate and pinpoint their customers.

The operating methodology of any CBS service needs to be developed to produce the most cost-effective system achievable. In order to do so, the collection frequency, method and process need to be optimised to account for the local geography and conditions encountered, and to ensure that the entire operation is as efficient as possible within the specific local circumstances and conditions.

#### *4.1.4. Toilet hardware considerations*

The development of the toilets used by the different CBS organisations has generally been undertaken in isolation. This has led to a duplication of the efforts required to produce their hardware due to a lack of sharing or pooling of knowledge gained from the individual developmental processes. With the creation of the CBS Alliance in 2016, the standardisation of product designs and parts, and closer collaboration between the organisations should lead to improved efficiencies for all the members of the Alliance.

Most of the organisations use relatively low-tech solutions for their hardware, which can be manufactured locally and from locally available materials. This approach generally provides a cost effective and sustainable source of hardware, and also provides a valuable source of employment within the host communities.

X-runner have differed in their approach to tackling the issue of toilet supply for use in their service, by opting to use an off-the-shelf product rather than developing their own bespoke model. By using an available existing product, X-runner have avoided the costs, time and teething troubles associated with the development of the toilets that the other organisations have experienced. However, the Separett toilets that X-runner use are manufactured in Sweden and have a significantly higher capital cost than the toilets used by any of the other organisations. The appearance and quality of the Separett toilet is, without doubt, very good but the increase in cost affects the potential sustainability and efficiency of the service. However, if a toilet of a similar standard could be produced as a result of pooling the resources and knowledge of the individual members of the CBS Alliance, then improvements could be achieved in terms of economies of scale in placing orders, but also in terms the quality of the facilities that the individual organisations are able to offer to their customers.

For any future implementations of CBS, the toilet hardware to be utilised needs to be considered both from a cost perspective, but also with respect to the potential for production within the host country. Producing in-country is potentially beneficial for financial, sustainability and social reasons; however, in order to do so, the skill base and raw materials required to produce the toilets in sufficient quantities need to be available in order that supply will be able to meet the potential demand.

#### *4.1.5. Reuse of end products*

With the exception of Clean Team, all of the CBS organisations produce end-use products, which are offered for sale in order to provide an additional source of revenue to support the businesses. The success of this element of the individual organisations appears to be variable; X-runner are still yet to find a reliable customer for their compost product, while Sanitation First recoup approximately 5% through their compost sales (Kirby-Garton, KII, 24/5/17). Loowatt's annual revenue for fertiliser is estimated at US$ 7,200, whilst for sales of energy the figure is estimated at US$500 (Gardiner et al. 2017), although it is not known how this figure translates into a percentage of their overall costs.

Sanivation have done research into the potential revenue from various different products created from faeces, and their findings identified fuel, specifically charcoal briquettes, as the most promising due to the size of the available market, but also the high margin and thus revenue associated with the product (Berner et al. 2017a). The treatment and reuse production aspect of Sanivation's operations currently has an estimated gross margin of +120% revenue

compared to the treatment costs and these figures are expected to improve with increased scale (Woods, KII, 22/5/17).

Sanergy are also starting to produce other products in addition to compost/fertiliser and biogas, which potentially generate higher revenues; their animal feed product utilises a colony Black Soldier Flies whose larvae consume the waste and subsequently form the input of the feed. The residue from the feed production process is then used to create fertiliser. The sale price of Sanergy's reuse products currently stand at approximately US$400/ton for their fertiliser while the animal feed retails at approximately US$900/ton; the production costs of the animal feed is however greater than that of the fertiliser so the overall margins for each product are comparable (Auerbach, KII, 7/6/17).

In order to select an end-use product with the highest potential for revenues and profit, the scale of the market for the different product options needs to be assessed within the target area. The potential for any cultural issues or resistance to the use of the products also needs to be investigated to ensure that origin of the product (i.e. human waste) does not impact on the uptake of the products by consumers. The treatment costs and the potential sale price should be calculated and compared, and these results then considered in conjunction with the potential market size to determine the most financially beneficial choice of product, and thus generate the greatest margin.

#### *4.1.6. Financial considerations*

The financial aspects of the CBS services are currently a major consideration of all the organisations in their attempts to drive efficiencies and make their operational processes lean in order develop business models that are as efficient and sustainable as possible. There are many aspects which affect the financial performance of the organisations, all of which need to be addressed in order to create the most efficient, effective and economical mechanism for delivery of the service within their individual contexts.

In order to collect user fees cost-effectively, a reliance on door-to-door collections should be avoided in preference to other forms of payment such as Mobile Money where possible. This principle was reiterated during every KII held with CBS organisations. Collection from individual households is a time consuming and inefficient process, compounded by many issues such as customers being away at the time of collection, or difficulties in identifying or locating customer properties. The move to Mobile Money is seen as a key step in improving the financial performance of Clean Team (Mikhael, KII, 26/5/17).

The cost of the toilet hardware needs to be as low as possible, as generally the toilet is provided free at the commencement of the service provision, and this cost is therefore difficult to recoup. From the KIIs, the organisations that procure and manufacture their hardware within the country of operation from locally available materials, generally have much lower costs incurred by the

provision of the actual toilets themselves. However, through cooperation, knowledge sharing and increased group purchasing power, the CAPEX costs to the sector as a whole should be reduced following the work of the CBS Alliance.

From the CBS KIIs, all the organisations expect that their financial performance will improve over time; the reasons for the anticipated improvements are generally associated with the economies of scale that are created from an increase in both the number and density of customers, enhanced purchasing power and advances in efficiency. The densification of the customer base is a crucial factor in ensuring that the collection and transport phases of the service are as economical and thus sustainable as possible in order to minimise the time, and therefore the cost, associated with each individual collection. For example, the current monthly cost to Sanivation to provide their CBS service stands at US$10 per household, based on their existing customer base of 100 households. However, Sanivation's calculations show that with an increase in the number of customers to 500, the cost to Sanivation per household drops to US$4.50 a month, and is therefore a very significant saving. Densification of customers is also a current objective of Clean Team in their efforts to drive efficiencies, combined with the reduction in the number of collections from 2 to 1 per week, and also through the transfer of their customers to the use of Mobile Money (Mikhael, KII, 26/5/17). In order to develop a CBS service that is as efficient as possible, the distances travelled are crucial; this not only includes the distance from the community served to the treatment or disposal site, but more importantly, the distance between customers (Schaub-Jones 2005).

The focus and emphasis placed on efficiency and costs by the CBS services is due to the fact that all the organisations currently rely on some form of subsidy or grant in order to operate, as the revenues generated from the user fees and sale of end-use products do not cover the costs associated with providing the service. Therefore, all the organisations are constantly refining and tweaking their operating procedures and processes to continually improve their financial performance in an attempt to develop a stand-alone, sustainable model that can provide the service without the need for the support of a grant or subsidy. Whether this goal is achievable is unknown at this stage and will only become apparent once sufficient scale is realised, and more indicative costs are ascertained.

#### *4.1.7. Willingness and ability to pay*

The willingness to pay (WTP) for a new sanitation service is very much influenced by whether a history of paying for sanitation existed in the operational area prior to the introduction of a CBS service. This was found by both Clean Team and Sanergy, who were both able to promote the uptake of their toilets based on a pricing structure developed using the cost that families were previously spending on the use of paid public toilets prior to the introduction of the service. By setting their price point at a monthly fee less than the cost that an average family would spend using public toilets, the service is attractive to customers as a means of actually saving money.

SOIL found that the absence of an existing culture of paying for a sanitation service was a significant barrier encountered during the establishment and development of their service (Kramer, KII, 22/5/17). During the establishment of the service, a WTP survey was undertaken (Russel et al. 2015) to try to ascertain the levels of WTP and ATP and to establish how the potential charges for the service should be set.

Sanitation First's approach to this topic differs from the other CBS organisations as they specifically target the very poorest sections of the society by offering a free-at-the-point-of-use service. The ATP of their users is assumed to be negligible and thus the corresponding levels of WTP and ATP are not considered as part of their business model.

If a CBS service to be introduced is planned to be operated as a sustainable and cost-effective business, the WTP and ATP of the potential customer base needs to be ascertained. As has been highlighted by the experiences of Sanergy and Clean Team, a history of paying for sanitation in the area is a helpful indicator, as the possible barrier of the acceptance to payment is significantly reduced. If the business model is based on a more philanthropic or humanitarian approach however, whereby the users themselves are not charged to use the service as is the case with Sanitation First, then obviously the WTP and ATP of the members of the community is much less relevant.

#### *4.1.8. Learning opportunities*

Many of the learning opportunities suggested during KIIs with CBS organisations were to implement changes to their services to overcome many of the issues raised in the previous sections. For example, issues relating to the level of familiarity with the concept of actually putting a monetary value on a sanitation service and the costs incurred from the development of their own hardware due to a lack in the availability of an existing suitable product. Reduction in the cost of collecting payment and optimisation of logistics were also cited as ongoing issues by some of the organisations.

The X-runner model originally included an installation fee at first for the supply of the toilet unit. However, during the development of the service it was realised that the fee was a disincentive to new customers, and was therefore removed. If the fee had never been enforced it is thought that the organisation would have reached a critical mass of customers far sooner in the development of the service (Medem, KII, 10/7/17).

The availability of sufficient quantities of a suitably cost-effective cover material is another factor that needs to be considered at an early stage, especially if the service is expected to reach a large scale; therefore, the future extent of the service needs to be estimated so that the potential requirement for the demand of material can be assessed.

The initial establishment of the service standard and price by SOIL has affected their ongoing performance due to the level of the original charge and collection schedule; the difficulty and

potential for loss of business resulting from a reduction in the frequency of collection or an increase in the price after the service has been introduced is not comparable to the ease with which the reverse could be implemented if the initial charge was subsequently deemed to be too high (Kramer, KII, 22/5/17). Therefore, it is preferable to launch the service with an initially higher price or lower service, and then to subsequently reduce the cost or increase the collection regularity until a suitable and sustainable balance is achieved.

A further consideration in establishing the potential of an area for CBS implementation is to assess the extent to which cooperation of the existing utilities or municipality could be expected. The existence of an enabling environment could very much facilitate the introduction of a CBS service through measures such as the provision of a tax holiday, the contribution of sufficient land suitable for establishing a treatment plant or cooperation and assistance with the collection of sanitation tariffs (Mikhael, KII, 26/5/17). Measures such as these can help significantly, particularly in the early stages of establishment when revenues are at their lowest.

#### *4.1.9. Summary*

In order to ascertain whether conducive conditions exist within any area for a viable CBS service to be established, the factors identified above need to be considered for each case. This process should be undertaken in order to determine whether or how any factors may potentially impact on the success or operating methodology of the proposed service.

The physical characteristics of the communities need to be assessed to determine their impact on the operating methodology of the service. Likewise, research should be undertaken to identify the existence of any cultural practices or barriers that may affect the uptake of the service. The operating methodology needs to be implemented in an efficient as possible manner, utilising the most cost-effective hardware available. The market for reuse products should be analysed to compare the potential revenues and acceptability of the available options. The ease of obtaining payment should be assessed through factors such as levels of mobile phone ownership or bank account usage. If the service is to be paid for by the users, the levels of WTP and ATP need to be ascertained to determine the financial contribution that user fees would make to the overall business model. The extent to which an enabling environment exists, including the anticipated level of assistance or hindrance that might be received from existing utilities or government departments should also be established if possible.

Following the identification of the factors above, materials were developed to determine the extent to which they are present in the case study areas of Kathmandu. A transect walk record sheet (see Appendix E) was produced to assess and record the nature of the physical characteristics of the communities. A household questionnaire (see Appendix C) was developed to identify any potential cultural barriers to CBS, assess the existing sanitation practices, determine the WTP and ATP of the communities and also to gauge the reaction of the community to the use of products derived from human waste. A FGD guidance structure (see

Appendix D) was created to aid discussions on the existing sanitation practices and facilities, and to consider the potential for improved sanitation, incorporating aspects of CBS services.

Initially, the researcher planned to develop a decision-making framework to be used to determine the potential viability of CBS in any given area. However, after conducting research into the factors affecting the success, it was decided that the interaction and quantity of inputs and variables was too numerous, complex and interrelated to be able to generate a simple "yes" or "no" answer. Therefore, based on the findings of the research, a weighted scoring matrix (see Appendix G) was developed in order to create a tool that could be used to provide a means of assessing and recording the viability of CBS within an area by considering all the different affects, and weighting them according to their relative importance in the specific context.

## 4.2. Case study – Kathmandu, Nepal

### 4.2.1. Identification of case study areas

Four case study squatter settlements were selected which differed in terms of their size, duration of occupation, permanence of structures and their existing individual circumstances. The reason for selecting several settlements with different characteristics was to identify how the specific conditions found in each individual community impacted on the potential viability of CBS, and thus ascertain whether CBS was more suited to certain communities.

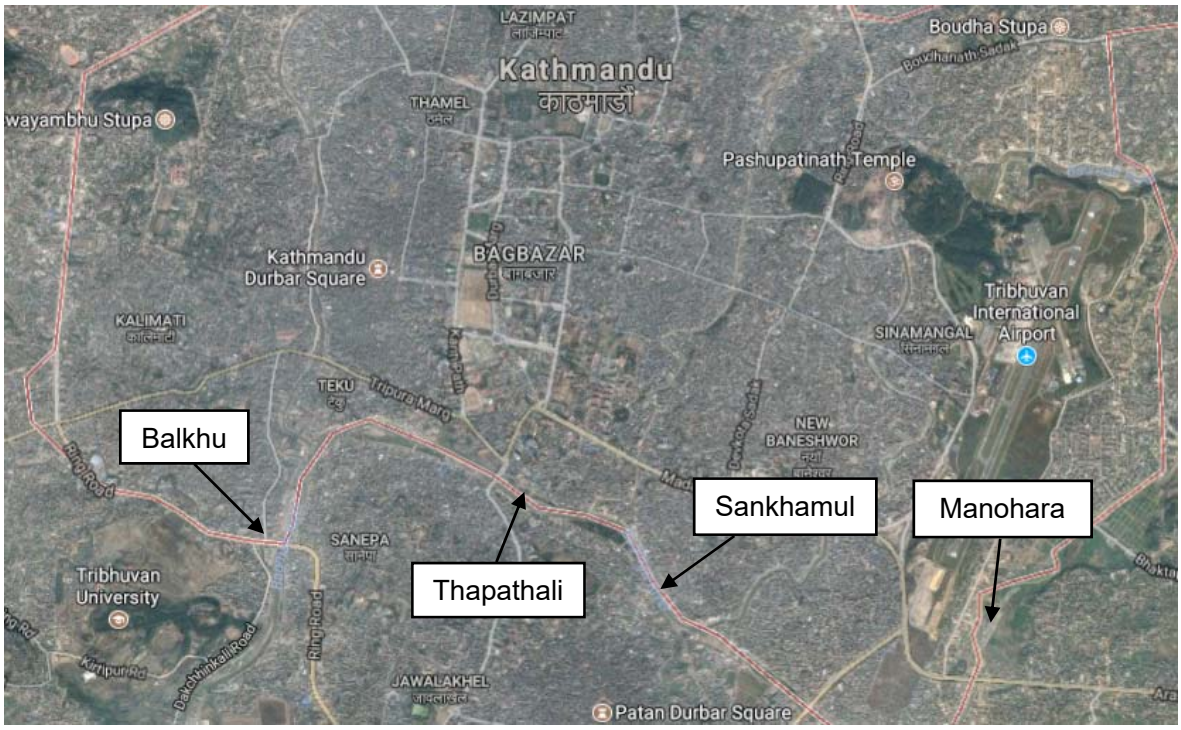


*Figure 4.1 Squatter settlement locations*

*Source: (Google 2017)*

The large number and relatively small size of communities (see Table 8.1), combined with their wide geographical spread (see Figure 8.1) could significantly affect the efficiency of any CBS collection service due to the anticipated length of journey times, and limited market available

within each community. The locations of the four selected squatter settlements relative to each other and the city of Kathmandu as a whole are shown above in Figure 4.1.

#### *4.2.1.1. Manohara*

Manohara was selected as a case study area as it is the largest individual squatter settlement in Kathmandu, with approximately 2500 residents in 2008 (Lumanti 2008), and therefore is home to approximately 20% of all the squatters in the city; however the size of the settlement has grown since the Lumanti survey was undertaken in 2008.

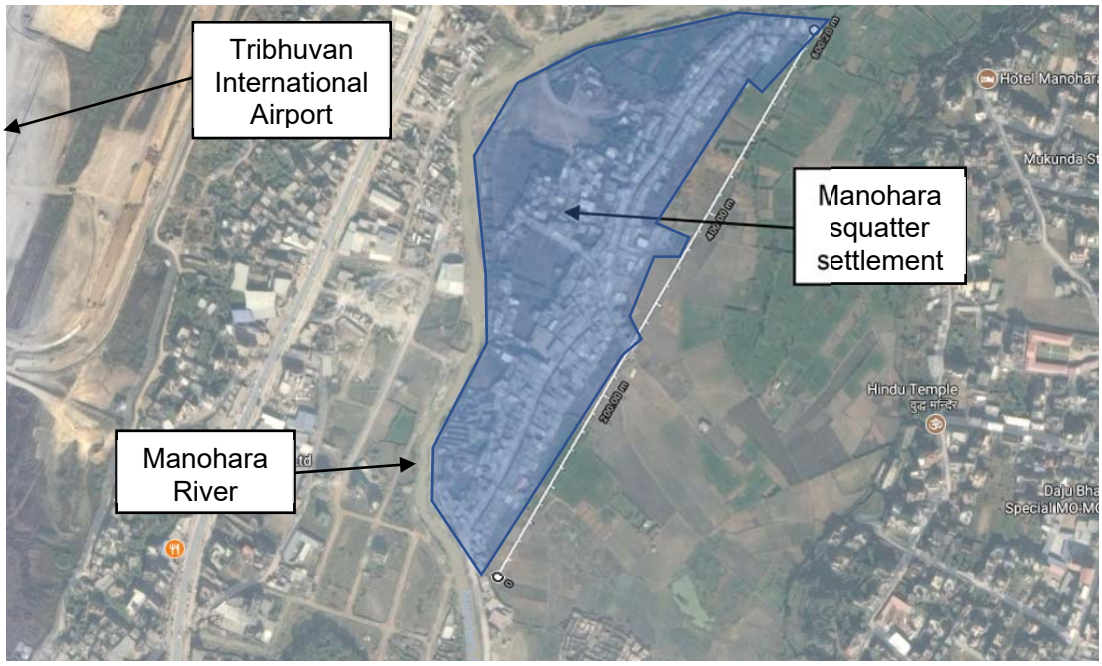


*Figure 4.2 Manohara Location*

*Source: (Google 2017)*

The settlement is located on the eastern bank of the Manohara River, adjacent to the south-east corner of the main runway of Tribhuvan International airport, in the Madhyapur Thimi municipality to the east of Kathmandu city itself. The overall size of the settlement is approximately 600m long by 130m at its widest point; the plan and location of the settlement is shown in Figure 4.2. The settlement was established as a result of the Maoist insurgency between 1996 and 2006, whereby land was provided to citizens who had fled the violence of the conflict (Joshi, KII, 19/06/17); therefore, although the residents do not actually possess formal land titles, they are permitted to remain in their homes, and are not currently in danger of eviction, which is not the case for all the settlements within the city.

#### *4.2.1.2. Sankhamul*

Sankhamul is a medium sized settlement located on the eastern bank of the Bagmati river in the south of Kathmandu, with a population of approximately 500 (Lumanti 2008) in 2008, although this had increased to approximately 1000 by 2017 (Joshi, KII, 19/06/17). The settlement was selected as a case study area as the community is one of the oldest and most established in the city. Good links exist between the community and organisations such as

Lumanti and the municipality as there is an active community organisation run by the community leader, Moti Lama, and therefore provides the community with a strong voice. The settlement is approximately 400m long by 50m wide and is shown in Figure 4.3 below.

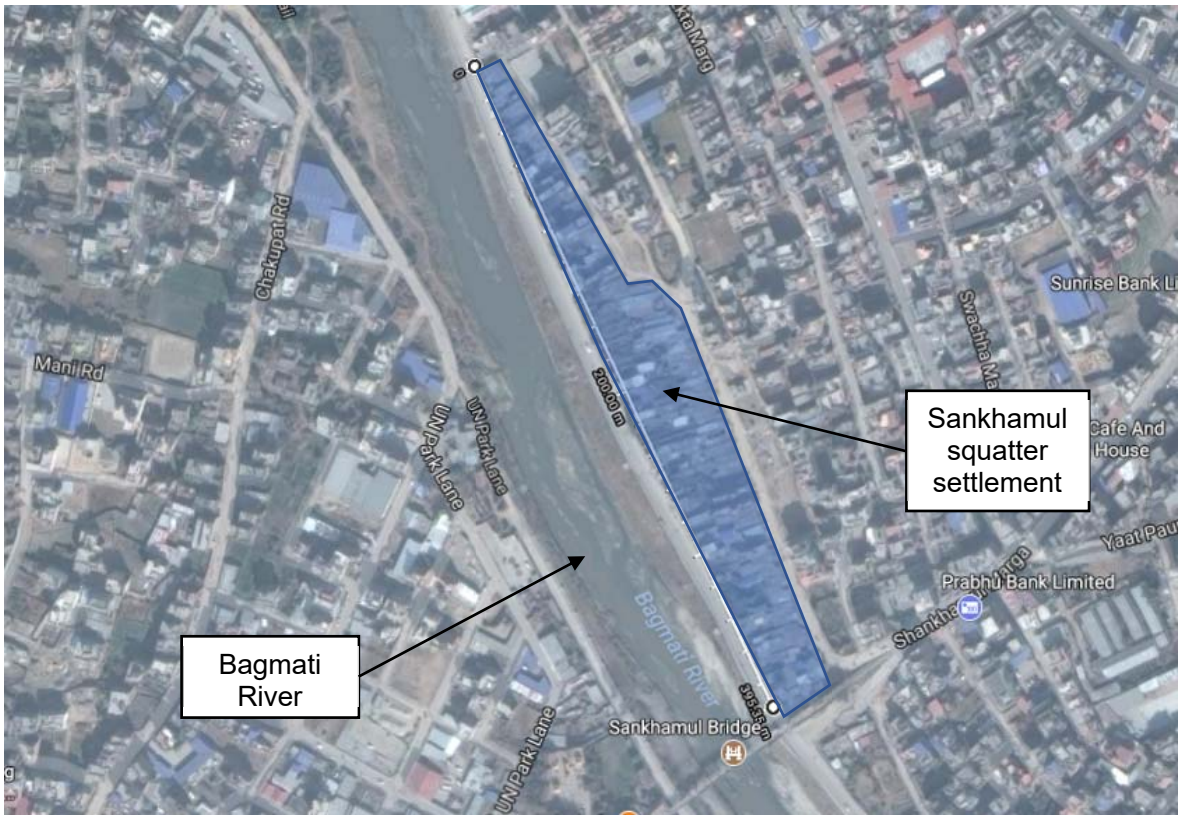


*Figure 4.3 Sankhamul settlement location*

*Source: (Google 2017)*

#### *4.2.1.3. Balkhu*

Balkhu is a relatively recent community, and as such was not included within the 2008 survey undertaken by Lumanti. The settlement is located on the western bank of the Bagmati river to the west of Patan, just inside the ring road in the district of Kuleshwor; the main Tribhuvan University campus is located just to the south of the area.

The main reason that the community was selected as one of the case study areas is because Balkhu is at the downstream end of the current project to improve the river corridors within the city and to install new sewer trunk mains along the banks of the rivers. Being located at the downstream end of the project means that the diameter of the pipes being installed as part of the project are at their largest in this location, and so the impact of the construction works is having a significant and very disruptive effect on the lives of the residents in the community. New wash walls along the banks of the river are also being constructed as part of the project, so the community is effectively enveloped along both sides by large scale construction works, which are therefore having a significant impact on the lives and sanitation of the residents in a very disruptive way. The settlement is approximately 430m long and 50m wide as shown below in Figure 4.4.

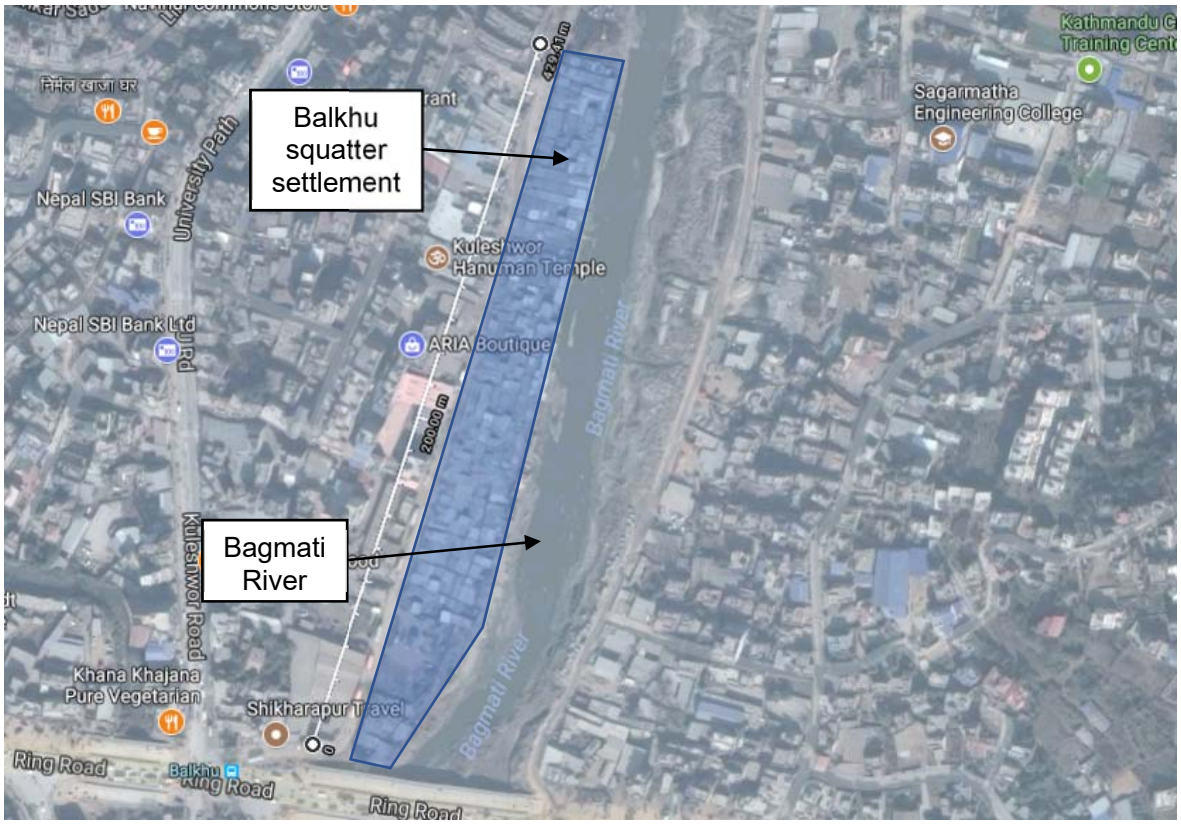


*Figure 4.4 Balkhu settlement location*

*Source: (Google 2017)*

#### *4.2.1.4. Thapathali*

Thapathali is also a relatively young community which is located in a central location on the northern bank of the Bagmati river in Kathmandu city, immediately adjacent to the main bridge crossing between Kathmandu and Patan; therefore, the settlement is situated in a high-profile location in terms of visibility which is shown below in Figure 4.5.

Due to its relatively recent establishment and central location, all 260 homes in the settlement were demolished in 2012 (Manandhar 2014) in a bid to evict the residents so that the government could implement its plans to improve and beautify the river corridor, and construct the new river wash walls and sewer trunk mains. However, do to a lack of alternative accommodation, the residents remained in the razed settlement and gradually started to reconstruct temporary homes. Therefore, this settlement was selected as a case study area, as the living conditions and general standard of accommodation within this community is much lower than those found within other squatter communities located in the city. The settlement is approximately 550m long by 40m wide and is therefore relatively narrow.


*Figure 4.5 Thapathali settlement location*

*Source: (Google 2017)*

### *4.2.2. Transect walks*

At the outset, a transect walk was undertaken in each of the four case study areas in order to make an initial assessment of the physical characteristics of the communities. A transect walk record sheet was developed as shown in Appendix E, in which the settlements were assessed according to various categories of relevant factors. These factors were scored for each settlement; a score of 1 shown in dark green was given for minimal or zero impact of the factor in question, ranging up to a score of 5 shown in red, whereby impact of the factor was assessed as being highly significant. The intermediate factor gradings of 2, 3 and 4 were colour coded in light green, yellow and orange respectively so that once completed, the summary of each of the transect walk records would provide a clear and visual indication of the sanitation status of each settlement. In this way, a settlement with a largely green transect walk record would be deemed to have a higher standard of sanitation than one in which the record showed a greater tendency towards orange and red gradings. This can be seen by comparing the result summaries of the various communities shown in tables 4.1, 4.2, 4.3 and 4.4 below.

#### *4.2.2.1. Manohara*

Manohara is the largest squatter settlement in Kathmandu with a population of approximately 2500 residents. The settlement is well established with numerous shops, a school and a church with widespread agricultural activities in evidence. There is good access from the Araniko Highway to the south and the main road through the community is wide but unsurfaced (See Figure 4.6). The buildings and homes are generally constructed of bricks/blocks or corrugated metal sheeting (See Figure 4.7). The settlement is linear in shape being located on a flat area of land adjacent to the Manohara River.

*Figure 4.6 Main access road through Manohara*

*Source: (R Dewhurst 2017)*

*Figure 4.7 Typical toilet structure (externally and internally) in Manohara*

*Source: (R Dewhurst 2017)*

The findings from the transect walk are summarised in Table 4.1 below.

*Table 4.1 Manohara transect walk results*

| Category | Observations |
|---|---|
| 1. Evidence of human faecal materials through open defecation | No visible evidence of human faeces through open defecation is seen. |
| 2. Evidence of human faecal materials through dumped faecal material | No visible evidence of dumped faecal sludge is seen. |
| 3. Access to water points | No piped water supply to households, but water is available from public standposts, vendors, private wells or boreholes. |
| 4. Coverage of household toilets (individual, or shared with known families) | More than 80% of households have access to a household toilet. |
| 5. Maintenance and cleanliness of household toilets | Most (more than 50%) appear to be well maintained. |
| 6. Maintenance and cleanliness of public sanitation facilities | There are no public facilities present. |
| 7. Housing and public space arrangement | Well organised community, with permanent and/or semi-permanent properties, but restricted access for public service vehicles and public spaces, including some open spaces. |
| 8. Paths - Routes wide enough for pedestrians and possibly motorbikes | Very narrow paths that can be used by pedestrians only (too narrow for motorbikes). |
| 9. Roads - Routes wide enough for vehicles (cars, 3-wheelers, donkey carts, etc.) | Gravel or paved roads, wide enough to allow two cars to pass. |
| 10. Dwelling and individual plot sizes | Dwellings generally larger than single room, with sufficient available outdoor space for expansion or for on-plot toilet construction. |
| 11. Drainage (storm water and greywater). | Limited drainage infrastructure, with signs of storm water and/or greywater having overflowed recently close to homes or water points. |
| 12. Sewerage (blackwater) | No evidence of blackwater or signs of leakage and/or blockages. |
| 13. Evidence of solid wastes | An adequate number of waste bins or enclosures are provided, with no overflow evident. |
| 14. Evidence of animal faecal materials | Animal faeces are seen one or two times, but in places away from the population. |

#### *4.2.2.2. Sankhamul*

Sankhamul is a very well established, densely populated settlement with an approximate population of 1000 residents, incorporating numerous businesses (e.g. a carwash, metalworker,

etc.), as well as a small school. There is good access from main roads along both the northern and southern boundaries of the settlement. The buildings and homes are generally constructed from bricks/blocks and corrugated metal sheeting (see Figure 4.8 and Figure 4.9 below).

*Figure 4.8 A view over the Sankhamul community*

*Source: (R Dewhurst 2017)*

*Figure 4.9 Typical household toilet in Sankhamul*

*Source: (R Dewhurst 2017)*

The settlement is linear in shape being located on a flat area of land to the north of the Bagmati River. The findings from the transect walk are summarised in Table 4.2 below.

*Table 4.2 Sankhamul transect walk results*

| Category | Observations |
|---|---|
| 1. Evidence of human faecal materials through open defecation | No visible evidence of human faeces through open defecation is seen. |
| 2. Evidence of human faecal materials through dumped faecal material | No visible evidence of dumped faecal sludge is seen. |
| 3. Access to water points | Some piped water supply to households, or boreholes. Other water is available from public standposts or vendors. |
| 4. Coverage of household toilets (individual, or shared with known families) | More than 80% of households have access to a household toilet. |
| 5. Maintenance and cleanliness of household toilets | They are in various conditions of maintenance and cleanliness. |
| 6. Maintenance and cleanliness of public sanitation facilities | There are no public facilities present. |
| 7. Housing and public space arrangement | Well organised community, with permanent and/or semi-permanent properties, but restricted access for public service vehicles and public spaces, including some open spaces. |
| 8. Paths - Routes wide enough for pedestrians and possibly motorbikes | Very narrow paths that can be used by pedestrians only (too narrow for motorbikes). |
| 9. Roads - Routes wide enough for vehicles (cars, 3-wheelers, donkey carts, etc.) | Well maintained gravel or paved road, wide enough for two cars to pass. |
| 10. Dwelling and individual plot sizes | Dwellings generally larger than single room, with existing access to household toilet. |
| 11. Drainage (storm water and greywater). | Limited drainage infrastructure, but with no signs of having overflowed close to homes or water points. |
| 12. Sewerage (blackwater) | No evidence of blackwater or signs of leakage and/or blockages. |
| 13. Evidence of solid wastes | Piles of solid waste are accumulating in one or two sites, but away from where people live and work. |
| 14. Evidence of animal faecal materials | Possible evidence of animal faeces is seen, mixed with solid waste. |

#### *4.2.2.3. Balkhu*

Balkhu is a less well established, densely populated settlement of approximately 250 dwellings, with several small shops as well as a small school and Buddhist worship centre. Access from the main ring road to the south is very poor due to the presence of ongoing construction works (see Figure 4.10 and Figure 4.11). The construction works are also impacting on the sanitation of the community with evidence of toilet discharge pipes having been excavated during the works on both the river and access road sides of the settlement, as shown in Figure 4.13 below. The buildings and homes are generally constructed from bricks/blocks, corrugated metal and plastic sheeting. The only communal toilets are a group of 6 pour-flush toilets constructed from corrugated metal sheet, and located on the northern access road of the settlement, as shown in Figure 4.12 below.

*Figure 4.10 Access to Balkhu from the ring road*

*Source: (R Dewhurst 2017)*

*Figure 4.11 Main access road to north of Balkhu*

*Source: (R Dewhurst 2017)*

The settlement is linear in shape being located on a flat area of land to the west of the Bagmati River.

*Figure 4.12 Communal toilets in Balkhu*

*Source: (R Dewhurst 2017)*

*Figure 4.13 Excavated toilet discharge pipes and standing blackwater in excavations*

*Source: (R Dewhurst 2017)*

The findings from the transect walk are summarised in Table 4.3 below.

