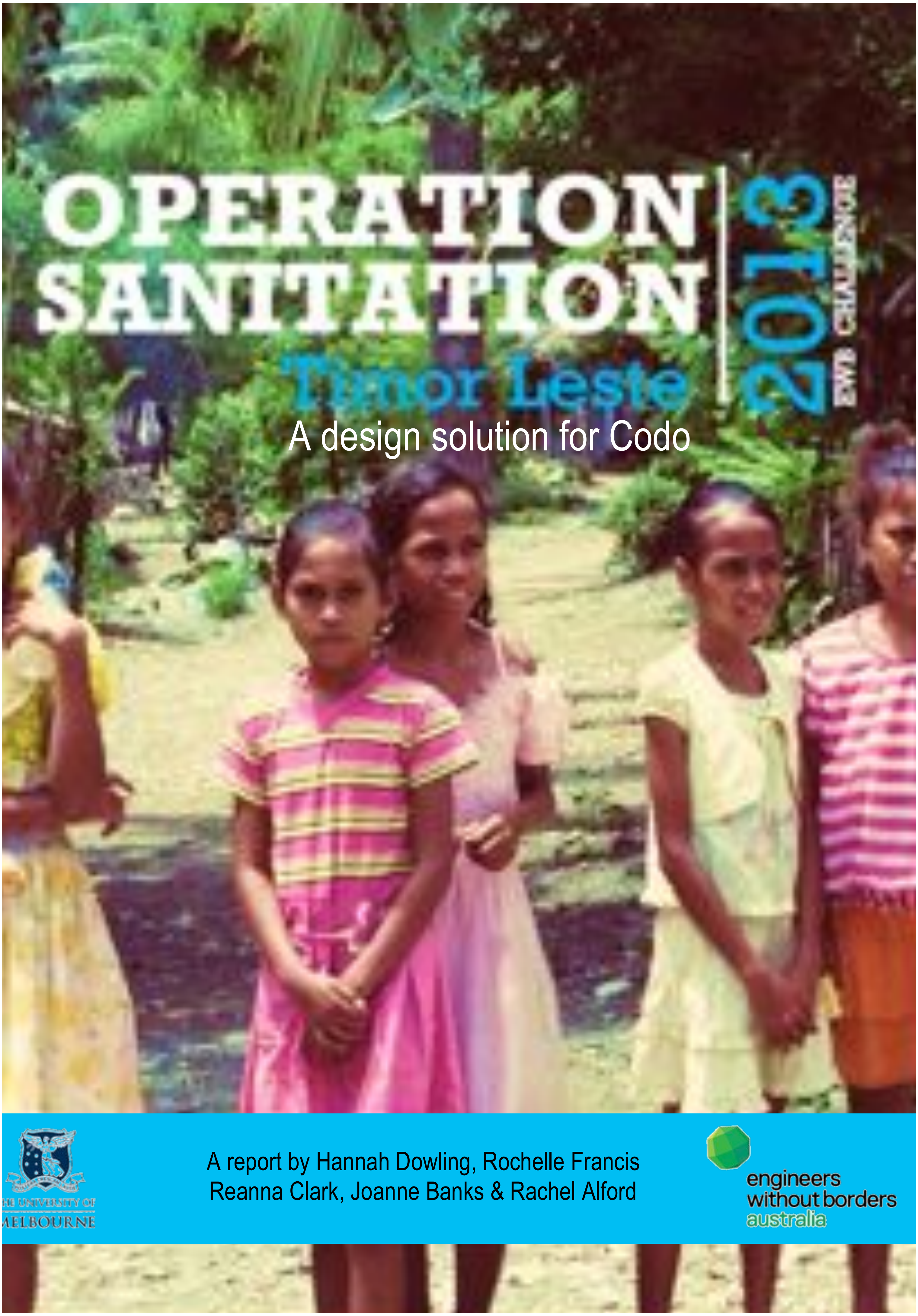

OPERATION SANITATION

Timor Leste

2013 EWB CHALLENGE

A design solution for Codo

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engineers without borders australia

Operation Sanitation Timor Leste: A design solution for Codo

2013 EWB Challenge

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EXECUTIVE SUMMARY 2013

On reviewing the EWB Deign Brief, we recognised the dire need for adequate sanitation infrastructure in Codo. We recognised that sanitation has become a commodity that is taken for granted by our lifestyle and as a team we prioritized sanitation as a fundamental need in the community, given Codo's lack of sanitation infrastructure.

Operation Sanitation is a project proposal that presents a sanitation system whose primary objective is to transition Codo from open-defecation to improved sanitation. We considered various sanitation systems that have been implemented in developing communities around the world to shift behavioural practices from open defecation; these sanitation systems have included the Composting Toilet, Ecological Sanitation technologies, the Earthworm Toilet design, Arbor Loos and the Biodigester Sanitation system. Rigorous evaluation of each of the systems, in light of the context of Codo, showed that the composting toilet design was the most appropriate for the village. The composting toilet is an ecosystem approach to sanitation; recycling the products of the system back into the environment. The toilet system has numerous health, social, economic and environmental benefits for the community and is relatively affordable and easy to use.

The mentality that framed the thought process of *Operation Sanitation*, more specifically the design criteria and the final design option, was **increased usage of latrines as opposed to increased number of latrines in Codo.** *Operation Sanitation* explores the composting toilet infrastructure that will be offered to the community of Codo and pairs it with an implementation strategy; both elements are necessary for the successful delivery of the project. The implementation strategy has two primary objectives; community mobilisation and community education and is delivered through a community-led total sanitation approach. Finally, *Operation Sanitation* presents a series of recommendations for the future of sanitation technologies in Codo.

Operation Sanitation is the power of "everyday people, working together … to change our government and our institutions for the better."

team reflection

Participating in the EWB Challenge 2013 has been a positive and rewarding experience for all members of our group and the benefits and knowledge we obtained throughout have been invaluable. First and foremost we were able to learn the importance of working as a team. Our project proposal would not have resulted the way it is had we all been working individually. By being in a team, we were able to explore more solutions in increasing depth by sharing the workload between us. This allowed us to make a more informed decision about what would best benefit the community of Codo.

Furthermore, despite coming from a similar course background, every member of our group had different strengths which we were able to utilize throughout the design process. Due to this, we learned the importance of being present at group meetings. Having five members in our group, it was difficult to arrange a meeting time outside of class which suited all members, so it became vitally important that we attended every class. We also maintained contact outside of class through the means of a wiki site and personal communication. Each member realised how important their presence was and this was reflected in the fact that not one member ever missed a class.

Every member of our team comes from an Arts background and that made the EWB challenge extra stimulating, as for many of us it was the first time we had ever produced a design brief. By working together we were able to establish a route to take to create a proposal and it was through this we were able to understand the key elements involved in successful project making; background information, understanding of the community and the necessity of community involvement. By assigning each member a different area to research, we were able to recognize the structure of the society within Codo and plan our design accordingly.

With all members coming from an Arts background we were all slightly sceptical about our ability to provide technical knowledge in regards to our chosen toilet design. However, after research and collecting data for the semester, when it came time to compare criteria to decide which design we would ultimately implement, it became apparent that out level of understanding of technical knowledge was higher than we had anticipated and we were able to easily compare the benefits and weaknesses of each design to select the one which we found to be most appropriate for Codo. This was most evident in the knowledge we gained about how waste can be utilized and the chemistry behind it.

Our technical knowledge was also demonstrated after we had selected which design to implement and we were attempting to modify it in order to fit the circumstances for the village of Codo. We found during this project that the best way to adapt the chosen design incorporated elements of each of our individual options. This epitomized the benefits of team work, as had we been working individually these adaptions may not have been possible with the depth of understanding there was.

“Everyday people, working together, have the power to change our government and our institutions for the better.”

- Maria Cantwe

contents

“Sustainable development is development that meets the needs of the present withou compromising the ability of future generations to meet their own needs.

- United Nation

1. PROBLEM DEFINITION

design area

The design solution proposed in this report is a response to the EWB Challenge 2013 and seeks to make a contribution to the development of Codo, a town in the Lautém region of Timor-Leste. 'Operation Sanitation' is an initiative towards the sustainable development of W.A.S.H (Water Supply, Sanitation and Hygiene). It presents a sanitation solution that seeks to change community behaviour and practices in Codo, with the aim of becoming open defecation free.

Figure 1. Map of Timor Leste and geographical location of Codo

context

Codo is a small town located in the province of Lautém in Timor-Leste. The village is located on a steep slope in a mountainous area of Lautém. Codo is a town with 419 inhabitants and 108 households. 57% of its population is younger than 20 years old.

GEOGRAPHY

Timor-Leste is an island nation located on the western end of the island of Timor, above the Timor Sea, north of Australia. Timor is a land of steep terrain and rugged hills. The climate is hot, with an average temperature of 24°C and 80% humidity. Timor experiences both wet and dry seasons because of its tropical location. The wet (monsoon) season is between November and April. As a result of this high precipitation during this time and the steep terrain, erosion is a serious issue in the area.

ENVIRONMENT

Inhabitants of Timor-Leste have a strong relationship with their natural environment, due to a long history of using it for food, shelter, clothing, and other essential activities. However, the environment of the nations suffered devastating losses due to exploitations by occupying nations. While the nation is beginning to recover, this has created additional hardship for a nation so dependent on natural resources. Air pollution is an issue faced by residents of Codo, due to a majority of cooking being done over an open fire. Women, who predominately cook for the household, are at particular risk of lung diseases resulting from exposure to smoke from the open fires.

The growing issue of climate change is a serious concern for inhabitants of Timor, adversely affecting the environment and agriculture of the nation due to an increase in severe weather. The altering of weather patterns due to climate change and the effects of El Niño are also impacting on agriculture, as famine in the nation is incredibly dependent on weather patterns.

Figure 2. The town of Codo

CULTURAL BELIEFS

In Timor-Leste 98% of the population are Catholic and over 70% of the population live in rural areas. Timorese people share a common set of beliefs and values that are linked to belonging to a certain place and Uma Lulik (sacred house). The Timorese people of the east are known as the Fataluku Community who speak Fataluku, however in Timor-Leste there is a range of languages spoken, including Portuguese and Tetum. 80% of the inhabitants in Codo speak Fataluku, with others speaking Makasae and a dialect known as Sa'ane. Timor-Leste prides itself on traditional arts such as tais weaving, pottery and wood-carving.

EDUCATION

Timor Leste has been the highest spending country in the world on education as a percentage of GDP (16.8%, CIA World Factbook 2012). Thanks to the government, NGOs and church groups, there has been an increase in education for all ages. However, it is important to note that Codo is a rural area and enrolment rates are lower in rural areas than in urban areas.

As open defecation is widely practiced in Codo there is a need for education in relation to the importance of sanitation and hygiene. In order for Codo to become open defecation free, community involvement will be critical as without all members of the community being involved it would be difficult. This will require a changed mindset and a willingness to use toilets. Plan-TL and Fraterna are already working on implementing a variety of sanitation programs advertising the importance of health and sanitation.

TRANSPORT

There is only one road into Codo; an unsealed 4WD track. This means that most of the materials used in construction have to be sourced locally. Currently, bamboo, stones/rocks, corrugated iron and palm/coconut fronds (for roofing) are used in the village. Concrete is also commonly used; however it has to be imported from Dili, and as a result is a lot more expensive than other building materials.

WATER

As Codo is situated on a hill, the water supply is sourced from springs at the top of the hill, and piped down through the village. Throughout the village there are several tap stands where this water is accessible and the villagers walk to the tap stands to collect water daily. There are three stands in Codo, and these are located in the middle of village as the water does not run the entire way down the hill. Water is transported from the tap stands to houses for daily cooking and drinking needs (it is carried by women in water containers or transported by water carts). It is usually then boiled over an open fire fuelled by wood. Water supply from the natural spring is fairly consistent and available all year round. The water available each day is more than what is required in Codo each day. Other uses of water in Codo include the toilets in the primary school where villagers use the water to wash themselves.

HEALTH

Over the past 10 years healthcare has advanced in East Timor, however it is a country still ravaged by chronic malnutrition (1/3 of children under 5) and other easily preventable illnesses. For 43.3% of East Timor's population it takes, on average, 3 hours walking to reach the nearest health service as there isn't a local service available. However it is estimated that 80% of sucos (villages) receive monthly visits by a mobile clinic. Lautém has one of the highest immunisation rates in the country although still has high rates of diarrhoea.

Poor sanitation contributes to 10% of the global Burden of Disease annually, with 2.6 billion people living with poor sanitation measures. In Codo, approximately one third of people suffered from some form of diarrhoeal illness at the time of interviewing.