*Table 4.3 Balkhu transect walk results*

| Category | Observations |
|---|---|
| 1. Evidence of human faecal materials through open defecation | No visible evidence of human faeces through open defecation is seen. |
| 2. Evidence of human faecal materials through dumped faecal material | No visible evidence of dumped faecal sludge is seen. |
| 3. Access to water points | Some piped water supply to households, or boreholes. Other water is available from public standposts or vendors. |
| 4. Coverage of household toilets (individual, or shared with known families) | Between 40% to 60% of households have access to a household toilet. |
| 5. Maintenance and cleanliness of household toilets | Most (more than 50%) appear to be poorly maintained. |
| 6. Maintenance and cleanliness of public sanitation facilities | There are no public facilities present. |
| 7. Housing and public space arrangement | Reasonably well organised community, with semi-permanent and/or temporary properties, limited access for public service vehicles and only a few clearly defined public spaces. |
| 8. Paths - Routes wide enough for pedestrians and possibly motorbikes | Poorly maintained dirt paths wide enough for motorbikes. |
| 9. Roads - Routes wide enough for vehicles (cars, 3-wheelers, donkey carts, etc.) | Unsurfaced roads wide enough for cars to pass. |
| 10. Dwelling and individual plot sizes | Dwellings generally larger than single room, but with limited or no available outdoor space for expansion or for on-plot toilet construction. |
| 11. Drainage (storm water and greywater). | Limited or no drainage infrastructure. Standing storm water and/or greywater is visible on the ground, close to homes or water points. |
| 12. Sewerage (blackwater) | Broken sewer pipes close to homes or water points, with signs of having overflowed recently. |
| 13. Evidence of solid wastes | Piles of solid waste are accumulating in three or more sites, close to where people live and work, but are not obstructing drainage or irrigation channels. |
| 14. Evidence of animal faecal materials | Visible evidence of animal faeces is seen, limited to a few locations. |

#### *4.2.2.4. Thapathali*

Thapathali is a very much less established, medium-density populated settlement of approximately 150 dwellings, with a single small shop and also a small school. Access from the main road to the north is good, although access within the community itself is poor due to a lack of formal access roads. Current construction works are impacting on the available space within the community although they do not appear to be affecting the sanitation facilities of the community. The buildings and homes are generally constructed from bamboo frames, with plywood, plastic and corrugated metal sheeting walls and roofs (see Figure 4.14). Some recently constructed toilet facilities provided by a Korean organisation were identified which have been connected to septic tanks (see Figure 4.15). The settlement is linear in shape being located on a flat area of land to the north of the Bagmati River.

*Figure 4.14 Typical dwelling construction in Thapathali*

*Source: (R Dewhurst 2017)*

*Figure 4.15 Original and recently constructed (Korean) sanitation facilities in Thapathali*

*Source: (R Dewhurst 2017)*

The findings from the transect walk are summarised in Table 4.4 below.

*Table 4.4 Thapathali transect walk results*

| Category | Observations |
|---|---|
| 1. Evidence of human faecal materials through open defecation | No visible evidence of human faeces through open defecation is seen. |
| 2. Evidence of human faecal materials through dumped faecal material | No visible evidence of dumped faecal sludge is seen. |
| 3. Access to water points | No piped water supply to households, but water is available from public standposts, vendors, private wells or boreholes. |
| 4. Coverage of household toilets (individual, or shared with known families) | Between 60% to 80% of households have access to a household toilet. |
| 5. Maintenance and cleanliness of household toilets | Most (more than 50%) appear to be poorly maintained. |
| 6. Maintenance and cleanliness of public sanitation facilities | There are no public facilities present. |
| 7. Housing and public space arrangement | Less well organised community, with mostly temporary housing, limited access for public service vehicles and very few clearly defined public spaces. |
| 8. Paths - Routes wide enough for pedestrians and possibly motorbikes | Poorly maintained dirt paths wide enough for motorbikes. |
| 9. Roads - Routes wide enough for vehicles (cars, 3-wheelers, donkey carts, etc.) | Unsurfaced roads, wide enough for small carts or 3-wheeler, but not for car access. |
| 10. Dwelling and individual plot sizes | Dwellings generally larger than single room, with sufficient available outdoor space for expansion or for on-plot toilet construction. |
| 11. Drainage (storm water and greywater). | Limited drainage infrastructure, with signs of storm water and/or greywater having overflowed recently close to homes or water points. |
| 12. Sewerage (blackwater) | No evidence of blackwater or signs of leakage and/or blockages. |
| 13. Evidence of solid wastes | Piles of solid waste are accumulating in one or two sites, but away from where people live and work. |
| 14. Evidence of animal faecal materials | Animal faeces are seen one or two times, but in places away from the population. |

#### *4.2.2.5. Analysis of transect walk results*

As can be seen from the results above, the conditions encountered within the different communities are highly variable. However what is particularly striking is the stark contrast in the conditions found in the more established communities of Manohara and Sankhamul compared to those found in Balkhu and Thapathali; this is evident from the tables above which show that for the more established communities there is a tendency towards green and yellow, whereas for the newer communities the emphasis is more towards yellow, amber and red, indicating generally lower levels of access, sanitation, cleanliness and available space in these areas.

Common to all areas was a general lack of evidence of open defecation and dumping of faecal waste. Limited access to tanked water exists, and levels of solid waste and animal faecal waste persist to some extent in all communities. The communities are all linear in shape which could lead to increased collection times for any CBS service. Housing density is generally high, so the potential for a dense customer base exists, provided that high levels of adoption of any CBS service were experienced.

In all the settlements studied, the size of the dwellings was larger than a single room; this factor would have a positive impact on the acceptability of locating a CBS toilet actually within the home. The level of available outdoor space for on-plot toilet construction was low in all settlements, except for Thapathali. This is less of an issue in the more established communities as a higher level of sanitation facilities already exists. However, in Balkhu the lack of outdoor available space and inadequate sanitation facilities would require that any CBS toilet would need to be located within the home.

Evidence of greywater and blackwater in the communities was low, although Balkhu had significant issues with blackwater due to the ongoing construction works, with many instances of broken or excavated sewer or toilet discharge pipes identified.

The standards, cleanliness and prevalence of existing sanitation facilities in the more established communities was far higher than for the more recent settlements. However, apart from the newly constructed toilets in Thapathali, the general sanitation provision within Balkhu and Thapathali was low; the situation in Balkhu was exacerbated due to the impact of the current construction works on the functionality and access to the facilities. The general standard of sanitation facilities in Manohara and Sankhamul would impact the potential WTP for a sanitation service as their facilities are reasonably widespread and clean. The level, quality and cleanliness of sanitation facilities in Balkhu and Thapathali would be more conducive to an increased WTP amongst residents; the lack of adequate facilities would provide an incentive for residents to pay in order to receive an improved level of sanitation.

The ease of access into the communities varies significantly, with the older, more established areas having much improved roads and paths compared to the less well organised more recent

settlements. This could impact on the efficiency of any CBS service especially given that the general level of sanitation facilities within the newer settlements seems to be lower, and thus the potential demand for improved sanitation in these communities would be greater.

### *4.2.3. Structured household questionnaires*

A total of 20 household questionnaires were conducted within the four case study communities studied with the data from the investigation being included within Appendix F. The content of the questionnaires was subdivided into six separate sections and the findings of each section of the survey is summarised below.

#### *4.2.3.1. Identity of respondents*

The selection of the residents chosen to taken part in the questionnaire was undertaken at random in order to get a cross-section of responses from within the communities. This can be seen from the spread of age ranges and genders of the respondents as illustrated in Figure 4.16 and Figure 4.17 below.

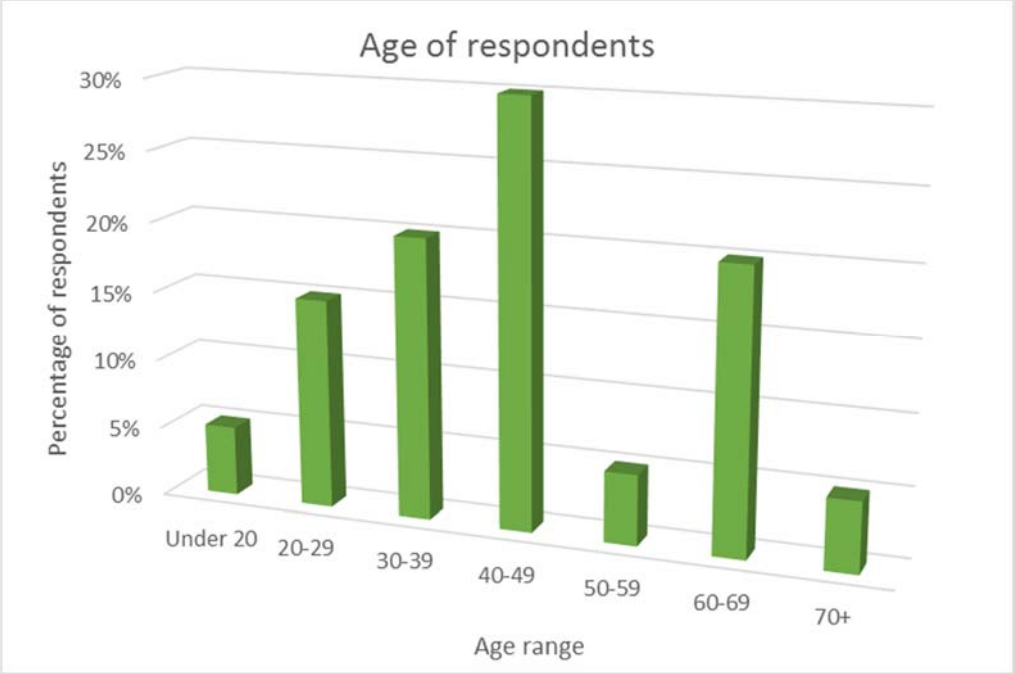


*Figure 4.16 Age ranges of participants in the household questionnaire survey*

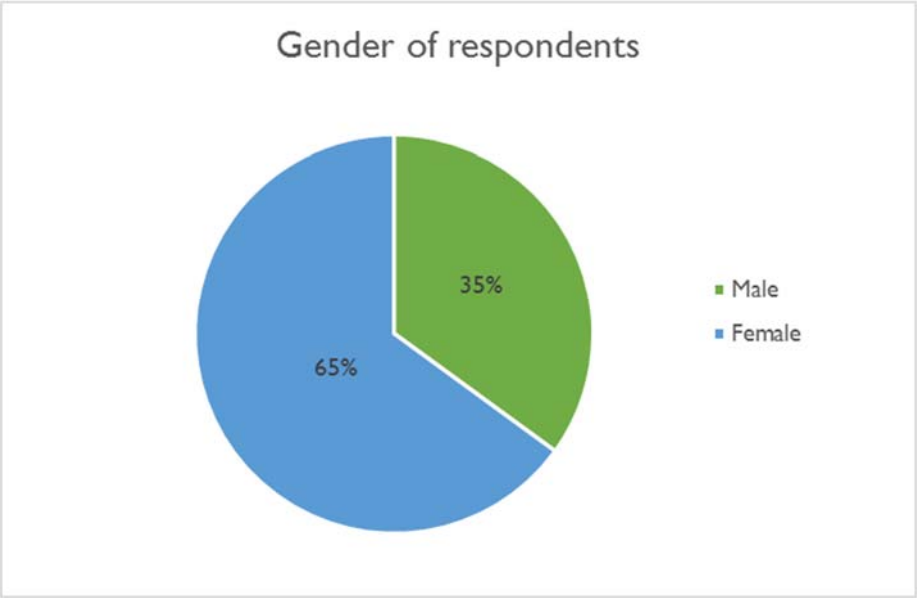


*Figure 4.17 Gender split of participants in the household questionnaire survey*

The religious beliefs of the respondents generally aligns with the make-up of the Nepalese population as a whole, although the percentage of Christians is higher than the national average figure of approximately 1.5% (Central Bureau of Statistics 2012). The breakdown of the religious beliefs of the respondents is illustrated in Figure 4.18 below.

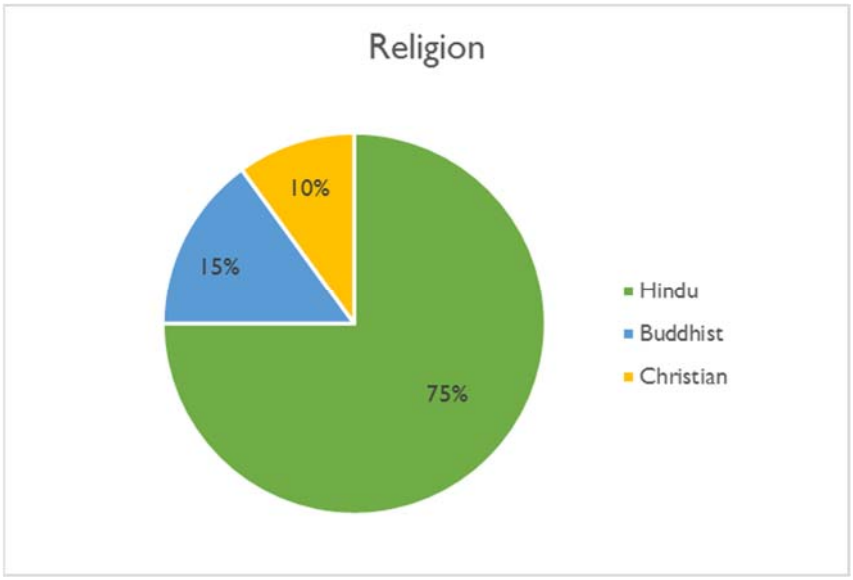


*Figure 4.18 Religious groups of participants in the household questionnaire survey*

#### *4.2.3.2. Household characteristics*

The number of rooms per dwelling was ascertained, and an average figure of 3.25 rooms per house was calculated; the statistical data is represented Figure 4.19 below. The general size of the dwellings should be a good indicator into the potential ability for CBS toilets to be located actually inside the homes. If the number of single or two-room dwellings within the communities was higher, then difficulties in obtaining sufficient space and also adequate levels of privacy would result, leading to a significantly lower uptake of any potential CBS service.

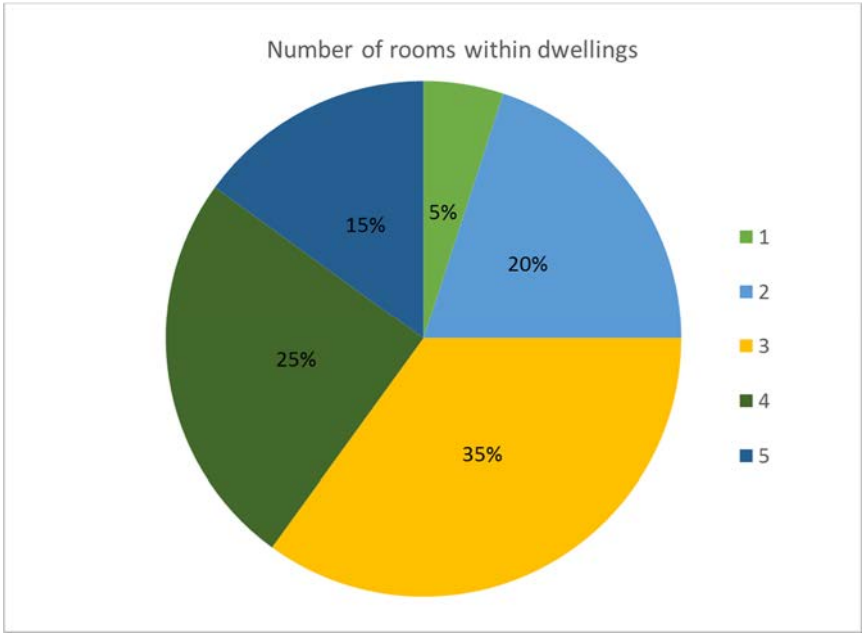


*Figure 4.19 Number of rooms within dwellings of participants of household questionnaires*

The tenure status of all the participants except for one, was that of a squatter living in their own home, and as such no rent was being paid. The extent of squatting taking place within the communities would suggest that the likelihood of any type of formal sanitation facilities being provided by government departments is very low, and therefore the communities will remain dependent on on-site sanitation long into the future. With this in mind, the potential longevity of any CBS market within the squatter communities would be considerable.

The statistics obtained for the settlements on the proneness to flooding and the presence of a high water table are conclusive for both factors due to the river bank location of all the communities. The prevalence of flooding and high water tables indicate that on-site forms of sanitation (e.g. pit latrines, septic tanks, etc.) are not suitable options in these settings; pit latrines would have a tendency to fill up quickly due to low infiltration rates, and would become sources of pollution during periods of flooding. A similar problem would exist with septic tanks, as they would become inundated during flooding, causing significant health and pollution risks.

The differences in construction materials used in the houses of the communities varies significantly depending upon how established the settlement is and the length of time that the residents have been living there. An overview of the construction materials used for the dwellings of the questionnaire participants is shown in Figure 4.20. below.

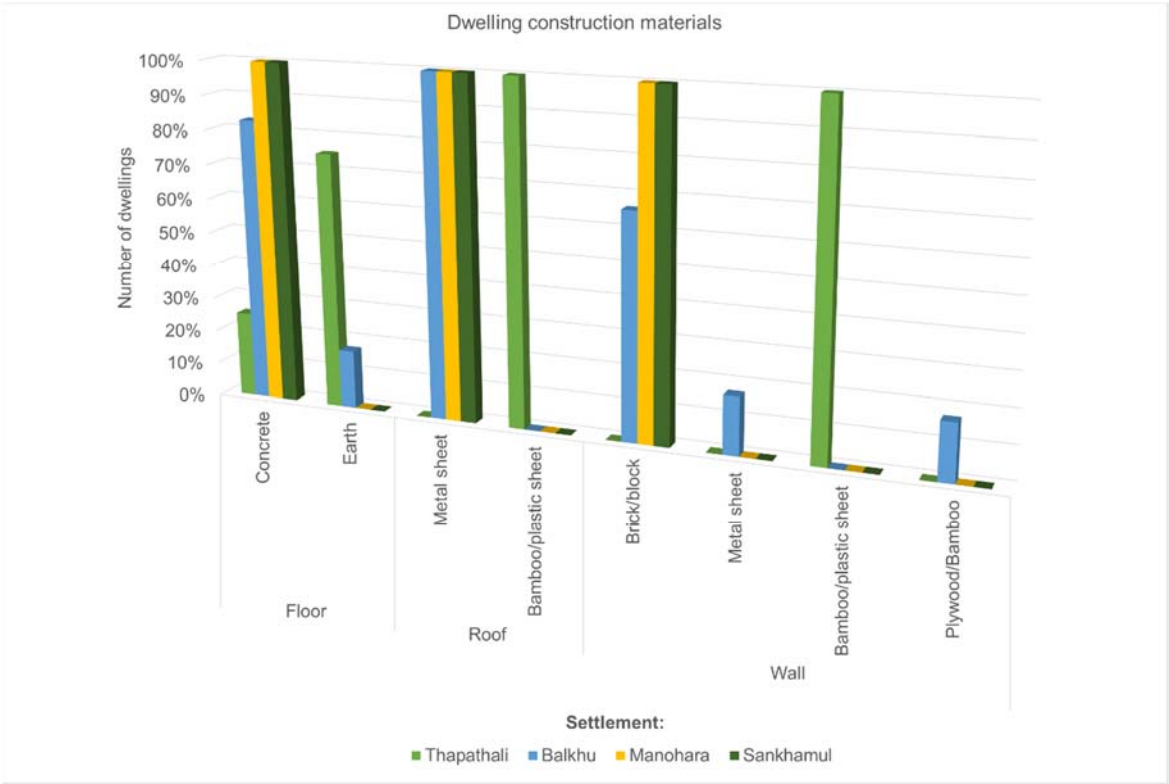


*Figure 4.20 Dwelling construction materials and methods within individual settlements*

The buildings in the two more established communities of Manohara and Sankhamul were generally of a more permanent nature; two of the residents of Sankhamul reported having lived in the community for over 30 years, with an average residency of 11 years and 18 years in Manohara and Sankhamul respectively. The buildings located in Thapathali and Balkhu are of a much more temporary nature. The reason for the much lower quality of construction, evident in Thapathali, is due to the recent eviction and demolition of the community in 2012, despite the relatively long occupation of many of the residents. This has led to a very low standard of accommodation within the community, with the majority of dwellings consisting of an earth floor and a bamboo superstructure clad with tarpaulin or plastic sheeting. The accommodation in Balkhu is of a better standard than that found in Thapathali, but is not as high as that of the buildings in Manohara and Sankhamul. Balkhu is a newer settlement than the others studied, with an average length of residency of only 8 years, and as a consequence the permanence and build quality of the houses is significantly lower.

#### *4.2.3.3. Socio-economic characteristics*

The size of the households in terms of total number of residents per dwelling in the survey areas varied significantly, from just a single dweller, up to 11 inhabitants in one house, with no real pattern in the data as illustrated in Figure 4.21 below.

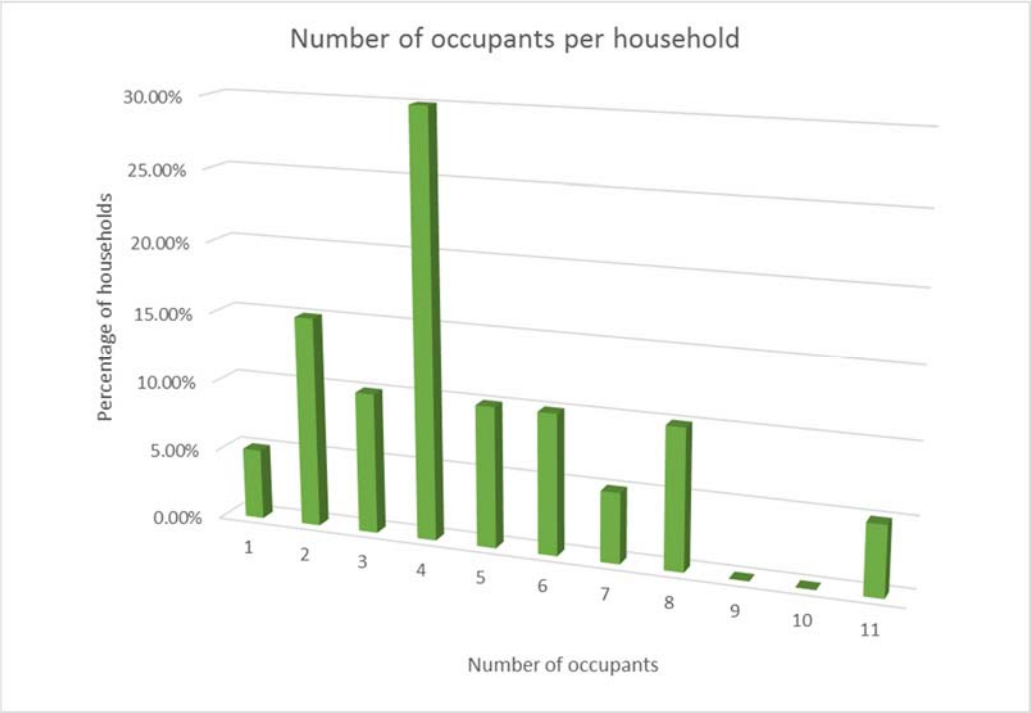


*Figure 4.21 Number of occupants per household*

The average household size for each community was reasonably consistent as shown in Figure 4.22 below with an overall average size of household of 4.65 found within the study areas. The average household size found during the study would be conducive to the efficient operation of a CBS service, as the hardware would be able to contain the quantity of excreta produced by families of this size. For example, the Clean Team toilet is suitable for families of up to 5 people (Clean Team 2017), so 70% of the households encountered in this study would sit within this bracket.

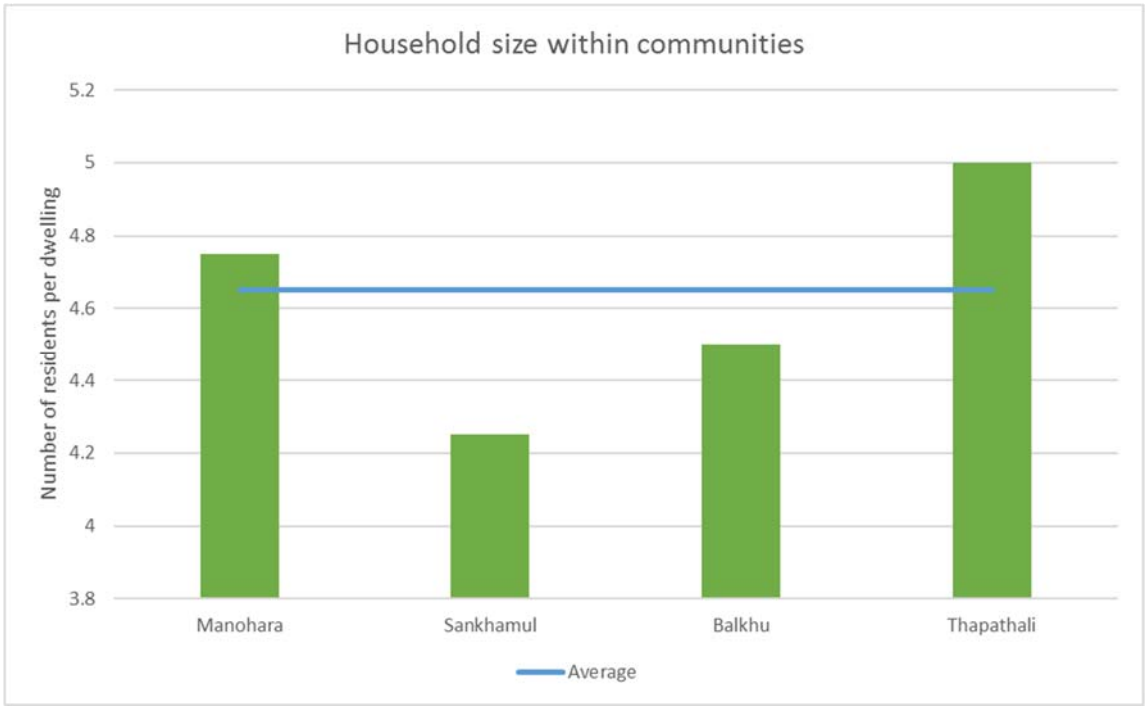


*Figure 4.22 Average household size of study communities*

The monthly household income of the participants of the survey is generally well below the national average figure for Nepal of approximately 35k NPR (salaryexplorer.com 2017), or approximately US$350. Only 10% of those questioned had combined household salaries of between 30k to 40k NPR, with the majority (55%) having a combined income of between 10k and 20k NPR, as illustrated in Figure 4.23 below.

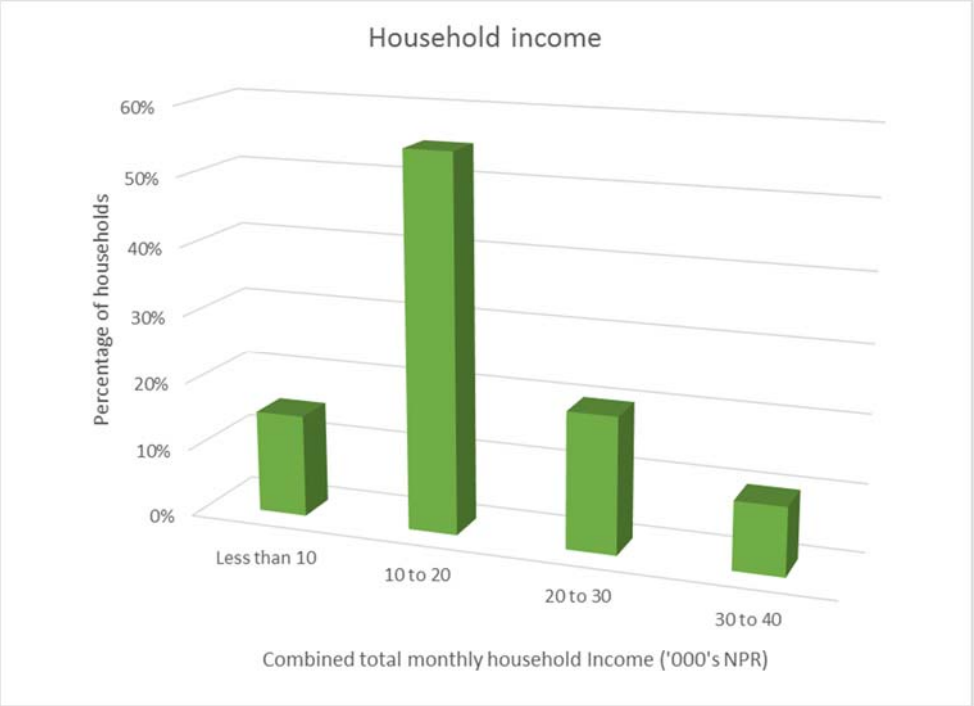


*Figure 4.23 Combined monthly household income of households with study*

The average combined household income of those in the study was only 18k NPR, which is effectively half the national average figure. This figure is considerably higher than that given in the Lumanti study in 2008, which gives an average household monthly income of only 4k NPR (Lumanti 2008); even allowing for inflation the difference between the figures is considerable so the income data obtained as part of this study may not be truly representative of the squatter communities as a whole. Depending upon the level at which the price point of any CBS service was set, the relative affordability of the service could be significantly affected. For example, if the cost of the service was based on an approximate figure of 2% of average household income of the area, as is the case with Sanivation (Woods, KII, 22/5/17) and SOIL (Kramer, KII, 22/5/17), then this would equate to a monthly charge of approximately 360 NPR/month. If, however, a higher figure was set, for example 6% of average income of the operational area, as charged by Clean Team (Mikhael, KII, 26/5/17), then the monthly charge would increase to 1,080 NPR/month. Obviously, any increase in the charge would have an effect on the level of uptake and the ATP of the residents, but also revenue per customer achieved. If the actual average incomes are more in line with the Lumanti data, a 2% contribution would equate to a monthly charge of only 80 NPR. This would concur with the actual level of WTP ascertained during this study from the residents who were found to be prepared to pay to receive a CBS service. The

actual price of the service would need to be calculated to ensure that the maximum efficiency of collection could be achieved by attracting as many customers as possible, whilst still remaining as a sustainable and functioning entity.

The data obtained on the questions of lost work and schooling days did not indicate any specific pattern, either in a single isolated community, or over the survey as a whole. Furthermore, there was not a significant level of incidence of diarrhoea or other illnesses related to poor sanitation contracted during the 6 months preceding the survey. The survey was undertaken prior to the commencement of the monsoon season, so any seasonal effects of the monsoon would not have been evidenced in the data. However, the low incidence of sanitation related illnesses, in itself a good sign, may impact on the potential uptake of CBS as residents would not necessarily see the health benefits of CBS as a potential advantage or driver in obtaining improved sanitation.

The data collected on mobile phone ownership indicated a high level of access to a mobile phone in the communities; only 10% of households within the survey reported not owning at least one mobile within their home, with the average number of mobile phones per household found to be 2.3, as illustrated by Figure 4.24 below. The high level of mobile phone usage could potentially indicate the feasibility of utilising Mobile Money for the collection of CBS payments. As was confirmed during KIIs with CBS organisations, cost-effective fee collection is a key factor in providing an efficient and sustainable service; the move to Mobile Money by the majority of CBS organisations reflects the importance of this issue, so the level of mobile phone availability within any potential community is a pertinent consideration.

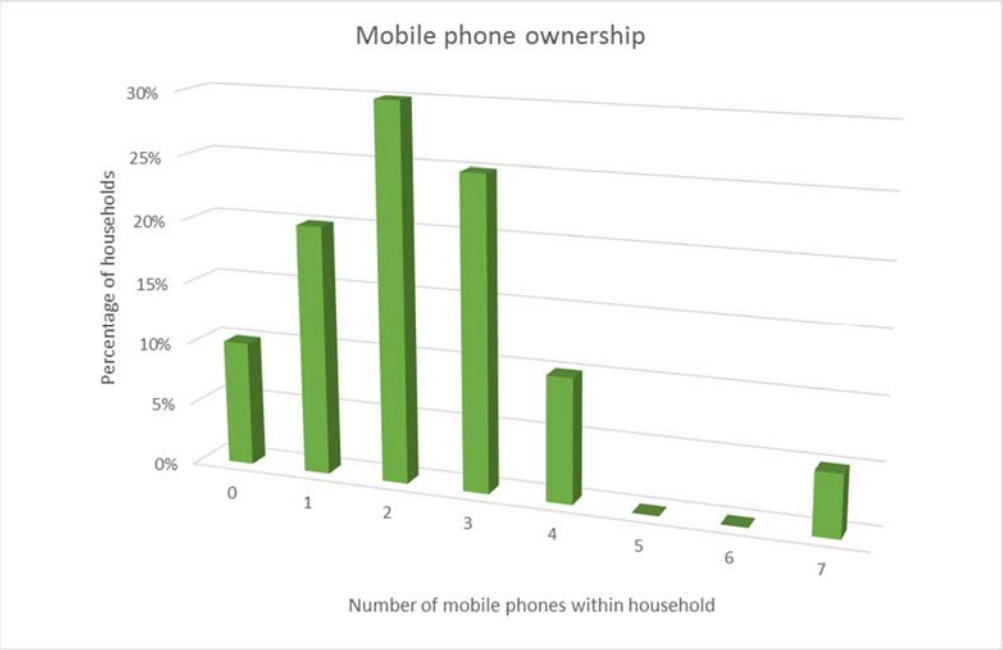


*Figure 4.24 Mobile phone ownership levels within households of the study*

The prevalence of bank account holders within the participant households was lower than the extensive levels of mobile phone ownership identified as demonstrated by Figure 4.25 below.

Over a third of households (35%) reported having no bank account holders within the home at all; as such any method of payment associated with the process of a direct bank transfer (e.g. standing order, direct debit) would not be a suitable payment option, as this would considerably restrict the potential customer base of the service.

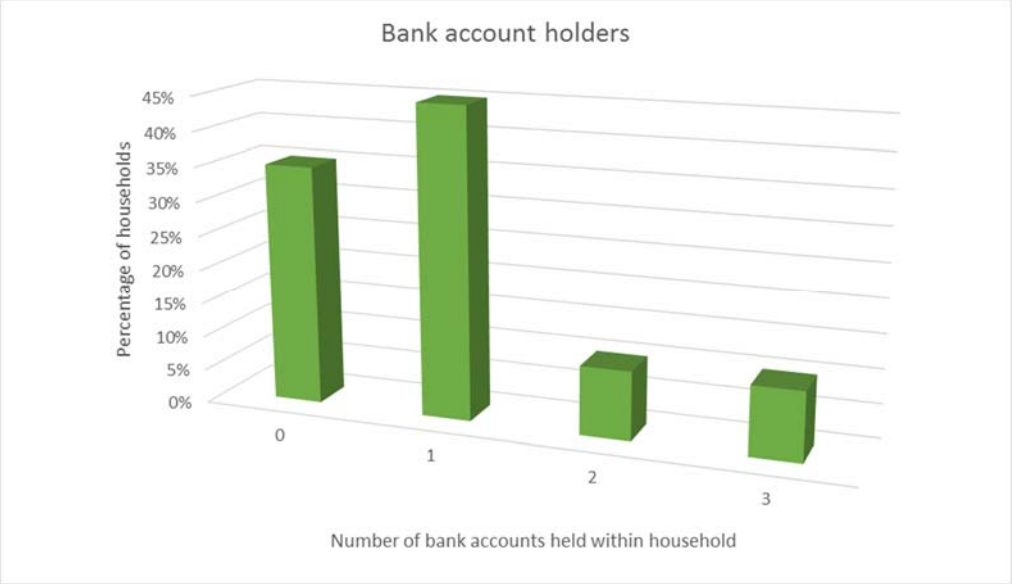


*Figure 4.25 Bank account holder levels within households of the study*

#### *4.2.3.4. Existing water, sanitation practices and infrastructure*

The water supply of the communities studied varied greatly between communities and was generally specific to each settlement as shown in Figure 4.26.

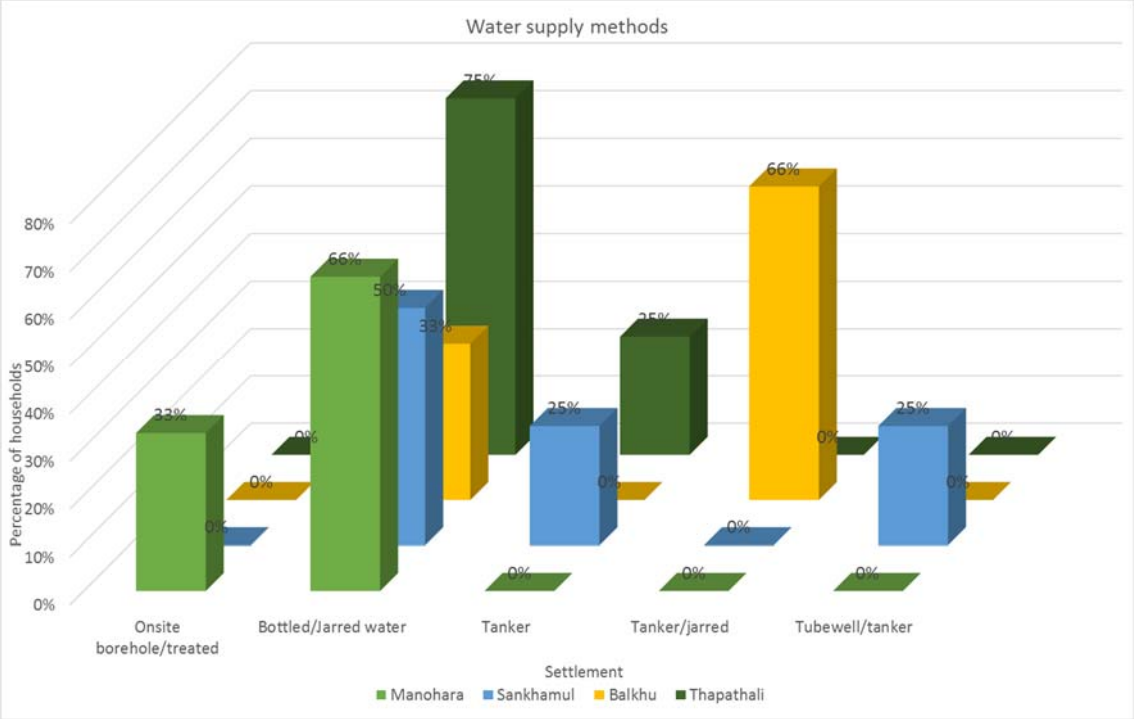


*Figure 4.26 Water supply methods within the surveyed communities*

Overall, a general reliance on bottled or jarred water was identified in all the communities, although the use of tanker supplies and water treated onsite were also reported; the existence of a piped water supply was not identified in any of the communities. The general reliance on bought water would suggest that any sanitation system implemented in the communities would either need to be waterless, or have a low requirement for water use that could easily be obtained from the nearby rivers.

The types of toilets used by the residents of the communities varied considerably between settlements dependent upon the length of occupation and how established the areas had become. It can be seen from Figure 4.27 below that generally, the more established the community, the higher the level of household toilet availability and thus a lower reliance on shared toilets. This can be seen by considering the data for Manohara and Sankhamul compared to that of Balkhu and, especially, Thapathali where 75% of respondents use shared facilities. This evidence would indicate that the potential market for CBS would generally be higher in the less well-established communities as the reliance on shared facilities is greater; therefore, the desire for a CBS toilet that was actually located within the home would be far greater within these communities. The general availability of sanitation facilities in the squatter settlements appears to have improved significantly since the Lumanti report of 2008 as shown in Table 8.2. For example, in Manohara in 2008, 40% of the population reported to either defecate on the river bank or openly defecate. When the researcher visited this community no evidence of open defection was apparent, and the availability of household toilets was widespread.

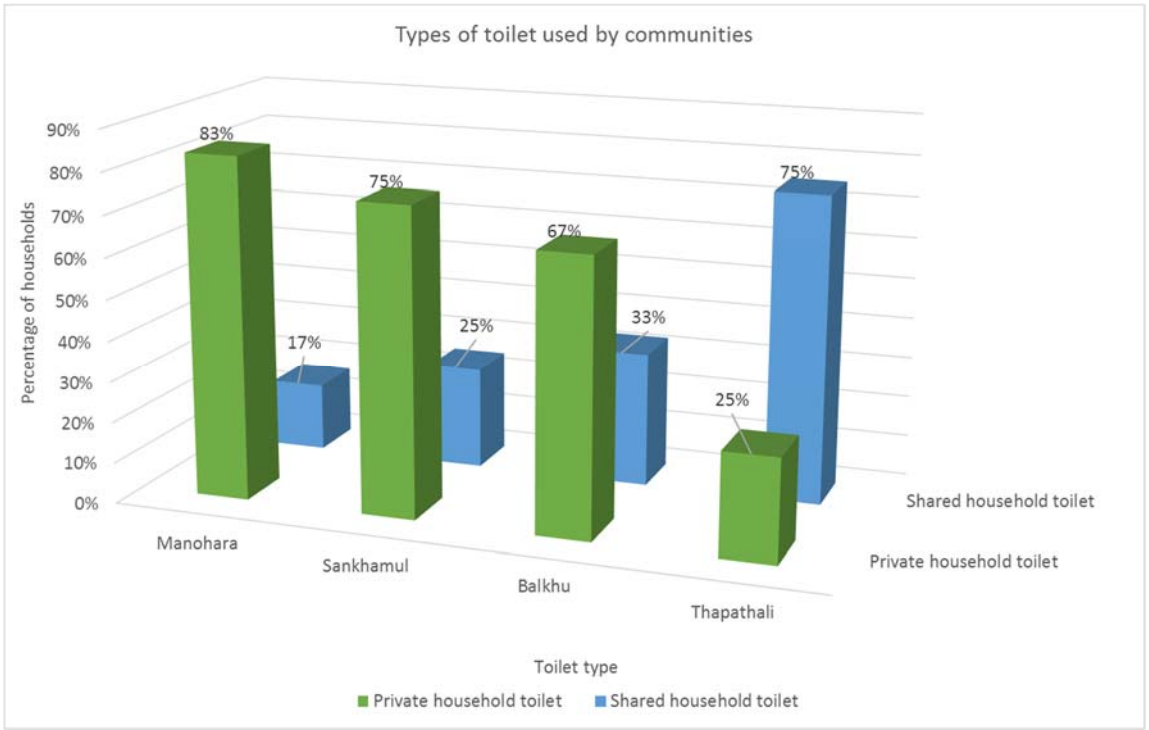


*Figure 4.27 Toilet types used by community residents*

The use of public toilets was not reported at all during the study; the actual provision of public toilets within Kathmandu itself is very low as discussed in section 2.4.5. The lack of public toilets within the city may potentially impact on the WTP of the communities for any sanitation service; the culture and practice of paying for sanitation is significantly reduced by this, with the only recorded payments for sanitation services being made for the emptying of septic tanks. The total number of participants of the study who reported actually paying for sanitation services was only 10%; this could form the basis of a cultural barrier that would need to be overcome should the introduction of a paid CBS service be considered. The use of toilets at works was also not reported as a type of sanitation facility utilised by the participants of the study.

The type of toilets used by the households was universally specified as a manual pour-flush type of toilet. The prevalence of such toilets may be due to the limited availability of water within the communities and also the widespread use of such toilets across Kathmandu as a whole.

The methods of toilet discharge identified within the communities appeared to be very specific to each community, and based upon the individual characteristics of the communities as shown in Figure 4.28 below.

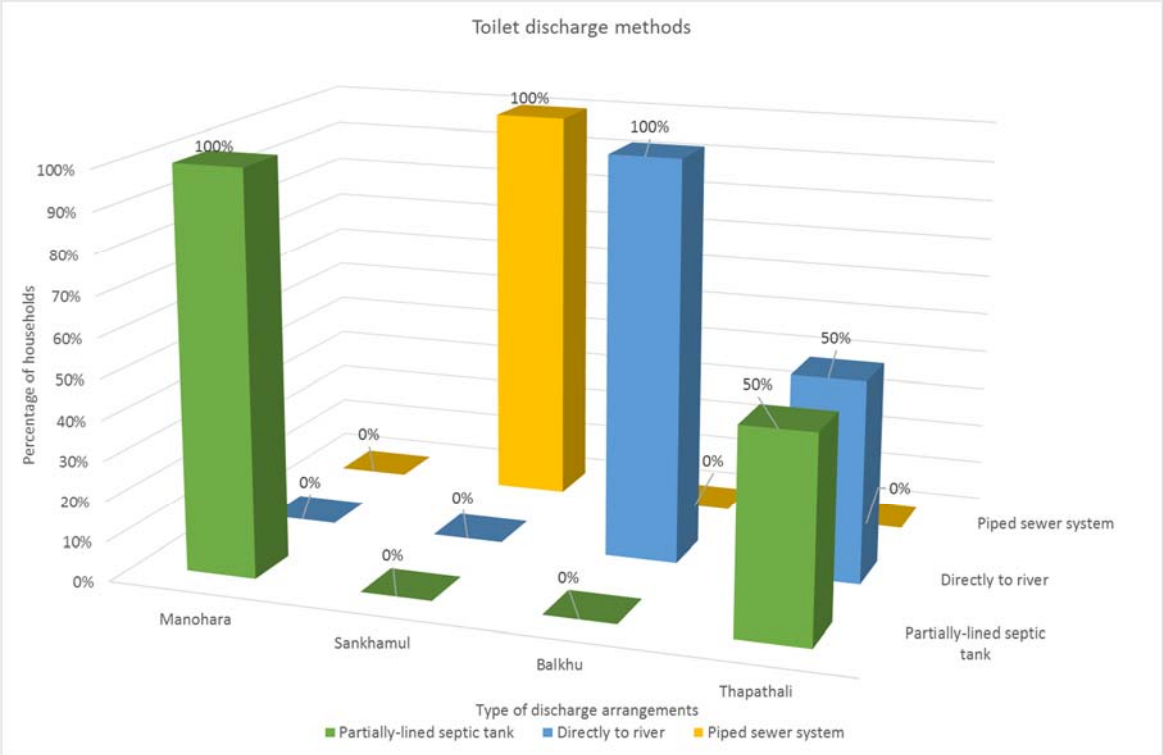


*Figure 4.28 Toilet discharge methods of sample communities*

For example, 100% of the participants in Manohara reported using septic tanks, whereas in Balkhu the figure was similar for direct discharge to the river. This difference is due to the fact that the settlement in Manohara is physically located much further from the river, so a direct connection would require much more significant lengths of connecting pipework to be able to discharge directly to the river. In Sankhamul, the settlement is very established, and is also positioned with a main road running between the community and the river, under which a sewer

is laid; the residents within the community have therefore connected their facilities directly into the existing adjacent sewer. Thapathali was the only community in which different methods were suggested; given the proximity of the river, and the generally lower quality of housing, the use of septic tanks in this community seems doubtful, but it was suggested by 50% of the participants. The four new higher quality toilet units constructed in the community by a Korean organisation are fitted with septic tanks; however, this may have been undertaken to avert criticism for polluting the river from the government or other organisations who might not be in favour of constructing toilets or infrastructure in such a controversial location.

Despite the different discharge methods identified utilised within the various settlements, the ultimate destination for all the waste produced by the communities is currently the same as that of the vast majority of Kathmandu residents. Due to the total lack of treatment facilities, 95% of all wastewater is disposed of directly to the river, as is the majority of FS. Therefore, the pollution impact of the squatter settlements is no worse than for every other community within the city.

The preferred posture for toilet use was universally confirmed as “squatting” as opposed to “sitting”. This preference may have a minor impact on the uptake of CBS, as generally CBS systems require their users to sit rather than squat, so a certain amount of resistance to altering the accepted practices might be expected.

The anal cleansing customs identified during the study would have a much more significant impact on any CBS implementation. With the response to the question of anal cleansing method being that of unanimous washing, any CBS system launched would need to take into account the containment, collection, transport and treatment of the wash water. This requirement can be an issue in the provision of CBS, as the toilet unit needs to be equipped with a mechanism for separating and containing the wash water; if the wash water is to be collected and treated as part of a CBS service, then this can significantly add to the costs, efficiency and therefore overall sustainability of the service. The issue has been addressed by both Sanitation First and Clean Team in different ways, but the approach to dealing with the matter requires careful consideration in order that the ensure that the complete SSC is managed without the introduction of prohibitive costs.

The levels of WTP expressed by the communities varied very much according to the degree of establishment of the settlement, and the resulting level and quality of sanitation provision found within each. Figure 4.29 shows that in the more permanent and established communities of Manohara and Sankhamul, the level of WTP encountered was 0%. However, in the two communities where the standard of sanitation is much lower, significantly more confirmatory responses to WTP were received. This evidence would again indicate that the potential market for CBS would be significantly higher in the less well-established communities.

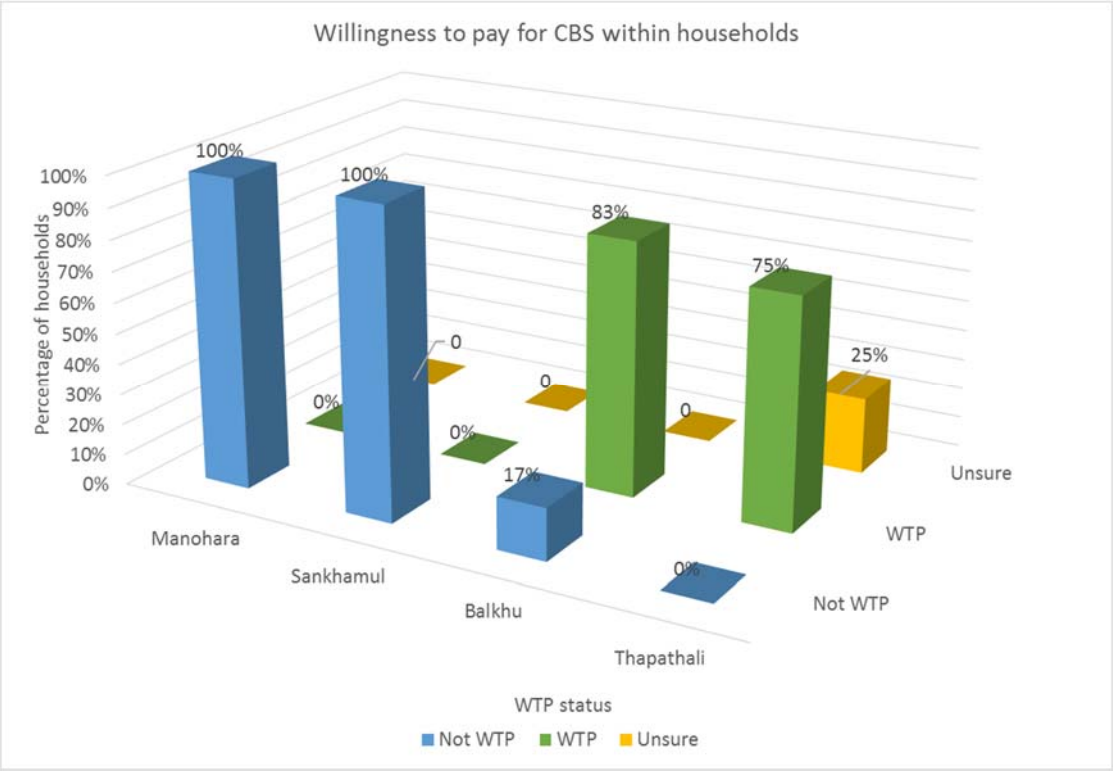


*Figure 4.29 Comparative WTP levels within communities*

The levels of satisfaction expressed by users of private household toilets and those of shared household toilets are illustrated by Figure 4.30 below. Only 8% of private household toilet users expressed concerns or issues compared to 71% of shared household toilet users.

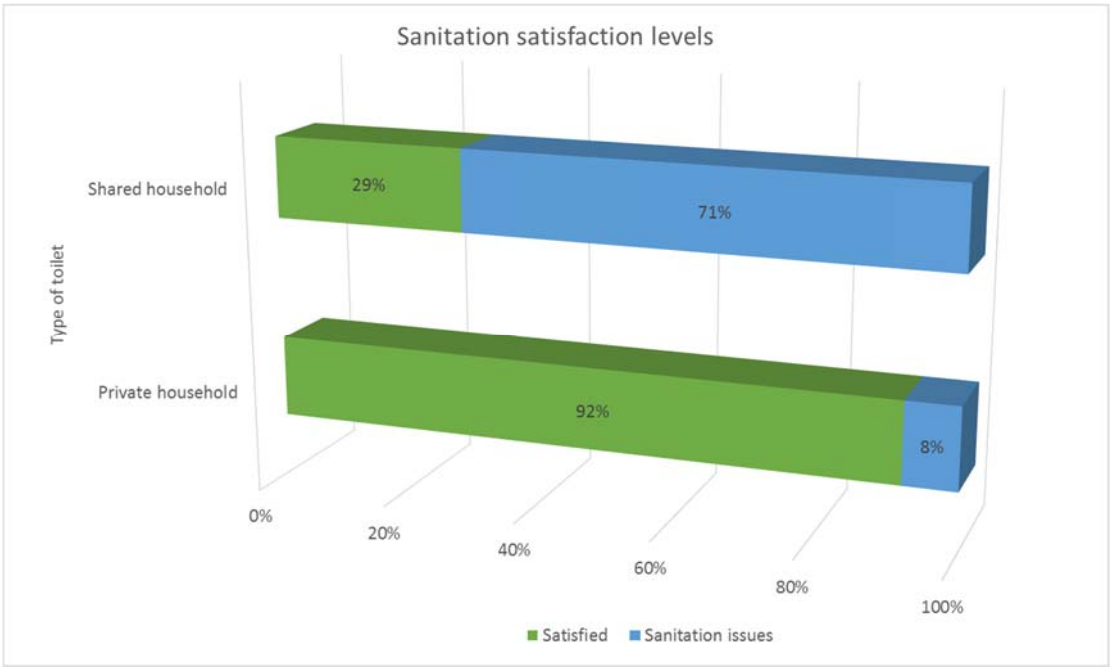


*Figure 4.30 Sanitation satisfaction levels by toilet type*

The majority of the shared toilet users questioned as part of the study live in the less established communities of Balkhu and Thapathali. This evidence would further reinforce the potential of demand in these areas for an improvement in the sanitation facilities provided as highlighted

earlier. The types of concerns raised by the users generally consisted of problems with cleanliness, odour and lighting, but long queues and access during periods of rain were also cited as issues. The low levels of satisfaction in communities with a high dependence on shared facilities would lead to an increased demand for any potential CBS service in these areas due to the general lack of contentment with these facilities as demonstrated by the user's responses.

#### *4.2.3.5. Cultural issues*

This existence of further cultural issues in the squatter communities that could potentially have an impact on the success of a CBS service appear to be minimal. The proportion of homes in the study sample with sufficient space to locate a CBS toilet within the dwelling was established as 90%, with only 5% of respondents having any issue with the potential acceptability of locating a CBS toilet within the home. In relation to the availability of sufficient space outside the dwelling but still on-plot, to locate a CBS toilet, the proportion was lower, with 35% of participants stating that the availability of space was insufficient. However, due to the high proportion of dwellings with sufficient space available within the home, the lack of external space is less of an issue, as generally users would prefer to locate the toilet inside their home in any case.

A reluctance towards the concept of handling containers of human urine or faeces did not emerge during the study. The level of acceptability from participants to this practice was high, with 90% of respondents having no issues with the potential handling or carrying of containers filled with human waste. This would be of an advantage to a CBS service provider, as users would generally be willing and able to dispose of their urine themselves in the rivers that the settlements are located alongside. This acceptability would also allow the possibility of users carrying their own container of faeces to a collection vehicle or transfer station themselves to be investigated, in a similar manner to the process operated by X-runner. Both of these factors could lead to potentially more efficient and cost-effective operating models for any prospective CBS operation.

#### *4.2.3.6. End-use products*

The level of acceptability for the reuse of products created through the treatment of human waste was found to be high, with 90% of respondents having no reservations of using either charcoal or biogas created in such a manner. A similarly high response was received in relation to the acceptability of purchasing vegetables or fruit grown using compost or fertiliser created as a result of the treatment of human waste. This response bodes well as to the potential acceptability for resale of products created by a CBS service provider as part of its treatment process. The potential market for charcoal may however be restricted compared to that of gas as 95% of participants specified their main fuel used for cooking as gas. Consequently, the market for gas would appear to be a healthy one, with an average of over 1100 NPR being spent on the fuel for cooking each month, and nearly 40% of participants spending 1500 NPR or more per month, as shown in Figure 4.31.

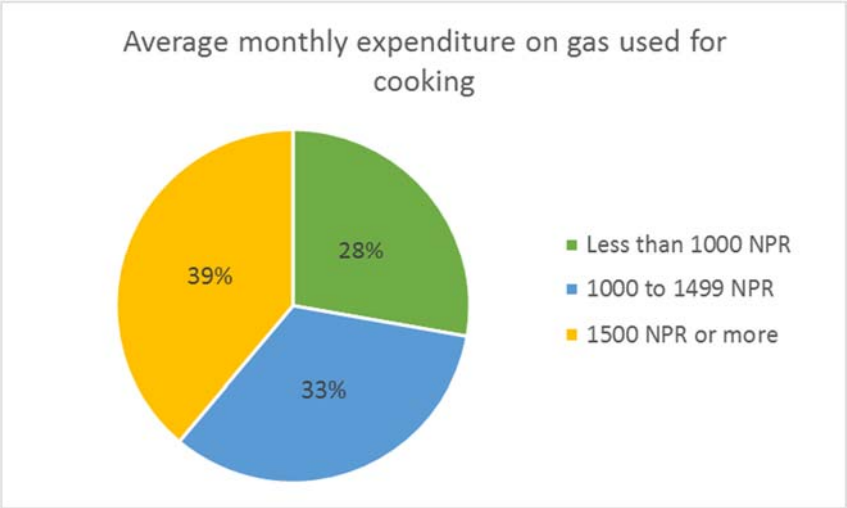


*Figure 4.31 Average monthly expenditure on gas used for cooking*

It would appear that the production of biogas by a CBS service would have a much bigger potential market than that for charcoal. This is not the case across the whole of Nepal however, as about 64% of the population use firewood as their usual source of fuel for cooking (Central Bureau of Statistics 2012), so the market for charcoal produced through CBS may still exist within the country as a whole.

### *4.2.4. Focus group discussion*

As described previously, it was originally intended to undertake a FDG in each of the four case study communities. After undertaking household questionnaires in Manohara and Sankhamul, and gaining an awareness of the level of sanitation provision there, it was decided that little added information would be gained by holding FGDs in these communities. The increased interest around CBS implementation and higher potential for uptake in Thapathali and Balkhu suggested that FGDs in these communities would be more relevant and would elicit meaningful levels of information. However due to the level of suspicion and animosity towards strangers encountered in Thapathali during the conduction of questionnaires, a FGD was never actually realised; it was deemed that the conversation could not be geared sufficiently towards the topic of CBS and sanitation to make the discussion worthwhile, as residents tended to have their own agenda and issues that they preferred to discuss.

The FGD conducted in Balkhu was held in the primary school, and was attended by 6 residents of the community. The initial phase of the discussion was centred around the current sanitation arrangements within the community, and the opinions of the residents to the standard and level of the sanitation available within the community. As mentioned previously, the community has suffered over the preceding two years due to the ongoing construction works that surround the settlement.

The participants in the FGD informed the researcher that approximately 50% of the community are reliant on a single group of 6 shared communal toilets (see Figure 4.12 above) and is therefore woefully inadequate. The group explained that previously the number of toilets was

much greater, but due to the ongoing construction works, most of the toilets had been broken, destroyed or had ceased to function due to damage sustained by the toilet discharge pipework. This type of damage had been previously noted by the researcher during the transect walk, whereby it was noted that excavations adjacent to toilets had been dug to expose the pipework; the pipes had been severed and the resulting excavations had therefore filled with blackwater. Examples of these types of excavations can be seen in Figure 4.32 and Figure 4.33 below.

*Figure 4.32 Severed toilet pipe discharging blackwater directly into the environment*

*Source: (R Dewhurst 2017)*

*Figure 4.33 Blackwater accumulation adjacent to damaged toilet discharge*

*Source: (R Dewhurst 2017)*

The reliance by such a large section of the community on so few toilets has led to long queues to use the facilities, and also issues surrounding their cleanliness, odour and flies. Residents also mentioned that accessing the toilets at night was particularly difficult as the remaining toilet block is on the opposite side of the boundary road to that of the housing; the road itself has no streetlights and is not surfaced so it becomes extremely muddy, particularly after rain and therefore very slippery and unpleasant to access, especially at night.

During discussions regarding the prevalence and effects of flooding on the community, the FGD participants informed the researcher that during the monsoon and periods of flooding access to the toilets, and even to their houses, becomes difficult; it was admitted by the participants that during these times, open defecation would take place as access to their homes and toilets was simply not feasible. The group also confirmed that open defecation had also been practiced during periods when the toilets had become blocked as a result of the ongoing construction work; the effect of this was identified by the researcher during a transect walk whereby the flow from the toilet block could be seen discharging directly into a large open excavation, presumably having been damaged by the contractors.

On the subject of the frequency of illness and disease incidence, the group commented on an increase in dysentery and diarrhoea during times of flooding, although the topic was not discussed at length, as the group did not appear to be in unanimous in agreement on the issue.

The researcher noted a general level of dissatisfaction with the sanitation facilities and the general living standards experienced by the participants, particularly with regard to the ongoing construction works and their impact on the resident's lives.

The second phase of the FGD centred around the suitability of the community and its dwellings for the installation of CBS toilets and the response of the participants to concept of paying for a CBS service. Additionally, the reaction of the participants to the handling of urine and faeces containers and to the level of acceptance of products created from human waste was assessed.

In general, there was no reluctance to locating a CBS toilet within the home by the group, an attitude that was echoed by the results of the household questionnaires. However, one issue that was raised was that some houses would not have sufficient space inside them to locate a CBS toilet, and this was cited as one of the main reasons why residents continue to rely on the shared toilets, despite their totally inadequate level of provision.

The potential WTP for a CBS service was discussed during the FGD, and after some debate a consensus within the group of approximately 50 NPR (≈ US$ 0.50) per month was reached. This figure was in line with the WTP pay suggested by most residents of Balkhu during the conduction of the household questionnaires.

On the topic of handling filled containers of urine or faeces, no specific concerns were raised; one comment made highlighted that the existing problems associated with unblocking the shared facilities and their general lack of cleanliness was seen as far worse than the prospect of handling CBS urine or faeces containers.

In terms of the use of products created from human waste, there were no issues declared by the participants to any of the suggested product types. All the participants reported to use gas as their cooking fuel, and had no issue with the potential use of biogas produced using human waste. One problem related to fuel use, described by the participants, was the high cost that the residents of the community were required to pay for electricity. The residents explained that by having no legal rights to the land, obtaining authorised electricity connections is not permissible; the residents are therefore reliant on receiving their electricity from adjacent properties who do have legal connections. However, the additional charges paid by the residents of the squatter community to receive their power in this way equate to a 2.5-fold increase in the price that they pay when compared to that of residents with legal connections. This underlines the impact and difficulties the squatter communities face in obtaining straightforward household services that would be of no issue to legally settled residents.

The responses obtained during the FGD generally concurred with the observations made during the transect walk, but also with the findings from the household questionnaires conducted in the settlement. The impact of the construction works and the general living conditions witnessed during the transect walk were borne out by the frustration expressed by the residents during the FGD with their current levels of sanitation. The response of the residents to the cultural factors relating to the potential of a CBS service within the community and the reaction towards issues such as handling filled containers, or end-use products, was in line with the results obtained from the household questionnaires.

#### *4.2.5. Semi-structured and unstructured KIIs*

A range of semi-structured and unstructured KIIs were conducted with various individuals from different organisations, NGOs and government departments in Kathmandu in order to understand more fully the current status of sanitation, WWT and FSM in addition to acquiring further information on the historic use of EcoSan within Nepal. The potential for CBS application in Nepal in various contexts, including squatter settlements as well as potentially in public toilets was also explored. The schedule of the Kathmandu based KIIs is provided in Appendix J, with the findings of these interviews providing the basis of the following section.

##### *4.2.5.1. Historic and existing sanitation practices in Kathmandu*

The historic use of methods to compost kitchen waste (Saaga) and reuse urine (Nauga) for use as traditional forms of fertiliser is long-established practice in Newari culture, as described earlier in section 2.4.4. More importantly, the 'Khiga' process of treating and reusing human faeces to create agricultural fertiliser (Amatya, KII, 16/6/17) suggests that the concept of handling and utilising products generated from the treatment of human waste is not a new practice culturally. This would be an encouraging consideration for any potential CBS operator in the country, as the likelihood of aversion to handling filled containers of human waste should be low; likewise, attitudes towards the reuse of products created from the treatment of human waste should be favourable due to the historical acceptability of such practices.

Current sanitation practices, particularly in an urban context, are moving toward pour-flush and flushing toilets connected to a sewered system. Approximately 70% of Kathmandu is currently sewered (Sherpa, KII, 12/6/17) with 91% of households already possessing their own toilet (Dangol, KII, 13/6/17). The high level of household level toilet provision across Kathmandu would restrict the potential size of the CBS market, and therefore confine any operation to specific communities in which the general level of sanitation facilities is low.

##### *4.2.5.2. Wastewater treatment and FSM in Kathmandu*

The WWTP at Guheshowri is currently the only operational WWT facility in the whole of Kathmandu (see Figure 4.34). The plant itself only treats 5% of all the wastewater produced in the city, and there is no current incorporation FS treatment at the plant. The plant is currently being expanded to increase its capacity from 16.4 ML/day to 32.4 ML/day, and also to

incorporate the facility for treatment of FS from pit latrines, septic tanks or other onsite sanitation facilities (Rajbanshi, KII, 20/6/17), including the construction of a new centrifuge for sludge dewatering as shown in Figure 4.35. The creation of this facility could provide a useful and cost-effective FS disposal method for any CBS service, if the production and resale of end-use products created as part of the operation were found to be uneconomical or if the size of the resale market were low.

*Figure 4.34 Existing WWTP at Guheshowri*

*Source: (R Dewhurst 2017)*

*Figure 4.35 Construction of new centrifuge as part of Guheshowri expansion project*

*Source: (R Dewhurst 2017)*

Another project underway in Kathmandu as part of the Bagmati action plan (HPCIDBC 2009) is the construction of new sewer trunk mains along the banks of the main rivers across the city. The objective of the project is to intercept all the existing sewers that currently discharge directly to the rivers, and to carry the waste to a new treatment facility or facilities that are planned to be constructed to the south of the city (Chitraker, KII, 25/6/17). Although this project will make a significant improvement to the condition and the pollution levels of the rivers once completed, there will be considerable additional pressure placed on many of the squatter communities as their settlements are generally located on the land where the new main trunk sewers are to be constructed. The evidence of this was seen by the researcher in Balkhu, where the lives of the residents have been seriously disrupted due to the surrounding construction works.

Once the project is completed, any infringement of pollution laws is likely to be more rigorously enforced; currently this is not done as there are no treatment alternatives, but once the availability of adequate treatment facilities exists then pollution of the rivers, as experienced by the author and highlighted in Figure 4.36 and Figure 4.37, will be seen as far less acceptable. If the squatter settlements remain in situ following the completion of the project, then revised sanitation facilities would be required as they would no longer be permitted to discharge directly to the river and may not be permitted to connect into the new trunk mains. This may increase the potential demand for CBS in these communities, and the new treatment facilities proposed as part of the project may also provide a useful disposal method for the FS generated as part of any CBS service.

*Figure 4.36 Untreated sewer discharge direct to the Bagmati river near Balkhu*

*Source: (R Dewhurst 2017)*

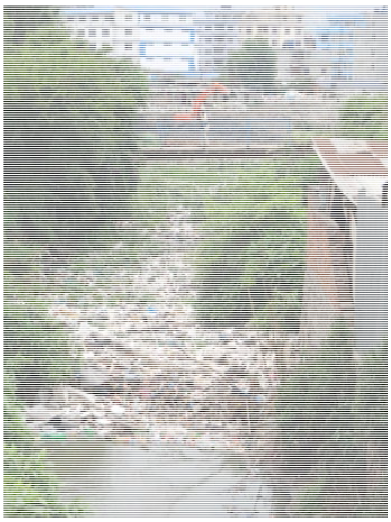

*Figure 4.37 Pollution of a tributary to the Bagmati river*

*Source: (R Dewhurst 2017)*

The capacity for FS treatment in Kathmandu is currently totally inadequate; 30% of the population are reliant upon on-site sanitation facilities, which require emptying and disposal for them to function. The last FS treatment plant operated by KMC at Teku, in the south of Kathmandu city, was in service until 2005 but became inoperative due to operation and maintenance issues with the pumps; the high quantity of plastics and solids that were found in the sludge prevented the pumps from operating reliably and so the plant was eventually closed after only operating for 7 years (Shrestha, KII, 22/6/17).

Presently, the only FS treatment plant in operation is a small pilot plant in Lubhu (see Figure 4.38), which can treat a maximum of 9m³ of sludge per week (Karki, KII, 23/6/17), meaning that the vast majority of sludge collected is disposed of either illegally directly to rivers and drains or, in rare cases, to agricultural land as a form of fertiliser.


*Figure 4.38 Faecal sludge treatment plant at Lubhu*

*Source: (R Dewhurst 2017)*

All new houses constructed in the city are required to be equipped with a septic tank if sewers are not available, and so residents' only option is to employ the services of private contractors

for emptying, who subsequently have very few “legal” options for disposal – a situation that requires immediate attention (Koirala, KII, 22/6/17).

Due to the limited capacity of the plant at Lubhu, it does not possess any spare capacity to accept additional sludge and so would not be a realistic disposal option for any CBS service. However, during a visit to the plant, the researcher was shown how the sludge is treated and transformed into fertiliser which is then used to grow vegetables, as illustrated in Figure 4.39. The facility provides the caretaker and a local orphanage with all their vegetables with the remaining surplus crops being sold to generate additional income.

*Figure 4.39 Vegetable cultivation at the FS treatment plant in Lubhu*
*Source: (R Dewhurst 2017)*

The water for the irrigation of the crops is also provided by the treatment process, in addition to producing enough gas to totally supply the caretaker of the facility and his family with their entire fuel requirements. Although only small, the facility demonstrates the advantages of this approach to FS management (e.g. biogas production, irrigation water, increased crop production) and also the acceptance of the residents to the purchase and consumption of produce grown with the aid of fertiliser created through the treatment of human waste.

#### *4.2.5.3. Solid waste management and treatment, biogas production and compost manufacture*

The site in Teku is now home to a solid waste management facility (see Figure 4.40) and a new waste-to-energy plant opened in June 2017 which was constructed to produce compost, biogas and treated water from organic waste collected in the city as shown in Figure 4.41. The construction of a new technologically advanced facility is a positive indicator towards the potentiality of the market for biogas and compost sales. Biogas production is undertaken on a large scale in Nepal with more than 2800 of the number of 3915 villages in all 75 districts of Nepal having a biogas facility installed (AEPC 2017).

*Figure 4.40 Existing solid waste management facility in Teku*

*Source: (R Dewhurst 2017)*

*Figure 4.41 New waste-to-energy plant in Teku*

*Source: (R Dewhurst 2017)*

A current EU funded project being undertaken by LMC to reduce the quantity of solid waste produced in the district by 20 tons per day, includes the construction of two new compost plants and two biogas plants (Rajbhandary, KII, 20/6/17). Additional existing composting operations are being undertaken by commercial organisations such as Blue Waste 2 Value (Blue Waste 2 Value 2016), who have not encountered any issues in obtaining sufficient land for setting up their plant (Maharjan, KII, 20/6/17); however, their plant is located in the Village Development Committee (VDC) of Lele which is quite a long distance outside the Kathmandu urban area, so establishing a plant nearer to the city may still present issues associated with opposition from the local residents. Encouragingly, Blue Waste 2 Value have not encountered any adverse reaction in regard to the origin of their compost product, which suggests that a CBS service would also be able to sell any compost created from their operation.

Other compost creation facilities were identified within the city, such as the one shown in Figure 4.42 located near the Budhanilkantha Temple, which uses the waste created from the temple offerings to produce compost which is subsequently resold, so the existing market for compost sales appears to be healthy.


*Figure 4.42 Compost plant near the Budhanilkantha Temple north of Kathmandu*

*Source: (R Dewhurst 2017)*

#### *4.2.5.4. Squatter settlements in the Kathmandu Valley*

Lumanti have worked with the squatter settlements in the Kathmandu Valley since 1993. During this time, many projects have been undertaken by the organisation to construct public toilets, household latrines and institutional latrines in areas of urban poverty (Rupakheti, KII, 22/6/17). Many of the projects undertaken by Lumanti in communities such as Khokana, Kirtipur and Khadipakha around Kathmandu incorporate rainwater harvesting, biogas plants and septic tanks to provide sustainable WASH solutions for the poorest communities. Some of the solutions implemented by Lumanti incorporate slurry drying beds, the contents of which are used to create compost which is then resold by the community. Due to the traditional use of faeces as a form of fertiliser, there has been no opposition to the sale and use of products created from the treated human waste obtained from the facilities that Lumanti have constructed. Lumanti has also been involved with the reconstruction and repair of many sanitation facilities following the major earthquake in 2015.