Improved sanitation has huge potential health benefits globally, but also in East Timor and specifically in Codo. Improved sanitation has been linked to not only a decrease in morbidity and disease but also improvements in health, quality of life and productivity. Improved sanitation is associated with a reduction of diarrhoeal diseases by between 32-37% (Mara D, Lane J, Scott B, Trouba D: 2010). Although targeted research on diseases in East Timor is difficult to find, considering its location in South-East Asia and the prominence of Neglected Tropical Diseases in neighbouring countries such as Indonesia, one could assume diseases like trachoma, helminths and schistosomiasis would also be found in Timor and could also be significantly reduced by improved sanitation.

VOLUNTEER GROUP

In Codo, there is a group of volunteers (comprising of five to ten teenage boys and older men) that assist with community projects. They would be involved in the maintenance and development of this project.

SANITATION

Sanitation in East Timor, in particular the Lautém region is minimal; it is estimated that 13% of the population in the district have access to adequate sanitation facilities. A recent survey found that 72.9% of households in the Lautém region do not have a toilet facility in or near their house. Within the village of Codo, sanitation is minimal. Open defecation is widely practiced, with the villagers dropping their waste anywhere. The men tend to do this without shame; however the women are usually more conservative and will do it in perceivably more private areas. There is also little to no wiping or washing after defecation. The only current sanitation infrastructure in Codo is a set of simple squat pit latrines (with a basic hand washing station), which are attached to the primary school in the village. The primary school has a relatively central location within the village however due to the location of the pit latrines, these toilets are typically used by the primary school children. The foundations for a second set of latrines have been dug at the present time (EWB 2013).

Figure 3. Sanitation infrastructure in Codo at the present time

technical review

GLOBAL TRENDS

It is estimated that every year between two to three million people die because of inadequate sanitation, insufficient hygiene and contaminated food and water. A contaminated environment as a result of open defecation practices places people at risk of exposure to pathogens and harmful organisms that lead to infection and disease. Those most affected are those living in urban parts of the world who become victims of the 'pathogen cycle' as victims and offenders of infection and disease live within close proximity of each other (Esrey et al. 2001: 8).

A 2013 statement by the World Health Organisation and UNICEF highlighted that the number of people without access to improved sanitation facilities was 2.5 billion and that the number of people practising open defecation at the end of 2011 was a little over 1 billion and comprised 15% of the global population (WHO & UNICEF 2013: 3). It was noted that 71% of these people live in rural areas of the world (WHO & UNICEF 2013: 5). The study found that 37% of Timor-Leste's rural population practiced open defecation at the end of 2011. In March of this year, the Deputy Secretary-General of the United National called upon the world to increase efforts and progress towards the Millennium Development Goals (MDG); it was a call to UN agencies governments, civil society and the private sector to help end open defecation practices by 2025 (WHO & UNICEF 2013: 3). The project proposed in this report is a move towards the MDGs by tackling open defecation practices in the town of Codo. We believe that access to sanitation is a fundamental human need and thus have chosen to investigate, develop and propose a sanitation solution that secures this human need.

Figure 4a. Open defecation practices across the globe

THE IMPORTANCE OF SANITATION

In this project proposal we will define sanitation as the safe disposal of human excreta. In 2007, sanitation was voted the most important medical milestone since 1840 by the British Medical Journal (Mara et al. 2010). Adequate sanitation, together with good hygiene and safe water, are fundamental to good health and to social and economic development (Mara et al. 2010). Successful sanitation programs have the potential to save lives, reduce diseases and improve the quality of life of populations. Studies have shown that access to sanitation facilities, paired with improved water supply and hygiene education, have saved millions of lives in rural and urban communities in Asia, Africa and Latin America (Esrey et al. 2001: 11). Lack of sanitation leads to disease transmission and illness. Figure 4b illustrates the importance of the safe disposal of human excreta in preventing disease transmission.

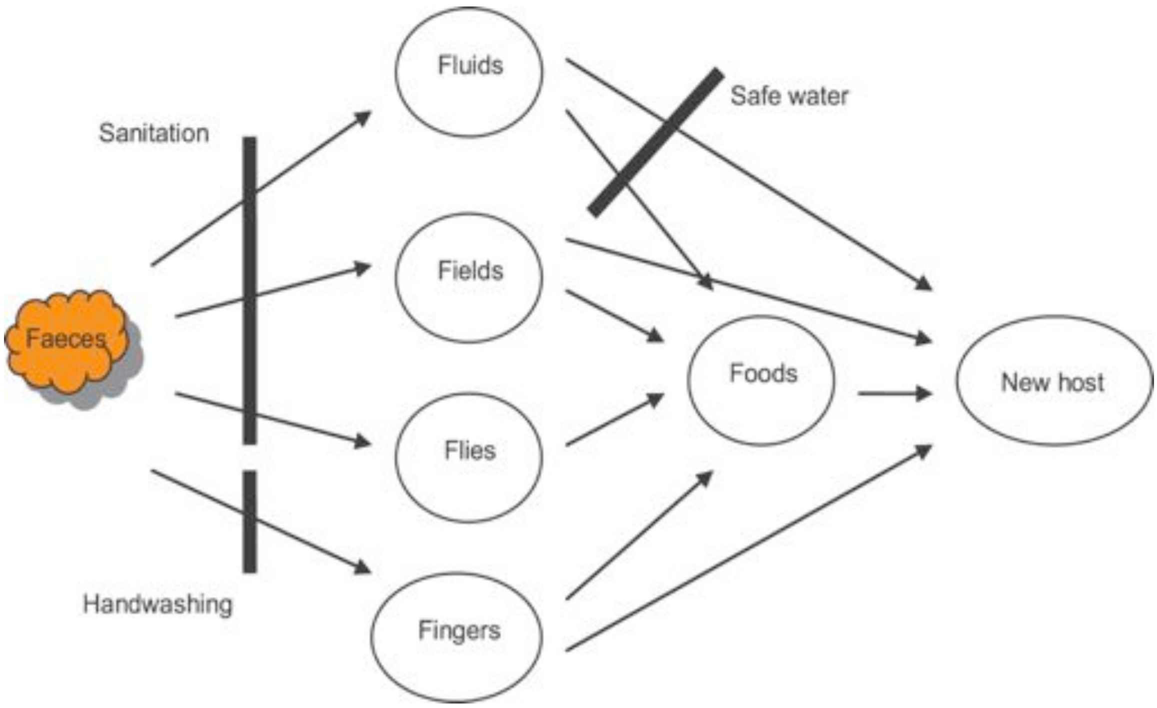

Figure 4b. The transmission of disease from human excreta

Social benefits: Sanitation practices allow for a sense of privacy and avoid embarrassment on the part of the toilet user. Sanitation avoids the dangers and discomforts of the open environment such as pests, rain or snakes and is a safety measure for women and girls; reducing the risk of rape and allowing girls to attend school whilst menstruating (Mara et al. 2010).

Economic benefits: Improved sanitation lowers health system costs, saves days lost at work or school because of illness, and makes time savings (time spent seeking a place to defecate). In total, the prevention of sanitation and water-related diseases could save some $7 billion per year in health system costs as half the hospital beds in the world are occupied by people with diarrhoeal diseases. One dollar spent on sanitation could generate about ten dollars' worth of economic benefit (Mara et al. 2010).

Sanitation has multiple links to health, social and economic developments and is therefore a fundamental need for the community of Codo and should be given priority before the other design areas. This project proposal seeks to transition Codo's sanitation infrastructure from open defecation to improved sanitation (see Figure 5).

Figure 5. The sanitation ladder

"Access to sanitation is one of the most overlooked and underserved human needs. It i
nothing less than a fundamental issue of human dignity and human rights.

- Ban Ki-Moon, United Nations Secretary Genera

2. DESIGN OPTIONS
composting toilet

WHAT IS A COMPOSTING TOILET?

In their most basic sense, composting toilets are dry toilets that utilise rapid aerobic composting to decompose human waste to a manageable state. Decomposition occurs by creating a warm environment in which bacteria can thrive, containing and immobilising harmful pathogens and transforming the nutrients into a safe end product that can be handled and used as a fertiliser (Compost Junkie, 2012).

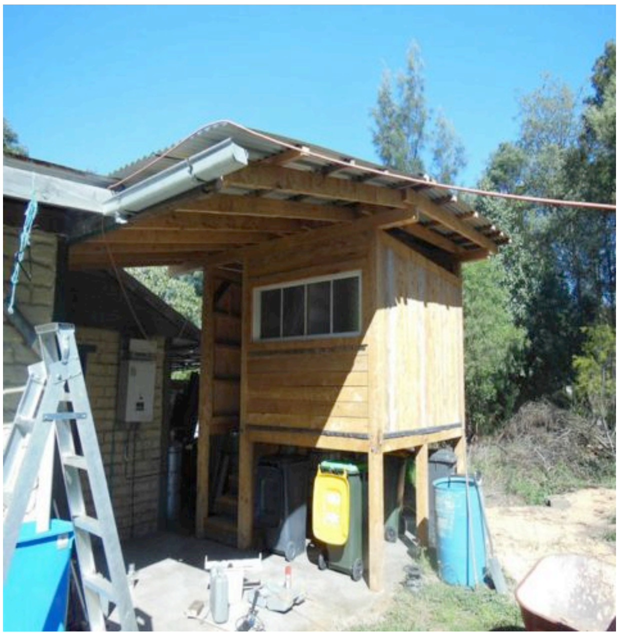

Figure 6.
Simple, site-building composting toilet on a permaculture farm

HOW DOES IT WORK?

There are four key components to composting toilets, which are as follows:

- **Moisture:** Moisture levels (e.g. urine waste) need to be controlled, as high levels of moisture result in anaerobic composting and an unpleasant odour. The level of moisture can be regulated by fans, evaporation chambers, and separate chambers for solid and wet waste. Bulking agents – such as peat moss, coconut coir and wood shavings – can also help control moisture.

- **Oxygen:** Oxygen levels also need to be controlled. This can be done so through automatic mixers, pile-levelling devised, bulking agents, and manual turning.

- **Heat:** This can come from the microbial activity of the pile itself, but can also be controlled through electrical or solar heat to speed up the process of decomposition.

- **Processing:** Composting toilets are either active or passive (e.g. decomposition is assisted or unassisted), and batch or continuous (e.g. multiple or single chamber systems).

(Compost Junkie, 2012)

TECHINAL CONSIDERATIONS

Materials:

Materials required would include wood, nails, large drums/containers for collecting the waste, some plastic/metal piping for the waste to fall through, a bulking agent and a toilets cover. Most of this would be relatively easy to access in Codo – in particular it would be beneficial to use local wood/bamboo in the construction, as well as coconut coir for the bulking agent (Engineering without Borders, 2013). Thatched bamboo could be utilised, as seen in Figure 6.

Costs:

Most materials could be locally sourced. While some materials may have to be transported in, they are relatively inexpensive, and the long term sustainability of the composting toilet would allow for true cost savings. Materials that would need to be imported are at the following costs (USD):

- House bricks: $0.65 per brick.
- Cement: $40.00 per 40kg bag.
- Nails: $2.00 per kg (varying lengths).

(Engineers Without Borders, 2013)

Adaptability:

The sourcing of local materials and choosing a design that could be built onsite would be a great opportunity to allow for community involvement. By allowing individuals to witness how the toilet is constructed and functions would improve our chances of successfully integrating the toilet into community life.

Maintenance:

A moderately low level of maintenance would be required for a composting toilet. Besides basic cleaning and building maintenance, the containers that hold the waste would need to be rotated. However, this would only have to occur when the containers reach their filling point (roughly every six months), then they would be allowed to decompose for a similar time period and be emptied. The maintenance is not excessive, and the continuing involvement of the community in up keeping the toilet would help improve their understanding and see the benefits of the toilet system.

Considerations:

The major issue of the composting toilet, as with many other toilet designs, is the education of members of the community in regards to using a toilet. Codo is currently in the practice of open defecation, so transferring a habit from being able to defecate anywhere to a set location may take some time (Engineering Without Border, 2013). However, by ensuring that the community is involved with the development of the toilet from day one and offering training packages to go along with it, this is certainly achievable. A key feature of the composting toilet is the separation of hard waste from urine – often requiring two separate toilet bowls – so this will need to be highlighted in an education package. However, the two separate bowls could prove an issue. A potential solution would be to construct a drainage system for excess water at the bottom of each waste receptacle – as seen in Figure 6 – so urine can drain away from the hard waste (Compost Junkie, 2012).

Due to Codo's tropical climate it is necessary to ensure that the lid of the composting toilet is closed at all times. Exposed waste will attract flies and mosquitoes, increasing the likelihood of disease spreading. As well as incorporating the need to shut a toilet lid in an education package, it may also be necessary to design a toilet lid with a spring mechanism. When the lid is lifted and the individual is squatting, the lid will be held in front of them. When the individual stands up, the lid will automatically close, preventing exposure to insects.