The squatter settlements along the banks of the rivers of Kathmandu are considered by the Nepalese Government to have encroached on public land (Rupakheti, KII, 22/6/17). The government's plans for the beautification of the rivers as part of a wider development across the city will require that many of the riverside squatter settlements are evicted, especially those of the less well established and impermanent communities. As such, Lumanti are reluctant to encourage the existence of the settlements, but until the government can provide alternative locations for the residents to relocate to, they continue to supply basic services to the communities from a humanitarian perspective. This stance by Lumanti and the apparent opposition to the continued occupation of many of the riverside settlements would suggest that little assistance or support from the government to establish services would be forthcoming, especially within the more controversial communities, and even some resistance from authorities could potentially be encountered.

#### *4.2.5.5. EcoSan*

The use of EcoSan has been promoted throughout Nepal by many organisations such as ENPHO, Lumanti and WaterAid. The historical use of practices such as the use of Nauga, Saaga and Khiga by the Newari community meant that the concept of reusing human wastes as fertiliser was not unfamiliar in Nepal. However, the hygiene levels of such practices were not high, and so the concept of EcoSan was promoted in order to improve this (Shrestha, KII, 4/7/17). The Sherpa community traditionally used a 'Chyakhang' (which literally means house for manure production), whereby a hole in the first floor of their property was utilised to defecate into the room below with organic matter being added as a cover material after defecation. This process is very similar to that of the dry EcoSan system, albeit with a lower level of assurance that all the pathogens have died off, so adoption of the EcoSan approach was not alien to the community. This familiarity with the process is a promising indication towards the acceptance of

a dry CBS toilet system, as the method of use is very similar. Therefore, any significant cultural barriers to the introduction of CBS should be minimal.

The number of EcoSan toilets in Nepal has grown steadily over the past 15 years, and now more than 1000 wet and dry EcoSan toilets have been constructed across the country (Shrestha, KII, 4/7/17). The main difference between the wet and dry EcoSan toilets is that in wet EcoSan toilets, only the urine is reused; a pour-flush pan is incorporated, which flushes the excreta into a pit or septic tank for subsequent disposal. An example of some existing dry EcoSan toilets that are still in use were are located by the author in Siddhipur to the south east of Kathmandu and are shown below in Figure 4.43

*Figure 4.43 Existing dry EcoSan toilets in use in Siddhipur*
*Source: (R Dewhurst 2017)*

In recent years, the popularity and demand for dry EcoSan toilets has diminished significantly for a number of reasons. The main reasons for the decline in the use of dry EcoSan toilets are:

- Changes in occupation/profession and lifestyle – fewer people are reliant on agriculture for employment.
- Difficulties in obtaining of a reliable source of ash for use as a cover material – many people are changing from the use of firewood to LPG as their main source of cooking fuel, so the prevalence of ash is becoming increasingly rare.
- Decreasing availability of agricultural land – linked with the changes in occupational practices.
- Low level of user-friendliness – dry EcoSan toilets are perceived as less user-friendly than pour-flush toilet due to the requirement to use cover materials.
  (Shrestha, KII, 4/7/17)

EcoSan toilets are still being constructed in Nepal, but nowadays generally only wet EcoSan toilets are built. The growing perception of dry EcoSan as being less user-friendly may have an impact on the appeal of CBS, which also generally require the use of a cover material in order

to operate. The availability of an adequate supply of cover material is also a key requirement, as revealed by the decline in the use of dry EcoSan. However, the general acceptance in the use of the process is a good indication that the existence of any likely strong cultural barriers to the use of CBS would not emerge.

#### *4.2.5.6. Public and mobile toilets*

The demand for additional public toilets within Kathmandu is very high as the current provision for such a large city is totally inadequate and of poor quality in terms of both cleanliness and hygiene, as seen from the examples in Figure 4.44.


*Figure 4.44 Existing public toilet facilities in Kathmandu and Patan*
*Source: (R Dewhurst 2017)*

As identified in the literature review, there are currently plans to invest significantly in the provision of public toilets across the city, and this was noted by the researcher in Kupondole, Lalitpur where advertisements for new public toilets due to be constructed were recorded (see Figure 4.45). As a consequence, the researcher was keen to determine whether CBS could potentially provide a solution to the lack of public facilities either in part or as a whole.

A previous trial of a system similar to that of CBS was undertaken in Kathmandu in approximately 2012 (Amatya, KII, 16/6/17). An “Ecoloo” (Ecoloo 2010) was installed near to the central zoo in Lalitpur. The trial was a failure however because the design of the toilet failed to take into account the anal cleansing practices of the population. A supply of water was not provided for washing, and no mechanism for separating any anal wash water was incorporated into the design; therefore the ‘water-free’ toilet was not able to deal with the quantity of water required if anal washing were to be practiced, which was not very feasible in any case as only a limited water supply was provided just for hand washing. Subsequently the toilet was only used for urination and so the urine collection container filled rapidly, whilst very little faeces were collected. Therefore, the toilet was only operated for a short time, before being closed and abandoned next to the Jawalakhel Police Station in Lalitpur, as illustrated in Figure 4.46.


*Figure 4.45 Advertisement for new public toilets near the Bagmati River in the south of Kupondole, Lalitpur*

*Source: (R Dewhurst 2017)*


*Figure 4.46 Abandoned "Ecoloo" near the central zoo, Lalitpur*

*Source: (R Dewhurst 2017)*

The prevalence of the practice of washing for anal cleansing, as demonstrated by the trial above, is a factor that would require serious consideration in relation to the possible implementation of a CBS public toilet service. Sanergy's FLTs do not have to manage large quantities of wash water, as the population that is served generally wipe to cleanse. The introduction of the requirement to provide anal washing facilities would necessitate the provision of additional water for washing, and also additional collection operations to manage the wash water. Furthermore, the design of the toilet would need to incorporate the added functionality to separate and store the anal wash water, as is the case with Sanitation First's GroSan model. The issue is not insurmountable, but the culture would have an impact on the operational model, the potential cost-effectiveness and efficiency of a CBS public toilet service provided within an area predominantly inhabited by residents who cleanse anally through the practice of washing.

The matter was further explored with the Chief of the Environmental Management Department of KMC. The researcher suggested the use of CBS as a potential solution to the current lack of public toilets, and the possibility of using the private sector to manage the service and thus remove the responsibility of the day-to-day running from the municipality. However, the opinion of the Chief was more in favour of introducing a more technological type of automatic, unmanned public toilet system called the e-toilet (Eram Scientific, 2017) which is currently being implemented in India (Shrestha, KII, 7/7/17); the potential for sustainability of such a high-tech solution would need to be established prior to a large scale deployment as the costs of such a system are likely to be high. With regard to the use of the private sector in operating and maintaining any public toilet service, the Chief informed the researcher that the new mayor of Kathmandu, who is presently instrumental in the promotion of the programme of improved public toilet provision, has specified that the new toilets are to be operated and maintained by the

municipality itself; this stipulation therefore leaves little opportunity for a potential PPP or similar collaboration with the private sector for the provision of public toilets in Kathmandu currently.

The researcher was aware of the existence of mobile toilets, identified during the literature review, that were being operated within the Kathmandu Valley as one solution to mitigate the issues associated with the limited availability of public toilets. The plans to develop a mobile toilet service across the city had not come to fruition, and the researcher was keen to investigate the reasons for the lack of expansion. The Chief of the Environmental Management Department of KMC confirmed that a mobile toilet service had previously been operated in the city, but due to a lack of agreement between the private operators and the municipality, the toilets had been deemed to be operating illegally, and as such were impounded by the municipality.


*Figure 4.47 Abandoned mobile toilet units at KMC in Teku*
*Source: (R Dewhurst 2017)*

The evidence for this was further confirmed by the researcher who located a collection of seized vehicles abandoned in the KMC facility in Teku as shown in Figure 4.47 above.

The inability to reach agreement between the private operators and KMC is particularly regrettable given the current requirement for additional public toilets within the city, using a concept which appeared to meet some of the demand without the need for any form of infrastructural investment. The lack of suitable treatment or disposal facilities available to the operators may have been a contributory factor, but their method of disposal would have been no more polluting or inappropriate than the ultimate destination of the waste produced by the vast majority of residents in the city which is discharged directly to the rivers untreated.

### *4.2.6. Summary*

The characteristics of the different squatter settlements identified in the study areas were highly variable and thus the suitability and potential of CBS in each of the communities is correspondingly varied. The degree of suitability depends upon the extent to which the

settlements are established, the permanence and status of the communities and the level of sanitation facilities that currently exist in each area. This variability was mirrored in the responses to the questionnaires whereby the residents of the more established settlements, whose existing sanitation facilities are more developed, were much less enthusiastic towards the potential introduction of a CBS service.

Cultural barriers in opposition to the possible use of CBS facilities do not appear to exist to any great extent and the high level of acceptability encountered towards the use of products created through the treatment of human waste indicated the potential for a healthy market for such products. These assertions were further confirmed by the scale of the widespread acceptance of EcoSan across the country.

The level of support that could be expected from the government to the establishment of a CBS service for squatter communities would depend upon the age and thus the level of permanence of the settlement, as the government is not keen to encourage the occupation of the more recently established settlements. However, the communities that are in most need of improved sanitation, and where the potential market for CBS is strongest is in the less well-established settlements, and so any support available from the government is likely to be minimal in these circumstances.

The potential of a CBS service to provide public toilets within the city would be limited by the requirement for the provision of an adequate supply of wash water; the facility to collect, store, transport and dispose of the wash water would also be necessary. The support of the government to utilise CBS as part of their public toilet expansion programme may also be minimal due to the existing internal preferences relating to operational responsibilities and also to current technological inclinations.

## *4.3. Weighted matrix analysis of results*

Following the establishment of the required conditions for viability and success criteria for CBS to operate effectively in section 4.1, a weighted scoring matrix was developed by the author; this was done as a means of determining the potential of any given area or city with regard to the implementation of CBS, as shown in Appendix G – CBS scoring matrix. The findings of section 4.2 were subsequently used to populate the matrix and to determine the overall level of viability for CBS in the context of Kathmandu. The results of this analysis are given in Appendix L and are summarised in Table 4.5 below, which highlights the main potential barriers and opportunities identified in each of the categories. The grouping of the factors into distinct categories, as shown in the table, enables the main areas of concern or potential inappropriateness of CBS to be easily identified.

*Table 4.5 Completed weighted matrix summary sheet*

| ***Country/City: Kathmandu, Nepal*** | | | |
|---|---|---|---|
| **Districts:** | **Manohara, Thapathali, Sankhamul & Balkhu** | **Date of Assessment:** | **12/08/17** |
| ***Summary:*** | | | |

| **Factors and Impacts** | | **Score** | **Main Issues and Barriers** | **Success Potential and Comments** |
|---|---|---|---|---|
| 1. | Cultural | -3 | • Very low familiarity with concept of paying for sanitation<br>• Universal practice of washing for anal cleansing | • Strong desire to obtain a toilet within the home<br>• High level of acceptability with handling containers of human urine and faeces |
| 2. | Existing Sanitation Facilities and Practices | -4 | • High level of availability of private facilities<br>• Very low maintenance costs of existing sanitation | • Very low levels of public toilet provision |
| 3. | Operational | -15 | • Very limited scope for local establishment of treatment facility<br>• No existing treatment facility capacity available | • Good availability of potential cover material |
| 4. | Geographical/ Geological | 19 | • No restrictions to excavation for construction of on-site sanitation facilities | • All areas very vulnerable to flooding<br>• High water table in all areas |
| 5. | Physical | -13 | • Disparate settlements spread across the city<br>• Access difficulties within the communities | • High density of housing |
| 6. | Financial | -12 | • Current level of payment for services is extremely low<br>• Disparate spread of communities | • High level of mobile phone ownership for potential payment by Mobile Money or similar |
| 7. | Accommodation | 17 | • No major barriers | • Most houses larger than a single room with average dwelling size of 3.25 rooms per house |
| 8. | End-use products | 28 | • No major barriers | • Very large market for biogas<br>• Very high levels of acceptability of all product types |
| 9. | Enabling Environment | -7 | • Limited appetite to support squatter settlements<br>• Availability of free issue land for treatment facility in very short supply | • Legal restrictions on the construction of infrastructure |

Each of the criteria in the matrix was considered in terms of the degree to which the condition was exhibited within the case study areas of Kathmandu. As such the individual criteria were scored between -3 and +3 depending upon the extent to which the condition was found to be

present with the case study environment; a score of -3 would imply that the level of incidence and impact of that specific condition within the study area context was universally negative. The range of values up to +3 would then reflect increasingly positive levels of impact upon the viability of CBS. A relative weighting factor of between +1 to +3 was then applied to each condition to give a total weighted value of between -9 and +9 for each component.

This process therefore was used in order to identify any factors which could significantly affect or even prohibit the successful implementation of a CBS service. Thus, any factors which attracted a weighted score of -9 would need to be recognised and considered carefully to determine the total extent of their likely impact on the potential viability of CBS. Likewise, factors with a weighted score of +9 should also be recognised for their potentially significant positive influence that they may have on the success of the service.

As part of the analysis, five negative factors were identified as having a maximum impact (weighted score of -9) while only one positive factor having a maximum impact (weighted score of +9) was revealed. These main negative and positive impact factors on the potential of CBS that were identified during the completion of the scoring matrix as shown in Appendix L are summarised in Table 4.6 below. This table thus extracts and highlights the key factors (i.e. those that scored either -9 or +9 in the scoring matrix shown in Appendix L) that may have significant positive or negative effects on the potential success of any CBS implementation.

*Table 4.6 Main negative and positive factors resulting from case study analysis*

| **Negative Factors** | |
|---|---|
| **Factor Description** | **Implication** |
| Extent of payment for sanitation services historically by residents of community. | Very low familiarity with concept of paying for sanitation, which will affect potential paying customer base |
| Impact of anal cleansing practices on CBS implementation | Anal washing practiced universally. Impact on running costs of service and potential for use in public toilet context |
| Availability of private household or on-plot sanitation facilities | High level of availability of private facilities, therefore limited demand for CBS service |
| Availability of required space locally for treatment facility establishment | Densely populated area. Very limited scope for local establishment of treatment facility |
| Willingness to pay/current level of payment (e.g. pit emptying, public toilets, etc.) within the community for sanitation services | Current low level of acceptance to paying for a sanitation service; therefore, a cultural change would be required for widespread adoption of any scheme |
| **Positive Factors** | |
| **Factor Description** | **Implication** |
| Impact of the average housing size on the potential for CBS implementation (e.g. number of rooms, type of rooms, etc.) | Most houses have more than a single room with average dwelling size of 3.25 rooms per house, therefore minimising issues around the location of a toilet within the home |

# 5. Discussion

## 5.1. Influencing factors and conditions affecting CBS viability

During the literature review and KIIs with CBS organisations the factors and influences affecting the potential success of any CBS service were found to be wide ranging and diverse, and very much dependent upon the context and culture within which the service is operating. This section aims to extract and collate the factors into general themes that should be considered prior to the implementation of any CBS service.

### *5.1.1. Cultural factors*

The impact of cultural factors on the viability of CBS can be significant. Many of the CBS organisations have encountered difficulties in identifying the existence of cultural barriers prior to the introduction of the service which have subsequently impacted their success or method of implementation. Based on the experience of the existing CBS businesses and their amassed knowledge, identifying the types of cultural barriers that exist is a little more straightforward. But due to the implicit context specific nature, and the wide-ranging existence of cultural factors, identifying them prior to implementation may not always be possible, as the issues may only come to light once customers actually start to use the service and the full scale of operations are commenced. Despite this, it is important to identify the existence of any potential cultural barriers to the service prior to implementation, as far as is reasonably practicable; this will ensure that the business model and method of operation align with the impacts of any cultural practices and to ensure that the service operates as efficiency as possible in the given context. In order to achieve this, thorough market research needs to be undertaken to establish the existence of any cultural barriers prior to determining the structure of the business model.

The acceptability of locating a toilet actually within the home needs to be determined if the service is to operate at a household level. The size of the properties may influence this, as it may not be convenient or afford much privacy if the houses are generally very small or are only a single room. The layout of the properties can also have an effect on this factor as often residents will not want to defecate near or in areas where food is prepared. Alternatively, the acceptability of locating a toilet on-plot but outside the dwelling should be assessed. This is particularly important if there is generally insufficient space available inside the dwelling or locating the toilet inside the home is found not to be acceptable for some other reason; for example, the room layout or not wishing to locate the toilet in a room which the inhabitants use for prayer may make the location of a toilet within the home socially unacceptable. The ideal conditions for CBS are for the size and layout of the dwellings to be sufficiently large to enable a toilet to be located within the home, without impacting on the lifestyle of the residents.

The reaction towards and the familiarity with the concept of paying for sanitation needs to be identified, especially if the business model of the service will be dependent upon a certain level

of payment. In areas where residents are not used to paying for sanitation services, implementation of a paid-for service will be more problematical and will require a change of culture which should be allowed for in the rate of uptake of the new service. The reaction of the residents to the concept of paying for a sanitation service should be assessed to determine the likely uptake of the service and will also give an indication as to the service charge that could be levied and thus the revenues that might be expected. Preferably the residents of an area being considered for potential CBS introduction would at least be familiar with the concept of paying for sanitation; ideally the residents would already be paying for a service, so the cost of the CBS service can be compared to their existing expenditure.

If the proposed model for CBS implementation involves the users emptying their own urine containers, or transporting their filled containers of faeces to a collection vehicle or waste transfer station, the level of acceptability of this requirement needs to be gauged within the target communities. If this process is deemed to be offensive or distasteful, the implications on the method of collection, and options for urine disposal need to be investigated and costed to determine the financial impacts on the business. If residents are accepting of this practice, more flexibility in the operational details would exist and also the potential for reduced operational costs.

The typical methods used by the community for anal cleansing need to be determined, as this can have significant impacts on both the hardware designs and the operational processes of the business. If washing is usually practiced, the collection and disposal of the wash water needs to be considered; additionally, the method by which the washing is undertaken by the user, needs to prevent the wash water from actually entering the faeces container. Conversely, if wiping is the usual method adopted for cleansing, then the disposal process of any wiping materials needs to be understood, although this is generally less of an issue as used toilet paper can usually be disposed of on-site by incineration or with household solid waste. Therefore, the widespread practice of wiping to cleanse anally would be more suitable for the introduction of CBS as it avoids the complications introduced by the collection and disposal of any wash water.

Most residents of developing countries usually tend to squat during defecation. However, the general posture adopted to use most CBS systems requires the user to sit on the CBS toilet itself and therefore the attitude and response towards this change of posture needs to be ascertained. In many cultures, the move towards a more western seated posture is seen as a status symbol, and one of prestige and desirability, although this is not unanimous; some cultures find making the switch from squatting to sitting difficult to make. The ideal initial situation from a CBS perspective would be either of a culture that is already familiar with the practice of sitting, or one in which the concept is found to be acceptable or preferably desirable.

Research should also be undertaken to identify any other cultural or religious practices performed that are specific to the proposed community, that may never have been encountered

by other CBS organisations before. In order to do this, the precise details of the service should be reviewed with a cross section of the community in order to obtain their response and to identify any concerns or barriers that might exist which could potentially affect the success or business model of the service.

#### *5.1.2. Existing sanitation factors*

The existing sanitation facilities and the level of satisfaction amongst the community with those facilities needs to be determined, as these factors will identify the potential requirement for an improvement in the services, but also the likely extent of the demand within the community.

The different types of services that are available need to individually assessed to gain an overview of the whole sanitation market of the area. If public toilets are used on a widespread basis, the user opinions on levels of convenience (e.g. opening hours), proximity, cleanliness, security and costs need to be determined. Similar responses into the relative availability, cleanliness, convenience and costs of other available sanitation facilities such as communal or shared amenities should be obtained, in addition to the prevalence of household toilets. By quantifying the availability of the existing sanitation and the levels of satisfaction with those facilities, an appreciation of the extent to which a convenient, hygienic and safe CBS service might be embraced can be acquired. A community reliant on limited sanitation options with inadequate levels of availability, cleanliness and convenience are likely to be more receptive to the concept of CBS, especially if the existing options require payment in order to use them.

The availability of a nearby piped water supply or suitably sized sewer network should be determined to understand the potential for, and likelihood of, future improvements in sanitation infrastructure within the community. If these services are not located nearby, and are not expected to be delivered in the future, then the necessity for alternative and acceptable sanitation facilities is amplified and thus increases the potential demand for a CBS service.

The ideal conditions for CBS implementation exist in communities with limited or non-existent access to a sewer network and with no impending likelihood of improvement in the infrastructure in the future. If the subsequent reliance of the communities is placed upon insufficient, expensive, inconvenient, insecure or remote public facilities or unhygienic, unreliable and malfunctioning on-site or communal facilities then the demand for CBS is further strengthened.

#### *5.1.3. Operational factors*

Depending on the logistical requirements of the collection service, sufficient space to locate waste transfer stations may be required. This can be particularly problematical in high-density, residential, urban and peri-urban environments, where the availability of sufficient space is limited and is compounded by low levels of acceptability by residents to the location of a human waste storage facility within their neighbourhood.

The same issues are relevant and apply to the establishment of treatment facilities. Therefore, if end-use products are to be created or a treatment and disposal facility is required, then the availability of appropriate and sufficient land needs to be ascertained. The close proximity of the treatment or disposal facility to the service area needs to be retained in order to minimise the transport costs and to maximise the efficiency of the process. Likewise, if the conditions for the resale of end-use products are not favourable, as described in section 5.1.8 above, or the costs of internal treatment are prohibitive, then the availability of existing, local treatment facilities with sufficient capacity needs to be pursued.

An economical and readily available supply of an appropriate cover material needs to be identified for most dry CBS systems to function economically, without requiring the use of bespoke sealing systems, such as the polymer membrane utilised by Loowatt. The prevalence of conducive local industries (e.g. sawmills), cultivation of crops with appropriate by-products (e.g. sugar cane, rice, etc,) or local customs (e.g. burning firewood to create ash) which are able to provide adequate quantities of suitable materials in a cost-effective manner need to be assessed; this is required in order to determine the financial and operational impacts of the logistics and costs associated in obtaining adequate quantities of suitable materials.

The availability of a suitably qualified workforce with the ability and tolerance towards the collection and sorting of human waste needs to be determined, although most CBS services have found that employees of existing manual pit emptying businesses have been keen to join their organisations due to the improved working conditions and hygiene associated with CBS.

Assessments should also be made of the relative levels of transience of the population and permanence of the structures within the communities. The temporal nature of the housing and layouts of the peri-urban communities in which CBS services are generally most appropriate have a tendency to change, both visibly and actually, on a regular basis leading to difficulties in locating and recognising customers' properties. In such situations, methods need to be established to deal with such obstacles, to ensure that collection is still achieved in an efficient manner. In a similar vein, the ease of exchanging the containers and collection of the fees need to be considered; understanding patterns in the hours of occupation of customers' homes can lead to more efficient collection schedules, while levels of mobile ownership can give a good indication as to the potential for Mobile Money payments, which can be used to significantly improve the cost-effectiveness of tariff collection.

#### *5.1.4. Geographical factors*

There are many geographical and geological factors that can affect the appropriateness of traditional on-site sanitation solutions, particularly pit latrines. In such circumstances, where residents have been restrained by their lack of options and have been required to accept inappropriate and poorly functioning sanitation facilities, CBS has real potential to improve the living conditions of residents, and therefore should have a considerable demand. For example,

areas where excavation is difficult either due to ground conditions (e.g. rocky ground, unstable ground) or existing hard surfacing (e.g. concrete, asphalt) may mean that construction of pit latrines simply isn't feasible. Areas where high water tables exist with subsequently low ground infiltration rates, are generally not conducive to the functionality of pit latrines; flood prone areas also present major pollution risks and inundation problems when on-site sanitation facilities are provided in such environments.

These factors all provide increased incentives and strong motivators to the likely potential for adoption of CBS, due to the inadequacy of the existing sanitation facilities. These conditions present challenging constraints to which CBS appears to be one of very few, if not the only, viable solution. Onsite sanitation can also seriously impact on the quality of groundwater sources used for drinking, a cause of pollution that can also be reduced through the use of CBS.

The topography of the community needs to be considered in order to determine whether it affects the type of collection vehicles that can be operated as part of the collection service. Although not generally a major issue, and certainly not one that could significantly affect the viability of any CBS service, it is something that still needs to be taken into account in determining the method of collection and transport – a process which can considerably impact on the efficiency and cost-effectiveness of the business model as a whole.

#### *5.1.5. Physical factors*

The physical characteristics of communities can affect the potential of successfully introducing a CBS service. CBS generally lends itself to high-density settlements, where a high concentration of customers can be established; this increases the overall efficiency of the service, and as such is a key requirement in creating a sustainable model. However, access into and within very dense settlements can inhibit access to large vehicles. Therefore, the ease of access into and around the community and any restrictions that the physical layout or width of alleys and passageways may impose on a CBS collection service need to be considered; this is especially significant in regard to the effect on potential efficiency, collection vehicle size and the overall process of collection.

The shape of the settlement can affect the efficiency of the service, as longer collection times will be experienced in linear rather than nucleated settlements due to the increased distances required to be covered. The size and market potential of settlements also impact on the potential economy of the service; if the potential setting consists of numerous, small, disparate communities, then the proximity of the individual areas in relation to each other needs to be assessed to determine the impact on the efficiency of collection.

#### *5.1.6. Financial factors*

The financial aspects and efficiency of every CBS service are key drivers in its development to become sustainable. The implications of the operational methodology and treatment method

have significant impacts on the cost-effectiveness of all the CBS organisations. In terms of the specific conditions that need to be considered in any given area, the existing practice of paying for sanitation services, and thus an implied high level of WTP is probably the most important factor, unless the chosen business model does not rely on payment by the users, as is the case with Sanitation First. The ATP should also be considered, although a true figure of WTP should reflect the community's actual ability to do so.

The identification of an efficient method of collecting tariffs is also an important factor as methods that involve door-to-door collections are highly inefficient and time-consuming. If a system such as Mobile Money can be utilised, or any system in which the onus is placed on the customer to make the payment rather than on the service provider to collect the payment, greater efficiencies will be achieved. Indicators such as level of mobile phone ownership can provide a good sign as to the potential for setting up some form of remote payment system.

The density of the potential customer base is a critical factor in achieving sustainability and efficiency. Density of customers differs from density of population, as a high density of population does not always convert to a high-density customer base if levels of adoption are low. The densification of customers is crucial if an efficient service is to be provided, as the collection and transport costs incurred are directly related to the time and distance travelled between individual collections.

The costs of the toilet unit itself need to be minimised, as often this cost element is difficult to recover. Therefore, if the toilet can be produced in country from local materials, not only will the product be more sustainable, it will also provide income for the local economy, and be less vulnerable to external factors. Therefore, the ability and capacity of the country to undertake this process should be evaluated.

#### *5.1.7. Accommodation factors*

The size of the properties, in terms of total number of rooms, occupants and dimensions, within the target area needs to be determined; if the houses are generally small, or a single room, or if they are overcrowded, the adoption of CBS will be severely affected due to issues associated with lack of privacy and available space. The layout of the houses is also an influence as if the only available space is near areas used for cooking or prayer, then there may be a reluctance to accept a toilet located within the home.

If the amount space within the home is a constraint, the availability of sufficient space outside the home, but still on-plot should be assessed. With the inherent mobility of CBS toilets, the unit can always be moved outside during the night or when not being used if sufficient space is available.

The number of storeys can also have an impact on the efficiency of the service, especially if the collection is to be undertaken by the service provider themselves. Multi storey buildings can

impede the use of trolleys or other manual trucks to reach customers individual properties and thus increase the collection times and effort required.

The degree of transience of the population can affect the level of adoption of a CBS service. If residents only see themselves as temporarily inhabiting an area then their inclination to sign up to a regular service may be reduced. Likewise, the costs of constantly signing up and deregistering a high turnover of customers with short contract periods is an expensive and unproductive process for any CBS organisation.

CBS can provide a useful and appropriate form of sanitation in areas where significant and prevalent issues associated with land ownership and tenure status exist. In areas where residents are squatting or occupying land illegally, there is little inclination of the residents to invest in infrastructure themselves, as they are unable to determine how long they might be permitted to remain in their homes. Likewise, utilities and authorities are usually unwilling to provide services to these settlements for fear of implying legitimacy onto the communities. This stalemate can be resolved through the introduction of CBS, which does not require any form of permanent construction for installation and is also quick and easy to remove should the residential status of a user change. With this in mind, the land tenure status of the residents of a community can provide a good indication towards the potential demand and appeal of a CBS service.

#### *5.1.8. End-use product factors*

In order to determine the end-use product potential for a CBS service in a given area, several factors need to be considered in order to ascertain the best strategy for implementation. Initially, the level of acceptability and the local response to the use and sale of products, created through the treatment of human waste, needs to be measured. If significant cultural or religious barriers exist, then the sale of such products would not be acceptable or cost-effective. Once the level of acceptance is established, the relative size of the potential markets for each of the product types should be determined, as there is little value in creating any form of product if a demand for that product does not exist. The cost of production and also the potential resale values of the different products need to be calculated; the resultant profit margins can then be applied to the previously determined market sizes to weigh up the relative financial potential of the different product options. The proximity of the market also needs to be considered as transport costs need to be minimised, so ideally an adequate demand for the produce should be available locally.

If the treatment and production costs of creating end-use products are significant, it may be that disposal of the waste is a more viable and cost-effective alternative proposition, but this is dependent upon an existing facility with sufficient capacity being available.

With regard to the identification of the ideal conditions required for an end-use product market to flourish, acceptance of the source of the raw materials needs to be widespread, with sufficiently low production costs incurred, combined with a healthy demand and resale value to make the process sustainable.

#### *5.1.9. Institutional factors*

The level of support and assistance that might be expected by government departments, utilities and other administrative bodies can provide significant help to a CBS service, particularly during the initial phases and launch of the service. Conversely, opposition or resistance to the introduction of the service can significantly affect the potential for successful establishment. The existence of an enabling environment, specifically with regard to the institutional opinion of CBS, needs to be evaluated to determine the impact that the existing institutions and authorities might have on the success of a CBS service.

Enquiries into the types of assistance that might be afforded to aid the establishment of CBS should be made with relevant utilities, departments and organisations. Help that could be offered by government or existing utilities might include:

- Provision of freely available land for the establishment of treatment facilities
- Collection of sanitation tariffs by an existing utility if an 'interest' and ability to do so exists
- Provision of a tax holiday, particularly during the early stages of establishment
- Provision of funding or subsidies to aid with cash flow and sustainability issues

The process of identifying any legal restrictions that might exist that could affect the operational methodology of a CBS service should be undertaken. Local regulations, such the Manual Scavenging Act encountered by Sanitation First in India, can have a significant impact on the way in which the service is actually delivered and therefore on the operating costs and efficiency of the service.

Legal restrictions on the construction of infrastructure in illegal settlements may actually increase the appropriateness and relevance of a CBS service, as this constraint may seriously restrict the range of sanitation options that are available to a community to those which rely on limited or no infrastructure at all. In illegal settlements authorities are often unwilling to give consent for the construction of formal sanitation in the communities for fear of implying legitimacy of occupation to the residents. Therefore, where such restrictions exist, CBS can offer a unique method of providing a vital sanitation service to the communities without a requirement to undertake any physical construction works.

#### *5.1.10. Summary of factors*

The number of influencing factors on the potential of CBS in any given area is extensive and very specific to each individual locale. Therefore, thorough investigation and research into the existence and prevalence of any influencing factors should be completed in order to determine

the extent and impact of their respective consequences. However, the typical conditions and situations in which CBS is particularly relevant and appropriate are in high-density, informal urban and peri-urban settlements, where no access to conventional sanitation exists (and is unlikely to exist in the future) leading to a reliance on public or on-site sanitation facilities. If those public facilities have additional shortcomings, such as inadequate levels of hygiene, inconvenient opening times or security issues and concerns, then the requirement for improved sanitation is intensified. Likewise, the existence of a high water table or proneness of an area to flooding can make a community that is reliant upon on-site facilities vulnerable to health and disease related risks. If these conditions exist then CBS can provide an appropriate sanitation solution, in environments where few other alternative options remain, provided that no local cultural or religious traditions are practiced which might conflict with the acceptability of the operation and inhibit the overall adoption of the service.

## *5.2. Improving the efficiency and cost-effectiveness of CBS*

The existing CBS organisations have spent recent years constantly refining and tweaking their processes and methodologies in efforts to streamline their procedures and develop sustainable models that can provide sanitation services in areas that have previously had very low levels of access to sanitation. However, none of the organisations are currently able to operate without financial assistance, through some form of subsidy or grant, in order to remain viable. Therefore, there is still a requirement to improve the efficiency of the services further to make their processes as economical and cost-effective as possible, for which there are many potential options to investigate.

Probably the most critical factor in achieving high levels of efficiency for a CBS service is the attainment of a dense customer base. This is required in order for the economics of the collection service to become financially viable. Fundamentally, this factor requires a collection team to cover as little ground as possible whilst still collecting as much waste as possible. Therefore, a focus on dense, urban slums provides the best conditions for CBS viability, although refugee camps may also prove to afford sufficiently high user density to ensure that a service is workable. A high-density customer base also leads to significant improvements in public health; if only 10% of the population have access to improved sanitation, the massive health risks associated with low sanitation coverage will still exist. However, once that level reaches a figure nearing total coverage, the improvement in health outcomes becomes significant, which is ultimately the goal of providing sanitation in the first place.

The density of the actual settlement itself remains a relevant consideration, as once communities become so dense that dwellings become restricted to a single room, then the provision of exclusive but shared facilities or public facilities need to be investigated. A dense customer base for CBS creates a much more efficient process logistically, more akin to a

western style refuse collection service, rather than a courier service for containers of faeces which is the case when a service runs at a very low density of customers.

An increase in the total number of customers will also bring with it inherent economies of scale in terms of buying power (of both the toilets themselves but also other materials/consumables), reduced overheads and the overall cost associated with each individual customer.

The logistics of any CBS service need to be optimised to their fullest to ensure that maximum efficiency is obtained. There are many ways that this can be achieved, and there are still options and possibilities that need to be explored. Areas for consideration include:

- The capacity of the collection vehicles - Capacity should be maximised in order to achieve the highest quantity of collections made per collection round.
- The number of collections made per customer – Minimising the frequency of collection will maximise the efficiency of the service, providing that odours and the volume of waste do not become a factor leading to increased customer attrition.
- Maximising the use of mobile payments to improve the efficiency of the tariff collection process - Improvements in automated billing systems and the management of customer data can also be achieved as a result of improved I.T. systems. Subsequent improvements in efficiency result from the use of tariff collection systems based on electronic or remote payments. Customer management processes can be streamlined through the adoption of electronic data management systems, leading to lower overheads for the organisation as a whole. The use of electronic or mobile payments is also far more secure, particularly when the area within which the service is provided is subject to high levels of crime.

Other innovations that may have the potential to improve the efficiency of the logistics would be through the introduction of mobile collection hubs. The service provider could deploy a collection vehicle or trailer to a specified location, at a specified time and for a specified duration. Customers would then be able to carry their own filled containers to the hub where they could exchange them for empty ones. This process would reduce the overall collection costs of the service provider and enable the collection to be undertaken by a much smaller workforce. The use of biodegradable bags by X-runner also removes their requirement to clean the containers which is a further efficiency saving, although the current cost to purchase the bags that are used needs to be reduced.

Another option that might have potential would be through the introduction of an improved cartridge design. If the cartridges were designed in such a way that, on removal from the toilet base, the cartridge is automatically sealed with a watertight, roller-shutter style of lid, then the risks posed to the user, by carrying the containers themselves, would be significantly reduced. Hubs could be left in position permanently, filled with a supply of empty cartridges that are

gradually exchanged by customers with their filled ones. The hub is then exchanged as a single unit by the service provider, thus dramatically improving the logistical costs of the operation, whilst still minimising any risks to the users. Empty cartridges could be inserted into the toilet by users themselves with the lid retracting automatically as the cartridge enters the base unit. This type of option would require further investigation into the potential viability of such a system, both in terms of the costs but also the usability of such a system, but it may be one way of improving the ultimate efficiency of the service.

If a high density of customer base is achieved over a significant area, then CBS collection could potentially be undertaken at the same time that household solid waste is collected. This would obviously require bespoke collection vehicles to maintain separation of the waste streams but could offer potential savings in terms of efficiency of collection. However, there is no reason to suggest that collection of human waste is *logistically* more complex than that for solid waste collection, which is practiced widely across the globe.

Until now, the CBS organisations have invested significant amounts of time, and therefore money, in developing their own individual toilet designs and models. Therefore, there has been a significant overlap and replication of the development process in creating products that are reasonably similar in principle. By pooling their knowledge and experience, the CBS organisations could develop a unified line of standardised products for use within different contexts. Currently none of the organisations are large enough to undertake mass production, and therefore are unable to obtain the kind of savings that could be made if they were able to do so. Through the creation of standardised designs and moulds large-scale, collective orders could be placed for mass production, thus minimising the initial purchase costs but also, through the sharing of knowledge, improving the quality and effectiveness of the overall design.

The market potential for the sale of end-use products needs to be assessed at a local level to determine whether sufficient demand exists for any of the currently available products. Once this is established, the cost-effectiveness of treatment and end-use product creation needs to be calculated and compared to the cost of utilising an existing disposal site, if one is available, to determine the most economic method of operation. In this way, it is the market that determines whether the waste is utilised to create an end-use product or whether treatment and/or disposal provides the most cost-effective option.

Through closer cooperation between CBS organisations and following the formation of the CBS Alliance, the efficiency of CBS services will become ever more efficient and cost-effective, as the processes and procedures are progressively refined and developed.

## *5.3. Future role and marketplace for CBS*

Despite the continual drive in constant pursuit of ever increasing efficiency by the CBS organisations, it is still unclear whether it will ever be possible to create profitable, or even

revenue neutral, standalone businesses. Despite the high initial costs of conventional sewers, the operating and maintenance costs of such systems should be lower than those of CBS, due to the lower levels of human resources and equipment required to collect and transport the waste; however, the actual costs incurred in operating and maintaining a sewer system are debatable. In any case, conventional sanitation systems across the globe generally do not recover their costs and require some form of subsidy to remain operational (Russel, KII, 11/7/17), so it seems unlikely that a service designed to serve the very poorest in the world would therefore be able to become cost neutral. In order to make the system profitable, the required increase in price would ultimately exclude the very poorest, who are generally the people in most need of the service.

Despite these financial complications, CBS remains an appropriate and viable sanitation solution in certain contexts. In high-density urban and peri-urban areas, where no formal sanitation exists, and other forms of on-site or public sanitation are either inappropriate, inadequate or inconvenient, then CBS is often the only feasible option, given the existing constraints. In order for many countries to meet their SDG targets, the demands of these communities need to be served, and so CBS does have a role to play in the overall suite of sanitation options available.

From their foundation, Sanitation First realised that in order to be sustainable, their service needed to be financially viable. However, they determined to achieve this through a mechanism other than charging the actual users to ensure that they would be able to serve the very poorest of the poor; this is achieved through the provision of a variety of grants and donations. For this reason, Sanitation First established their driving ethos from the outset to ease poverty through the provision of sanitation, by reducing the financial effects resulting from a lack of sanitation. Sanitation First recognised that by reducing the incidence of illness, and the resulting loss of work and school days, combined with the subsequent decrease in the expenditure required to purchase medication, the ongoing cycle of poverty could be broken (Kirby-Garton, KII, 24/5/17).

With the ever-increasing prevalence of water scarcity around the world, and the consequent increase in the value of water as a result, methods of dry sanitation will no doubt become more widespread. In a world where water is becoming such a finite resource, the use of it as a method of transporting faeces along pipes will become increasingly controversial, particularly in areas where the supply of water is limited. The addition of such large quantities of water to the faeces in order to transport it, adds to the complexity, energy requirements and costs of the treatment processes due to the high water content of the inflow when it eventually reaches the treatment facility; this is especially true if end-products are expected to be produced.

A promising future format of CBS provision could be through the formation of public private partnerships (PPPs), whereby the local government employs the services of a reputable CBS business to deliver a safe and hygienic sanitation service to areas that would otherwise not be

reached. By using PPPs, the added advantage to governments is that it can serve areas where issues associated with land tenure exist, without being seen to actually recognise the occupants right to remain there, or to legitimise the settlement, which is often one of the underlying reasons for lack of services in the first place. So, through the use of private companies, sanitation can be provided to illegal or squatter communities without the government actually having to engage directly with the community itself. The government may also be able to provide the CBS companies with the facility of using municipal treatment facilities; this would be a particular advantage if the local market for end-use products is not favourable. Through this type of support, the burden of treatment costs placed on CBS businesses would be removed, allowing them to concentrate on the collection and transport components of their service, and thus increasing their revenue potential.

One of the main reasons why the prevalence of CBS has not reached large scale deployment, and is still currently only provided by a few isolated organisations, is that the technology is not currently recognised by the Joint Monitoring Programme (JMP) as a form of improved sanitation, which has recently been further developed into “Limited”, “Basic” and “Safely Managed” categories (World Health Organization & UNICEF 2017). Without this accreditation, any application of CBS will therefore not be counted towards helping countries meet their SDG targets. With this in mind, countries who are focused on meeting these goals are unlikely to invest significantly in a technology that does not help them towards reaching their targets in any way. The recognition of CBS as a form of improved sanitation is therefore critical if the technology is to be adopted in large numbers across the world. For this reason, the recent recognition of the Kenyan government of including CBS as a form of improved sanitation in their Environmental Sanitation and Hygiene Policy is an important stamp of approval (Republic of Kenya Ministry of Health 2016). This gives the technology an increased air of legitimacy and provides further encouragement that the prospect of universal acceptance by the JMP and the wider WASH sector will be realised and that CBS will ultimately obtain the required acknowledgement as a recognised form of improved sanitation.

The creation of the CBS Alliance was established by the CBS community to create a charter and develop a code of conduct that will define standard practices and operating procedures for CBS. By working with WHO and government officials, the Alliance is working on the production of an SSP for CBS which will subsequently be used to create a typology of sanitation safety for CBS. Once completed, this will provide additional weight to the case for CBS to be recognised as an improved form of sanitation. If this recognition is achieved, then significant scale of CBS operations will be much more likely to become a reality.

Reaching scale would not necessarily be as a consequence of the growth of the existing CBS organisations. Replication of their business models would enable widespread, rapid growth in the deployment of the technology, through the use of a limited variety of standardised, approved

hardware for use in specific contexts. With replication however, would come the risk that without sufficient regulation, those who are purporting to provide CBS services do not actually adhere to the required standards, and therefore do not satisfy the steps of the SSC. It is therefore crucial that any organisation replicating the CBS model follows the standard operating procedures and doesn't attempt to 'cut corners' to prevent damage to the reputation of CBS, particularly during the early stages.

Another format for the future of CBS may take the form of splitting the delivery of the service into CBS solution providers (responsible for the provision of hardware, mobile applications and financing, etc.) and CBS service providers actually operating the services (undertaking the collection and transport, etc.) (Mikael, KII, 26/5/17). If strong branding is established in any given market, then the potential for franchising exists, similar to the model that Sanergy currently use to operate their FLTs. Once these types of arrangements have been established, concession contracts between governments and service providers could easily be agreed, similar to those used around the world for the collection of solid waste. In this way, governments would be able to provide sanitation in complex and problematical contexts without direct involvement, and thus improve their chances of meeting their SDG targets.

CBS may prove never to become a totally sustainable, standalone business model. However, CBS as a technology is uniquely suitable as a form of sanitation in certain contexts. In high-density communities, where issues of inadequate, unsanitary or inconvenient sanitation provision are compounded by land tenure or ownership problems, then CBS can provide an effective solution in situations where exceedingly few other satisfactory or realistic options exist.

## *5.4. The potential of CBS within Kathmandu*

Following analysis of the findings of the field work undertaken in Kathmandu, the potential of CBS within the city varies significantly between the different case study areas. The degree of permanence and organisation within the communities, combined with the varying levels of sanitation provision, result in contrasting levels of demand and requirement for improvements in sanitation.

In the more well-established settlements, the wide availability of existing household facilities seriously affects the need for an improved sanitation service and therefore demand would be low. Even in the less well-established and more temporary settlements, access to sanitation is not totally lacking, albeit with a far higher level of dependence on shared facilities; the lower level of availability was conveyed by the decreased satisfaction expressed by the community members in the less well-established areas, which led to increased demand and interest in the CBS concept. The degree of demand corresponded to a direct relationship with the level of WTP; in the more established settlements the WTP encountered was very low, whereas in the

more temporary communities, where conditions and sanitation facilities are far less acceptable, the WTP of the residents was found to be somewhat higher.

Within the city as a whole, a culture of paying for sanitation services does not feature strongly; a lack of paid-for public toilets and sewers discharging straight to rivers means that the only sanitation service anyone really ever pays for is used to empty septic tanks or pit latrines. This situation means that in order to introduce a service that would require a regular, ongoing payment, a total change in the mindset of the customers in their attitude towards the value of improved sanitation would be required, which may be a time consuming and costly process, with no guarantee of successful achievement.

The virtually universal, widespread practice of anal washing in order to cleanse after defecation introduces significant additional requirements and considerations for a CBS service provider; the impacts of wash water containment, collection and disposal will require consideration to establish the implications in terms of the overall costs and sustainability of the service. Complications, in terms of the additional water requirements, as well as the impact on the collection vehicles and processes would also need to be considered although the overall costs will no doubt increase as a result of this cultural practice; this may prevent a marginally sustainable business model from actually being able to exist without some form of subsidy or funding.

The high-density, built-up environment of Kathmandu city makes the location of sufficient and appropriate land to site both waste transfer stations and treatment facilities particularly difficult. KMC itself received opposition from local residents to their FSM plant in Teku whilst it was operational. If the ultimate treatment facility cannot be established within easy reach of the source communities, then the costs of the transport element of the service will be increased.

Characteristics of the sample communities which would have a positive impact on the potential of CBS were less numerous. However, the size and number of rooms within the dwellings of the communities would generally enhance the potential acceptance of the service as virtually all the homes surveyed have at least two rooms if not more.

In terms of the potential application of CBS as part of a solution to the current inadequate public toilet provision in Kathmandu, the two main barriers to this proposal would be the lack of institutional support, combined with the prevalence of the practice of anal washing. Despite the absence of any significant infrastructure improvements required to implement a CBS public toilet solution, the complications introduced by the culture of anal washing and the limited enthusiasm expressed by KMC would be prohibitive.

The appropriateness of CBS in the communities studied seemed to be entirely dependent on the very specific conditions found within each area; CBS would therefore appear to be more appropriate in specific circumstances due to localised conditions rather than to the squatter

settlements within the city as a whole. For example, in Balkhu the community is suffering as a result of the ongoing construction works, which have severely affected the functionality and quantity of sanitation facilities available, and thus increased the potential interest in CBS. However, without the presence of the current construction works, the residents may have been less inclined to express an interest in CBS as was the case in the more established settlements. Likewise, in Thapathali where the settlement had been demolished in 2012, the enthusiasm for CBS was heightened by the lower standard of sanitation resulting from the previous eviction. Therefore, widespread adoption of a CBS service by squatter communities of the city would seem to be unlikely, and especially not to a great enough extent to give the sufficiently high level of demand that is required in order to achieve an economical and sustainable service.

The sanitation facilities available to the majority of the residents living in the squatter communities are not of significant concern to the inhabitants. The standard of facilities, especially within the less well-established communities are unacceptable in many cases, but those in the more developed settlements are consistent with other facilities found in the city. The fact that the majority of the squatter communities are located on river banks, enables reasonable standards of sanitation to be established relatively easily without significant costs. The toilets in the communities can just discharge directly to the adjacent rivers without the need for lengthy sections of pipework. Direct discharge of their toilets to the watercourses, although far from ideal, is ultimately no different to that of 95% of the entire population of Kathmandu; despite the widespread prevalence of household toilets, whether connected to a sewer or septic tank, the vast bulk of human waste eventually ends up being discharged into the rivers without treatment. Therefore, the inhabitants of the squatter communities are no guiltier of polluting the environment than the remaining majority of the population of the city.

The main issue within Kathmandu, in terms of the sanitation, is the sheer lack of WWT and FSM. Once this has been resolved then the methods the squatter communities employ to dispose of their human waste might be scrutinised to a greater degree, at which point CBS may become a more appropriate option, but until such time the potential of CBS within Kathmandu would certainly seem to be limited.

# 6. Conclusions and recommendations

This research set out to establish under what conditions and in what context the concept of CBS becomes viable, and then investigate whether the squatter communities in Kathmandu presented an opportunity for the successful application of the technology. Research objectives were established that would need to be met in order to accomplish the overall aim of the study. To determine whether this aim has been satisfied, a review of the research objectives has been undertaken in order to establish the extent to which success has been achieved.

## *6.1. Achieving the research objectives*

The research objectives presented in section 1.8 are reintroduced in this section in order to review the findings of the study and establish whether each individual objective has been successfully accomplished.

### *6.1.1. Research objective 1*

*Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work.*

Through a combination of reviewing the limited publicly available literature and interviews of key individuals within the sphere of CBS, a thorough comparison of the different business models and processes employed by the organisations to provide their service was made. The reasons for the variations, in terms of how the services are actually delivered in relation to their specific contexts, were also explored; this was carried out in order to understand how the environment and circumstances within which the service is provided influences and shapes the ultimate model used for delivery. Every stage of the SSC was considered for each organisation to explore the obstacles that have been encountered and the resulting solutions devised to overcome the hurdles in each case. A review of the actual toilets that have been developed was incorporated into this element of the research in order to understand how the designs had evolved and for what reasons. The assorted types of end-use products created by the different organisations were appraised to understand the reasons for the variation in kind of products made.

On completion of this objective, a much clearer picture of the CBS community emerged in terms of the overall processes, scale and contexts in which the organisations operate. Initially, the services appeared to be very similar, but following further investigations distinct differences between them emerged, the reasons for which required resolution through the satisfaction of the following research objective.

### *6.1.2. Research objective 2*

*Investigate CBS services to determine and "distil" the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation.*

In order to fulfil the second objective, deeper exploration was undertaken to investigate the preceding conditions within the areas of operation prior to the introduction of the service and to understand why the concept of CBS had been considered to be appropriate in the first place. This process enabled the identification of the factors and conditions required in order for CBS to be an appropriate option for consideration as a potential sanitation solution.

The developmental processes that the organisations have undergone were discussed in order to reveal any cultural practices or traditions that had been encountered and which had caused issues or problems that had needed to be resolved. The methods of resolution were also discussed to establish how potential barriers had been dealt with, and what the implications of the difficulties encountered were on the eventual method of implementation. Other problems and hindrances that were faced, due to the physical, geographical or political conditions presented by the locations where the services operate, were ascertained in order to understand the full scope and range of possible difficulties and obstacles that might be encountered by any future application of CBS.

Through this process of enquiry, a comprehensive range of the diverse conditions that can affect CBS viability was developed; additionally, an understanding of the extensive variety of factors and influences that might affect the likelihood of success, sustainability and practicality of CBS in any given area was obtained. These factors were collated and discussed in section 5.1 to establish an overall range of relevant influences, conditions and requirements, which were subsequently grouped into distinct categories of factors as listed below:

- Cultural factors
- Existing sanitation factors
- Operational factors
- Geographical factors
- Physical factors
- Financial factors
- Accommodation factors
- End-use product factors
- Institutional factors

The total number of factors identified are too numerous to discuss them individually in this section. However, as discussed in section 5.1.10, the ideal conditions and situation in which CBS is particularly relevant and appropriate are in high-density, informal urban and peri-urban

settlements, where no access to conventional sanitation exists leading to a reliance on public or on-site sanitation facilities.

### *6.1.3. Research objective 3*

*Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any barriers that may affect the successful implementation of a CBS service.*

Following the identification and collation of the various factors and conditions that can affect the potential of CBS, case study areas in Kathmandu were selected and subsequently assessed. As part of this process, the standard and level of the existing sanitation facilities within the communities was determined. Following this, the presence of any of the factors determined during the preceding objective were identified; this process enabled the researcher to detect the existence of any significant barriers to the implementation of CBS in terms of the overall concept, the WTP and the attitude or acceptance of residents to the creation of end-use products.

The mixed methods approach employed to undertake this element of the research was used in order to obtain triangulated data and to gain a broader understanding of the whole environment. The methods employed ranged from transect walks and questionnaires to KIIs and FGDs. In this way observations that were made could be corroborated by residents' personal opinions and discussed during KIIs. Investigations were undertaken to identify the existence of any cultural barriers within the communities that might affect the adoption or acceptability of a CBS service. Additionally, attitudes and opinions of the existing facilities were gathered to understand the level of satisfaction with the current sanitation arrangements within the communities.

Generally, the sanitation facilities found within the squatter communities were reasonably adequate although in certain circumstances localised conditions and complications conspired to prevent adequate sanitation facilities from being available to all of the residents in some of the communities. The availability of private household toilets was high in most of the settlements, with the remaining residents being highly dependent upon shared facilities of varying standards.

A weighted scoring matrix was developed and populated with the findings of the research to determine the existence of any significant barriers which could seriously impact on the potential viability of CBS in the study areas. The main findings, as shown in Table 4.6, detailed the major positive and negative factors present, but the principal barriers to CBS viability and CBS opportunities are given again in Table 6.1. below.

*Table 6.1 Barriers and opportunities for CBS viability in squatter settlements of Kathmandu*

| **Barriers to CBS viability** | |
|---|---|
| **Factor Description** | **Implication** |
| Extent of payment for sanitation services historically by residents of community. | Very low familiarity with concept of paying for sanitation, which will affect potential paying customer base |
| Impact of anal cleansing practices on CBS implementation | Anal washing practiced universally. Impact on running costs of service and potential for use in public toilet context |
| Availability of private household or on-plot sanitation facilities | High level of availability of private facilities, therefore limited demand for CBS service |
| Availability of required space locally for treatment facility establishment | Densely populated area. Very limited scope for local establishment of treatment facility |
| Willingness to pay/current level of payment (e.g. pit emptying, public toilets, etc.) within the community for sanitation services | Current low level of acceptance to paying for a sanitation service; therefore, a cultural change would be required for widespread adoption of any scheme |
| **Opportunities for CBS viability** | |
| **Factor Description** | **Implication** |
| Impact of the average housing size on the potential for CBS implementation (e.g. number of rooms, type of rooms, etc.) | Most houses have more than a single room with average dwelling size of 3.25 rooms per house, therefore minimising issues around the location of a toilet within the home |

#### *6.1.4. Research objective 4*

*Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements or for other applications within Kathmandu.*

All aspects of the existing CBS models were considered, from the handling of filled containers of faeces or urine to the potential market for the resale of end-use products. Relative levels of WTP and ATP were assessed by considering the existing levels of payment for sanitation services combined with enquiries into the ranges of salaries earned by the residents. Additionally, the response and reaction of residents to the proposal of CBS was measured to determine the level of potential demand that might exist, were a CBS service to be offered.

Following an analysis of the data collected, it was determined that the potential for success of CBS within the context of squatter settlements within Kathmandu was low and would therefore not provide a suitable environment within which the technology could be employed. The general wide availability of existing sanitation, low level of potential WTP and the almost universal practice of anal washing are the main reasons for reaching the conclusion that the potential for CBS to provide a sustainable sanitation solution to the squatter communities of Kathmandu is very low.

The use of CBS as a suitable technology to provide additional public toilets was also discounted due to the widespread practice of washing as a method of anal cleansing, and also due to the lack of enthusiasm and support that is anticipated both institutionally and governmentally.

#### *6.1.5. Research objective 5*

*Establish criteria of the required conditions necessary future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach.*

The conditions required for CBS to flourish in any context were developed during the investigations to determine the factors and success criteria required for CBS to become a realistic and viable option. However, the future potential of CBS and its application as a method of sanitation provision was considered as part of a separate, but parallel, area of interest. As part of this process, the requirement for CBS to become recognised as a form of improved sanitation became evident, in order for the technology to be adopted on a large scale by governments and utilities across the globe.

Following this recognition, CBS will be uniquely positioned to offer a sanitation solution in contexts where very few other options exist. CBS could present high density, urban communities with a new sanitation solution that would overcome many of the existing issues such as the lack of available space or complex land tenure challenges that are found in so many of the poorest areas in cities across the developing world.

#### *6.1.6. Summary*

Overall the original objectives of the research have been satisfied. A comprehensive array of factors, influences and conditions which all have the potential to affect the success and viability of CBS to varying degrees was gathered and categorised into distinct sets of criteria. These categories are broken down in section 5.1 into discrete groups of the factors.

The conditions and requirements identified were subsequently applied to the case study areas in Kathmandu with analysis undertaken of the findings, whereby it was demonstrated that the appropriateness of CBS in the context of the squatter communities of Kathmandu was not a viable option as a sanitation solution.

## *6.2. Recommendations*

As mentioned above, due to the conditions encountered in Kathmandu, it is not recommended that CBS would be an appropriate technology for use in such circumstances. However, the potential for CBS to address some of the world's most complex and critical sanitation challenges would appear to be significant. The ability of the technology to meet these challenges rests on the successful attainment of the universal recognition of the technology as a form of improved sanitation. If this classification is acquired, the scope for mass adoption and application will become a very realistic possibility.

Continual refinements of the operational processes already being undertaken by the CBS community will no doubt continue, but increased sharing and pooling of experience and knowledge should be maximised to capitalise on the combined expertise of the individual

organisations and to prevent the repetition and parallel development that has previously taken place.

The development of a standardised line of hardware should be undertaken to enable the services to reach economies of scale much quicker, particularly with regard to the impact on the individual organisations' buying power. Through a combination of shared knowledge and design inputs, a suite of improved toilet designs, based on the collective knowledge of the community, could be developed for use in a variety of contexts.

### *6.2.1. Recommendations for further research*

The scope for further research into various aspects of CBS technology and processes certainly exists, in addition to the identification of potential market opportunities for future implementations of CBS. Possible considerations for additional further research are listed below:

- Employing the success criteria and conditions collated during this research, other potentially appropriate areas or opportunities should be identified for the application of CBS technology. Through the analysis of other contexts and environments then a clearer understanding of the global demand potential of CBS could be obtained
- Carry out a comparison of the currently used CBS toilet units to extract the advantages and disadvantages of each design. A parallel analysis of the different potential contexts should be undertaken to establish the design criteria required for each specific situation. A standardised line of improved hardware could subsequently be developed which would provide the best possible CBS solution for different circumstances based on the knowledge and expertise of the whole CBS community.
- Investigation into the potential of more sophisticated, self-sealing cartridges that would minimise the pollution risks, and potentially increase the collection efficiency of services. The additional costs of producing such components should be compared with the potential savings realised through the introduction of more efficient collection processes. The research could include additional investigation into the possibilities and practicalities of utilising the concept of mobile or fixed collection hubs, as described in section 5.2.
- Further exploration and investigation into the potential markets for end-use products, particularly with respect to the latest technological innovations, for example the recent development of biochar which can be used as type of soil conditioner that is created from human waste (Liu et al. 2014).
- Investigation into the possible barriers and potential for combining collections of solid waste with those of human waste.
- Many research possibilities would open up as a result of CBS attaining the recognition as a form of improved sanitation. Exploration of the potential for PPPs, franchising and licensing could all be undertaken to establish the best approach in reaching the largest customer base through the most efficient means possible.

- Further research into ways that the efficiency of services can be further increased should be carried out. Investigation into topics such as techniques to increase the capacity of the collection vehicles, ways of minimising the number of collections made per customer and methods to maximise the use of mobile or alternative payment systems should all be considered.

# 7. References


Adhikari, K., 2015. *Sanitation in Nepal:... Past, Present and Future*, Kathmandu, Nepal: Kunti Bhoomi Memorial Trust.

AEPC, 2017. Alternative Energy Promotion Centre (AEPC). Available at: http://www.aepc.gov.np/?option=renewable&page=subrenewable&mid=2&sub_id=16&id=3 [Accessed August 13, 2017].

Berner, C., Woods, E. & Foote, A., 2017a. FSM4 Abstracts of Presentations given within Track 2: Case Studies. In *FSM4*. Chennai, India: SuSana, pp. 3–5. Available at: http://www.susana.org/_resources/documents/default/3-2733-7-1488368801.pdf.

Berner, C., Woods, E. & Foote, A., 2017b. Waste Transformation, Not Waste Treatment: Lessons learned from Sanivation's Value-added Processing of Fecal Waste. In *FSM4*. Chennai, India: SuSana. Available at: http://www.susana.org/_resources/documents/default/3-2744-7-1488876548.pdf.

Biobag, 2017. BioBag - Compostable products | BioBag. Available at: https://biobagworld.com/ [Accessed July 28, 2017].

Blue Waste 2 Value, 2016. Blue Waste 2 Value. Available at: http://bw2v.com/ [Accessed August 13, 2017].

Castizo, R. & Buckland, H., 2016. *Study of Social Entrepreneurship and Innovation Ecosystems in the Latin American Pacific Alliance Countries*, Available at: https://publications.iadb.org/bitstream/handle/11319/8030/Study-of-Social-Entrepreneurship-and-Innovation-Ecosystems-in-the-Latin-American-Pacific-Alliance-Countries-Regional-Analysis-Chile-Colombia-Costa-Rica-Mexico-Peru.pdf?sequence=4.

Central Bureau of Statistics, 2016. *Annual Household Survey 2014/15* First Edit., Kathmandu, Nepal: Government of Nepal. Available at: http://cbs.gov.np/image/data/2016/Annual Household Survey Report 2014-15.pdf.

Central Bureau of Statistics, 2012. *National population and housing census 2011*, Kathmandu, Nepal: Government of Nepal.

Central Bureau of Statistics, 2014. *Nepal Commercial Floriculture Survey 2015/16*, Kathmandu, Nepal. Available at: http://cbs.gov.np/image/data/2016/Nepal Commercial Floriculture Survey 2072_73.pdf.

Central Bureau of Statistics, 2011. *Nepal Living Standards Survey 2010/11: Statistical Report Volume 2*, Kathmandu, Nepal. Available at: http://cbs.gov.np/image/data/Surveys/Nepal Living Standard Survey 2010_11-English/Statistical_Report_Vol2.pdf.

Clean Team, 2017. cleanteamtoilets. Available at: https://www.cleanteamtoilets.com/ [Accessed July 20, 2017].

Denscombe, M., 2014. *The good research guide: for small-scale social research projects*, McGraw-Hill Education (UK).

Ecoloo, 2010. EcoLoo Group. Available at: http://www.ecoloogroup.com/ecoloo.html [Accessed August 13, 2017].

ENPHO, 2017. ENPHO Homepage. Available at: http://enpho.org/ [Accessed July 31, 2017].

ENPHO, 2016. Faecal Sludge Treatment Plant at Lubhu. Available at: http://enpho.org/featured/faecal-sludge-treatment-plant-at-lubhu/ [Accessed July 31, 2017].

Eram Scientific, 2017. About eToilet | Eram Scientific. Available at: http://www.eramscientific.com/?q=productoftheyear [Accessed August 14, 2017].

Gardiner, V. et al., 2017. Serviced Household Toilets, FSM and ICT in Antananarivo: Lessons Learned. In *FSM4*. SuSana. Available at: http://www.susana.org/_resources/documents/default/3-2744-7-1489140211. et alpdf.

Gautam, R.P., Vaidya, S. & Sharma, H.B., 2004. District Development Profile of Nepal.

Google, 2017. Google Maps. Available at: https://www.google.co.uk/maps [Accessed October 2, 2017].

HPCIDBC, 2009. *Bagmati Action Plan (2009-2014)*, Kathmandu, Nepal: High Powered Committee for Integrated Development of the Bagmati Civilization.

HPCIDBC, 2011. *Status and Strategy for Faecal Sludge Management in the Kathmandu Valley*, Kathmandu, Nepal: High Powered Committee for Integrated Development of the Bagmati Civilization.

Huberts, J.D. et al., 2016. A cross-sectional survey to assess household sanitation practices associated with uptake of " Clean Team " serviced home toilets in Kumasi , Ghana. , 28(2), pp.583–598.

Kirby-Garton, L., 2017. Inner City Sanitation: India. In *SanCoP19: Container-Based Sanitation*. Sanitation First. Available at: http://www.susana.org/_resources/documents/default/3-2797-7-1496410249.pdf.

Laws, S. et al., 2013. *Research for development: A practical guide*, Sage.

Little, A., 2012. Field Assessment Concerning Multiple Deprivations in Squatter Settlements and Slum Communities in Kathmandu, Nepal. *Kathmandu: Mercy Crops*.

Liu, X. et al., 2014. Characterization of human manure-derived biochar and energy-balance analysis of slow pyrolysis process. *Waste management*, 34(9), pp.1619–1626.

London, T. & Esper, H., 2014. Assessing poverty-alleviation outcomes of an enterprise-led approach to sanitation. *Annals of the New York Academy of Sciences*, 1331(1), pp.90–105.

Loowatt, 2017a. Global Sanitation Loowatt. Available at: https://loowatt.com/global-sanitation-madagascar-toilets/ [Accessed July 20, 2017].

Loowatt, 2017b. Technology Loowatt Waterless Toilet Technology. Available at: https://loowatt.com/technology/ [Accessed July 20, 2017].

Lumanti, 2017. Lumanti Support Group For Shelter Homepage. Available at: http://lumanti.org.np/cms/ [Accessed July 31, 2017].

Lumanti, 2008. *Status of Squatter communities along Bagmati River and its tributaries in Kathmandu Valley*, Kathmandu, Nepal.

Manandhar, S., 2014. Evicted Once, Nepali Squatters Living in the Ruins of a Razed River Settlement Fear a Recurring Nightmare. *Global Press Journal*. Available at: https://globalpressjournal.com/asia/nepal/evicted-once-nepali-squatters-living-in-the-ruins-of-a-razed-river-settlement-fear-a-recurring-nightmare/ [Accessed August 5, 2017].

Mattens, M., 2012. *Evaluation of Loowatt's ecological sanitation project in a poor urban area of Antananarivo, Madagascar*. Cranfield University. Available at: http://www.loowatt.com/wp-content/uploads/2012/11/Final_thesis_report-Mattens.pdf.

McSorley, B., 2016. Container based sanitation could solve the world's toilet problems | Oxfam GB | Policy & Practice. Available at: http://policy-practice.oxfam.org.uk/blog/2016/05/container-based-sanitation-could-solve-the-worlds-toilet-problems [Accessed July 21, 2017].

Medland, L.S., Scott, R.E. & Cotton, A.P., 2016. Achieving sustainable sanitation chains through better informed and more systematic improvements: lessons from multi-city research in Sub-Saharan Africa. *Environmental Science: Water Research & Technology*, 2(3), pp.492–501.

Mikhael, G., Shepard, J. & Stevens, C., 2017. *The world can't wait for sewers: advancing container-based sanitation businesses as a viable answer to the global sanitation crisis*, Kumasi, Ghana. Available at: http://www.wsup.com/resource/the-world-cant-wait-for-sewers-advancing-container-based-sanitation-businesses-as-a-viable-answer-to-the-global-sanitation-crisis/.

MWSS, 2017. *Faecal Sludge Regulatory Framework for cities of Nepal*, Kathmandu, Nepal.

Nepali, G.S., 1965. An Ethno-Sociological Study of a Himalayan Community. *Bombay, United Asia*.

O'Keefe, M. et al., 2015. Opportunities and limits to market-driven sanitation services: Evidence from urban informal settlements in East Africa. *Environment and Urbanization*, 27(2), pp.421–440.

Oxfam, 2016. Oxfam Sanitation Summit. In *Workshop Summary*. Oxford, UK: Oxfam.

Picard, L., 2000. *Dr. Johnson's London: Coffee-Houses and Climbing Boys, Medicine, Toothpaste and Gin, Poverty and Press-Gangs, Freakshows and Female Education*, Basingstoke, UK: Macmillan.

Pruss-Ustun, A. et al., 2008. Safer water, better health: costs, benefits and sustainability of

interventions to protect and promote health.

Purves, I.J. & Gardiner, V., 2012. Culturally and financially sustainable applications of Loowatt technology in Antananarivo, Madagascar - Early feedback. In *FSM2*. Loowatt. Available at: http://www.loowatt.com/wp-content/uploads/2012/10/Loowatt_FSM2_Paper.pdf.

Reade, A., 2016. *What Potential is there for Container Based Sanitation and the Social Enterprise in Urban Emergencies?*,

Remington, C. et al., 2016. A social business model for the provision of household ecological sanitation services in urban Haiti. *WEDC 2016: Ensuring Availability and Sustainable Management of Water and Sanitation for All*.

Renouf, R. & Drabble, S., 2017. *Practice Note 28 - Learning from innovation in sanitation business models: shared serviced and container-based sanitation in kisumu*, London, UK. Available at: http://www.wsup.com/resource/learning-from-innovation-in-sanitation-business-models-shared-serviced-and-container-based-sanitation-in-kisumu/.

Republic of Kenya Ministry of Health, 2016. *Kenya Environmental Sanitation and Hygiene Policy 2016 - 2020*, Nairobi, Kenya.

Ross, I. et al., 2016. Fecal sludge management tools: data collection instruments.

Russel, K. et al., 2015. User perceptions of and willingness to pay for household container-based sanitation services : experience from. *Environment & Urbanization*, 27(3), pp.525–540.

salaryexplorer.com, 2017. Salary Survey in Nepal| Salary Comparison. Available at: http://www.salaryexplorer.com/salary-survey.php?loc=151&loctype=1 [Accessed August 11, 2017].

SanCoP, 2017. SanCoP 19. In *SanCoP19: Container-Based Sanitation*. London, UK: SanCoP. Available at: http://www.susana.org/files/Sancop-19-synopsis-final.pdf.

Sanergy, 2016. *iHud: In-Home Toilet Project Update Annex 1*, Nairobi, Kenya.

Sanergy, 2017. The Sanergy Model « Sanergy. Available at: http://saner.gy/our-work/the-sanergy-model [Accessed July 20, 2017].

Sanitation First, 2017a. GroSan works | Sanitation First. Available at: http://sanitationfirst.org/grosan-works/ [Accessed July 28, 2017].

Sanitation First, 2017b. Sanitation First Homepage. Available at: http://sanitationfirst.org/ [Accessed May 11, 2017].

Sanivation, *Blue Box Details*, Naivasha, Kenya.

Sanivation, 2016. *Product Market Fit Analysis*,

Sanivation, 2017. Sanivation Homepage. Available at: http://www.sanivation.com/ [Accessed June

16, 2017].

Schaub-Jones, D., 2005. Sanitation partnerships: Beyond storage: On-site sanitation as an urban system. *BPD Sanitation Series, Building Partnerships for Development in Water and Sanitation, London*.

Separett, 2017. Home | Separett. Available at: http://www.separett.com/ [Accessed July 28, 2017].

Shahi, P., 2011. *Mobile toilet in limbo!*, Kathmandu, Nepal. Available at: http://www.wash-rcnn.net.np/mobile-toilet-in-limbo.

Shaw, R., 2014. *A Collection of Contemporary Toilet Designs*, Loughborough, UK: WEDC. Available at: http://wedc.lboro.ac.uk/resources/books/Contemporary_Toilet_Designs.pdf.

Shields, B. & Ruehle, E., 2016. The Sanitation Crisis and Social Media: Sanergy in Kenya.

Shrestha, B.K., 2013. Squatter settlements in the Kathmandu valley: Looking through the prism of land rights and tenure security. In *Urban Forum*. Springer, pp. 119–135.

SOIL, 2017. SOIL Haiti | What We Do. Available at: https://www.oursoil.org/what-we-do/ [Accessed July 19, 2017].

The Guardian, 2012. From flying toilets to fertiliser, sanitation in Nairobi's slums is changing | Clar Ni Chonghaile | Global development | The Guardian. Available at: https://www.theguardian.com/global-development/2012/nov/19/flying-toilets-fertiliser-slum-sanitation-nairobi [Accessed July 21, 2017].

The Himalayan Times, 2009. Mobile toilets: Convenient and eco-friendly - The Himalayan Times. *The Himalayan Times*. Available at: https://thehimalayantimes.com/news-archives/latest/mobile-toilets-convenient-and-eco-friendly/ [Accessed August 1, 2017].

The Kathmandu Post, 2017. KMC to build 300 public conveniences - Capital - The Kathmandu Post. *The Kathmandu Post*. Available at: http://kathmandupost.ekantipur.com/news/2017-06-22/kmc-to-build-300-public-conveniences.html [Accessed August 1, 2017].

Tilmans, S. et al., 2015. Container-based sanitation : assessing costs and effectiveness of excreta management in Cap Haitien , Haiti. *Environment & Urbanization*, 27(5), pp.89–104.