CASE STUDY

Composting toilets have seen to be successfully integrated into developing communities. One such example is in the Republic of Kiribati. A dual-chamber batch composting toilet was built, costing just over $2000 US (International Environmental Technology Centre, 1995). Community involvement in the project was strongly encouraged, which saw the individuals become more accepting of the toilet. Many individuals were initially sceptical of using human waste as compost, but as they saw how it decomposed over time they became intrigued and more open to the idea (International Environmental Technology Centre, 1995). The composting toilets constructed in the community used a similar chamber design to that which is proposed here, draining liquid to the bottom of the container using a grate. From here, the liquid was then drained out into small gardens that would benefit from the nutrients (International Environmental Technology Centre, 1995).

EVALUATION

Composting toilets can be purchased pre-built from manufacturers using modern materials and engineering. However, in the context of Codo we would opt to utilise a simpler, site-built design, as seen in Figure 7. There are many designs available online, and the flexibility to create a toilet based on the context it is being built in

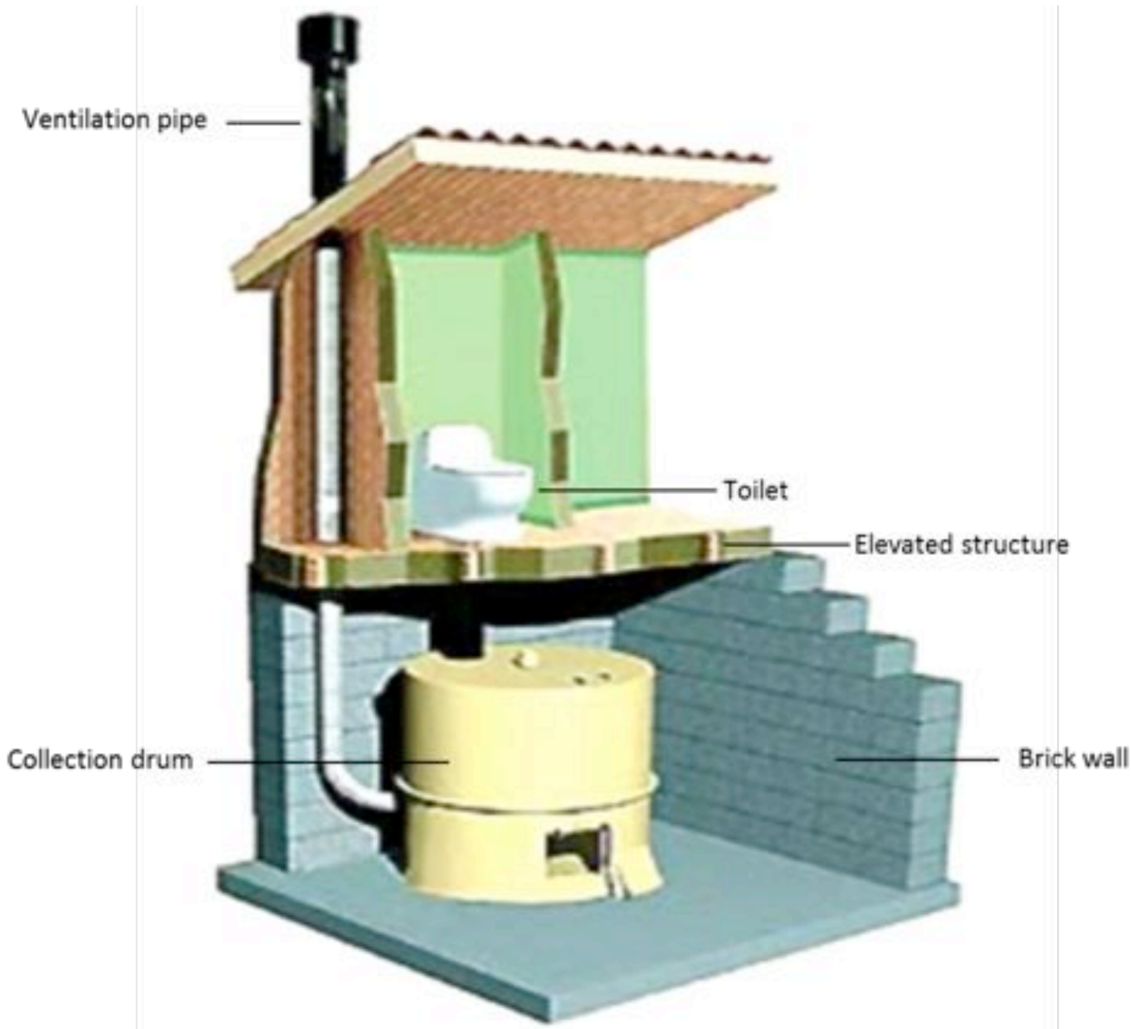

Figure 7. Simple composting toilet design

allows for the composting toilet to be very adaptable. The terrain of Codo is very steep, and the reality of monsoonal rain and erosion are all factors that need to be considered in the design. Many site-built toilets are built on a raised platform, so a design incorporating such a feature may be a potential solution. However, finding a way to safely secure the receptacles containing the composting waste may prove a bit more of a challenge. A potential solution would be to construct a brick wall – facing uphill – to present the receptacles from monsoonal rain and landslides.

An attractive feature of the composting toilet model is its ability to safely turn human waste into reusable compost. It requires no chemicals; the waste simply decomposes over a period of time – usually six months, but this time frame can be reduced for tropical climate. As Codo is primarily responsible for its own agriculture, harnessing this rich compost could be beneficial. The urine waste can also be used as fertiliser, though requires dilution prior to use – a ratio of one litre of urine to 10 litres of water (Greywater Action, 2013). The only issue with this is that the community may not be willing to utilise human waste as fertiliser due to cultural issues.

Overall, the major benefits of the composting toilet design are that it does not require water, it is relatively simple to install, and it has been seen to be successfully installed in rural environments. However, composting toilets do require regular maintenance (e.g. rotating of waste receptacles when full), and also require periodic cleaning. On the whole though, the design is sustainable, flexible, and with further planning could be successfully adapted for the community of Codo.

Figure 8. Composting toilet structure

ecosan

WHAT IS ECOSAN?

Ecological sanitation (EcoSan) is an ecosystem approach to sanitation. The basic premise of ecological sanitation is that human excrement is not waste but a resource – see Figure 9 (Boot 2007: 1). The ecological sanitation approach has three primary outcomes:

- Recovers and recycles plant nutrients and organic matter
- Prevents disease and promotes health by destroying pathogens before excreta are returned to the environment
- Protects the environment, prevents pollution and conserves water (Esrey et al. 2001: 13)

Ecological sanitation is a closed, waterless, dehydration/ evaporation system that provides a safe, non-polluting, sustainable and cost effective solution to the sanitation problem. The most common form of EcoSan is the urine separating toilets which collects urine and faeces separately and recycles them back into the environment and into productive systems. Research indicates that human waste from one person can supply enough nutrients to produce 250kg of cereals annually. The majority of nutrients are contained in the urine; however, the faeces when treated correctly act as a good soil conditioner.

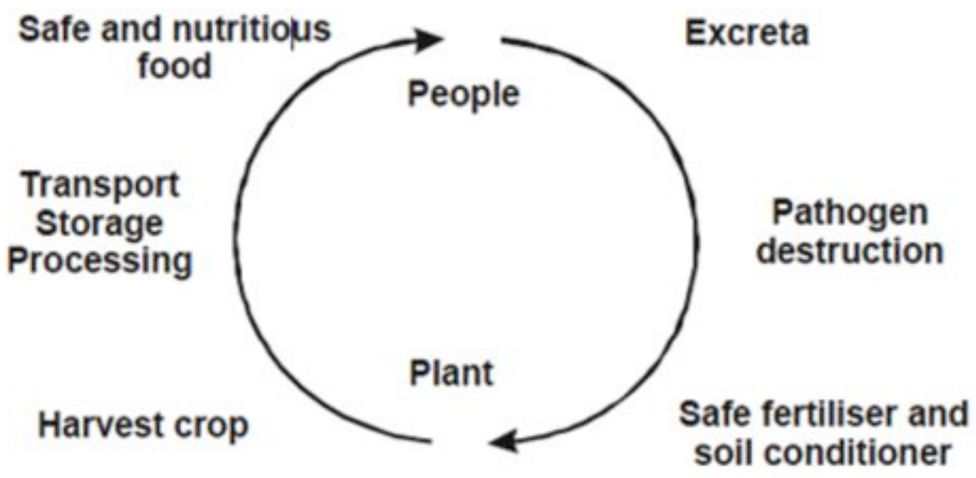

Figure 9. Ecosan – an ecosystem approach

HOW DOES IT WORK?

There are two types of ECOSAN toilet designs:

Dry Ecosan

The principle of dry EcoSan is mainly to collect faeces in dry state. The urine is diverted and collected separately. The only water consumption and wastewater produced in this type of toilet is during the process of anal cleaning; the wastewater is collected separately in a soak pit or a small wetland outside the toilet. This toilet design has two latrines and is constructed above ground level for faeces collection and to avoid ground water seepage. Solid waste is collected in a chamber below the latrine. Lye, sand and sawdust are added to the waste after each use to remove excess moisture and speed up the decomposition process. Each latrine is approximately 1m square and 1.5m in depth; sized for a family of six – see Figure 10. Once a latrine is full, the second is used whilst the first is left for dehydration. Once both latrines are full, the first is emptied (using the opening in the back side of the vault) and reused (i.e. further composted or applied directly in the fields as soil conditioner to aid agricultural production). In this way, the vaults are used alternatively every six months or five years, depending on the capacity of the pit latrine. Outside of the toilet block is the urine collection tank. The urine collected has multiple uses; used directly as fertiliser, disposed of in an evapo-transpiration bed, stored for later use or evaporated. (ENPHO 2007: 3)

Figure 10. The components of an Ecosan toilet and their use

Wet Ecosan

The distinguishing feature of the Wet EcoSan toilet from the Dry EcoSan system is that water is used for flushing the faeces. It operates in the same manner as Dry EcoSan; the advantage of this toilet design is that using the toilet is easier as water can be used for flushing. The main disadvantage of this toilet design is that it uses the same amount of water as an ordinary toilet and recycling the faeces can be difficult. (ENPHO 2007: 6)

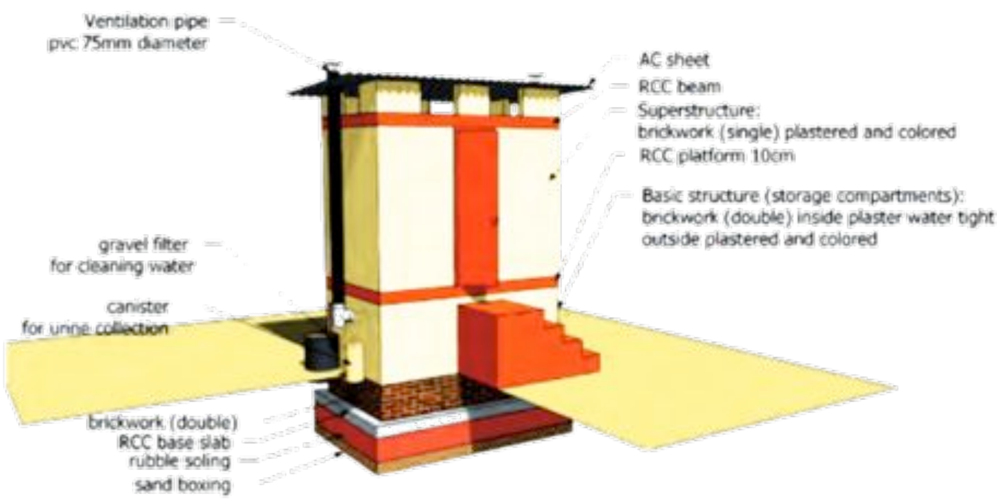

Figure 11. Materials necessary for the construction of an Ecosan toilet system

TECHNICAL CONSIDERATIONS

Materials:

The materials necessary for the construction of an EcoSan toilet include brick for the construction of the external structure of the EcoSan latrine, concrete cement for the base structure of the latrine, PVC pan and PVC pipes and fittings, a pan cover which can be made from metal, cement, PVC or plastic to prevent fly breeding and control the odour of the latrine – see Figure 11. Finally, a plastic container below the latrines for the collection of faeces and a 100L airtight plastic container for the collection of urine will be required for the construction of an EcoSan toilet. Most of these materials are easily available from Dili in Timor.

Cost:

Through examination of EcoSan systems in various developing countries, the cost of a double latrine EcoSan toilet is estimated between $110-$245 AUD (includes materials and building). (Boot 2007: 15)

Adaptability:

The benefit of EcoSan over other sanitation systems is that the toilet design is tailored to the community it is being developed for. The following variables will influence the choice of EcoSan system in a community: climate, population density and settlement pattern, social and cultural practices, economy and financial resources, technical capacity and agriculture. Depending on these factors, components of the EcoSan toilet design can be modified to address the needs of the community in Codo.

Maintenance:

Efforts at ecological sanitation in any community will only be successful if users take responsibility for the proper functioning of the toilet.

The amount of maintenance that users of EcoSan systems need to do, varies with the design of the EcoSan toilet. Systems that rely on composting often require the regular addition of bulking agents immediately after defecation. Many systems require that the squatting hole for the second latrine be closed-off when not in use. All systems require periodic inspection of urine collectors, pipes and tanks to ensure effective functioning (i.e. that vent pipes are not blocked by debris, spider webs or nesting insects).

CASE STUDY

EcoSan systems are appropriate for rural and urban areas with no sanitary sewer system and limited water supplies. Developing communities in Mexico, Sri Lanka, Zimbabwe, Bangladesh and Nepal have seen the successful implementation of EcoSan technologies within their communities – see Figure 12.

Figure 12. Ecosan toilet in Bangladesh

EVALUATION

Most sanitation systems promoted today adopt a linear approach to sanitation; 'drop-and-store' systems hide human excreta in deep pits and 'flush-and-discharge' systems flush and dilute human excreta in rivers, lakes and the sea. EcoSan is a shift from these common approaches. The concept of ecological sanitation has many benefits for the community in Codo. The EcoSan approach is most appropriate for rural and urban areas with no sanitary sewer system and limited water supplies. It is appropriate for rocky and/ or flooded areas, can be constructed using local materials, doesn't require a constant source of water, reduces odours and insects, has a low operating cost and an unlimited lifespan. Ecosan improves the environment in a community whose ancestors depended on the environment for food, clothing, building materials and everything else essential for life (EWB 2013). The EcoSan toilet design is compatible with the climate in Codo and the recycling of nutrients assists agricultural production and improves food security on which the livelihoods of the community are dependent upon through its safe and hygienic recovery and use of nutrients, organics, water and energy. Finally, EcoSan provides a safe and sustainable solution to the problem of open defecation in Codo by reducing the pathogens from human excreta.

Social acceptance of the EcoSan approach is a major pre-requisite in the consideration of this design option. In many societies, handling human excreta is considered to be a cultural taboo and this can be a major barrier for promoting EcoSan. The Ecosan design will need to include a strong component of public awareness and community mobilization to ensure its approval and adoption by the Codo community; this is the system's major weakness. In Mexico, a series of field visits were conducted as part of the ecological sanitation movement and in Zimbabwe ecological sanitation technologies are promoted by national programs (Esrey et al. 2001). Other constraints of the Ecosan design include its high capital cost and regular maintenance.

In summary, ecological sanitation technologies provide a viable solution for the problem of open defecation in Codo. This system is not without its shortcomings which will need consideration and modification to address the needs of the community in Codo.

earthworm toilet

WHAT IS AN EARTHWORM TOILET?

Earthworm toilets, more specifically tiger worm toilets can be arranged in a variety of ways but they are essentially toilets that involve composting human waste so that it is safe to handle and use as a fertilizer through the use of worms. The worms prosper and multiply with the more waste there is to consume; making the process one that is very simple and sustainable.

HOW DOES IT WORK?

Tiger worms (also known as eisenia fetida, redworms and brandling worms) are a species of earthworm which thrive in rotting vegetation, compost and manure and assist the decay of organic material. The tiger worms produce useful nutrients and reduce bad odours. The more waste that the worms consume, the better they will reproduce; they generally breed very quickly. Tiger worms can be used in most designs of composting toilets and is generally known as vermicompost. These worms originate from Europe, although they are found in every continent (except Antarctica) today.

The reason this is such a sustainable method is that it turns waste into a resource. Food scraps and human waste are fed to the worms (who reside in a large container) and as the organic material passes through the worms' bodies it becomes compost. This compost is very good for plants as it is highly rich in nutrients. Nutrients are taken from plants and consumed by people and this process allows the nutrients to be returned to the soil in order for plants to thrive. Whilst this can be achieved through a compost toilet that doesn't involve worms, the use of worms makes the process far more efficient. Very little effort is required in this process and it doesn't require complex knowledge, training and technology.

Figure 13. Tiger worms composting

Since worms breed quickly (especially with so much waste to consume) not many would be needed initially. As they reproduce some could be removed and given a new home in a new composting container attached to a toilet. Some could also be removed and used for fishing (Cornell Composting 1996 & Oxfam 2013).

TECHNICAL CONSIDERATIONS

Materials:

Tiger worm toilets are relatively simple to set up. They require the same materials as most composting toilets- a large tank/container (which can be made of a variety of materials, however, corrugated iron or plastic would probably work best), some soil to partially fill the container initially and the toilet itself, which would include a base and walls. The obvious key feature is the worms. The tiger worms can be brought into Codo and will reproduce. Most of the work needed would be at the start to set it up. From then onwards all that will be required will be the adding of the organic waste, monitoring the moisture levels and emptying out the composted material.

Cost:

Composting with tiger worms is very cheap. The cost of the toilet depends on the design and the materials that are selected. The most expensive aspect of the toilet will be the tiger worms. In Australia it was found that you can have 500g of tiger worms (which is approximately 2000 worms) delivered to your door for $47.95 (wormsrus.com.au 2013). The cost of getting these worms to Codo would have to be taken into account, however, we predict that composting worms would be available for purchase within East Timor, if not, in nearby countries.

Adaptability:

The tiger worm design is very adaptable to Codo as most of the materials required for its construction can be sourced locally. The only material that has an external source is the tiger worms. Whilst the worms might not be easy to get to Codo, they will only have to be brought in once as they will reproduce quite rapidly. The fact that it is simple to set up, use and maintain also makes it ideal for a community that is accustomed to the practice of open-defecation. As with any toilet design there will be difficulties with getting the community to use the toilet, however with a good education program in place highlighting the importance of sanitation, members of the community will be motivated to engage in these practices of using a toilet for their own benefit. There should be no problem with learning how to build and maintain the toilets as long as community members are provided with the right training.

Maintenance:

The maintenance required is very little. Moisture levels will need to be monitored and action will need to be taken when necessary. This simply involves adding thickening materials (such as sawdust) or adding water. The containers will need to be emptied as well.

CASE STUDY

The use of tiger worms doesn't require a specific design of toilet as evident in the following examples.

1. *Series of above ground containers that are emptied from the bottom:*

A study by F. F. Kassam (Sanitation Updates 2012) assessed the performance of a worm based sanitation system. A series of above ground tubs were used. There were four tubs placed on top of each other with a mesh bottom that allowed the composting waste and the worms to pass through. On top of the mesh sat woodchip and coconut coir bedding which assists in the composting process. The top container had faeces added to it each day. The containers also had moisture sensors and thermocouples while the base container had a tap at the bottom for effluent to drain out of. This design would be used with a toilet that is raised above the ground and sits on top of the series of containers that is sitting on the ground. This would allow the compost to be removed from the bottom container through the tap at the bottom. The rate at which solid waste can accumulate and worms can improve the quality of effluent by reducing pathogen levels and concentrations of harmful chemicals was examined. The investigation verified that the tiger worm toilet provides an effective, low cost, low tech solution to less economically developed countries' sanitation problems.

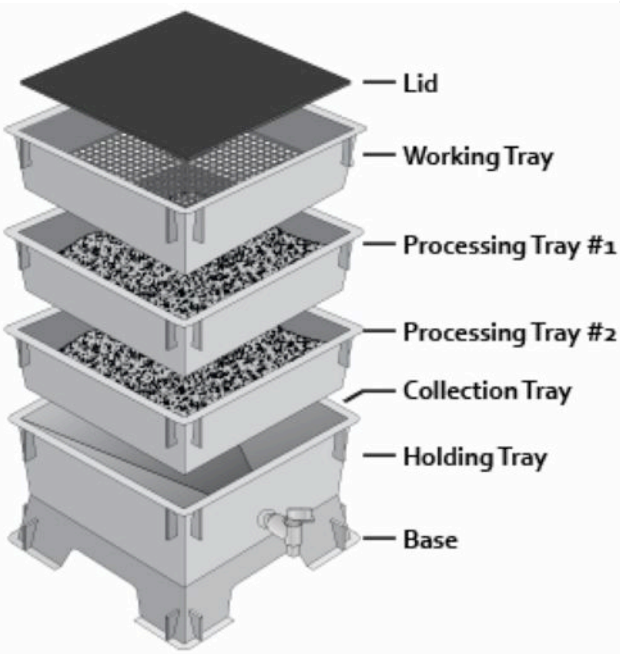

Figure 14. A tiger worm composting system

2. Split tank emptied from top:

A different but equally effective design involves using a tank that is split into two parts and a moveable pipe that allows changing the side where the waste goes once one side is full. There is a two-part lid. Inside the tank are two semi-circular open baskets. Near the top, resting on wire mesh is a worm bed, where the tiger worms live in a material such as coir. The human waste is flushed from the toilet onto one of the semi-circular beds, via a delivery pipe. The liquid drains down onto a filter bed where it's treated by aerobic bacteria to produce high-quality effluent. This will either evaporate or drain away. After six months, the user switches the delivery pipe to the basket on the other side. The worms will follow their food source across to carry on digesting freshly-flushed material. Digestion and decomposition of their waste matter will carry on in the first side. After another six months the first side will be ready to empty, i.e. safe to handle (non-pathogenic), dry and with no offensive smell. This means users can empty the system themselves, by opening the lid above the half not being used and lifting out the cage. Then they move the pipe back to the first side, and the six-monthly side-to-side cycle is repeated (Sanitation Ventures 2013).

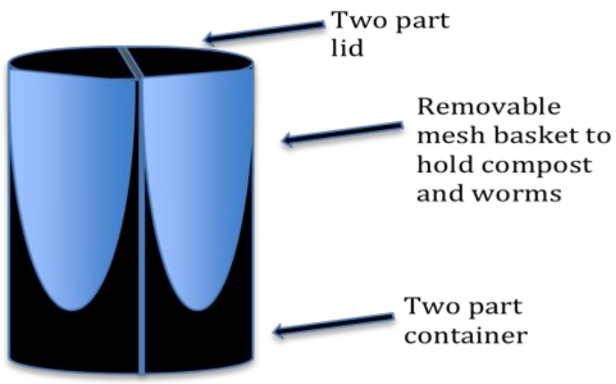

Figure 15. A split container for worm composting

EVALUATION

The key advantage to using tiger worms is that they compost waste more efficiently than the aerobic composting process would alone. This means that the storage space for composting waste can be smaller as it is emptied faster and can be used sooner. It is also a very sustainable method of composting, as it doesn't require chemicals or excessive materials. The fact that other organic materials (like food scraps, coconut coir and sawdust) can be used to assist the process is also very useful.

Another reason why tiger worms are so effective is because of the rate they reproduce. Since tiger worms multiply so efficiently, only a very minimal amount would be required initially which, in turn, keeps expenses down. Provided with plenty of composting material, there will never be a shortage of tiger worms. Tiger worms are very safe and environmentally friendly. They will not do any damage to existing plants, crops or wildlife, which adds to their sustainability. It should also be noted that there would be no problems with tiger-worms and Codo's climate because of the worms' ability to adapt to most climates.

Another reason why using composting tiger-worms is a sustainable method is because the waste can be turned into a resource. The worms provide the community with nutrient-rich compost that will make their crops and plants healthier and stronger, which will, in turn, increase the community's food supply.

The biggest disadvantage and possible setback of using tiger worms is that they will most likely have to be brought in to the community of Codo. Tiger worms are found in Asia but because Codo is in quite a remote area there could be some difficulties in getting them to the community. This would incur additional costs because of the need to transport them. It also means that with the tiger worm toilet design, it would be impossible to have all materials locally sourced.

The tiger-worm toilet is very effective in turning waste into a resource at an efficient rate, which makes it suitable for Codo. It is a simple design making it an ideal 'first step' for a community that is transitioning from the practice of open defecation. Although, it's major flaw is the fact that the worms are most likely not locally available, which could result with difficulties sourcing them and additional costs. For this reason, it might be better that they are considered as a future option to be used in a composting toilet if the community decides they would be beneficial.

Figure 16. Composting tiger worms

arbor loo

WHAT IS AN ARBOR LOO?

This toilet is a simple design. A shallow pit (1 – 1.5m deep and with a 0.9m diameter, approximately) is dug and then a concrete slab is placed over it. An optional toilet house can be placed around as well, to increase privacy. A family will use this toilet until the pit is full (approximately 6 months) and then will dig a new pit and move the concrete slab and toilet house to make this the new toilet. The old pit is then covered by a layer of soil and a fruit tree is planted in order to use the human waste as fertilizer, as demonstrated by Figure 17. Due to the shallowness of the pits, no supports need to be added (Morgan, 2000).

HOW DOES IT WORK?