UN, 2014. United Nations Population Division | Department of Economic and Social Affairs. Available at: http://www.un.org/en/development/desa/population/ [Accessed May 11, 2017].

UN Habitat, 2016a. Slums Almanac 2015-16. *Tracking Improvement in the Lives of Slum Dwellers. Nairobi*.

UN Habitat, 2016b. World cities report 2016. Urbanization and development. Emerging futures. *Nairobi: UN Habitat*.

UNDP, 2009. Tackling with urban sanitation | UNDP in Nepal. *UNDP in Nepal*. Available at:

http://www.np.undp.org/content/nepal/en/home/ourwork/democraticgovernance/successstories/tackling-with-urban-sanitation.html [Accessed August 1, 2017].

UNICEF, 2013. Children dying daily because of unsafe water supplies and poor sanitation and hygiene. *Release by Unicef Press Centre*.

WaterAid Nepal, 2008. *Assessment of Urine Diverting Ecosan Toilets in Nepal*, Kathmandu, Nepal.

WHO/UNICEF, 2015. *Progress on sanitation and drinking water–2015 update and MDG assessment*, Geneva/New York: World Health Organization/UNICEF.

World Health Organization & UNICEF, 2017. *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*, World Health Organization.

X-runner, 2017. What we do - x runner. Available at: http://xrunner-venture.org/the-system/ [Accessed July 20, 2017].

# 8. Appendices

## *Appendix A - Research framework*

| Research title: The required conditions and success criteria for CBS viability and the potential for implementation in Kathmandu | | | | |
|---|---|---|---|---|
| **Aim** | **Research Objectives** | **Research Questions** | **Method of Research** | **Key Informants/Target Groups** |
| Determination of the required conditions and success criteria for CBS to be viable and the subsequent potential for successful implementation in Kathmandu, Nepal | Undertake an analysis of the current CBS services, their operational processes, and contexts within which they work | • How do the current CBS services deal with each stage in the sanitation service chain in terms of their operating methodology?<br>• How do the business models and the financial arrangements of the CBS services compare?<br>• What does the actual toilet unit consist of and how is it operated for each of the CBS organisations?<br>• Are any end use products created from the collected waste and what is required to implement the production? | • Literature review<br>• Semi-structured interviews with key stakeholders | • CBS service providers (SOIL, Sanitation First, X-runner, Sanergy, Sanivation, Clean team, Loowatt)<br>• WSUP<br>• i-San<br>• CBS Alliance |
| | Investigate CBS services to determine and “distil” the factors required for success in their individual contexts and develop a weighted scoring matrix to assess the potential for CBS implementation. | • Why was the specific area of operation chosen and what was it about that area that made it suitable for the implementation of CBS?<br>• What cultural issues or practices were present in the operational area that influence the ongoing effectiveness, success or implementation methodology of the service?<br>• What other issues or problems were encountered during the development of the service, and are any ongoing issues still present affecting the success, | • Literature review<br>• Semi-structured interviews with key stakeholders | • CBS service providers (SOIL, Sanitation First, X-runner, Sanergy, Sanivation, Clean team, Loowatt)<br>• WSUP<br>• i-San<br>• CBS Alliance |

| | | | | |
|---|---|---|---|---|
| | | uptake or performance of the operation? | | |
| | Identify and assess the current existing sanitation arrangements within the selected squatter settlements of Kathmandu, and any cultural barriers that may affect the successful implementation of a CBS service | • What are the current sanitation practices adopted by the residents living within the sample communities of Kathmandu?<br>• What alternative sanitation infrastructure currently exists within target areas of Kathmandu?<br>• What cultural barriers exist within the sample communities of Kathmandu which may affect the likelihood of successful implementation of a CBS system?<br>• What other barriers currently exist to prevent the implementation of any form of improved sanitation? | • Literature review<br>• Semi-structured and unstructured interviews with key stakeholders<br>• Transect walks & observations<br>• Focus Group Discussions<br>• User surveys/ questionnaires | • Lumanti<br>• UN Habitat<br>• WSSCC<br>• ENPHO<br>• Residents living in squatter communities<br>• Lalitpur Municipality<br>• Kathmandu Metropolitan City<br>• DWSS<br>• HPCIDBC |
| | Determine the suitability and appropriateness of CBS services for use within the selected squatter settlements or for other applications within Kathmandu | • What would the response of the residents to utilising the different range of end-use products that can be produced from the faecal matter collected in CBS systems, or to the potential consumption of foodstuffs grown using fertiliser/compost produced as a result of CBS?<br>• What level of payment could be realistically expected in return for the provision of a CBS service within the sample communities of Kathmandu?<br>• How suitable or appropriate would CBS be for implementation in the target areas, and what would be the most appropriate model in terms of the | • Semi-structured and unstructured interviews with key stakeholders<br>• Transect walks & observations<br>• Focus Group Discussions<br>• User surveys/ questionnaires<br>• Analysis of output from stages 1 - 3 | • Lumanti<br>• UN Habitat<br>• WSSCC<br>• ENPHO<br>• Residents living in squatter communities<br>• Lalitpur Municipality<br>• Kathmandu Metropolitan City<br>• DWSS<br>• HPCIDBC |

| | | | | |
|---|---|---|---|---|
| | | individual stages of the sanitation service chain?<br>• How relevant or appropriate is CBS for any other contexts or sanitation applications in Kathmandu? | | |
| | Establish criteria of the required conditions necessary for future implementations of CBS services in other contexts or regions where currently sanitation provision is inadequate and evaluate the future potential of the CBS approach | • What are the cultural criteria that need to be satisfied in order for future CBS systems to be successfully implemented in other regions or countries?<br>• What physical, geographical or socio-economic factors need to be considered in order to establish the potential for success of any future CBS services?<br>• What are the financial considerations or implications for any future implementations of CBS based on the experience of the current CBS service providers?<br>• What other factors need to be considered (e.g. political, enabling environment, etc.) in order to establish the appropriateness or success potential when evaluating any given area for the possible implementation of CBS?<br>• What are the current barriers to progress and foreseeable issues going forward for CBS to flourish as a successful and widely used method of sanitation globally in specific, appropriate contexts? | • Literature review<br>• Semi-structured interviews with key stakeholders | • CBS service providers (SOIL, Sanitation First, X-runner, Sanergy, Sanivation, Clean team, Loowatt)<br>• WSUP<br>• i-San<br>• CBS Alliance |

## *Appendix B – CBS service provider semi-structured interview*

**CONTAINER–BASED SANITATION SERVICE PROVIDER:**

**CONTAINER-BASED SANITATION SERVICE OPERATIONAL AREA:**

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| ***1*** | ***Selection and details of the operational area*** | | ***Keywords:*** |
|---|---|---|---|
| **a)** | What was the need for the service initially and how was the need identified in the specific chosen area? | | • Context |
| **b)** | Why was the specific city/area/district chosen for the development of a CBS service? | | • Context |
| **c)** | What was it about the chosen area that made CBS an option? | | • Context |
| **d)** | What level of sanitation infrastructure existed in the operational area prior to the introduction of the service? | | • Context |
| **e)** | How does the topography of the chosen area affect how the service is implemented or the overall success of the operation? | | • Geographical |
| **f)** | How does the housing density of the chosen area affect how the service is | | • Geographical |

| | | | |
|---|---|---|---|
| | implemented or the overall success of the operation? | | |
| **g)** | Were any other socio-economic factors present in the operational area which made CBS an option, for example:<br>• lack of open space<br>• inability to excavate due to permission issues<br>• insecurity at night (for women, children or men)<br>• land tenure/ownership issues | | • Socio-economic |
| **h)** | Were there any geographical or geological factors present in the operational area which made CBS an option, for example:<br>• high water table<br>• risk of flooding<br>• low infiltration rate<br>• hard surfacing or rocky ground conditions<br>• unstable ground conditions | | • Geographical |

| ***2*** | ***Initial conditions and sanitation practices in the operational area*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | What were the sanitation practices generally adopted by the population prior to the launch of the service? | | • Existing sanitation practices |
| **b)** | Were there any cultural traditions or practices in the operational area which affected the potential of CBS uptake, for example:<br>• aversion to having a toilet actually located in the home | | • Existing sanitation practices<br>• Cultural factors |

| | | | |
|---|---|---|---|
| | • aversion to handling urine or faeces<br>• preference for squatting or sitting whilst using the toilet<br>• preference of washing or wiping for anal cleansing | | |
| **c)** | Was the uptake of the scheme by the residents of the operational area lower than that expected prior to the commencement of the service and if so, by how much? | | • Residents reaction |
| **d)** | Was there any resistance or opposition to the introduction of the service by the local community or any groups within the community? | | • Residents reaction |
| **e)** | Were there certain sectors of the community more enthusiastic about the implementation of the service than others, and what was their difference in response? | | • Residents reaction |
| **f)** | Do any alternative sanitation solutions or services exist within the operational area and if so what do they consist of? | | • Existing sanitation practices |
| **g)** | Did any political drivers or constraints exist (at either a national, local or at a city level) which influenced the decision-making process during the development of the service? | | • Political |

| ***3*** | ***Operating Methodology*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | How often do the facilities require emptying/collection? | | • Containment /collection |

| | | | |
|---|---|---|---|
| **b)** | Is the urine diverted or collected in the same container as the faecal matter? | | • Containment /collection |
| **c)** | If the urine is diverted, who is responsible for emptying the urine collected, and how is the collected urine generally disposed of? | | • Containment /collection<br>• Treatment |
| **d)** | Is a cover material used to place over the faeces after defection, and what does the cover material consist of? | | • Cover material |
| **e)** | Have you experienced any difficulties in obtaining sufficient, economic quantities of cover material for your operation? | | • Cover material |
| **f)** | Is the system public, household, institution or community based? | | • Operating model |
| **g)** | What volume of material can be contained prior to prior to the requirement for collection? | | • Containment /collection |
| **h)** | Is a waste transfer station utilised during the collection and transport phase of the process and if so, who is it operated by? | | • Collection/ transport |
| **i)** | If so, what type of vehicles are utilised for collection and transport to the transfer station? | | • Collection/ transport |
| **j)** | Does the housing density of the operational area affect the use of the collection vehicles? | | • Collection/ transport |
| **k)** | What size area can a transfer station serve? | | • Collection/ transport |
| **l)** | Is the collection and transport phase of the process operated by a third party? | | • Collection/ transport |

| | | | |
|---|---|---|---|
| **m)** | What type of vehicles are utilised for collection and transport to the end treatment facility? | | • Collection/ transport |
| **n)** | What size area can the end treatment facility serve? | | • Treatment |
| **o)** | Is the faecal matter generated from the service treated by a third party, and if so, who undertakes the treatment? | | • Treatment |
| **p)** | Does the treatment process used require any other inputs (e.g. food waste, electricity, etc.)? | | • Treatment |
| **q)** | How many customers and or CBS facilities are currently managed by the organisation in the operational area? | | • Organisation |
| **r)** | How many employees are currently engaged in order to provide the level of service offered? | | • Organisation |

| ***4*** | ***Toilet unit/hardware considerations*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | Is the toilet unit constructed locally or from locally available materials or it is prefabricated/manufactured remotely? | | • Sustainability |
| **b)** | What is the anticipated/actual durability/useful life span for each unit? | | • Durability |
| **c)** | What level of skill, knowledge or training is required for the O&M of the service? | | • Required skills |
| **d)** | What level of skill, knowledge or training is required for the initial construction/ installation of each facility/unit? | | • Required skills |

| | | | |
|---|---|---|---|
| **e)** | Does a suitably qualified and educated workforce exist in the operation area of sufficient size to undertake the toilet manufacture and the other required operational roles? | | • Required skills/ workforce |

| ***5*** | ***Reuse of end products*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | Is an end use product produced from the collected material? | | • End product reuse/sale |
| **b)** | Is any revenue created through the sale of any end use products to contribute towards the operating costs? | | • End product reuse/sale |
| **c)** | If so, what percentage of the operating costs are recouped by the sale of end use products? | | • End product reuse/sale |

| ***6*** | ***Financial considerations*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | Are the facilities paid for per use, or on a weekly/monthly/annual basis? | | • Payment |
| **b)** | How are the payments collected from customers (e.g. door-to-door collection, mobile money, etc.) | | • Payment |
| **c)** | Do users/customers pay for the purchase or rental of the toilet unit/facility? | | • Payment |
| **d)** | If so, how much do users pay for the purchase/rental of the toilet unit/facility? | | • Payment |
| **e)** | What is the capital cost to provide each facility/toilet? | | • Operating Costs |
| **f)** | Is an installation fee required for setting up the toilet unit and if so, what is the cost? | | • Payment |

| | | | |
|---|---|---|---|
| **g)** | Do users/customers pay for maintenance or emptying services? | | • Payment |
| **h)** | If so, how much do users pay to receive this service? | | • Payment |
| **i)** | How do the costs incurred by customers compare to the average income of the residents of the operational area? | | • Operating Costs<br>• Incomes |
| **j)** | Does the service require subsidies or funding by third parties? | | • Funding |
| **k)** | What percentage of the operating costs are covered by the revenues generated by the service? | | • Operating costs<br>• Revenues |
| **l)** | Is it envisaged that the financial performance of the organisation will improve over time and if so, for what reason? | | • Revenues |

| ***7*** | ***Willingness and ability to pay*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | Was a willingness-to-pay (WTP) survey carried out prior to the introduction of the service? | | • WTP |
| **b)** | If a WTP survey was carried out prior to the commencement of the service, does the ability-to-pay (ATP) of the customers concur with the findings of that survey? | | • WTP<br>• ATP |
| **c)** | If a WTP survey was not carried out prior to the commencement of the service, how was the price of the service to customers established? | | • Payment<br>• WTP |

| | | | |
|---|---|---|---|
| **c)** | Was there a history of paying for sanitation services in the operational area prior to the introduction of the service? | | • Payment |
| **d)** | If so, what were the payments for (e.g. latrine emptying, public toilets, etc.) and how did these costs compare to the CBS charges? | | • Payment |
| **e)** | What was the initial reaction of the residents to the proposal of paying for a sanitation service and to the expected level of charges? | | • Payment |

| *8* | ***Learning opportunities*** | | ***Keywords*** |
|---|---|---|---|
| a) | What issues were encountered during the development of the service that impacted on the progress/success of the scheme? | | • Operational issues |
| b) | Are there any ongoing issues which still need to be resolved, and if so what are they, and what are the current proposals to overcome the issues? | | • Operational issues |
| c) | Were any cultural issues encountered which affected the success of the service or the process by which the system is now implemented? | | • Cultural factors<br>• Operational issues |
| d) | If the knowledge gained by the organisation through the development of the scheme was known prior to the commencement of the service, would anything have been done differently, and if so in what way? | | • Success factors/ criteria<br>• Operational issues |

| | | | |
|---|---|---|---|
| e) | Are there future plans to expand the service into any other areas/cities/countries? | | • Future expansion |
| f) | What do you think are the key factors which led to the success of the service within the area where the scheme currently operates? | | • Success factors/ criteria |
| g) | What factors need to be considered if a similar service were to be introduced in a different region/country? | | • Success factors/ criteria |

| ***9*** | ***Other issues*** | | ***Keywords*** |
|---|---|---|---|
| **a)** | Are there any other key factors or issues relating to the service which are not covered or addressed by the preceding questions? | | • Success factors/ criteria |
| **b)** | Are there any key documents or other relevant material that you are aware of that may provide additional information? | | |

## *Appendix C – Household questionnaire*

**Interview #:** _____

# Household Questionnaire

**Name and status of the community:** _____

**Section 1: Identity data:**

| Question | Response |
|---|---|
| 1.Date of Interview: | |
| 2. Name: | |
| 3. Age: | |
| 4. Gender: | |
| 5. Ethnicity: | |
| 6. Religion: | |
| 7. Location: | |

**Section 2: Household Characteristics:**

| Question | Response |
|---|---|
| 1. How many rooms are there in your household? | |
| 2. Is the house owned, rented, rent-free or mortgaged? | |
| 3. If rented, what is your average monthly household expenditure on rent? | |
| 4. How long have you/your family been living in this location/house? | |
| 5. What is the main construction material of the floor? | |
| 6. What is the main construction material of the roof? | |
| 7. What is the main construction material of the walls? | |
| 8. Is the area where you live prone to flooding? | |
| 9. Does the area where you live have a high water table? | |

**Section 3: Socio-Economic information:**

| Question | Response |
|---|---|
| 1. How many people live in your household? | |
| a. Number of men? | |
| b. Number of women? | |
| c. Number of children? | Girls: Boys: |
| d. What are ages of the children? | |
| 2. Are there any disabled or elderly people in your household? | |
| 3. How many people in your household work, and what are their occupations? | |
| 4. What is the combined monthly income of the household? | |
| 5. How many days of work have been missed by members of the household in the last 6 months due to illness? | |
| a. What were the main causes of the illnesses? | |
| 6. a. Are there any schools located within the community? | |
| b. If so, how many children attend the schools? | |
| c. What type of toilets are available at the schools, and what is their level of sanitation? | |
| 7. How many days of schooling have been missed by the children of the household in the last 6 months due to illness? | |
| a. What were the main causes of the illnesses? | |
| 8. Do any members of the household own a mobile phone? If so, how many? | |
| 9. Do any members of the household have a bank account? | |
| 10. Are there any other services available within the community, for example Health Clinics, etc.? | |

**Section 4: Water, Sanitation Practices and Infrastructure:**

1. What is the main source of drinking water for members of your household?
   - ☐ Piped into dwelling
   - ☐ Piped to yard/plot
   - ☐ Public tap/ standpipe
   - ☐ Tube well/ borehole
   - ☐ Protected dug well
   - ☐ Unprotected dug well
   - ☐ Protected spring
   - ☐ Unprotected spring
   - ☐ Rainwater collection
   - ☐ Bottled water
   - ☐ Refilled bottled water
   - ☐ Cart with small tank/ drum
   - ☐ Tanker-truck
   - ☐ Surface water (river, dam, lake, pond, stream, canal, irrigation channels)
   - ☐ Others (specify)

2. What is the location of sanitation facilities are usually used by members of your household (tick all that apply):

   ☐ Household toilet (private)

   Frequency of use and by whom?:_____

   ☐ Shared household toilet

   Frequency of use and by whom?:_____

   Number of households sharing the toilet?:_____

   Number of people using this toilet regularly?:_____

   ☐ Public toilets

   Frequency of use and by whom?:_____

   How long does it normally take on average to use the toilet (walk there, queue, use and return)?:

   _____

   How many times a day do you use this toilet?:_____

   Do you have to pay to use this toilet, and if so how much?:

   ☐ No ☐ Yes How much?:_____

☐ Toilets at work

Frequency of use and by whom?:_____

3. What type of toilet facility do members of your household normally use?

☐ Automatic cistern flush
☐ Pour/manual flush
☐ Ventilated improved pit latrine
☐ Pit latrine with slab
☐ Pit latrine without slab/open pit
☐ Composting toilet
☐ Hanging toilet/hanging latrine
☐ No facilities or open defecation
☐ Other (Specify)

_____

4. Where do the contents of this toilet discharge to?

☐ Piped sewer system
☐ Fully-lined septic tank with soakaway
☐ Fully-lined septic tank with overflow to drain / open ground / other
☐ Partially-lined septic tank (bottom and/or sides unlined)
☐ Fully-lined pit
☐ Pit with unlined bottom or sides
☐ Directly to open drain / ditch
☐ Directly to sea, lake or river
☐ Directly to open ground
☐ Don't Know
☐ Other (Specify)

_____

5. Do children use the same methods of sanitation as the adults?

☐ Yes ☐ No

If No, what do method do the children use and why?_____

6. Do you prefer to sit or squat whilst using the toilet? ☐ Sit ☐ Squat

7. Do you prefer to wash or wipe to clean yourself after using the toilet?

☐ Wash ☐ Wipe

If you wipe, what material do you normally use (e.g. toilet paper, cardboard, etc.)?

_____

8. Would you be prepared to pay for a toilet service located in your house?

☐ Yes If yes, how much per month? _____ ☐ No

9. Would you be prepared to pay for a toilet service shared between houses in the same community?

   ☐ Yes If yes, how much per month? _____ ☐ No

10. Do you currently pay for any sanitation services?

    ☐ Yes If yes, how much per month? _____ ☐ No

11. How many of your household use paid public toilets? _____

12. Do any of these issues apply to the public toilets that are used by your household?

    ☐ Inconvenient opening times (i.e. closed at night)

    ☐ Inconvenient location (i.e. a long way from housing)

    ☐ Insecure or unsafe for women/children to visit

    ☐ Insecure or unsafe to visit at night

    ☐ Expensive

    ☐ Other:

    _____

13. Do the toilets that are used most regularly by your household have any unsanitary or unpleasant characteristics?

    ☐ Dirty

    ☐ Flies

    ☐ Odour

    ☐ Poorly lit

    ☐ Other:

    _____

**Section 5: Cultural Issues:**

1. Is there sufficient space within your house to locate a toilet?

   ☐ Yes ☐ No

2. Would the presence and use of a toilet within your house be acceptable to you?

   ☐ Yes ☐ No

3. Is there sufficient space outside your house but on-plot to locate a toilet?

   ☐ Yes ☐ No

4. Would the presence and use of a toilet adjacent or outside your house be acceptable to you?

   ☐ Yes ☐ No

5. Would you have any issues with emptying, handling or transporting a vessel containing human excreta?

   ☐ Yes ☐ No

6. Would you have any issues with emptying, handling or transporting a vessel containing human urine?

   ☐ Yes ☐ No

**Section 6: End-use Products**

1. What do you normally use for cooking food (e.g. charcoal, wood, gas, etc.)?

   _____

2. What is your average monthly household expenditure on fuel for cooking?

   _____

3. Would you have any reservations about using charcoal produced from human excreta for cooking food?

   ☐ No ☐ Yes If yes, why?_____

4. Would you have any reservations about using biogas produced from human excreta for cooking food?

   ☐ No ☐ Yes If yes, why?_____

5. Would you have any reservations about purchasing vegetables grown using fertiliser or compost produced from human excreta?

   ☐ No ☐ Yes If yes, why?_____

6. Would you have any reservations about purchasing fruit from trees that have been grown using fertiliser or compost produced from human excreta?

   ☐ No ☐ Yes If yes, why?_____

## *Appendix D – Focus group discussion*

Loughborough University

# Focus Group Discussions

**Community Name:** _____ **Community Status:** _____

**Current Sanitation Practices:**

| *Topic area for discussion* | Primary questions | Secondary questions | Tertiary questions |
|---|---|---|---|
| *Availability of latrine/toilet options:* | Do people generally have toilets in their own homes, to what extent, and if so, what type? | To what extent are latrines shared between numerous households? | Do residents feel safe/secure when visiting the shared toilets at night? |
| *Satisfaction levels with current latrine/toilet options:* | How satisfied are the community's residents with the cleanliness, convenience and maintenance of the latrines/toilets used most frequently? | What ways could the latrines/toilets be improved? | What aspects of the current sanitation arrangements are most inconvenient or unpopular (e.g. Dirty, Flies, Odour, Poorly lit, Queues, Inundation or overflow of pits/septic tank during rainy season, etc?) |
| *Flooding impacts on the community* | In what ways does flooding impact on the lives of the residents within the community? | How does flooding affect the sanitation facilities within the community (e.g. access to facilities for children or elderly residents, pit/tank filling frequency and overflowing, etc.)? | Are illnesses or sickness more prevalent during periods of flooding? |
| *Current emptying and transport services* | How easy is it for families to obtain pit/septic tank emptying services in the area and what is done after the pit/tank is filled? | What method of emptying is usually carried out (e.g. suction tanker, manual emptying, dig replacement pit, etc)? | Does the emptying method produce any additional risks (e.g. spillages of waste)? |
| | What is the current approximate cost of pit/septic tank emptying services in the area? | How often is pit/septic tank emptying generally required? | Who is responsible for emptying the pits/septic tanks? |
| | What faecal sludge transport services are utilised in the local area? | Do the transport methods utilised produce any additional risks? | |

## Potential for future sanitation improvements:

| *Topic area for discussion* | Primary questions | Secondary questions | Tertiary questions |
|---|---|---|---|
| *Housing/plot sizes and space availability* | How many rooms are there in the typical dwellings within the community, and are toilets generally located within dwellings (approx. %)? | Do residents generally have sufficient space within their houses to locate a toilet? | Would residents have any reservations about the presence of a toilet within their home if they don't already have one, and if so, for what reason? |
| | Is there generally available space on-plot but outside the house to locate a toilet? | Would residents have any reservations about the presence of a toilet on-plot? | Would there be any reasons why a toilet on-plot would not be used by residents? |
| *Potential for payment* | What are residents' opinions on paying for the provision of a household level container-based sanitation service? | What level of payment would residents be willing to pay (i.e. for initial installation and for maintenance)? | |
| | What are residents' opinions on paying for the provision of a shared sanitation service? | What level of payment would residents be willing to pay? | Would the level of willingness to pay vary between urination and defecation? |
| *Handling of excreta or urine* | What are residents' views on handling or transporting containers of human excreta? | What are the underlying reasons behind any negative responses? | |
| | What are residents' views on handling, emptying or transporting containers of human urine? | What are the underlying reasons behind any negative responses? | |
| *Potential for end-use product* | What are residents' opinions on purchasing vegetables grown with fertiliser produced from human excreta? | What are residents' opinions on purchasing fruit grown on trees using fertiliser produced from human excreta? | |
| | What fuel do people generally use for cooking food (e.g. charcoal, wood, gas, etc.)? | What are residents' opinions on the purchase or use of charcoal produced from human excreta? | What are residents' opinions on the purchase or use of biogas produced from human excreta? |
| | Do residents ever use or purchase electricity outside the home, or is electricity generally available with the home? | Would residents be willing to buy or use electricity produced by fuel derived from human excreta? | |

*Appendix E – Transect walk record sheet*

Loughborough University

## Transect Walk Record Sheet

**Date:** _____ **Community/Location:** _____

**Approximate size of settlement (Number of dwellings):** _____

**Shape of settlement:** **Linear** ☐ **Compact** ☐

**Economic status of the area:** **Middle-income** ☐ **Low-income** ☐ **Mixed-income** ☐

**Weather conditions at time of survey:** _____

**Nearest road access:** _____

**Is the area at risk or prone to flooding?** **Yes** ☐ **No** ☐ **Not possible to determine** ☐

**Evidence of high water table?** **Yes** ☐ **No** ☐

**Topography of area:** _____

**Dwelling construction:** **Mixed** ☐ **Brick/block** ☐ **Mud/stones** ☐ **Bamboo/sticks/mud** ☐ **Plywood** ☐ **Plastic sheet/tent** ☐

**Other (Specify):** _____

| Category | Description of Observations | Score | Location(s) where high risk is seen | How often does this risk occur? Annually = 1 Monthly = 2 Weekly = 3 Daily = 4 |
|---|---|---|---|---|
| **1. Evidence of human faecal materials – through open defecation** | Frequent visible, widespread evidence of human faeces is seen. | 5 | | |
| | Visible evidence of human faeces is seen, but limited to a few locations. | 4 | | |
| | Human faeces are seen one or two times, but in places away from the population. | 3 | | |
| | Possible evidence of human faeces is seen, mixed with solid waste. | 2 | | |
| | No visible evidence of human faeces through open defecation is seen. | 1 | | |
| | | | | |
| **2. Evidence of human faecal materials – through dumped faecal material** | Frequent visible and widespread evidence of dumped faecal sludge is seen. | 5 | | |
| | Visible evidence of dumped faecal sludge is seen, but limited to a few locations. | 4 | | |
| | Dumped faecal sludge is seen one or two times, but in places away from the population. | 3 | | |
| | Possible evidence of faecal sludge is seen, mixed with solid waste. | 2 | | |
| | No visible evidence of dumped faecal sludge is seen. | 1 | | |
| | | | | |
| **3. Access to water points** | No piped water supply to households or public water points are identified. | 5 | | |
| | No piped water supply to households, but water is available from public standposts, vendors, private wells or boreholes. | 4 | | |
| | Some piped water supply to households, or boreholes. Other water is available from public standposts or vendors. | 3 | | |
| | Intermittent piped water supply to all or most households. Water from vendors may also be available. | 2 | | |
| | Continuous piped water supplies to public standposts, on-plot or in-house. Water from vendors may also be available. | 1 | | |
| | | | | |
| **4. Coverage of household toilets (individual, or shared with known families)** | Less than 20% of dwellings have access to a household toilet. | 5 | | |
| | Between 20% to 40% of dwellings have access to a household toilet. | 4 | | |
| | Between 40% to 60% of dwellings have access to a household toilet. | 3 | | |
| | Between 60% to 80% of dwellings have access to a household toilet. | 2 | | |
| | More than 80% of dwellings have access to a household toilet. | 1 | | |

| | | | | |
|---|---|---|---|---|
| **5. Maintenance and cleanliness of household toilets** | The majority (more than 75%) appear to be poorly maintained. | 5 | | |
| | Most (more than 50%) appear to be poorly maintained. | 4 | | |
| | Most (more than 50%) appear to be well maintained. | 3 | | |
| | Most (more than 75%) appear to be clean and well-maintained. | 2 | | |
| | They are in various conditions of maintenance and cleanliness. | 1 | | |
| | | | | |
| **6. Maintenance and cleanliness of public sanitation facilities** | Where public facilities are present, they are all poorly maintained with evidence of faecal contamination in the local environment. | 5 | | |
| | Where public facilities are present, most (more than 50%) are poorly maintained with some evidence of faecal contamination in the local environment. | 4 | | |
| | Where public facilities are present, they are in various conditions of maintenance and cleanliness. | 3 | | |
| | Where public facilities are present, most (more than 50%) are generally clean and well maintained. | 2 | | |
| | Where public facilities are present, they are in frequent use, clean and well-maintained.<br>OR<br>There are no public facilities present. | 1 | | |
| | | | | |
| **7. Housing and public space arrangement** | Less well or poorly organised community, with highly restricted access for public service vehicles and no clearly defined public spaces. | 5 | | |
| | Less well organised community, with mostly temporary housing, limited access for public service vehicles and very few clearly defined public spaces. | 4 | | |
| | Reasonably well organised community, with semi-permanent and/or temporary properties, limited access for public service vehicles and only a few clearly defined public spaces. | 3 | | |
| | Well organised community, with permanent and/or semi-permanent properties, but restricted access for public service vehicles and public spaces, including some open spaces. | 2 | | |
| | Well organised community, with permanent and/or semi-permanent properties, good access for public service vehicles and public spaces, including open spaces. | 1 | | |

| | | | | |
|---|---|---|---|---|
| **8. Paths - Routes wide enough for pedestrians and possibly motorbikes** | Very narrow paths that can be used by pedestrians only (too narrow for motorbikes). | 5 | | |
| | Poorly maintained dirt paths wide enough for motorbikes. | 4 | | |
| | Well-maintained dirt paths wide enough for motorbikes. | 3 | | |
| | Gravel or paved paths, in poor condition, wide enough for motorbikes. | 2 | | |
| | Gravel or paved paths, in good condition, wide enough for motorbikes. | 1 | | |
| | | | | |
| **9. Roads - Routes wide enough for vehicles (cars, 3-wheelers, donkey carts, etc.)** | Unsurfaced roads, wide enough for small carts or 3-wheeler, but not for car access. | 5 | | |
| | Unsurfaced roads wide enough for cars to pass. | 4 | | |
| | Gravel or paved roads, wide enough for small carts or 3-wheeler, but not for car access. | 3 | | |
| | Gravel or paved roads, wide enough to allow two cars to pass. | 2 | | |
| | Well maintained gravel or paved road, wide enough for two cars to pass. | 1 | | |
| | | | | |
| **10. Dwelling and individual plot sizes** | Dwellings generally single room, with limited or no available outdoor space for expansion or for on-plot toilet construction. | 5 | | |
| | Dwellings generally single room, but with sufficient available outdoor space for expansion or for on-plot toilet construction. | 4 | | |
| | Dwellings generally larger than single room, but with limited or no available outdoor space for expansion or for on-plot toilet construction. | 3 | | |
| | Dwellings generally larger than single room, with sufficient available outdoor space for expansion or for on-plot toilet construction. | 2 | | |
| | Dwellings generally larger than single room, with existing access to household toilet. | 1 | | |
| | | | | |
| **11. Drainage (storm water and greywater).** | Limited or no drainage infrastructure. Standing storm water and/or greywater is visible on the ground, close to homes or water points. | 5 | | |
| | Limited drainage infrastructure, with signs of storm water and/or greywater having overflowed recently close to homes or water points. | 4 | | |
| | Limited drainage infrastructure, but with no signs of having overflowed close to homes or water points. | 3 | | |
| | Drainage channels in a poor condition directing storm water and/or greywater away from homes and water points. | 2 | | |
| | Drainage channels, well maintained and adequate to take flows. | 1 | | |

| | | | | |
|---|---|---|---|---|
| **12. Sewerage (blackwater)** | Limited or no sewer infrastructure with visible standing blackwater close to homes or water points. | 5 | | |
| | Broken sewer pipes close to homes or water points, with signs of having overflowed recently. | 4 | | |
| | Broken sewer pipes close to homes or water points, but with no signs of having overflowed. | 3 | | |
| | Piped sewers with signs of some leakage or blockages. | 2 | | |
| | Adequate and well maintained piped sewers, with no signs of leakage or blockages. | 1 | | |
| | | | | |
| **13. Evidence of solid wastes** | Piles of solid waste are accumulating in many sites, close to where people live and work, and at times are obstructing drainage or irrigation channels. | 5 | | |
| | Piles of solid waste are accumulating in three or more sites, close to where people live and work, but are not obstructing drainage or irrigation channels. | 4 | | |
| | Piles of solid waste are accumulating in one or two sites, but away from where people live and work. | 3 | | |
| | Waste bins or enclosures are provided for solid waste collection, but the number of bins is inadequate and overflow is evident. | 2 | | |
| | An adequate number of waste bins or enclosures are provided, with no overflow evident. | 1 | | |
| | | | | |
| **14. Evidence of animal faecal materials** | Frequent visible and widespread evidence of animal faeces is seen. | 5 | | |
| | Visible evidence of animal faeces is seen, limited to a few locations. | 4 | | |
| | Animal faeces are seen one or two times, but in places away from the population. | 3 | | |
| | Possible evidence of animal faeces is seen, mixed with solid waste. | 2 | | |
| | No visible evidence of animal faeces is seen. | 1 | | |