The Arbor Loo works by maintaining a certain level of moisture within the shallow pit at all times. This is done by adding sawdust and ash after each use, which also helps to eliminate odours. This moisture consistency within the pit allows the human excreta to be turned into fertilizer more rapidly (Morgan, 2000). Once the pit is full it is covered by a layer of soil, which needs to be approximately 20cm deep, and it is into this soil that the young tree is planted. This means that by the time the roots grow long enough to reach where the old pit was finished, the human waste would already by fertilizer and would assist in the tree's growth.

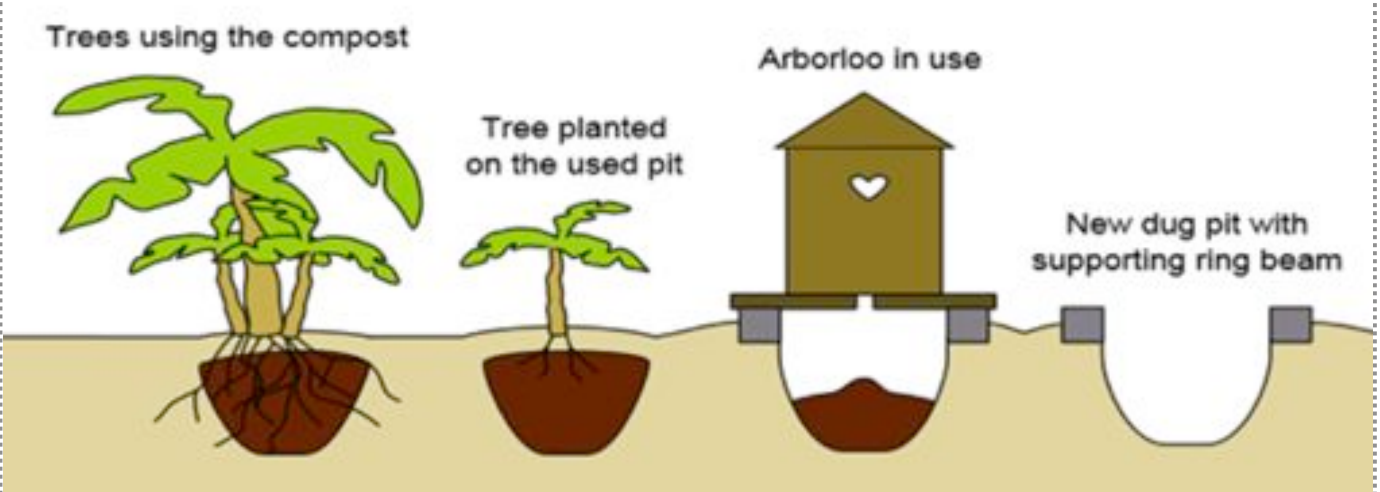

Figure 17. Basic design of the Arbor Loo

TECHNICAL CONSIDERATIONS

The cost of this project would be very cheap. The only material that would need to be sourced from outside the village would be concrete, in order to make the slab which could be imported from Dili, the rest of the materials can be found within the village. As seen in Figure 18, the measurements for the concrete slab are a diameter of 1300mm x 50mm, with the concrete being mixed at a 3:1 sand to cement ratio. For each slab, approximately 5L of cement and 15kg of sand is needed. Given that concrete can be sourced from Dili for $US6, and sand for $US25 (EWB, 2013), the approximate cost, per slab, would be $US20.

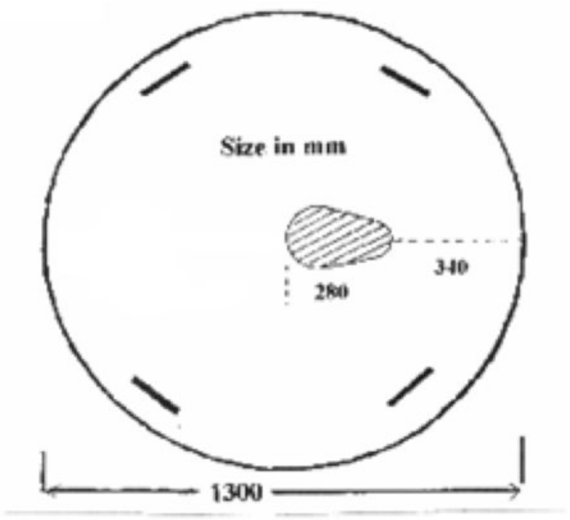

Figure 18. Possible dimensions for a concrete slab

Figure 19. Ring beam being constructed using bricks

All other materials needed would be able to be sourced from within Codo itself. As seen in Figure 19, a ring beam is being constructed using bricks; however it is possible to construct one with stones which can be sourced from Codo. Similarly, Figure 20 shows a toilet house constructed from bamboo which can also be found in Codo. Palm fronds could be used for the roof. Both the concrete slab and toilet house are reusable and can be moved when the hole is moved.

The maintenance required for Arbor Loos can be quite high, as pits must be re-dug and the toilet moved often. Other maintenance required would be periodic repairing to the toilet house.

Figure 20. Arbor Loo movable toilet house constructed with bamboo

CASE STUDY

Arbor Loo systems have been implemented in many developing countries, including villages in Ethiopia, Malawi and Haiti. These case studies have had positive outcomes. In one village in Ethiopia, prior to the introduction of Arbor Loos, the open defection rate was almost 100%. Due to its simplistic design and accessibility, three years after the Arbor Loo was introduced the open defection rate had dramatically dropped to being less than 1% (IRC, 2013).

Figure 21. Arbor Loo toilet in Ethiopia

EVALUATION

This design option has a number of benefits. First, the simple design means that it can be used by all the villagers of Codo, and can be implemented on a household level which would make the behavioural change from open defecation to using toilets more rapid. These toilets are not a long term solution; however they can offer a beneficial first step in behavioural change. Furthermore, this design option can help food security as well. The use of human waste to plant trees would benefit families on a household level to produce more fruit. In previous cases where these toilets were implemented, the fruit trees have said to have grown more rapidly and heartily than regular fruit trees (SSA, 2010). These toilets can also be used on agricultural fields in order to help crops grow, and to encourage the village farmers to use toilets while at work.

However, there are of course downfalls with this solution. One is that in order to operate properly, the pits must not be too wet (Morgan, 2000). Due to Codo's monsoonal rains in the wet season, this could pose a challenge. Options to combat this could be the construction of a ring beam around the head of the pit and a roof over the top of the toilet house. This would divert some of the water; however with Codo's mountainous location and the volume of rainfall, this would probably not be enough to entirely protect the pit. Another issue regarding the implementation of these toilets is the need for educative service to be provided in not just how to use the toilets but also on how to care for and grow the trees planted. The Arbor Loo needs to stay relatively dry; sawdust and ash must be applied after each use. There must be instruction on how much should be applied and why this must be done. Previous projects involving Arbor Loos have reported that villagers are reluctant to put sawdust in the hole, as it is already a shallow pit and they do not want to fill it too rapidly (Morgan, 2000). They also must be correctly trained on how to plant trees properly. If the layer of soil is not thick enough, of the roots of the tree are planted directly into the human waste then the tree will not grow. Villagers must be educated on this.

While the Arbor Loo is a simplistic first step design in the shifting of behaviours away from open defecation, in the context of Codo, this design seems impractical because of Codo's hillside location and heavy rainfall. The Arbor Loo would need serious modifications before its successful implementation in Codo.

biodigester toilet

WHAT IS A BIODIGESTER?

The biodigester toilet is a system which breaks down human waste in anaerobic conditions (no oxygen) to create biogas and biol. These products of the biodigester can be used for several things; the gas can be used for cooking or heating and the biol can be used as a fertilizer on crops to help improve yield.

HOW DOES IT WORK?

The basic design of a biodigester is seen in Figure 22. There are 4 main components to the biodigester toilet.

The first are the **inlet pipes**; in Figure 22 there are two separate inlets, however often there is just one pipe directly from the toilet to the tank below. This is where the human (and animal) waste is loaded into the system.

The second main component is the **digester tank/biogas tank.** This tank is completely sealed from oxygen to cater for the anaerobic decomposition of the waste. In this tank there can be bacteria added to help speed up the decomposition; however this is not necessary as microorganisms will break the waste

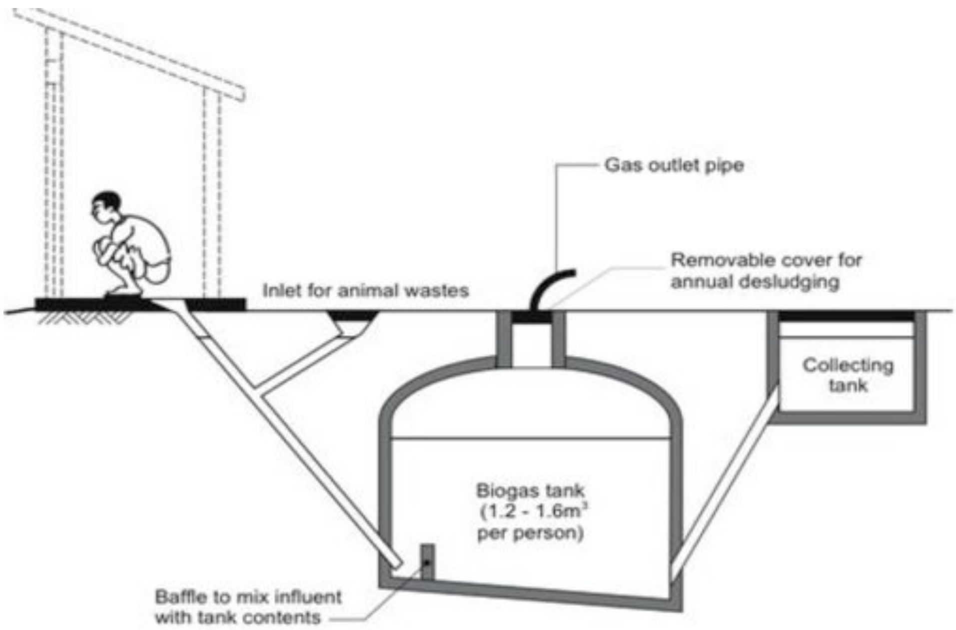

Figure 22. The components of a biodigester toilet

down. At the top of this tank there is a dome which goes above the ground- as seen in Figure 23. Figure 24 also shows the gas outlet which connects to the top of the dome. The biogas is formed in the tank by decomposition of the biodegradable material and is collected, then piped to a home, where it can be used for hot water, cooking or heating. Unless concreted or bricked the dome must be surrounded by a wall or fence to prevent animals or humans damaging the tank.

Often surrounding this valve at the top of the dome there is a shallow pool of water which, by bubbling, indicates whether biogas is unsafely leaking out of the valve. Furthermore some systems bubble the biogas through SO2 (steel wool), to remove the smell of biogas, and then water, to help remove impurities such as CO2, before piping it into the house.


Figure 23. The gas dome of a biodigester toilet

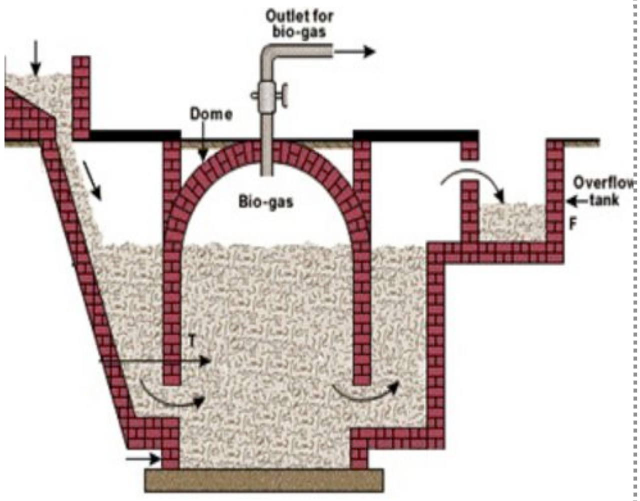

Figure 24. Fixed dome-type biogas plant

The third component is the **collecting tank/outlet tank.** This is where the biol is transferred and can be collected for use. It is predominantly manure and water that has been fermented and can be diluted with water and then sprayed over crops. Once dried, it can also be used as compost. The use of biol has been found to significantly boost the yield of certain crops.

The fourth and last main component of the biodigester is the **overflow tank** as can be seen in Figure 24 (not shown in Figure 22). This is used to capture any overflow of the system. This chamber helps ensure the biogas tank does not explode from built up pressure before the gas is released, and similarly that the collecting tank doesn't overfill and begin to spill biol.

TECHNICAL CONSIDERATIONS

Materials for the biodigester are relatively low cost in East Timor, as can be seen below in US dollars:

- House bricks: $0.65 per brick.
- Cement: $40.00 per 40kg bag.
- Bamboo Sheeting: $1.50 per sheet
- Timber: $5.50-$7.00 per length (various lengths)
- Nails: $2.00 per kg (various lengths).

(Engineers without Borders, 2013)

Biodigesters are also low maintenance; requiring simply the water around the valve to be maintained (if used), sulphur wool to be replaced (if used) and de-sludging every few years; which requires little training.

However, despite the overwhelming positive benefits, there have been some criticisms. Firstly, in some locations the pipes, valves and tubing required for the system are not locally available, so must be sourced from overseas at a higher price. It is hard to gauge if these materials would be available in East Timor, or in Lautém before commencing the project.

Biodigesters can last for a minimum 5-6 years (Ideassonline, 2012), although the longevity varies greatly depending on the materials used. If plastic were used for the tanks it would last potentially longer than bricks, however, is more fragile so may require replacing more frequently if not protected properly. Plastic tanks may not be affordable or available in Codo, so bricks, concrete and other more available materials may be used instead. In Vietnam there has been a shift towards cheaper concrete digesters so this may be viable in Codo also.

Furthermore, the system is designed to be constructed close to a dwelling, minimising the risk of damage to the biogas pipe so it doesn't have to extend far. In the village of Codo this would most likely mean constructing one toilet at each dwelling, or constructing a toilet block, or several, throughout the village, where all the villagers come to use communal cooking area (where the gas stoves could be set up). The nearby toilet smell wouldn't be an issue, as biodigesters don't have an odour, however it does raise questions such as:

- Would it be culturally appropriate for the people of Codo to use a communal cooking area outside of their own home?
- Would it be affordable to have one biodigester in each home?
- Would they use the biogas to cook food? (Culturally appropriate or not? In some places like India, this is not accepted)
- Would the villagers walk to go to a bathroom which is further from their home or go back to their habits of open defecation?

CASE STUDY

Biodigesters have been used in many different countries; both developing and developed such as Cambodia, Guatemala, China, India, Kenya, The United States of America, Vietnam and Mexico. In China, Cambodia, Guatemala and India there have been severe fluctuations in supply and price in regards to energy and gas in rural regions. The use of biogas has been hugely successful in these countries at tackling energy supply problems and has significantly reduced deforestation of surrounding areas.

The economic benefits of biodigesters have been evident in almost all case studies; in Guatemala biodigesters have provided more economic stability and independence for farmers as opposed to using chemical fertilizers which are costly and unsustainable, and tend to fluctuate in price. For families in India biodigesters have provided another source of income as they are able to sell the biol fertilizer.

Environmental benefits have been widely noted; particularly in the USA, where studies have been conducted looking into the reductions of methane and carbon dioxide in the atmosphere due to biodigesters.

EVALUATION

There have been extremely positive responses to the implementation of biodigesters in various countries; particularly in response to the helpful by-products of the system which address issues in agriculture as well as energy, sanitation and safe food.

As in China, this system would be appropriate in Codo as there have been widespread power failures for a number of years, and the villagers rely on wood stoves to cook their food. This has been found to be particularly detrimental to the respiratory health and overall well-being of women and children in a number of countries as they tend to be around the cooking more than the men. By using biogas instead of wood stoves this could reduce the risk for house fires, but also the negative health impacts caused by smoke inhalation. In many countries biogas has also reduced deforestation significantly (as seen in China). Furthermore the time which would be used for collecting wood could be used to focus on other things, such as education or training. The biodigester can produce approximately 700L of biogas per day which is enough for 3 hours of cooking.

The use of biol has been found to increase crop yields by 30% (Ideassonline, 2012) and therefore has decreased the need to expand agricultural lands and deplete the natural environment surrounding. Many agriculturalists have also noted the savings made by not having to use expensive and limited chemicals on their crops to keep up with ever-increasing industrialisation of agriculture. In countries like Benin the improved crops have bettered the health of animals too; consequently increasing milk production and quality from cows and goats. Up to 80L of biol can be produced per day by the biodigester (Ideassonline, 2012).

The system, like some other toilet systems, reduces flies, and consequently the many diseases (mastisis and trachoma) associated with flies coming into contact with faeces and then humans or animals.

Unlike other toilets, the biodigester is good for the environment and reduces pollution; trapping the release of greenhouse gases such as methane (in human and animal waste) and preventing pollution of waterways/food sources. Methane is said to be 23 times more harmful than CO_2 for the atmosphere (Ideassonline, 2012), so this could be significant in reducing the effects of global warming also.

In conclusion, if accompanied with appropriate training the biodigester would help reduce open defecation and illness in the village of Codo. The system has the potential to exponentially boost well-being, productivity and savings for the people and the environment of Codo through the useful by-products. Biodigesters have enabled people in many different countries to gain a footing to step out of the poverty cycle by decreasing:

- time spent searching for wood (increasing time doing other things, for example going to school)
- ill health from contamination of food/water sources, flies and smoke inhalation, (increased time able to spend working/learning; increase productivity and income)
- money spent on chemicals and crop production.

This could be helpful in breaking the poverty cycle for many marginalised people in Codo living in an impoverished, developing country like East Timor.

However considerations need to be made with the location of the biodigesters and ensuring appropriate consideration is taken in regards to materials and cultural sensitivities.

<table>
<tr><th>POSITIVES:</th><th>NEGATIVES:</th></tr>
<tr><td>

Biogas:

Addresses energy/gas supply problems as well as human waste
Decrease deforestation
Increase time available (not spent looking for wood)
Reduce risk of fires
Health benefits (no smoke)

Biol:

increases crop yields
economic savings (no chemicals)
improved health of animals

increased milk production
increased profit

Reduces flies and associated diseases
Reduces pollution

Reduces methane released into atmosphere
Sustainable environmentally

Relatively low cost
Low maintenance

</td><td>

Supplies not locally available in some areas

Hard to get concrete information on what is available in East Timor
Plastic tanks last longer but:

are fragile
may not be available

Should be close to cooking space

One at each house is probably not affordable
Communal toilet/cooking blocks

may not combat open defecation (distance)
may not be culturally appropriate (communal cooking, use of biogas)

</td></tr>
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Table 1. Evaluation of a biodigester system in Codo

“Sanitation is more important than indepedence

- Mahatma Gandh

3. DESIGN CRITERIA

In order to deem the most appropriate toilet design for the community in Codo, the following design criteria were developed. The design criteria evaluate five key areas of each toilet design; set up, sustainability, operation, maintenance and appropriateness. Each of the toilet design options; Composting Toilets, Ecosan, Earthworm Toilets, Arbor Loo and Biodigester are given a rating on a scale of 1-5 for each of the elements with an area of criteria. A score of 1 indicates a failure to address the design criteria specified and a score of 5 on the opposite end of the spectrum indicates that the toilet design satisfies this criteria.

set up

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
Transport	3	2	3	5	3
Cost	3	3	2	4	2
Compliance with laws	5	5	5	5	5
Timely	4	4	2	5	4
TOTAL	**15**	**14**	**12**	**19**	**14**

sustainability

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
Long-Life	4	4	4	1.5	4
Environmentally friendly	5	5	5	5	5
Productive	4	4	4	4	5
Local resources	4	3.5	2.5	5	3.5
TOTAL	**17**	**16.5**	**15.5**	**15.5**	**17.5**

operation

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
Convenient	2	2	4	3.5	4
Safe	4	4	4	4	4
Effective	3.5	3.5	4	4.5	3.5
TOTAL	**9.5**	**9.5**	**12**	**12**	**11.5**

maintenance

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
Training and Education	2	2	3	3	3
Maintenance	3.5	3	3.5	1.5	2.5
TOTAL	**5.5**	**5**	**6.5**	**4.5**	**5.5**

appropriateness

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
Community Involvement	3.5	4	3.5	5	4
Reduces waste	4	4	4	4	5
Culturally appropriate and acceptable	3	3	3	3	3
Meets community needs	5	5	5	5	5
Accessible to the community	4	4	4	5	3.5
Aligns with PLAN's values	5	5	5	5	5
Appropriate for environment and climate	3.5	3.5	3.5	1	3.5
TOTAL	**28**	**28.5**	**28**	**28**	**29**

final evaluation

	COMPOSTING TOILETS	ECOSAN	EARTHWORM TOILETS	ARBOR LOO	BIODIGESTER
SET UP	15	14	12	19	14
SUSTAINABILITY	17	16.5	15.5	15.5	17.5
OPERATION	9.5	9.5	12	12	11.5
MAINTENANCE	5.5	5	6.5	4.5	5.5
APPROPRIATENESS	28	28.5	28	28	29
TOTAL	**75**	**73.5**	**74**	**79**	**77.5**

From this evaluation it is evident that the Arbor Loo toilet design received the highest score using the design criteria, however we decided that it just really wasn't suited to the environment of Codo. Firstly, the necessity to re-locate the system every six months was labour-inducive. Secondly, we were concerned that the hilly terrain of Codo would prove problematic for finding ample sites to relocate to, as the system requires a flat surface to build on. Thirdly, the Arbor Loo pit must be kept dry for the effective functioning of the toilet and this is almost impossible to achieve in Codo because of the monsoonal rains. Furthermore, in most case studies, it was stated that this was not a sustainable, long-term solution, more a 'gateway' toilet to encourage the use of toilet systems. We opted to not implement a short-term solution despite its obvious benefits.

Ecosan was ruled out, as a sanitation solution because of the complex nature of the toilet design. The successful implementation and effective use of the Ecosan toilet relies on the education and co-operation of its users to use it appropriately. Because of its complex nature and high maintenance (i.e. two toilet holes – one for urine collection and one for faeces collection, the need to swap toilets every six months and the need to sprinkle saw dust or lye over the faeces after each use); we concluded that there was a large disparity in behavioural practices from open defecation to using this toilet. Thus the likelihood of behavioural change and hence success of the Ecosan toilet in Codo is minimal.

The Earthworm toilets are a viable option, as they are cheap and can be combined with another design option. However, we found it was challenging to ascertain if the tiger worms are locally available or not. If not locally sourced they would be too expensive to import from overseas. Furthermore, Earthworm toilets aren't a system in themselves, more an addition to another system; so they aren't an option to stand in solitude, but something to be considered alongside another system.

We were then left with two designs: the biodigester and the composting toilet (which could potentially be combined with the earthworm design). The composting toilet has the obvious benefit of the fertilizer bi-product, and is also considerably simpler than other designs.

The biodigester system was the second highest scoring by a slight amount, due to the multiple and useful bi-products of the system, as well its capability to address multiple issues such as energy, pollution and deforestation. However despite its overwhelming benefits we found it difficult to ascertain if biofuel would be culturally and practically appropriate in Codo, given the climate and geography of the region. We decided that there was too much disparity between the current practices of widespread open defecation and the use of the more-complex biodigester. The system also required a higher level of training and maintenance (for the safe and appropriate use of biogas).

The simplicity of the composting toilet system made more sense to us in the context of Codo and would be less adjustment from current practices. The system requires less maintenance and training however still involved the local volunteers both in the building and operation phases. We also concluded that composting toilets are more flexible than the biodigester; both systems could be built at the household level, but the biodigester poses extra complications with the use of biogas and consequent location of stoves and cooking areas. In our proposal, we recommend investigation into the implementation of the biodigester toilet in the long-term future following the successful implementation of composting toilets in the near future.

“Let us not be tempted to build and develop modern hospitals that are costly and i
vhich only half a dozen people benefit from good treatment. Let us concentrate above a
on planning intensive campaigns of sanitation, prevention, and the treatment o
epidemics and endemics for the whole population.

- Xanana Gusmão, De-facto President of East Timo

4. FINAL PROPOSAL
design description

DESIGN SUMMARY

Our design option will include the implementation of an education program to introduce the community to the concept of sanitation and toilet construction which will commence shortly after the commencement of the education program. While we have made numerous suggestions about key aspects of the project, we would ultimately leave it up to the community of Codo to decide on these independently.