## *Appendix F – Questionnaire data*

| Resident Questionnaire | | | | | | | |
|---|---|---|---|---|---|---|---|
| Section 1 - Identity Data | | | | | | | |
| **Questionnaire Number** | **Community Name** | **Q1 - Date of Interview** | **Q3 - Age** | **Q4 - Gender** | **Q5 - Ethnicity** | **Q6 - Religion** | **Q7 - Location** |
| | | | | | | | |
| 1 | Manohara | 25/06/2017 | 58 | Male | Brahmin | Hindu | Western edge of settlement |
| 2 | Manohara | 25/06/2017 | 44 | Male | Tamang | Buddhist | Main street of settlement |
| 3 | Manohara | 25/06/2017 | 30 | Female | Brahmin | Hindu | Eastern side street |
| 4 | Manohara | 25/06/2017 | 40 | Female | Newar | Hindu | Shop owner/Main Street |
| 5 | Manohara | 25/06/2017 | 38 | Female | Brahmin | Hindu | Eastern side street |
| 6 | Manohara | 25/06/2017 | 27 | Female | Ghising | Hindu | Eastern side street |
| 7 | Balkhu | 29/06/2017 | 40 | Female | Nepali | Hindu | On Northern access road |
| 8 | Balkhu | 29/06/2017 | 35 | Female | Nagorkoti | Hindu | On Northern access road |
| 9 | Balkhu | 29/06/2017 | 67 | Male | Bika | Hindu | Internal settlement alley |
| 10 | Balkhu | 29/06/2017 | 29 | Female | Khadka | Hindu | Internal settlement alley |
| 11 | Balkhu | 29/06/2017 | 75 | Male | Krai | Hindu | Internal settlement alley |
| 12 | Balkhu | 29/06/2017 | 47 | Female | Bhattrai | Christian | Internal settlement alley |
| 13 | Thapathali | 02/07/2017 | 45 | Male | Bishwakarmi | Christian | Adjacent to river bank |
| 14 | Thapathali | 02/07/2017 | 41 | Female | Zimba | Buddhist | Shop owner/River Bank |
| 15 | Thapathali | 02/07/2017 | 20 | Male | Majhi | Hindu | Adjacent to river bank |
| 16 | Thapathali | 02/07/2017 | 14 | Female | Rai | Hindu | 50m from River |
| 17 | Sankhamul | 05/07/2017 | 64 | Female | Brahmin | Hindu | Northern boundary road |
| 18 | Sankhamul | 05/07/2017 | 62 | Female | Lama | Buddhist | Internal settlement alley |
| 19 | Sankhamul | 05/07/2017 | 35 | Female | Magar | Hindu | Northern boundary road |
| 20 | Sankhamul | 05/07/2017 | 69 | Male | Karki | Hindu | Northern boundary road |

| Resident Questionnaire | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Section 2 - Household Characteristics | | | | | | | | | |
| Questionnaire Number | Q1 - Number of rooms in dwelling | Q2 - Tenure status of the dwelling | Q3 - Average monthly rent expenditure ('000's NR) | Q4 - Length of occupation of dwelling (in years) | Q5 - Main construction material of the floor | Q6 - Main construction material of the roof | Q7 - Main construction material of the walls | Q8 - Flooding risk of dwelling location | Q9 - Water table level in dwelling location |
| 1 | 5 | Squatter with owned house | N/A | 15 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 2 | 4 | Squatter with owned house | N/A | 5 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 3 | 2 | Squatter with owned house | N/A | 10 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 4 | 4 | Squatter with owned house | N/A | 14 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 5 | 4 | Squatter with owned house | N/A | 12 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 6 | 2 | Squatter with owned house | N/A | 12 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 7 | 3 | Squatter with owned house | N/A | 5 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 8 | 3 | Squatter with owned house | N/A | 8 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 9 | 3 | Squatter with owned house | N/A | 10 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 10 | 2 | Squatter with owned house | N/A | 8 | Concrete | Corrugated metal sheeting | Corrugated metal sheeting | Yes | Yes |
| 11 | 3 | Squatter with owned house | N/A | 11 | Earth | Corrugated metal sheeting | Plywood/ Bamboo | Yes | Yes |
| 12 | 2 | Squatter with owned house | N/A | 7 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 13 | 4 | Squatter with owned house | N/A | 13 | Earth | Bamboo frame with plastic sheeting | Bamboo frame with plastic sheeting | Yes | Yes |
| 14 | 3 | Squatter with owned house | N/A | 11 | Concrete | Bamboo frame with plastic sheeting | Bamboo frame with plastic sheeting | Yes | Yes |
| 15 | 3 | Squatter with owned house | N/A | 8 | Earth | Bamboo frame with plastic sheeting | Bamboo frame with plastic sheeting | Yes | Yes |
| 16 | 4 | Squatter with owned house | N/A | 9 | Earth | Bamboo frame with plastic sheeting | Bamboo frame with plastic sheeting | Yes | Yes |
| 17 | 3 | Rented | 3 | 1 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 18 | 5 | Squatter with owned house | N/A | 34 | Concrete | Corrugated metal sheeting | Brick/block | Yes - 5 times in 34y. Home and posessions had to be replaced each time | Yes |
| 19 | 1 - Original house split to accommodate inlaws | Squatter with owned house | N/A | 5 | Concrete | Corrugated metal sheeting | Brick/block | Yes | Yes |
| 20 | 5 | Squatter with owned house | N/A | 33 | Concrete | Corrugated metal sheeting | Brick/block | Yes - many times | Yes |

| Resident Questionnaire | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section 3 - Socio-Economic Information | | | | | | | | | | | | | | |
| Questionnaire Number | Q1 - Number of residents in household | | | | | | | | Q2 - Number of disabled or elderly residents in household | Q3 - Number of household residents working and their occupations | | | | |
| | a) Men | b) Women | c) Children | | d) Ages of Children | | | | | Number | Occupations | | | |
| | | | Boys | Girls | #1 | #2 | #3 | #4 | | | #1 | #2 | #3 | #4 |
| 1 | 1 | 2 | 0 | 2 | 3 | 4 | - | - | 1 | 0 | Retired farmer | - | - | - |
| 2 | 3 | 3 | 1 | 0 | 3 | - | - | - | 0 | 3 | Poultry farmer | Poultry farmer | Poultry farmer | - |
| 3 | 1 | 1 | 2 | 0 | 7 | 9 | - | - | 0 | 1 | Plumber | - | - | - |
| 4 | 1 | 3 | 0 | 0 | - | - | - | - | 0 | 2 | Office worker | Shop owner | - | - |
| 5 | 1 | 1 | 0 | 2 | 12 | 14 | - | - | 0 | 1 | NGO | - | - | - |
| 6 | 1 | 1 | 1 | 0 | 12 | - | - | - | 0 | 2 | Driver | Social Worker | - | - |
| 7 | 4 | 2 | 1 | 1 | 9 | 10 | - | - | 1 | 1 | Tailor | - | - | - |
| 8 | 1 | 1 | 1 | 1 | 3 | 10 | - | - | 0 | 2 | Construction worker | Water seller | - | - |
| 9 | 1 | 1 | 0 | 0 | - | - | - | - | 1 | 1 | Intermittent temporary employment | - | - | - |
| 10 | 1 | 2 | 1 | 2 | 2 | 4 | 11 | - | 0 | 1 | Driver | - | - | - |
| 11 | 3 | 3 | 0 | 2 | 8 months | 3 | - | - | 1 | 4 | Construction worker | Construction worker | Construction worker | Tailor |
| 12 | 1 | 1 | 0 | 0 | - | - | - | - | 0 | 1 | Printer | - | - | - |
| 13 | 2 | 1 | 0 | 1 | 9 | - | - | - | 0 | 2 | Painter | Dairy worker | - | - |
| 14 | 2 | 2 | 0 | 2 | 9 | 15 | - | - | 0 | 2 | Shop keeper | Labourer | - | - |
| 15 | 0 | 1 | 2 | 1 | 14 | 16 | - | - | 0 | 1 (working abroad) | Labourer (based in Malaysia) | - | - | - |
| 16 | 1 | 1 | 0 | 1 | 14 | - | - | - | 0 | 1 | Labourer | - | - | - |
| 17 | 0 | 1 | 0 | 0 | - | - | - | - | 1 | 0 | Supported by daughter | - | - | - |
| 18 | 2 | 7 | 2 | 0 | 6 months | 6 | - | - | 1 | 1 | Driver | - | - | - |
| 19 | 1 | 1 | 0 | 0 | - | - | - | - | 0 | 1 | Labourer | - | - | - |
| 20 | 2 | 1 | 2 | 0 | 11 | 12 | - | - | 1 | 1 | Cattle farmer | - | - | - |

| Resident Questionnaire | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Section 3 - Socio-Economic Information | | | | | | | | | | | |
| **Questionnaire Number** | **Q4 - Combined monthly income of the household ('000's NR)** | **Q5 - Work days lost to illness in last 6 months and causes of illness** | | **Q6 - Schooling avaialbility, attendance and sanitation levels** | | | **Q7 - Schooling days lost to illness in last 6 months and causes of illness** | | **Q8 - Number of mobile phone owners within the household** | **Q9 - Number of bank account holders within the household** | **Q10 - Additional other service availability within the community** |
| | | **Number of work days lost** | **Main causes of illness** | **a) School availability** | **b) Number of children from household attending school** | **c) Type of toilets and level of sanitation at school** | **Number of schooling days lost** | **Main causes of illness** | | | |
| 1 | 30-40 | 0 | N/A | Y | 0 | N/A | N/A | N/A | 3 | 3 | Health clinic, church, shops |
| 2 | 25-30 | 5 | Headache | Y | 1 | Children attend school outside of settlement | 0 | N/A | 7 | 1 | Health clinic, church, shops |
| 3 | 30 | 0 | N/A | Y | 2 | Unknown | 0 | N/A | 2 | 1 | Health clinic, church, shops |
| 4 | 40 | Recurring illness | Gastroenteritus | N/A | 0 | N/A | N/A | N/A | 4 | 2 | Health clinic, church, shops |
| 5 | 10 | 3 | Diarrhoea | Y | 2 | Unsatisfactory | 0 | N/A | 2 | 2 | Health clinic, church, shops |
| 6 | 10 | 5 | Fever/Flu | Y | 1 | Unknown | 5 | Fever/Flu | 2 | 1 | Health clinic, church, shops |
| 7 | 20-30 | 0 | N/A | Y | 2 | Pour-flush - clean and well maintained | 0 | N/A | 1 | 1 | Church, shops, Buddhist centre |
| 8 | 15 | 0 | N/A | Y | 2 | Pour-flush - clean and well maintained | 0 | N/A | 1 | 0 | Church, shops, Buddhist centre |
| 9 | 2-3 | 0 | N/A | Y | 0 | N/A | N/A | N/A | 0 | 0 | Church, shops, Buddhist centre |
| 10 | 15-20 | 0 | Regular boughts of diarrhoea, but no days lost | Y | 2 | Pour-flush - clean and well maintained | 0 | Regular boughts of diarrhoea, but no days lost | 3 | 3 | Church, shops, Buddhist centre |
| 11 | 10-15 | Numerous | Fainting/passing out | Y | 0 | N/A | N/A | N/A | 4 | 1 | Church, shops, Buddhist centre |
| 12 | 25-30 | 0 | N/A | Y | 0 | N/A | N/A | N/A | 1 | 1 | Church, shops, Buddhist centre |
| 13 | 18-19 | 0 | N/A | Y | 1 | Pour-flush - clean and well maintained | 0 | N/A | 3 | 1 | School, small shop |
| 14 | 15-20 | Numerous | Asthma/fever/pneumonia due to previous work sand mining in the river | Y | 2 | Pour-flush - clean and well maintained | 0 | N/A | 2 | 0 | School, small shop |
| 15 | 15-21 | 0 | N/A | Y | 3 | Pour-flush - clean and well maintained | 0 | N/A | 3 | 1 | School, small shop |
| 16 | 15 | 0 | N/A | Y | 1 | Pour-flush - clean and well maintained | 0 | N/A | 2 | 0 | School, small shop |
| 17 | N/A | 0 | N/A | N/A | 0 | N/A | N/A | N/A | 0 | 0 | Health clinic, school, shops |
| 18 | 15 | 0 | Vomiting and diarrhoea, but not affecting the working family member | Y | 1 | Pour-flush - clean and well maintained | 0 | N/A | 1 | 0 | Health clinic, school, shops |
| 19 | 19 | 0 | N/A | N/A | 0 | N/A | N/A | N/A | 2 | 0 | Health clinic, school, shops |
| 20 | 4-5 | 0 | N/A | Y | 2 | Pour-flush - clean and well maintained | 0 | N/A | 3 | 1 | Health clinic, school, shops |

| Resident Questionnaire | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section 4 - Water, Sanitation Practices and Infrastructure | | | | | | | | | | | | |
| Questionnaire Number | Q1 - Main Source of Drinking Water | Q2 - Location of sanitation facilities used by members household | | | | | | Q3 - Type of toilet normally used by household | Q4 - Toilet discharge arrangements | Q5 - Do children use the same sanitation method | | Q6 - Preferred method of toilet use |
| | | Household toilet (private) | | Shared household toilet | | | | | | Yes/No | If No, what do children use and why? | Sit/Squat |
| | | Frequency of use | Members of household using toilet | Frequency of use | Members of household using toilet | Number of households sharing the toilet | Number of people sharing the toilet regularly | | | | | |
| 1 | Public tap/Onsite treated water from borehole | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank emptied by suction tanker | No | Potty - very young children | Squat |
| 2 | Public tap/Onsite treated water from borehole | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank emptied by suction tanker | Yes | - | Squat |
| 3 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank | Yes | - | Squat |
| 4 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank | N/A | - | Squat |
| 5 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank | Yes | - | Squat |
| 6 | Bottled/Jarred water | - | - | All Day | All | 2 | 7 | Pour/manual flush | Partially-lined septic tank | Yes | - | Squat |
| 7 | Tanker-truck during winter, jarred water during summer | All day | All | - | - | - | - | Pour/manual flush | Directly to river | Yes | - | Squat |
| 8 | Tanker-truck during winter, jarred water during summer | All day | All | - | - | - | - | Pour/manual flush | Directly to river | Yes | - | Squat |
| 9 | Tanker-truck | All day | All | - | - | - | - | Pour/manual flush | Directly to river | N/A | - | Squat |
| 10 | Tanker-truck during winter, jarred water during summer | All day | All | - | - | - | - | Pour/manual flush | Directly to river | Yes | - | Squat |
| 11 | Tanker-truck during winter, jarred water during summer | - | - | All Day | All | 60-80 | 300-400 using a block of 6 toilets | Pour/manual flush | Directly to river | N/A | - | Squat |
| 12 | Tanker-truck | - | - | All Day | All | 60-80 | 300-400 using a block of 6 toilets | Pour/manual flush | Directly to river | N/A | - | Squat |
| 13 | Bottled/Jarred water | - | - | All Day | All | 5-6 | 25-30 | Pour/manual flush | Partially-lined septic tank | Yes | - | Squat |
| 14 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Partially-lined septic tank | Yes | - | Squat |
| 15 | Bottled/Jarred water | - | - | All Day | All | 5-6 | 25-30 | Pour/manual flush | Directly to river | Yes | - | Squat |
| 16 | Tanker-truck | - | - | All Day | All | 6-7 | 30-35 | Pour/manual flush | Directly to river | Yes | - | Squat |
| 17 | Tube well/tanker-truck | All day | All | - | - | - | - | Pour/manual flush | Piped sewer system | N/A | - | Squat |
| 18 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Piped sewer system | Yes | - | Squat |
| 19 | Tanker-truck | - | - | All Day | All | 2 | 6 | Pour/manual flush | Piped sewer system | N/A | - | Squat |
| 20 | Bottled/Jarred water | All day | All | - | - | - | - | Pour/manual flush | Piped sewer system | Yes | - | Squat |

| Resident Questionnaire | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section 4 - Water, Sanitation Practices and Infrastructure | | | | | | | | | | |
| Questionnaire Number | Q7 - Preferred method of cleaning after toilet use | | Q8 - Preparedness to pay for toilet service located in the house | | Q9 - Preparedness to pay for toilet service shared between houses in the same community | | Q10 - Current level of payment for sanitation services ('000's NR per year) | Q11 - Number of members of household using paid public toilets | Q12 - Issues surrounding the use of public toilets | Q13 - Issues surrounding the use toilets used by the household |
| | Wash/Wipe | Material used if wiping preferred | Yes/No | If yes, how much prepared to pay per month (NR) | Yes/No | If yes, how much prepared to pay per month | | | | |
| 1 | Wash | N/A | No | N/A | No | N/A | 7.5 | 0 | N/A | No issues |
| 2 | Wash | N/A | No | N/A | No | N/A | 1 | 0 | N/A | No issues |
| 3 | Wash | N/A | No | N/A | No | N/A | Septic tank has never filled | 0 | N/A | No issues |
| 4 | Wash | N/A | No | N/A | No | N/A | Never emptied septic tank in 8 yrs | 0 | N/A | No issues |
| 5 | Wash | N/A | No | N/A | No | N/A | Septic tank has never filled | 0 | N/A | No issues |
| 6 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |
| 7 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |
| 8 | Wash | N/A | Yes | 50 | No | N/A | 0 | 0 | N/A | Odour |
| 9 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |
| 10 | Wash | N/A | Yes | 50 | , with the extent | N/A | 0 | 0 | N/A | No issues |
| 11 | Wash | N/A | Yes | 100 | No | N/A | 0 | 0 | N/A | Dirty, Odour, Poorly lit, Queues |
| 12 | Wash | N/A | Yes | 50-100 | No | N/A | 0 | 0 | N/A | Dirty, Odour, Poorly lit, Difficult to access during rain |
| 13 | Wash | N/A | Yes | 100 | No | N/A | Septic tank has never filled | 0 | N/A | No issues |
| 14 | Wash | N/A | Yes | 50 | No | N/A | Septic tank has never filled | 0 | N/A | No issues |
| 15 | Wash | N/A | Yes | 50-100 | No | N/A | 0 | 0 | N/A | Dirty, Odour |
| 16 | Wash | N/A | Unsure | N/A | No | N/A | 0 | 0 | N/A | Dirty, Odour |
| 17 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |
| 18 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |
| 19 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | Dirty, due to the number of users |
| 20 | Wash | N/A | No | N/A | No | N/A | 0 | 0 | N/A | No issues |

| Resident Questionnaire | | | | | | |
|---|---|---|---|---|---|---|
| Section 5 - Cultural Issues | | | | | | |
| **Questionnaire Number** | **Q1 - Sufficient space within dwelling to locate a CBS toilet** | **Q2 - Acceptability of locating a CBS toilet inside the dwelling** | **Q3 - Sufficient space outside dwelling but on-plot to locate a CBS toilet** | **Q4 - Acceptability of locating a CBS toilet outside the dwelling, but on-plot** | **Q5 - Issues with carrying or handling a vessel containing human excreta** | **Q6 - Issues with carrying or handling a vessel containing human urine** |
| 1 | Yes | Yes | Yes | Yes | No | No |
| 2 | Yes | Yes | N/A - Toilet in home already | N/A - Toilet in home already | No | No |
| 3 | Yes | Yes | N/A - Toilet in home already | N/A - Toilet in home already | No | No |
| 4 | Yes | Yes | N/A - Toilet in home already | N/A - Toilet in home already | No | No |
| 5 | Yes | Yes | N/A - Toilet in home already | N/A - Toilet in home already | No | No |
| 6 | Yes | Yes | Yes | Yes | No | No |
| 7 | Yes | Yes | No | Yes | Yes | Yes |
| 8 | Yes | Yes | No | Yes | No | No |
| 9 | Yes | Yes | No | Yes | No | No |
| 10 | Yes | Yes | No | Yes | No | No |
| 11 | No | Yes | No | Yes | No | No |
| 12 | Yes | Yes | No | Yes | No | No |
| 13 | Yes | Yes | Yes | Yes | No | No |
| 14 | Yes | Yes | Yes | Yes | No | No |
| 15 | Yes | Yes | Yes | Yes | No | No |
| 16 | Yes | Yes | Yes | Yes | No | No |
| 17 | Yes | Yes | No | Yes | No | No |
| 18 | Yes | Yes | Yes | Yes | No | No |
| 19 | No | No - insufficient space | Yes | Yes | No | No |
| 20 | Yes | Yes | Yes | Yes | Yes - would need to see the method of use | Yes - would need to see the method of use |

| Resident Questionnaire | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section 6 - End-use Products | | | | | | | | | | |
| Questionnaire Number | Q1 - Usual fuel used for cooking purposes | Q2 - Average monthly expenditure on fuel for cooking (000's NR per month) | Q3 - Reservations of using charcoal produced from human excreta | | Q4 - Reservations of using biogas produced from human excreta | | Q5 - Reservations about purchasing vegetables grown using fertiliser/compost produced from human excreta | | Q6 - Reservations about purchasing fruit from trees grown using fertiliser/compost produced from human excreta | |
| | | | Yes/No | If yes, why? | Yes/No | If yes, why? | Yes/No | If yes, why? | Yes/No | If yes, why? |
| 1 | Gas | 1 | No | - | No | - | No | - | No | - |
| 2 | Gas | 0.75 | No | - | No | - | No | - | No | - |
| 3 | Gas | 0.75 | No | - | No | - | No | - | No | - |
| 4 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 5 | Gas | 1 | No | - | No | - | No | - | No | - |
| 6 | Gas | 1 | No | - | No | - | No | - | No | - |
| 7 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 8 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 9 | Wood | 0.5 | Yes | Because it originates from human excreta | Yes | Because it originates from human excreta | Yes | Because it originates from human excreta | Yes | Because it originates from human excreta |
| 10 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 11 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 12 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 13 | Gas | 1 | No | - | No | - | No | - | No | - |
| 14 | Gas | 1.5 | No | - | No | - | No | - | No | - |
| 15 | Gas | 0.75 | No | - | No | - | No | - | No | - |
| 16 | Gas | 0.75 | No | - | No | - | No | - | No | - |
| 17 | Gas | Unknown | No | - | No | - | No | - | No | - |
| 18 | Gas | 1 | No | - | No | - | No | - | No | - |
| 19 | Gas | 0.75 | No | - | No | - | No | - | No | - |
| 20 | Gas | 1 | Yes | Unsure - would need to see how the system operates | Yes | Unsure - would need to see how the system operates | Yes | Unsure - would need to see how the system operates | Yes | Unsure - would need to see how the system operates |

## *Appendix G – CBS scoring matrix*

## *CBS – APPROPRIATENESS AND POTENTIAL SCORING MATRIX*

| Level | Description – the impact of the factors that affect the potential success or ease of implementation of a CBS service | Status |
|---|---|---|
| **-3** | Reality within study area may a highly negative effect on the potential success of CBS | |
| **-2** | Reality within study area may have a moderate negative effect on the potential success of CBS | |
| **-1** | Reality within study area may have a low negative effect on the potential success of CBS | |
| **0** | Reality within study area will have no or negligible effect on the potential success of CBS | |
| **1** | Reality within study area may have a low positive effect on the potential success of CBS | |
| **2** | Reality within study area may have a moderate positive effect on the potential success of CBS | |
| **3** | Reality within study area may have a highly positive effect on the potential success of CBS | |
| **X** | Reality within study area is not possible to determine or factor is not applicable | |

**Weighting/Importance Factor**

| Level | Description | Multiplication Factor |
|---|---|---|
| **H** | High level of importance | X3 |
| **M** | Medium level of importance | X2 |
| **L** | Low level of importance | X1 |

**Weighted Impacts thresholds**

| Weighted Impact Score | Impact Level Description/Category | Action |
|---|---|---|
| **-9** | Potentially prohibitive level of impact on the success of CBS | Factor needs to be addressed to allow CBS to operate |
| **-4 to -8** | Significant negative level of impact on the success of CBS | Factor needs careful consideration for CBS to operate |
| **-3 to 3** | Low level of impact on the success of CBS | Awareness required of factor and impact |
| **4 to 8** | Significant positive level of impact on the success of CBS | Maximise potential of positive factor/impact |
| **9** | Very significant positive level of impact on the success of CBS | Maximise potential of positive factor/impact |

| ***Country/City:*** | | | |
|---|---|---|---|
| **District:** | | **Date of Assessment:** | |
| ***Summary:*** | | | |

| **Factors and Impacts** | **Score** | **Main Issues and Barriers** | **Success Potential and Comments** |
|---|---|---|---|
| 1) Cultural | | | |
| 2) Existing Sanitation Facilities and Practices | | | |
| 3) Operational | | | |
| 4) Geographical/ Geological | | | |
| 5) Physical | | | |
| 6) Financial | | | |
| 7) Accommodation | | | |
| 8) End-use products | | | |
| 9) Enabling Environment | | | |

| *1. Cultural Factors and Impacts* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Reaction to payment for sanitation services by residents of community. | | | | | | | | | | |
| **H/M/L** | Level of acceptability to residents of the concept of having a toilet located within the dwelling. | | | | | | | | | | |
| **H/M/L** | Level of acceptability to residents of the concept of having a toilet located on-plot but outside of the dwelling. | | | | | | | | | | |
| **H/M/L** | Level of acceptability to residents of the concept of handling sealed containers of human excreta. | | | | | | | | | | |
| **H/M/L** | Level of acceptability to residents of the concept of handling sealed containers of human urine. | | | | | | | | | | |
| **H/M/L** | Impact of anal cleansing practices on CBS implementation | | | | | | | | | | |
| **H/M/L** | Preference of toilet usage type (e.g. squatting, sitting, etc.) | | | | | | | | | | |
| **H/M/L** | Impact of religious or cultural practices on use/type of toilet | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 2. Existing Sanitation Facilities/Practices Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Convenience/opening hours of using public facilities | | | | | | | | | | |
| **H/M/L** | Cost of using existing public facilities | | | | | | | | | | |
| **H/M/L** | Proximity of nearest public facilities | | | | | | | | | | |
| **H/M/L** | Cleanliness and quality of public facilities | | | | | | | | | | |
| **H/M/L** | Security issues of using public facilities during the night | | | | | | | | | | |
| **H/M/L** | Security issues of using public facilities during the day | | | | | | | | | | |
| **H/M/L** | Availability of private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Cleanliness of private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Convenience of private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Maintenance costs of private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Quantity of water required of private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Availability of alternative non-private household or on-plot | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | sanitation facilities (e.g. communal, shared, etc.) | | | | | | | | | | |
| **H/M/L** | Cleanliness of alternative non-private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Convenience of alternative non-private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Maintenance costs of alternative non-private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Quantity of water required of alternative non-private household or on-plot sanitation facilities | | | | | | | | | | |
| **H/M/L** | Availability/proximity of piped water supply | | | | | | | | | | |
| **H/M/L** | Availability/proximity of functional sewers for potential connection | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| ***3. Operational Factors and Impacts*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Availability of required space and acceptability locally for waste transfer station establishment | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **H/M/L** | Availability of required space locally for treatment facility establishment | | | | | | | | | | |
| **H/M/L** | Availability of existing treatment facility with sufficient functioning capacity for treatment or disposal of collected waste | | | | | | | | | | |
| **H/M/L** | Proximity of existing treatment facility with sufficient functioning capacity for treatment or disposal of collected waste | | | | | | | | | | |
| **H/M/L** | Availability of suitable cover material for use within toilets | | | | | | | | | | |
| **H/M/L** | Availability and low cost of additional required inputs in the treatment process (e.g. food waste, electricity, etc.) | | | | | | | | | | |
| **H/M/L** | Availability of workforce/ waste collectors with ability/ desire to collect/sort human waste | | | | | | | | | | |
| **H/M/L** | Ease of identification of individual customer dwellings | | | | | | | | | | |
| **H/M/L** | Ease of communication with individual customers and bill payers | | | | | | | | | | |
| **H/M/L** | Ease of collection and exchange of CBS containers (i.e. access, resident dwelling hours of occupation, etc.) | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 4. Geographical/Geological Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Impact of the local topography on the operational or implementation potential | | | | | | | | | | |
| **H/M/L** | Vulnerability of the area/community to flooding | | | | | | | | | | |
| **H/M/L** | Severity of flooding in the area/community | | | | | | | | | | |
| **H/M/L** | Frequency of flooding in the area/community | | | | | | | | | | |
| **H/M/L** | Water-table level within the locality of the community | | | | | | | | | | |
| **H/M/L** | Ground infiltration rates within the locality of the community | | | | | | | | | | |
| **H/M/L** | Ground conditions preventing excavation (e.g. rock, unstable ground, etc.) | | | | | | | | | | |
| **H/M/L** | Surfacing materials preventing excavation (e.g. concrete, tarmacadam, etc.) | | | | | | | | | | |
| **H/M/L** | Level of impact of existing sanitation practices (e.g. pit latrines) on drinking water supplies (e.g. shallow wells) | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 5. Physical Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Impact of the housing density on the ability to establish alternative sanitation facilities to CBS | | | | | | | | | | |
| **H/M/L** | Impact of the housing density on the potential density of the customer base | | | | | | | | | | |
| **H/M/L** | Impact of the housing density on the operational or implementation approach of a CBS service | | | | | | | | | | |
| **H/M/L** | Impact of the ease of access within the area on the potential operation processes of a CBS service | | | | | | | | | | |
| **H/M/L** | Vehicular restrictions and proximity of nearest access | | | | | | | | | | |
| **H/M/L** | Impact of settlement shape on the economics and practicalities of collection (e.g. linear, dispersed, nucleated, etc.) | | | | | | | | | | |
| **H/M/L** | Overall physical size/number of dwellings within settlement and the implications on the implementation of CBS | | | | | | | | | | |
| **H/M/L** | Overall population size of settlement and the potential market for CBS | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **H/M/L** | Proximity of additional potential target market areas or populations for potential incorporation into a CBS service | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| ***6. Financial Factors and Impacts*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Willingness to pay/current level of payment (e.g. pit emptying, public toilets, etc.) within the community for sanitation services | | | | | | | | | | |
| **H/M/L** | Ability to pay within the community for sanitation services | | | | | | | | | | |
| **H/M/L** | Ease of establishing an economical method of collecting tariffs from customers (e.g. mobile money, etc.) | | | | | | | | | | |
| **H/M/L** | Percentage/Level of potential customer uptake of CBS (i.e. density of potential customer base) | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 7. Accommodation Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Impact of the average housing size on the potential for CBS implementation (e.g. number and type of rooms) | | | | | | | | | | |
| **H/M/L** | Impact of number of storeys or individual dwellings within each property on the potential for CBS implementation | | | | | | | | | | |
| **H/M/L** | Implications of internal arrangement and room layout within dwellings | | | | | | | | | | |
| **H/M/L** | Effect of the availability of outdoor space on-plot on the potential for household level CBS implementation | | | | | | | | | | |
| **H/M/L** | Effect of the availability of outdoor space in the community on the potential for shared CBS implementation | | | | | | | | | | |
| **H/M/L** | Level housing permanence/ transience of population within the community | | | | | | | | | | |
| **H/M/L** | Impact/level of private land ownership within the community | | | | | | | | | | |
| **H/M/L** | Impact of tenure status of residency of the community | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 8. End-use Product Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Acceptability of the use of compost produced from human waste | | | | | | | | | | |
| **H/M/L** | Size of potential market for the use of compost produced from human waste (i.e. agricultural practices, types of produce grown, proximity of potential customers, potential value of the product, etc.) | | | | | | | | | | |
| **H/M/L** | Acceptability of the use of charcoal briquettes produced from human waste | | | | | | | | | | |
| **H/M/L** | Size of potential market for the use of charcoal briquettes produced from human waste (i.e. scale/level of existing use of product and potential uptake, proximity of potential customers, potential value of the product, etc.) | | | | | | | | | | |
| **H/M/L** | Acceptability of the use of biogas produced from human waste | | | | | | | | | | |
| **H/M/L** | Size of potential market for the use of biogas produced from human waste (i.e. scale/level of existing use of product and potential uptake, | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | proximity of potential customers, potential value of the product, etc.) | | | | | | | | | | |
| **H/M/L** | Acceptability of the use of electricity produced from human waste | | | | | | | | | | |
| **H/M/L** | Size of potential market for the use of electricity produced from human waste (i.e. scale/level of existing use of product and potential uptake, proximity of potential customers, potential value of the product, etc.) | | | | | | | | | | |
| **H/M/L** | Acceptability of the use of animal feed produced from human waste | | | | | | | | | | |
| **H/M/L** | Size of potential market for the use of animal feed produced from human waste (i.e. agricultural practices, proximity of potential customers, potential value of the product, etc.) | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

| 9. Enabling Environment Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H/M/L** | Potential/inclination within local utility or municipality to collect sanitation tariffs | | | | | | | | | | |
| **H/M/L** | Legal implications/restrictions on the potential of CBS implementation (e.g. manual scavenging laws, legitimisation of illegal/ squatter settlements, etc.) | | | | | | | | | | |
| **H/M/L** | Legal restrictions on the construction of infrastructure | | | | | | | | | | |
| **H/M/L** | Availability of potential funding/subsidy from local municipality, organisations, or other institutional bodies | | | | | | | | | | |
| **H/M/L** | Opportunity or availability of free-use land in local proximity from municipality to minimise set-up and running costs | | | | | | | | | | |
| **H/M/L** | The rate of tax, and potential opportunity for a tax holiday to aid with the establishment of CBS business | | | | | | | | | | |
| **TOTAL SCORE** | | | | | | | | | | | |

## *Appendix H – Research diary*

| Research Diary & Plan | | | |
|---|---|---|---|
| **Day** | **Date** | **Planned Activity** | **Actual Activity** |
| Saturday | 10th June | Travel | Travel |
| Sunday | 11th June | Settle in | Settle in |
| Monday | 12th June | Introduction/Initial Meeting/Review interview & meeting programme | Initial meeting with Sabitri. KII with Mingma Sherpa |
| Tuesday | 13th June | Interviews @ Lumanti/ENPHO/UN Habitat | KII @ ENPHO with Bipin Dangol (Executive Director). Transect walk through Kupondole settlement |
| Wednesday | 14th June | Field visit/transect walk - Community 1 | Transect walk through Balkhu. KII with Gunaraj Shrestha |
| Thursday | 15th June | Field visit/transect walk - Community 2 | Day Off - Sabitri busy at NEC |
| Friday | 16th June | Field visit/transect walk - Community 3 | KII with Prakash Amatya |
| Saturday | 17th June | Day Off | Day Off |
| Sunday | 18th June | Day Off | Transect walk through Manohara. |
| Monday | 19th June | Prepare Interview/Focus Group material | KII @ Lumanti with Lumanti Joshi |
| Tuesday | 20th June | Focus Group Discussions - Community 1 (Female/mixed) | KII @ Lalitpur Municipality with Pradeep Amatya and Jayshree Rajbhandary. Visit to WWT plant @Guheshowri |
| Wednesday | 21st June | Focus Group Discussions - Community 1 (Female/mixed) | Reviewing Interviews |
| Thursday | 22nd June | Resident surveys/interviews - Community 1 | KII @ Kathmandu Metropolitan City with Rabin Man Shrestha and Nisha Koirala. KII with Umesh Rupakheti @ Lumanti |
| Friday | 23rd June | Writing up results/Admin | Visiting FS treatment plant @ Lubhu. Visit to traditional settlement at Siddhipur |
| Saturday | 24th June | Day Off | Day Off |
| Sunday | 25th June | Day Off | Resident surveys @ Manohara. KII with Yogendra Chitrakar @ HPCIDBC. KII with Prabhu Raj Pandey @ SILT consultancy |

| Research Diary & Plan | | | |
|---|---|---|---|
| **Day** | **Date** | **Planned Activity** | **Actual Activity** |
| Monday | 26th June | Focus Group Discussions - Community 2 (Female/mixed) | Writing up resident surveys |
| Tuesday | 27th June | Focus Group Discussions - Community 2 (Female/mixed) | Transect walk through Sankhamul |
| Wednesday | 28th June | Resident surveys/interviews - Community 2 | KII @ UN Habitat with Bhusan Tuladhas. KII @ DWSS with Prem Shrestha |
| Thursday | 29th June | Writing up results/Admin | Amend Focus group discussion plan. Resident surveys @ Balkhu. |
| Friday | 30th June | Focus Group Discussions - Community 3 (Female/mixed) | Day Off |
| Saturday | 1st July | Day Off | Writing up resident surveys |
| Sunday | 2nd July | Day Off | Resident surveys @ Thapathali |
| Monday | 3rd July | Focus Group Discussions - Community 3 (Female/mixed) | Focus Group Discussion @ Balkhu |
| Tuesday | 4th July | Resident surveys/interviews - Community 3 | KII @ ENPHO with Rajendra Shrestha. |
| Wednesday | 5th July | Writing up results/Admin | Resident surveys @ Sankhamul |
| Thursday | 6th July | Municipality/Local Government Interview | Day Off |
| Friday | 7th July | Spare Day | KII @ Kathmandu Metropolitan City with Rabin Man Shrestha |
| Saturday | 8th July | Travel | Travel |

## *Appendix I – CBS key informant interview record*

| Date | Name | Organisation | Interview Details/Relevance |
|---|---|---|---|
| 18/05/17 | Mary Roach | Loowatt | Semi-structured KII with Global Partnerships manager at CBS organisation |
| 22/05/17 | Emily Woods | Sanivation | Semi-structured KII with CEO and Co-Founder of CBS organisation |
| 22/05/17 | Sasha Kramer | SOIL | Semi-structured KII with Executive Director of CBS organisation |
| 23/05/17 | Catherine Berner | Sanivation | Unstructured KII with Technical lead of CBS operator |
| 24/05/17 | Louise Kirby-Garton | Sanitation First | Semi-structured KII with Chief Executive of CBS organisation |
| 25/05/17 | Brian McSorley | Oxfam/ Sanergy | Semi-structured KII with Water & Sanitation Engineering Advisor for Oxfam; Played key role in establishing the household level CBS operations of Sanergy |
| 26/05/17 | Georges Mikhael | WSUP | Semi-structured KII with Head of Sanitation at WSUP to discuss experience of Clean Team |
| 31/05/17 | Laura Kwong | Stanford University | Semi-structured KII to discuss previous research into CBS potential in Bangladesh and other contexts |
| 5/06/17 | Mingma Sherpa | 500B Solution | Unstructured KII to discuss potential of CBS in Kathmandu/Nepal and FSM in Kathmandu |
| 5/06/17 | Adrien Mazeau | i-san | Unstructured KII with i-san consultant considering the latest findings of the current ongoing World Bank commissioned due diligence study on CBS |
| 6/06/17 | Andy Narracott | Clean Team | Semi-structured KII to discuss previous experience as Co-Creator and Chairman for Clean Team |
| 7/06/17 | David Auerbach | Sanergy | Semi-structured KII with Co-Founder at CBS organisation |
| 10/07/17 | Isabel Medem | X-runner | Semi-structured KII with CEO and Co-Founder of CBS organisation |
| 11/07/17 | Kory Russel | CBS Alliance | Semi-structured KII with Chairman of CBS Alliance to discuss the history and future potential of CBS |