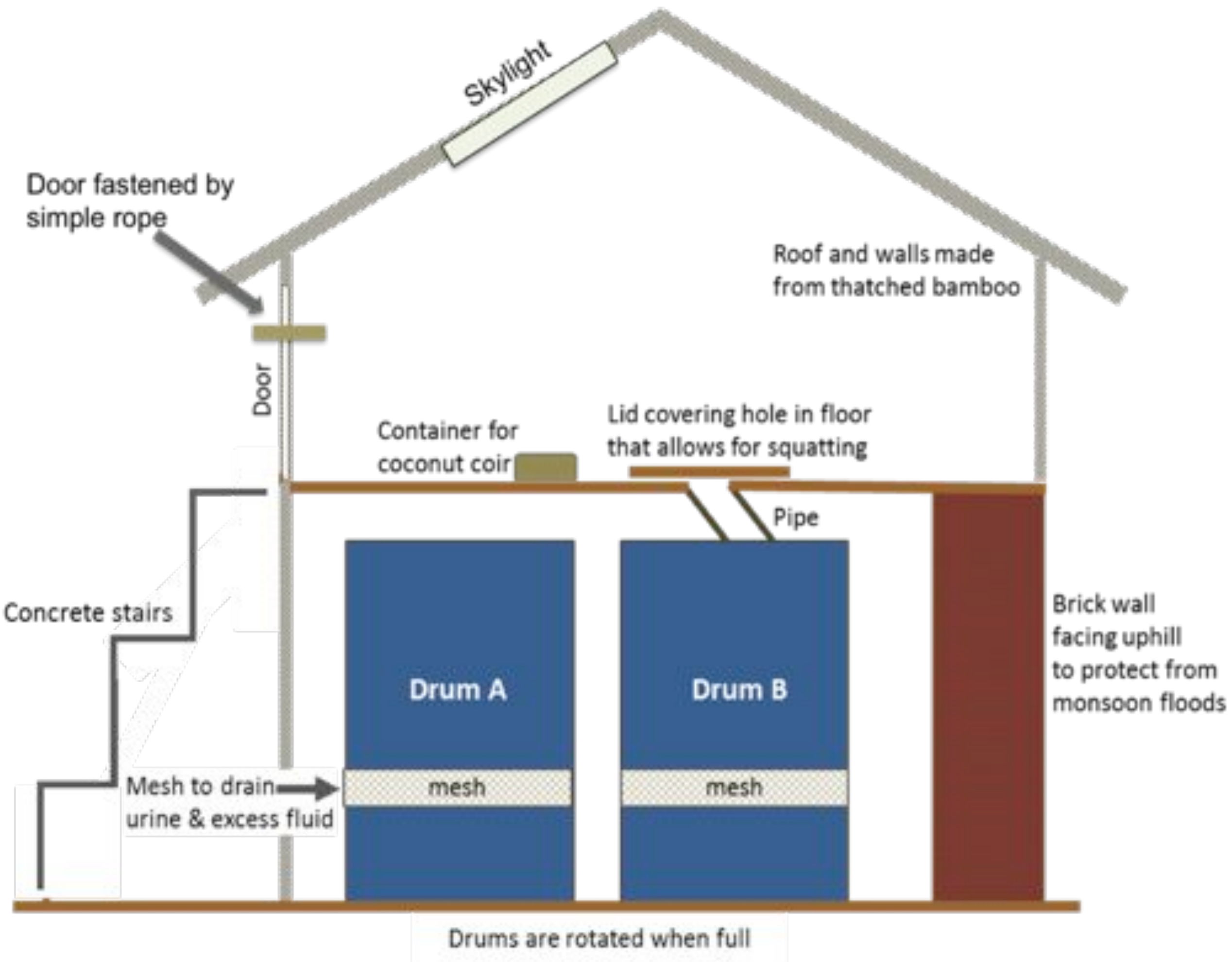

Figure 25. Functional diagram of composting toilet design for Codo

DETAILED DESCRIPTION

Key Features:

Drums: The drums that collect the compost need to be large enough so that they take approximately six months to fill. However, if none that are large enough are available the number of containers per toilet structure could be increased to allow for more constant rotation of full drums. The toilet drums need to be secure so as to allow for the control of oxygen levels for anaerobic processing to take place. We would recommend plastic drums, if they can be sourced, as these would allow for simpler manoeuvring of full drums. Furthermore, this would facilitate easier collection of the waste matter; as a hole could be drilled into the drum connecting the squatting hole to it, thereby allowing for the drum to receive the waste directly.

Toilet lid: The toilet design will include a lid that covers the squatting pit of the toilet. The lid will be constructed as such that toilet users hold the lid in front of them whilst using the squatting pit. The purpose of the lid is so that the squatting pit is kept covered at all times to reduce exposure to insects that could transmit diseases.

Figure 26. Coconut coir can be harvested locally

Mesh: The mesh that sits in the toilet drum serves to drain the excess liquid from the composting waste, thereby reducing the odour and allowing for anaerobic processing to take place. The mesh can be easily built using a galvanised mesh frame with a polyethylene surround (Milkwood, 2013).

Coconut coir: Coconuts are another abundant resource in Codo. Coconut coir is a natural fibre extracted from the husk of the coconut that serves as a bulking agent in this toilet (see Figure 26). By harnessing this local product we would further increase the sustainability of the project.

Bamboo: Bamboo is readily available in Codo as a resource, and is already in widespread use for the construction of buildings within the community. We would take advantage of the pool of resources that exists within the community when constructing each toilet by encouraging community members to utilize their own skill and expertise in the process. This also allows for involvement of the community in the implementation of the toilet.

Door: The door of the toilet structure will be constructed from bamboo and fastened with a simple rope.

Brick wall:

The structure of the toilet is above ground to allow for the proper functioning of the toilet (ie. the collection drums to be located below the toilet). The base structure of the toilet will be constructed by brick on three sides of the structure to protect the structure from monsoonal floods during the wet season.

Detailed information about obtaining the components of this toilet are found in the *Supporting Documents* section.

CONSTRUCTION PROCEDURE:

The construction of the hut would begin during Phase 2 of the education program as will be discussed in more depth in the *Implementation Section*. The construction of the toilet would commence once the location of the toilets has been determined by the community.

1. **Acquiring materials**

   Materials for the construction of the toilet will be sourced from Codo and neighbouring districts in the region. Coconut coir could begin to be prepared for use on the completion of the toilet.

2. **Levelling of ground:**

   Due to the steep terrain of Codo, a flat surface would be required for the base of the toilet structure.

3. **Construction of the toilet hut:**

   The raised hut and protective brick wall would form the basic structure of the toilet design. The toilet drums themselves would need to be prepared – with a large hole in which the removable pipe/chute can be placed, and the mesh draining system being placed partway down the container. A smaller pipe running from a hole in the base of the container would also need to attached, with the opposing end being placed in a garden area for the liquid to run out into. As seen in Figure 25 the containers would be placed underneath the hut, with a removable pipe/chute running down from the squatting hole.

4. **Use of toilets:**
   Once the construction and Phase 3 of the education program are completed, the use of the toilets by the community members can commence.

5. **Maintain control of moisture and oxygen levels:**
   Controlling moisture and oxygen levels are an integral aspect of the decomposition process. Volunteers would be trained to regularly check the moisture and oxygen levels of the drums. This training would include ensuring the containers are sealed, the liquid is effectively draining out of the containers, and that coconut coir is being placed in the toilet after each use.

6. **Rotation of full containers:**
   When the containers have reached their designated fill point, volunteers in charge of toilet maintenance would be required to rotate the drums. This would be done by detaching the pipe from the full drum and attaching it to an empty drum. The full drum would be allowed to decompose for at least six months before the compost is used. This process may be quicker in warmer months.

7. **Harvesting the compost**:
   The compost is ready for use when it becomes dark and crumbly (MMSB, 2013). This process should take approximately 4-6 months, depending on the temperature of the climate at the time. The compost could be used to fertilise crops as the community sees fit (see *Technical Considerations*).

8. **Continuation of Project:**
   One of our main goals for this project is to encourage a shift away from open defecation behavioural practices, but more so to empower community members to assume responsibility for their health and sanitation and want to build more composting toilets in the village. Resources would still be made available by volunteers from local NGOs, but we hope that the community volunteer group will be able to assume responsibility and continue the project through self-direction.

SUPPORTING DOCUMENTS

While the cost of the composting toilet design is cheaper relative to the other design options, a significant amount of the material must be imported from outside of Codo. This includes items such as cement bags which can be imported from Indonesia and sand which can be imported from Dili. Other items can be sourced from Lautém, including timber, bricks, piping, buckets, rope, nails and mesh. However, there was a

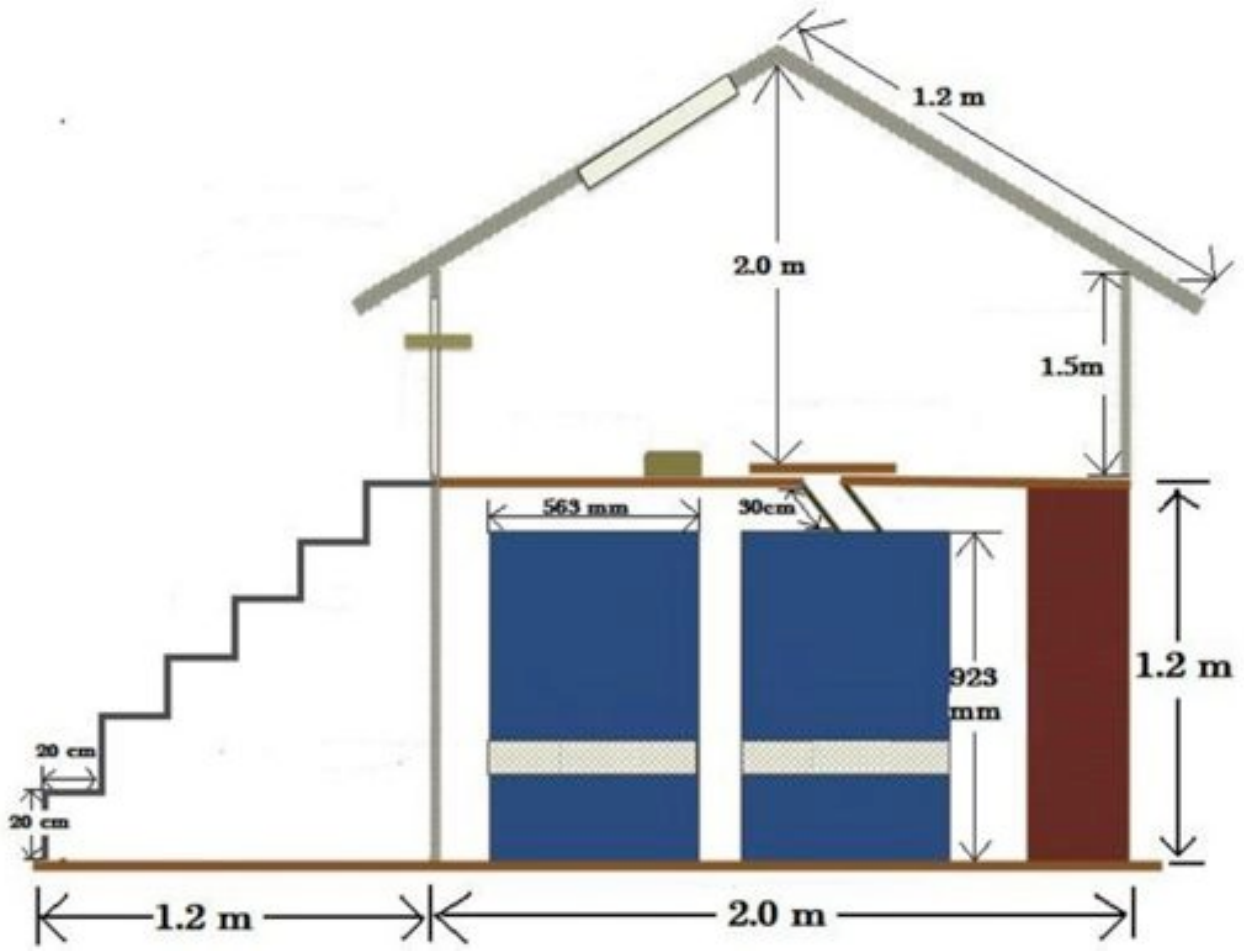

Figure 27. Dimensions of the composting toilet design for Codo

lack of information available in regards to whether or not plastic drums and gravel could be sourced within Timor, and so estimations have been made in regards to these products using $US.

Using the measurements in Figure 27, the design of the composting toilet can be separated into separate parts and prices estimated for each option.

We have assumed a length of 2.0m and height of 1.2m for our base structure, as an estimated drum option would have the drums having a height of 923mm and diameter of 563mm. This would allow ample room for four tubs to allow for sufficient rotation. This would require the piping from the squat hole to the drum to be 30cm. Of course, if different tubs were used, different measurements would be required.

Assuming a length of 2.0m, the number of bricks needed to build the brick wall can be estimated. Information in regards to how big bricks are in Codo is unavailable, so an assumption brick size has been used for these calculations, that being of 8.5 x 2.5 inches. Using a thickness of one brick, there is an estimated need for 145 bricks.

Mortar will also be needed to connect the bricks, using a ratio of 1:6 cement to sand, for a wall of this size approximately 10kg of cement and 60kg of sand will be needed. The total cost is summarized in Table 2.

MATERIAL	AMOUNT (KG)	COST ($US)
Brick	145	94.25
Cement	10	1.50
Sand	60	0.41
	TOTAL	**96.16**

Table 2 Table showing costs of materials for base structure

Typically, floors of building in Codo are made of compacted earth, however for the base of the toilet block and storage of waste containers we highly recommend that a concrete floor be used in an attempt to divert erosion due to rain. Again, using the measurements provided in Figure 27 and assuming a length of 2.0m (enough space to store four drums) we have provided an estimated price. Using a cement to sand to gravel ratio of 1 to 2 to 3, we have predicted that 240kg of cement, 480kg of sand and 720kg of gravel will be required to fit this space. The costs have been summarised in Table 3. Note, however, that due to a lack of solid information about gravel prices in Timor, these costs have been estimated in $US.