## *Appendix J – Kathmandu key informant interview record*

| | | | |
|---|---|---|---|
| 13/06/17 | Bipin Dangol | ENPHO | Unstructured KII with Executive Director of ENPHO to discuss potential of CBS in Kathmandu and status of FSM and sanitation in Nepal |
| 14/06/17 | Gunaraj Shrestha | WSSCC | Unstructured KII with National Coordinator for WSSCC to discuss potential of CBS in Kathmandu/Nepal |
| 16/06/17 | Prakash Amatya | WASH Consultant | Unstructured KII with WASH Consultant to discuss potential of CBS in Kathmandu/Nepal |
| 19/06/17 | Lumanti Joshi | Lumanti | Unstructured KII with Programme Manager at Lumanti to discuss status of squatter communities in Kathmandu and the potential of CBS in those communities |
| 20/06/17 | Jayshree Rajbhandary | Lalitpur Metropolitan City | Unstructured KII with Project Coordinator at LMC to discuss potential sale and reuse of CBS by-products in Kathmandu/Nepal |
| 20/06/17 | Nabin Bikash Maharjan | Blue Waste to Value | Unstructured KII with CEO of Blue Waste to Value to discuss potential market of compost/fertiliser produced from CBS operations in Kathmandu/Nepal |
| 20/06/17 | Pradeep Amatya | Lalitpur Metropolitan City | Unstructured KII with Environmental Engineer at LMC to discuss potential sale and reuse of CBS by-products in Kathmandu/Nepal |
| 20/06/17 | Anjita Kajbanshi | HPCIDBC | Unstructured KII to discuss the WTP at Guheshowri and the current WTP expansion project |
| 22/06/17 | Rabin Man Shrestha | Kathmandu Metropolitan City | Unstructured KII with Chief of the Environment Management Department at KMC to discuss the former FS plant and new waste to energy plant at Teku |
| 22/06/17 | Nisha Koirala | Kathmandu Metropolitan City | Unstructured KII with Environmental Engineer at the Environment Management Department at KMC to discuss the former FS plant and new waste to energy plant at Teku |
| 22/06/17 | Umesh Rupakheti | Lumanti | Unstructured KII with Technical WASH Coordinator at Lumanti to discuss sanitation |

| | | | |
|---|---|---|---|
| | | | progress and status of squatter communities in Kathmandu |
| 23/06/17 | Kripa Karki | ENPHO | Unstructured KII with Sanitation Engineer at ENPHO to discuss the FS plant at Lubhu |
| 25/06/17 | Vaibhav Pandey | Sharma and Company | Unstructured KII with Contract Manager at Sharma & Co to discuss the new Municipal Trunk Sewer Main Project as part of KVWSIP |
| 25/06/17 | Yogendra Chitraker | HPCIDBC | Unstructured KII with Deputy Project Manager for the HPCIDBC for the new Municipal Trunk Sewer Main Project as part of KVWSIP |
| 25/06/17 | Prabhu Raj Pandey | SILT Engineers and Consultants | Unstructured KII with Director of SILT and their role in the new Municipal Trunk Sewer Main Project as part of KVWSIP |
| 28/06/17 | Bhusan Tuladhas | UN Habitat | Unstructured KII with Regional Technical Advisor for UN Habitat to historic EcoSan use and potential of CBS in Kathmandu/Nepal |
| 28/06/17 | Sanjaya Adhikary | DWSS | Unstructured KII with WASH Governance Advisor for DWSS to discuss WASH and FS management in Kathmandu/Nepal |
| 4/07/17 | Rajendra Shrestha | ENPHO | Unstructured KII with Outreach Director at ENPHO to discuss EcoSan deployment and usage across Nepal |
| 7/07/17 | Rabin Man Shrestha | Kathmandu Metropolitan City | Unstructured KII with Chief of the Environment Management Department at KMC to discuss the plans for public toilet construction, and potential of CBS as an option. |

## *Appendix K – Kathmandu squatter settlement data*

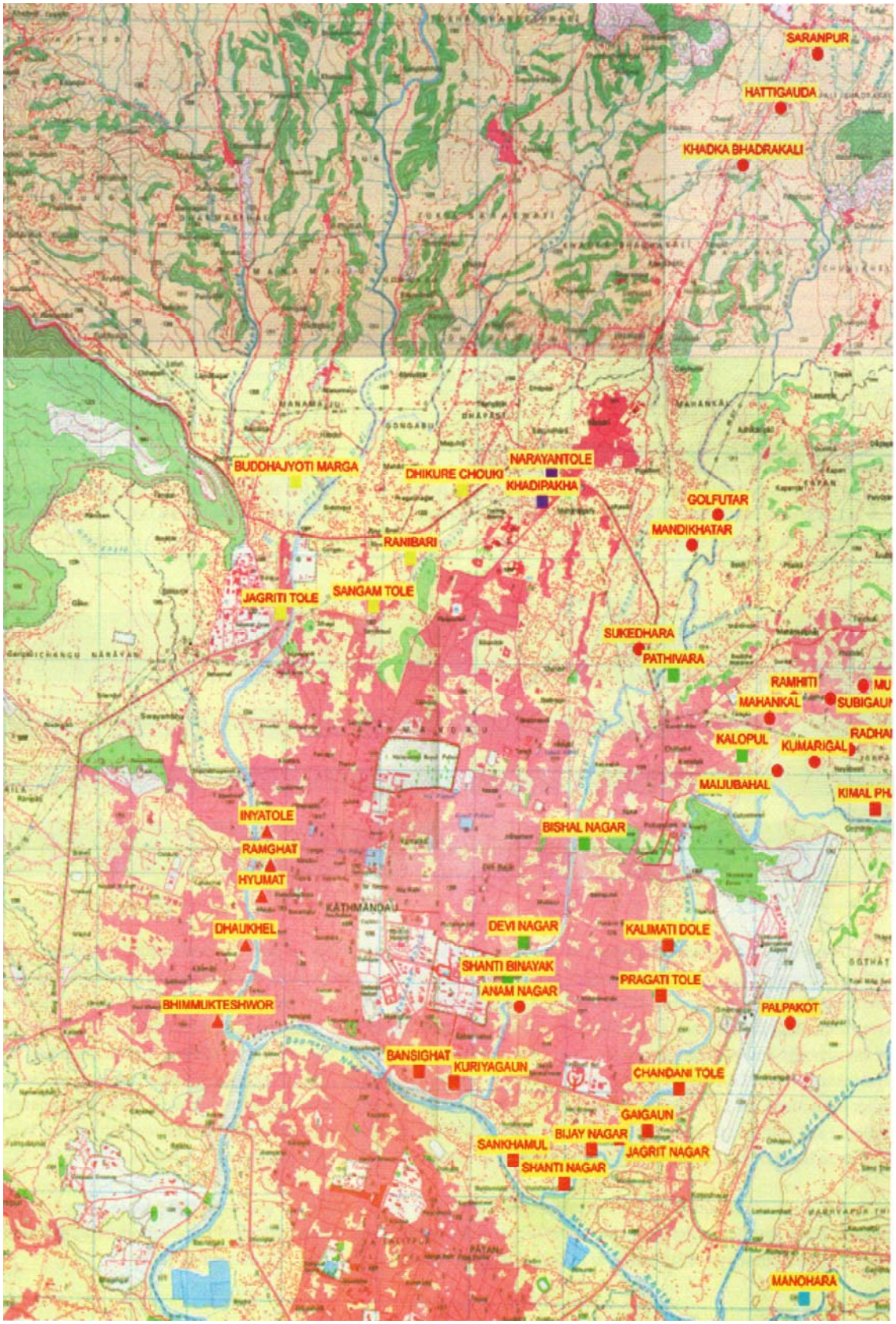


*Figure 8.1 Kathmandu Squatter Settlement Locations*

*Source: (Lumanti 2008)*

*Table 8.1 Number of households and population of squatter and indigenous settlements*

*Source: (Lumanti 2008)*

| SN | Squatters/Indigenous Settlements | Number of household | Population | | | Average household size |
|---|---|---|---|---|---|---|
| | | | Male | Female | Total | |
| | **Squatters** | | | | | |
| 1 | Manohara Bhaktapur | 589 | 1,290 | 1,132 | 2,422 | 4.1 |
| 2 | Shanti Nagar | 360 | 864 | 768 | 1,632 | 4.5 |
| 3 | Bijay Nagar | 25 | 69 | 49 | 118 | 4.7 |
| 4 | Jagrit Nagar | 120 | 235 | 227 | 462 | 3.9 |
| 5 | Gaigaun | 46 | 108 | 99 | 207 | 4.5 |
| 6 | Chandani Tole | 48 | 120 | 102 | 222 | 4.6 |
| 7 | Pragati Tole | 11 | 29 | 27 | 56 | 5.1 |
| 8 | Kalimati Dole | 16 | 31 | 36 | 67 | 4.2 |
| 9 | Palpakot | 30 | 96 | 62 | 158 | 5.3 |
| 10 | Anam Nagar | 17 | 42 | 37 | 79 | 4.6 |
| 11 | Shanti Binayak | 42 | 104 | 88 | 192 | 4.6 |
| 12 | Devi Nagar | 32 | 69 | 60 | 129 | 4 |
| 13 | Bishal Nagar | 37 | 93 | 85 | 178 | 4.8 |
| 14 | Maijubahal | 25 | 84 | 68 | 152 | 6.1 |
| 15 | Kumarigal | 11 | 29 | 23 | 52 | 4.7 |
| 16 | Radhakrishna Chowk | 16 | 51 | 46 | 97 | 6.1 |
| 17 | Kimal Phant | 26 | 56 | 48 | 104 | 4 |
| 18 | Mulpani | 12 | 24 | 36 | 60 | 5 |
| 19 | Kapan Dhungen | 13 | 30 | 33 | 63 | 4.8 |
| 20 | Subigaun | 34 | 98 | 102 | 200 | 5.9 |
| 21 | Ramhiti | 122 | 315 | 353 | 668 | 5.5 |
| 22 | Mahankal | 15 | 34 | 43 | 77 | 5.1 |
| 23 | Kalopul | 6 | 10 | 10 | 20 | 3.3 |
| 24 | Pathivara | 154 | 377 | 351 | 728 | 4.7 |
| 25 | Dhumbarahi Sukedhara | 14 | 40 | 29 | 69 | 4.9 |
| 26 | Mandikhatar | 78 | 187 | 175 | 362 | 4.6 |
| 27 | Golfutar | 24 | 55 | 68 | 123 | 5.1 |
| 28 | Saranpur Budhanilkantha | 80 | 198 | 175 | 373 | 4.7 |
| 29 | Hattigauda | 6 | 14 | 19 | 33 | 5.5 |
| 30 | Khadka Bhadrakali | 33 | 93 | 88 | 181 | 5.5 |
| 31 | Narayantole Maharajgunj | 30 | 55 | 53 | 108 | 3.6 |
| 32 | Khadipakha Maharajgunj | 146 | 404 | 331 | 735 | 5 |
| 33 | Dhikure Chouki | 26 | 45 | 67 | 112 | 4.3 |
| 34 | Kumaristhan Buddhajyoti Marga | 73 | 153 | 167 | 320 | 4.4 |
| 35 | Balaju Jagriti Tole | 126 | 346 | 345 | 691 | 5.5 |
| 36 | Sangam Tole | 36 | 103 | 111 | 214 | 5.9 |
| 37 | Ranibari | 45 | 121 | 106 | 227 | 5 |
| 38 | Bansighat | 96 | 264 | 222 | 486 | 5.1 |
| 39 | Kuriyagaun | 10 | 23 | 23 | 46 | 4.6 |
| 40 | Sankhamul | 105 | 253 | 250 | 503 | 4.8 |
| | **Total** | **2,735** | **6,612** | **6,114** | **12,726** | **4.7** |
| | **Indigenous Settlements** | | | | | |
| 1 | Inyatole | 34 | 71 | 61 | 132 | 3.9 |
| 2 | Ramghat | 20 | 35 | 19 | 54 | 2.7 |
| 3 | Hyumat | 5 | 19 | 12 | 31 | 6.2 |
| 4 | Dhaukhel | 17 | 43 | 40 | 83 | 4.9 |
| 5 | Bhimmukteshwor | 33 | | 108 | 217 | 6.6 |
| | **Total** | **109** | **277** | **240** | **517** | **4.7** |
| | **Grand Total** | **2,844** | **6,889** | **6,354** | **13,243** | **4.7** |

*Table 8.2 Toilet ownership of households in squatter and indigenous settlements*

*Source: (Lumanti 2008)*

| SN | Squatters/Indigenous Settlements | Total household | Household without toilet | | | Percentage of household with toilet | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Open space | Riverside | Total | Modern toilet | Pit latrine | Latrine drained to river | Total |
| | **Squatters** | | | | | | | | |
| 1 | Manohara Bhaktapur | 589 | 9% | 31% | 40% | 1% | 58% | 1% | 60% |
| 2 | Shanti Nagar | 360 | 0% | 6% | 6% | 18% | 2% | 75% | 94% |
| 3 | Bijay Nagar | 25 | 0% | 0% | 0% | 0% | 0% | 100% | 100% |
| 4 | Jagrit Nagar | 120 | 0% | 7% | 7% | 0% | 3% | 91% | 93% |
| 5 | Gaigaun | 46 | 33% | 33% | 65% | 0% | 2% | 33% | 35% |
| 6 | Chandani Tole | 48 | 0% | 8% | 8% | 0% | 4% | 88% | 92% |
| 7 | Pragati Tole | 11 | 0% | 9% | 9% | 64% | 0% | 27% | 91% |
| 8 | Kalimati Dole | 16 | 0% | 0% | 0% | 88% | 0% | 13% | 100% |
| 9 | Palpakot | 30 | 0% | 0% | 0% | 40% | 57% | 3% | 100% |
| 10 | Anam Nagar | 17 | 0% | 0% | 0% | 0% | 6% | 94% | 100% |
| 11 | Shanti Binayak | 42 | 7% | 2% | 10% | 0% | 0% | 90% | 90% |
| 12 | Devi Nagar | 32 | 0% | 0% | 0% | 0% | 0% | 100% | 100% |
| 13 | Bishal Nagar | 37 | 0% | 0% | 0% | 0% | 14% | 86% | 100% |
| 14 | Maijubahal | 25 | 12% | 0% | 12% | 0% | 0% | 88% | 88% |
| 15 | Kumarigal | 11 | 18% | 0% | 18% | 0% | 55% | 27% | 82% |
| 16 | Radhakrishna Chowk | 16 | 6% | 0% | 6% | 94% | 0% | 0% | 94% |
| 17 | Kimal Phant | 26 | 0% | 0% | 0% | 0% | 0% | 100% | 100% |
| 18 | Mulpani | 12 | 0% | 0% | 0% | 0% | 83% | 17% | 100% |
| 19 | Kapan Dhungen | 13 | 0% | 0% | 0% | 0% | 0% | 100% | 100% |
| 20 | Subigaun | 34 | 3% | 0% | 3% | 0% | 3% | 94% | 97% |
| 21 | Ramhiti | 122 | 2% | 0% | 2% | 70% | 25% | 3% | 98% |
| 22 | Mahankal | 15 | 0% | 0% | 0% | 0% | 0% | 100% | 100% |
| 23 | Kalopul | 6 | 0% | 100% | 100% | 0% | 0% | 0% | 0% |
| 24 | Pathivara | 154 | 1% | 3% | 3% | 0% | 1% | 96% | 97% |
| 25 | Dhumbarahi Sukedhara | 14 | 0% | 0% | 0% | 0% | 14% | 86% | 100% |
| 26 | Mandikhatar | 78 | 1% | 0% | 1% | 0% | 4% | 95% | 99% |
| 27 | Golfutar | 24 | 0% | 0% | 0% | 0% | 100% | 0% | 100% |
| 28 | Saranpur Budhanilkantha | 80 | 60% | 0% | 60% | 24% | 16% | 0% | 40% |
| 29 | Hattigauda | 6 | 0% | 0% | 0% | 17% | 0% | 83% | 100% |
| 30 | Khadka Bhadrakali | 33 | 3% | 0% | 3% | 12% | 0% | 85% | 97% |
| 31 | Narayantole Maharajgunj | 30 | 10% | 0% | 10% | 0% | 23% | 67% | 90% |
| 32 | Khadipakha Maharajgunj | 146 | 3% | 1% | 3% | 0% | 0% | 97% | 97% |
| 33 | Dhikure Chouki | 26 | 4% | 4% | 8% | 92% | 0% | 0% | 92% |
| 34 | Kumaristhan Buddhajyoti Marga | 73 | 0% | 1% | 1% | 15% | 0% | 84% | 99% |
| 35 | Balaju Jagriti Tolc | 126 | 3% | 13% | 17% | 56% | 21% | 6% | 83% |
| 36 | Sangam Tole | 36 | 0% | 0% | 0% | 83% | 0% | 17% | 100% |
| 37 | Ranibari | 45 | 0% | 2% | 2% | 87% | 4% | 7% | 98% |
| 38 | Bansighat | 96 | 2% | 16% | 18% | 2% | 2% | 78% | 82% |
| 39 | Kuriyagaun | 10 | 20% | 10% | 30% | 0% | 70% | 0% | 70% |
| 40 | Sankhamul | 105 | 0% | 3% | 3% | 63% | 8% | 27% | 97% |
| | **Total** | 2735 | 5% | 10% | 16% | 17% | 19% | 48% | 84% |
| | **Indigenous settlements** | | | | | | | | |
| 1 | Inyatole | 34 | 6% | 24% | 29% | 71% | 0% | 0% | 71% |
| 2 | Ramghat | 20 | 0% | 15% | 15% | 80% | 0% | 5% | 85% |
| 3 | Hyumat | 5 | 0% | 0% | 0% | 100% | 0% | 0% | 100% |
| 4 | Dhaukhel | 17 | 0% | 29% | 29% | 71% | 0% | 0% | 71% |
| 5 | Bhimmukteshwor | 33 | 0% | 3% | 3% | 27% | 3% | 67% | 97% |
| | **Total** | 109 | 1.80% | 15.60% | 17% | 61% | 1% | 21% | 83% |
| | **Grand total** | 2844 | 5% | 11% | 16% | 19% | 18% | 47% | 84% |

## *Appendix L – Completed CBS scoring matrix for Kathmandu*

## *CBS – APPROPRIATENESS AND POTENTIAL SCORING MATRIX*

| Level | Description – the impact of the factors that affect the potential success or ease of implementation of a CBS programme | Status |
|---|---|---|
| **-3** | Reality within study area may a highly negative effect on the potential success of CBS | |
| **-2** | Reality within study area may have a moderate negative effect on the potential success of CBS | |
| **-1** | Reality within study area may have a low negative effect on the potential success of CBS | |
| **0** | Reality within study area will have no or negligible effect on the potential success of CBS | |
| **1** | Reality within study area may have a low positive effect on the potential success of CBS | |
| **2** | Reality within study area may have a moderate positive effect on the potential success of CBS | |
| **3** | Reality within study area may have a highly positive effect on the potential success of CBS | |
| **X** | Reality within study area is not possible to determine or factor is not applicable | |

**Weighting/Importance Factor**

| Level | Description | Multiplication Factor |
|---|---|---|
| **H** | High level of importance | X3 |
| **M** | Medium level of importance | X2 |
| **L** | Low level of importance | X1 |

**Weighted Impacts thresholds**

| Weighted Impact Score | Impact Level Description/Category | Action |
|---|---|---|
| **-9** | Potentially prohibitive level of impact on the success of CBS | Factor needs to be addressed to allow CBS to operate |
| **-4 to -8** | Significant negative level of impact on the success of CBS | Factor needs careful consideration for CBS to operate |
| **-3 to 3** | Low level of impact on the success of CBS | Awareness required of factor and impact |
| **4 to 8** | Significant positive level of impact on the success of CBS | Maximise potential of positive factor/impact |
| **9** | Very significant positive level of impact on the success of CBS | Maximise potential of positive factor/impact |

| *Country/City: Kathmandu, Nepal* | | | |
|---|---|---|---|
| **Districts:** | **Manohara, Thapathali, Sankhamul & Balkhu** | **Date of Assessment:** | **12/08/17** |

***Summary:***

| Factors and Impacts | Score | Main Issues and Barriers | Success Potential and Comments |
|---|---|---|---|
| 1) Cultural | -3 | • Very low familiarity with concept of paying for sanitation<br>• Washing practiced universally for anal cleansing | • Strong desire to obtain a toilet within the home<br>• High level of acceptability with handling containers of human urine and faeces |
| 2) Existing Sanitation Facilities and Practices | -4 | • High level of availability of private facilities<br>• Very low maintenance costs of existing sanitation | • Very low levels of public toilet provision |
| 3) Operational | -15 | • Very limited scope for local establishment of treatment facility<br>• No existing treatment facility capacity available | • Good availability of potential cover material |
| 4) Geographical/ Geological | 19 | • No restrictions to excavation for construction of on-site sanitation facilities | • All areas very vulnerable to flooding<br>• High water table in all areas |
| 5) Physical | -13 | • Disparate settlements spread across the city<br>• Access difficulties within the communities | • High density of housing |
| 6) Financial | -12 | • Current level of payment for services is extremely low<br>• Disparate spread of communities | • High level of mobile phone ownership for potential payment by Mobile Money or similar |
| 7) Accommodation | 17 | • No major barriers | • Most houses larger than a single room with average dwelling size of 3.25 rooms per house |
| 8) End-use products | 28 | • No major barriers | • Very large market for biogas<br>• Very high levels of acceptability of all product types |
| 9) Enabling Environment | -7 | • Limited appetite to support squatter settlements<br>• Availability of free issue land for treatment facility in very short supply | • Legal restrictions on the construction of infrastructure |

| 1. Cultural Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **H** | Reaction to payment for sanitation services by residents of community. | X | | | | | | | | -9 | Very low familiarity with concept of paying for sanitation |
| **M** | Level of acceptability to residents of the concept of having a toilet located within the dwelling. | | | | | | | X | | 6 | High level of acceptability encountered |
| **L** | Level of acceptability to residents of the concept of having a toilet located on-plot but outside of the dwelling. | | | | | | | X | | 3 | High level of acceptability encountered |
| **L** | Level of acceptability to residents of the concept of handling sealed containers of human excreta. | | | | | | | X | | 3 | High level of acceptability encountered |
| **M** | Level of acceptability to residents of the concept of handling sealed containers of human urine. | | | | | | | X | | 6 | High level of acceptability encountered |
| **H** | Impact of anal cleansing practices on CBS implementation | X | | | | | | | | -9 | Washing practiced universally |
| **L** | Preference of toilet usage type (e.g. squatting, sitting, etc.) | X | | | | | | | | -3 | Universal preference for squatting |
| **L** | Impact of religious or cultural practices on use/type of toilet | | | | X | | | | | 0 | No impacts identified |
| **TOTAL SCORE** | | | | | | | | | | **-3** | |

| 2. Existing Sanitation Facilities/Practices Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **L** | Convenience/opening hours of using public facilities | | | | | | X | | | 2 | Facilities closed at night |
| **L** | Cost of using existing public facilities | | | | X | | | | | 0 | Public facilities not used |
| **L** | Proximity of nearest public facilities | | | | | | | X | | 3 | Very few facilities available |
| **L** | Cleanliness and quality of public facilities | | | | | | | | X | - | Not assessed |
| **L** | Security issues of using public facilities during the night | | | | | | | | X | - | Unknown |
| **L** | Security issues of using public facilities during the day | | | | | | | | X | - | Unknown |
| **H** | Availability of private household or on-plot sanitation facilities | X | | | | | | | | -9 | High level of availability of private facilities |
| **M** | Cleanliness of private household or on-plot sanitation facilities | | X | | | | | | | -4 | Private facilities generally clean |
| **M** | Convenience of private household or on-plot sanitation facilities | | X | | | | | | | -4 | Close proximity and high prevalence |
| **M** | Maintenance costs of private household or on-plot sanitation facilities | X | | | | | | | | -6 | Very low maintenance costs due to proximity of river |
| **L** | Quantity of water required of private household or on-plot sanitation facilities | | | | | X | | | | 1 | Low as generally pour-flush facilities utilised |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **M** | Availability of alternative non-private household or on-plot sanitation facilities (e.g. communal, shared, etc.) | | | | | X | | | | 2 | Level of availability depends on area, but fairly low level where shared facilities are present |
| **M** | Cleanliness of alternative non-private household or on-plot sanitation facilities | | | | | X | | | | 2 | Generally low levels of cleanliness in shared facilities |
| **M** | Convenience of alternative non-private household or on-plot sanitation facilities | | | | | X | | | | 2 | Queues and access issues reported by users |
| **L** | Maintenance costs of alternative non-private household or on-plot sanitation facilities | | | X | | | | | | -1 | Low maintenance costs, but quality of facilities received for payment is low |
| **L** | Quantity of water required of alternative non-private household or on-plot sanitation facilities | | | | | X | | | | 1 | Low as generally pour-flush facilities utilised |
| **L** | Availability/proximity of a piped water supply | | | | | | | X | | 3 | Supply not close, but impact is low |
| **M** | Availability/proximity of functional sewers for potential connection | | | | | | X | | | 4 | Proximity of sewer system varies, but obtaining legal connection unlikely |
| **TOTAL SCORE** | | | | | | | | | | **-4** | |

| ***3. Operational Factors and Impacts*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **L** | Availability of required space and acceptability | | X | | | | | | | -2 | Densely populated area. Localised transfer stations may |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | locally for waste transfer station establishment | | | | | | | | | | be possible in/near communities |
| **H** | Availability of required space locally for treatment facility establishment | X | | | | | | | | -9 | Densely populated area. Very limited scope for local establishment of treatment facility |
| **M** | Availability of existing treatment facility with sufficient functioning capacity for treatment or disposal of collected waste | X | | | | | | | | -6 | No capacity available. CBS service would be required to undertake their own treatment |
| **M** | Proximity of existing treatment facility with sufficient functioning capacity for treatment or disposal of collected waste | X | | | | | | | | -6 | Existing treatment facility unavailable, although one is under construction |
| **M** | Availability of suitable cover material for use within toilets | | | | | | X | | | 4 | Prevalence of carpentry and agricultural activities |
| **L** | Availability and low cost of additional required inputs in the treatment process (e.g. food waste, electricity, etc.) | | | | | | | | X | - | Not assessed |
| **L** | Availability of workforce/ waste collectors with ability/ desire to collect/sort human waste | | | | | | X | | | 2 | No issues encountered with handling human waste. Adequate workforce available |
| **L** | Ease of identification of individual customer dwellings | | | | | X | | | | 1 | Dwellings generally permanent and recognisable. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **L** | Ease of communication with individual customers and bill payers | | | | | | | X | | 3 | High level of mobile phone usage and ownership |
| **M** | Ease of collection and exchange of CBS containers (i.e. access, resident dwelling hours of occupation, etc.) | | | X | | | | | | -2 | Access difficult in some areas, but generally female occupants present during the day |
| **TOTAL SCORE** | | | | | | | | | | **-15** | |

| ***4. Geographical/Geological Factors and Impacts*** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **L** | Impact of the local topography on the operational or implementation potential | | | | X | | | | | 0 | No impact expected |
| **M** | Vulnerability of the area/community to flooding | | | | | | | X | | 6 | All areas very vulnerable due to riverside locations |
| **M** | Severity of flooding in the area/community | | | | | | X | | | 4 | High levels of property loss and damage reported |
| **M** | Frequency of flooding in the area/community | | | | | | X | | | 4 | 7-year frequency suggested |
| **M** | Water-table level within the locality of the community | | | | | | | X | | 6 | High level but limited use of septic tanks |
| **L** | Ground infiltration rates within the locality of the community | | | | | | | X | | 3 | Low rates but limited use of infiltrating facilities (e.g. pits) |
| **L** | Ground conditions preventing excavation (e.g. rock, unstable ground, etc.) | X | | | | | | | | -3 | No restrictions to excavation for construction of on- |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | site sanitation facilities |
| L | Surfacing materials preventing excavation (e.g. concrete, tarmacadam, etc.) | X | | | | | | | | -3 | No restrictions to excavation for construction of on-site sanitation facilities |
| L | Impact of existing sanitation practices (e.g. pit latrines) on drinking water supplies (e.g. shallow wells) | | | | | | X | | | 2 | Ground water pollution expected but generally used to supply drinking water |
| **TOTAL SCORE** | | | | | | | | | | **19** | |

## *5. Physical Factors and Impacts*

| Weighting/ Importance | Factor Description | -3 | -2 | -1 | 0 | 1 | 2 | 3 | X | Weighted impact score | Comments/ implications |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M | Impact of the housing density on the ability to establish alternative sanitation facilities to CBS | | | | | | X | | | 4 | Varying levels of density but highest density areas have low land availability |
| H | Impact of the housing density on the potential density of the customer base | | | | | | X | | | 6 | Varying levels of density but good prospects for a dense customer base in some areas |
| L | Impact of the housing density on the operational or implementation approach of a CBS service | | X | | | | | | | -2 | Very dense housing leading to a network of narrow paths and passageways and restricting vehicle access |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **M** | Impact of the ease of access within the area on the potential operation processes of a CBS service | X | | | | | | | | -6 | Access within the communities is variable, but is very poor in the less well-established settlements |
| **M** | Vehicular restrictions and proximity of nearest access points | | | X | | | | | | -2 | Access points from main roads generally close to settlements |
| **L** | Impact of settlement shape on the economics and practicalities of collection (e.g. linear, dispersed, nucleated, etc.) | X | | | | | | | | -3 | All settlements linear, therefore affecting the potential density of customers |
| **M** | Overall physical size/number of dwellings within settlement and the implications on the implementation of CBS | | | | | X | | | | 2 | Settlements generally compact |
| **H** | Overall population size of settlement and the potential market for CBS | | X | | | | | | | -6 | Populations of most settlements within city are low thus affecting potential cost-effectiveness |
| **M** | Proximity of additional potential target market areas or populations for potential incorporation into a CBS service | X | | | | | | | | -6 | Large number of disparate settlements spread across the city |
| **TOTAL SCORE** | | | | | | | | | | **-13** | |

## 6. Financial Factors and Impacts

| Weighting/ Importance | Factor Description | -3 | -2 | -1 | 0 | 1 | 2 | 3 | X | Weighted impact score | Comments/ implications |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H | Willingness to pay/current level of payment (e.g. pit emptying, public toilets, etc.) within the community for sanitation services | X | | | | | | | | -9 | Current level of payment extremely low |
| H | Ability to pay within the community for sanitation services | | | X | | | | | | -3 | Household incomes lower than average but not insignificant |
| M | Ease of establishing an economical method of collecting tariffs from customers (e.g. mobile money, etc.) | | | | | | | X | | 6 | High level of mobile phone ownership and usage |
| H | Percentage/Level of potential customer uptake of CBS (i.e. density of potential customer base) | | X | | | | | | | -6 | Disparate spread of communities with low potential uptake in each community |
| TOTAL SCORE | | | | | | | | | | -12 | |

## 7. Accommodation Factors and Impacts

| Weighting/ Importance | Factor Description | -3 | -2 | -1 | 0 | 1 | 2 | 3 | X | Weighted impact score | Comments/ implications |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H | Impact of the average housing size on the potential for CBS implementation (e.g. number of rooms, type of rooms, etc.) | | | | | | | X | | 9 | Most houses have more than a single room with average dwelling size of 3.25 rooms per house |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **L** | Impact of number of storeys or individual dwellings within each property on the potential for CBS implementation | | | | | | X | | | 2 | All dwellings single storey |
| **M** | Implications of internal arrangement and room layout within dwellings | | | | | | | | X | - | Not possible to assess |
| **L** | Effect of the availability of outdoor space on-plot on the potential for household level CBS implementation | | X | | | | | | | -2 | General limitation on the availability of outdoor space on-plot for locating toilet |
| **L** | Effect of the availability of outdoor space in the community on the potential for shared CBS implementation | | | X | | | | | | -1 | Very low impact due to the internal size of dwellings and number of rooms |
| **L** | Level of population transience/housing permanence within the community | | | | | | | X | | 3 | Low levels of transience – communities generally established for long periods |
| **L** | Impact/level of private land ownership within the community | | | | | | | X | | 3 | No land ownership in any communities. Formal sanitation unlikely to be provided |
| **L** | Impact of general tenure status of residency of the community | | | | | | | X | | 3 | All communities consist of squatters |
| **TOTAL SCORE** | | | | | | | | | | **17** | |

| 8. End-use Product Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **L** | Acceptability of the use of compost produced from human waste | | | | | | | X | | 3 | Historical use of compost derived from human waste |
| **L** | Size of potential market for the use of compost produced from human waste (i.e. agricultural practices, types of produce grown, proximity of potential customers, potential value of the product, etc.) | | | | | | X | | | 2 | Limited market within urban context, but larger market exists in rural areas. Additional transport costs required |
| **L** | Acceptability of the use of charcoal briquettes produced from human waste | | | | | | | X | | 3 | High level of acceptability for use |
| **L** | Size of potential market for the use of charcoal briquettes produced from human waste (i.e. scale/level of existing use of product and potential uptake, proximity of potential customers, potential value of the product, etc.) | | X | | | | | | | -2 | Very limited market within urban context, but larger market may exist in rural areas, although use of wood as a fuel is diminishing. Additional transport costs required |
| **M** | Acceptability of the use of biogas produced from human waste | | | | | | | X | | 6 | High level of biogas use within Nepal as a whole – therefore high level of acceptability for use |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **M** | Size of potential market for the use of biogas produced from human waste (i.e. scale/level of existing use of product and potential uptake, proximity of potential customers, potential value of the product, etc.) | | | | | | | X | | 6 | Very large market in urban context and growing market in rural areas |
| **L** | Acceptability of the use of electricity produced from human waste | | | | | | | X | | 3 | High level of acceptability for use |
| **L** | Size of potential market for the use of electricity produced from human waste (i.e. scale/level of existing use of product and potential uptake, proximity of potential customers, potential value of the product, etc.) | | | | | | | X | | 3 | Large market exists but initial CAPEX costs are high |
| **L** | Acceptability of the use of animal feed produced from human waste | | | | | | | X | | 3 | High level of acceptability for use |
| **L** | Size of potential market for the use of animal feed produced from human waste (i.e. agricultural practices, proximity of potential customers, potential value of the product, etc.) | | | | | X | | | | 1 | Limited market within urban context, but larger market exists in rural areas. Additional transport costs required |
| **TOTAL SCORE** | | | | | | | | | | **28** | |

| 9. Enabling Environment Factors and Impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighting/ Importance** | **Factor Description** | **-3** | **-2** | **-1** | **0** | **1** | **2** | **3** | **X** | **Weighted impact score** | **Comments/ implications** |
| **L** | Potential/inclination within local utility or municipality to collect sanitation tariffs | | X | | | | | | | -2 | Limited budgets of municipality and utilities |
| **H** | Legal implications/ restrictions on the potential of CBS implementation (e.g. manual scavenging laws, legitimisation of illegal/ squatter settlements, etc.) | | | X | | | | | | -3 | Reluctance of government to legitimise squatter settlements |
| **M** | Legal restrictions on the construction of infrastructure | | | | | | | X | | 6 | Many settlements impede official development plans |
| **H** | Availability of potential funding/subsidy from local municipality, organisations, or other institutional bodies | | | | | | | | X | - | Not established |
| **M** | Opportunity or availability of free-use land in local proximity from municipality to minimise set-up and running costs | | X | | | | | | | -4 | Available and appropriate land for treatment facility in very short supply |
| **M** | The rate of tax, and potential opportunity for a tax holiday to aid with the establishment of CBS business | | X | | | | | | | -4 | Limited appetite to support developments in squatter settlements |
| **TOTAL SCORE** | | | | | | | | | | **-7** | |