MATERIAL	AMOUNT (KG)	COST ($US)
Cement	240	36.00
Sand	480	3.50
Gravel	720	15
	TOTAL	**54.50**

Table 3 Table showing costs of materials for floor of base structure

Another aspect which would have to be constructed is the floor of the actual toilet structure. We propose constructing this out of timber. Timber can be transported from Lautém at a cost of $US5.50 per 2cm x 40cm x 400cm length. For the measurements we propose, 5 lengths of this timber would be sufficient to both construct the floor and provide a cover for the squat lid. This would cost $US27.50. Of course, nails would also be required to construct this flooring, which can be sourced from Lautém at a cost of $US2.0 per kilogram. In order to lower costs, we propose using bamboo to construct the walls and roof of the structure. Not only is this cost effective, but this will allow for greater ventilation than brick walls.

We also propose that steps be constructed using concrete to lead up to the toilet house. By constructing 6 steps measuring 20cm x 20cm each, this would be sufficient to reach the height. We also propose that the steps be constructed with 1m width and 1.2m length. Using these measurements and a 1 to 2 to 3 ratio of cement to sand to gravel the costs are summarized in Table 4 below.

MATERIAL	AMOUNT (KG)	COST ($US)
Cement	269	42.00
Sand	504	3.50
Gravel	1008	21.00
	TOTAL	**66.50**

Table 4 Table showing costs of materials for concrete stairs

Of course, this adds a considerable cost to the construction price, so an alternative would be to use a bamboo ladder instead; however we recommend that the stairs be used. Not only are they safer, but make the toilet more accessible and simpler to use, encouraging the shift away from open defecation.

The total cost per toilet have been summarised in Table 5 including costs without the concrete stairs.

Material	Cost ($US)	Source	Cost per toilet ($US)
Cement (40kg bag)	6.00 per bag	Indonesia	79.50 (without stairs: 43.50)
Sand (1 truck load – approx. 2.5m^3)	25.00 per truck load	Dili	7 (without stairs: 3.70)
Timber (2cm x 20cm x 400cm)	5.50 per length	Lautém	27.50
Brick	0.65 per brick	Lautém	94.25
Piping (galvanized iron, 3”, 6m long)	95.00 per length	Lautém	4.75
Bucket	1.00	Lautém	1
Rope (1m)	5.00 per metre	Lautém	1
Nails (7cm)	2.00 per kg	Lautém	2
Mesh	2.00	Lautém	2
Plastic drums	10.00 per drum	China	40
Gravel (tonne)	20.00	China	36 (without stairs: 15)
	TOTAL COST:		**295 USD (No stairs: 234.70 USD)**

Table 5 Table showing total cost of one toilet structure

There are also tools which will be needed in order to construct these toilet blocks which will need to be purchased; these costs are summarized in Table 6.

MATERIAL	COST ($US)
Saw	8.00
Trowel	2.00
Building string (100m)	1.00
Tape Measure	3.00
	TOTAL: 14

Table 6 Table showing costs of tools needed in the construction of the toilet structure

From the data provided in Table 5, the indicated cost of one toilet structure for Codo is 295 USD and 234.70 USD if a bamboo ladder is used in place of the concrete stairs. As will be discussed in our *Implementation Strategy*, we recommend six initial toilet structures in Codo at the commencement of this project. Factoring in the cost of the tools needed in the construction of each toilet structure, the overall cost of the project is estimated at 1854 USD and 1492.20 USD without the concrete stairs. This does not include the transportation costs of materials to Codo.

implementation strategy

The implementation strategy proposed has two elements; an education component and the physical implementation of the system. Both are equally necessary, complementing each other to ensure the successful implementation of composting toilets in Codo.

EDUCATION PROGRAM

A four phase education program will be introduced to implement this project proposal in the town of Codo. The education program is developed as such to coincide with the construction of the composting toilet facility, as both aspects are necessary for the successful implementation of the project. The phases of the education program are seen in Figure 28:

Figure 28. Stages of the education program

Phase 1: Initial Community Engagement

With the help of volunteers from local NGOs and major community leaders in Codo, a series of community meetings would be organised and held at central meeting points in the town (ie. the church). The purpose of the meetings would be to raise awareness about sanitation issues, draw to the attention of the community the link between open defecation practices and illness and facilitate a forum for discussion of the social, environmental and economic benefits of sanitation as discussed in the *Technical Review* section. Figures 29, 30 and 31 will be used as part of the initial community awareness and engagement campaign. Once the community is aware of the harmful consequences of open defecation, the project proposal would be introduced at a basic level; primarily highlighting the benefits of the project. Discussion around the project proposal and feedback would be encouraged. At this stage, the community would be consulted about their preference for the location of the toilets. The overall objective of Phase 1 is to create a sense of understanding about the composting toilet design and boost their confidence to install it by highlighting the harmfulness of open defecation practices and the benefits of sanitation.

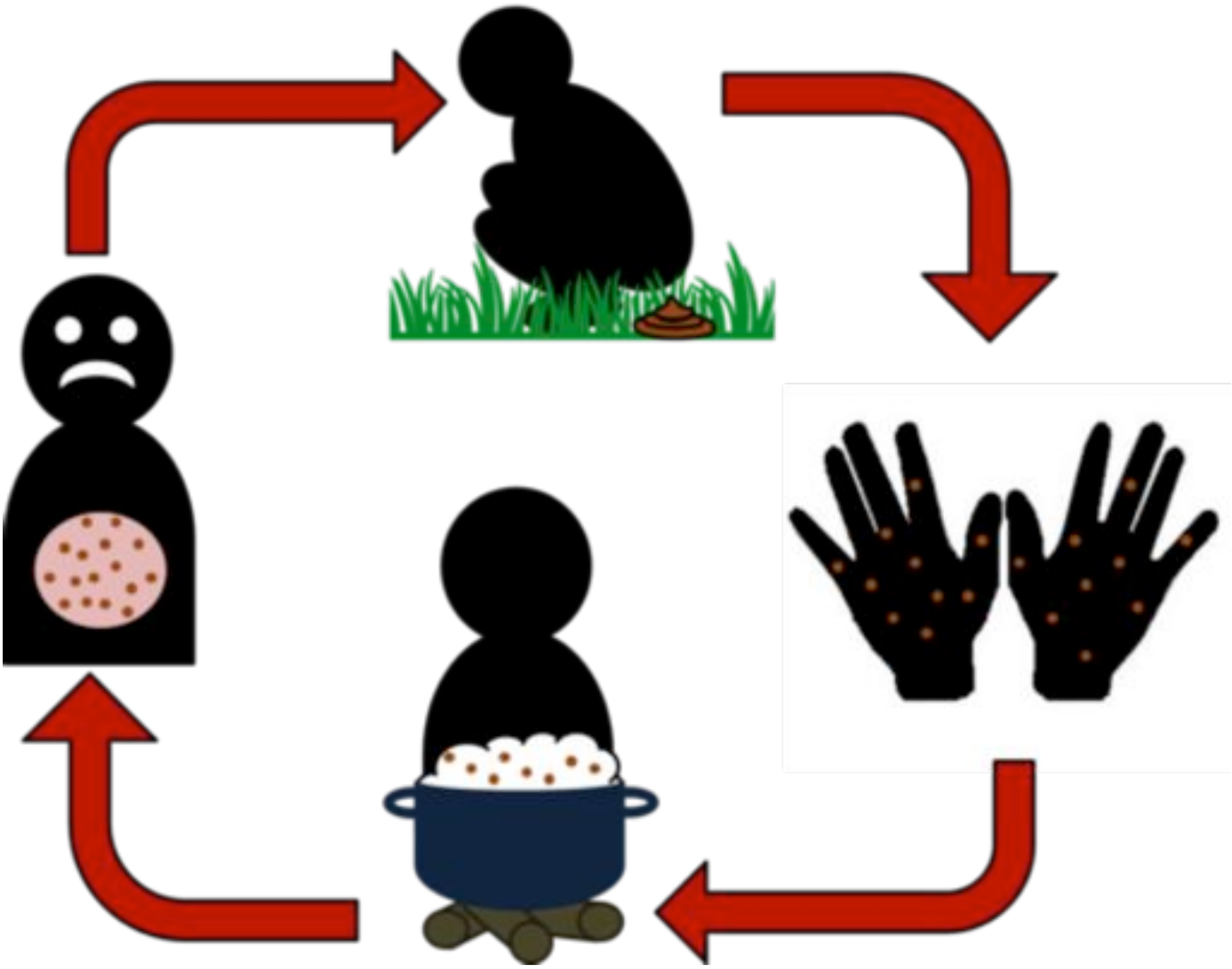

Figure 29. Poster showing the harmful consequences of open defecation practices
(to be used during Phase 1 of the education program)

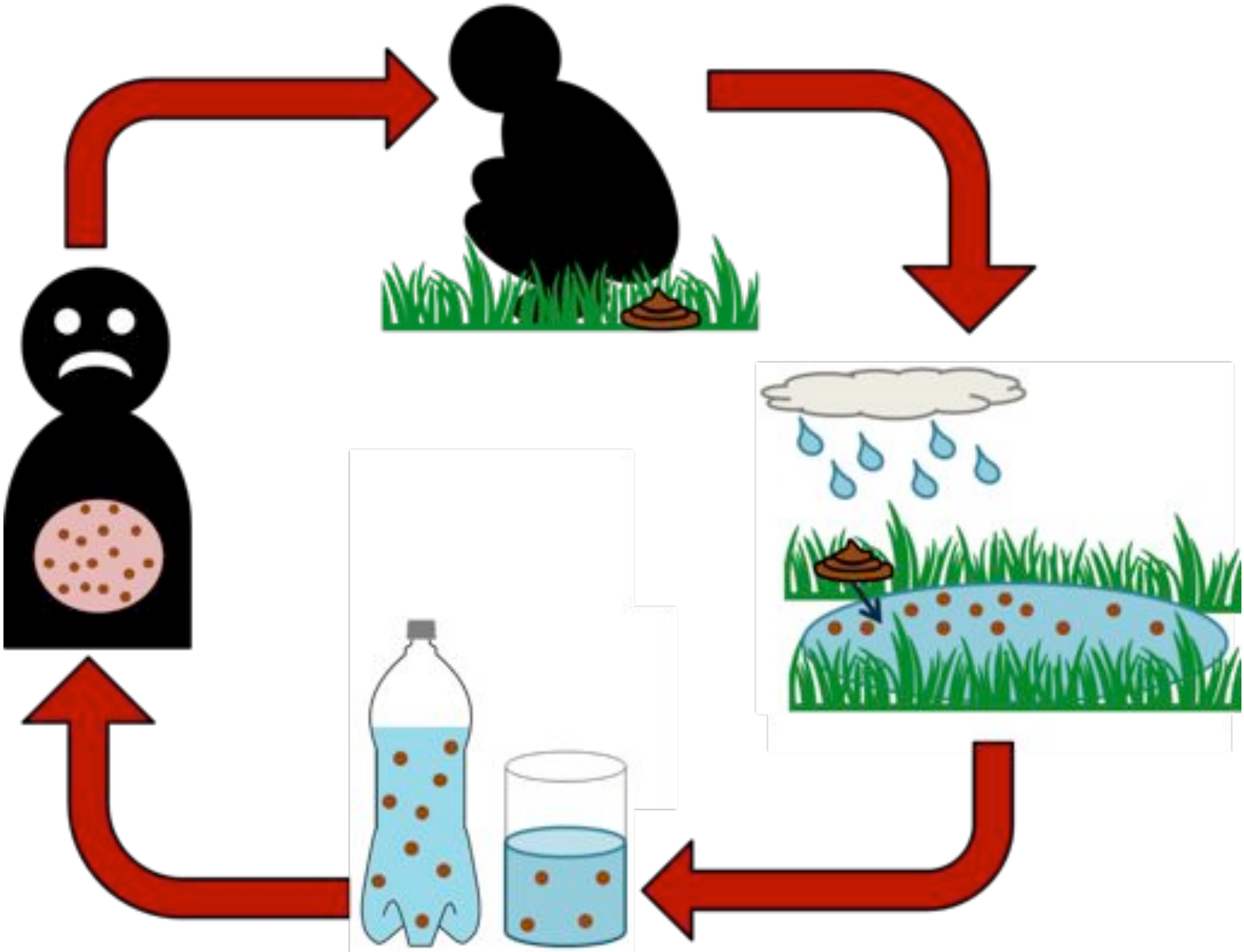

Figure 30. Poster showing the harmful consequences of open defecation practices
(to be used during Phase 1 of the education program)

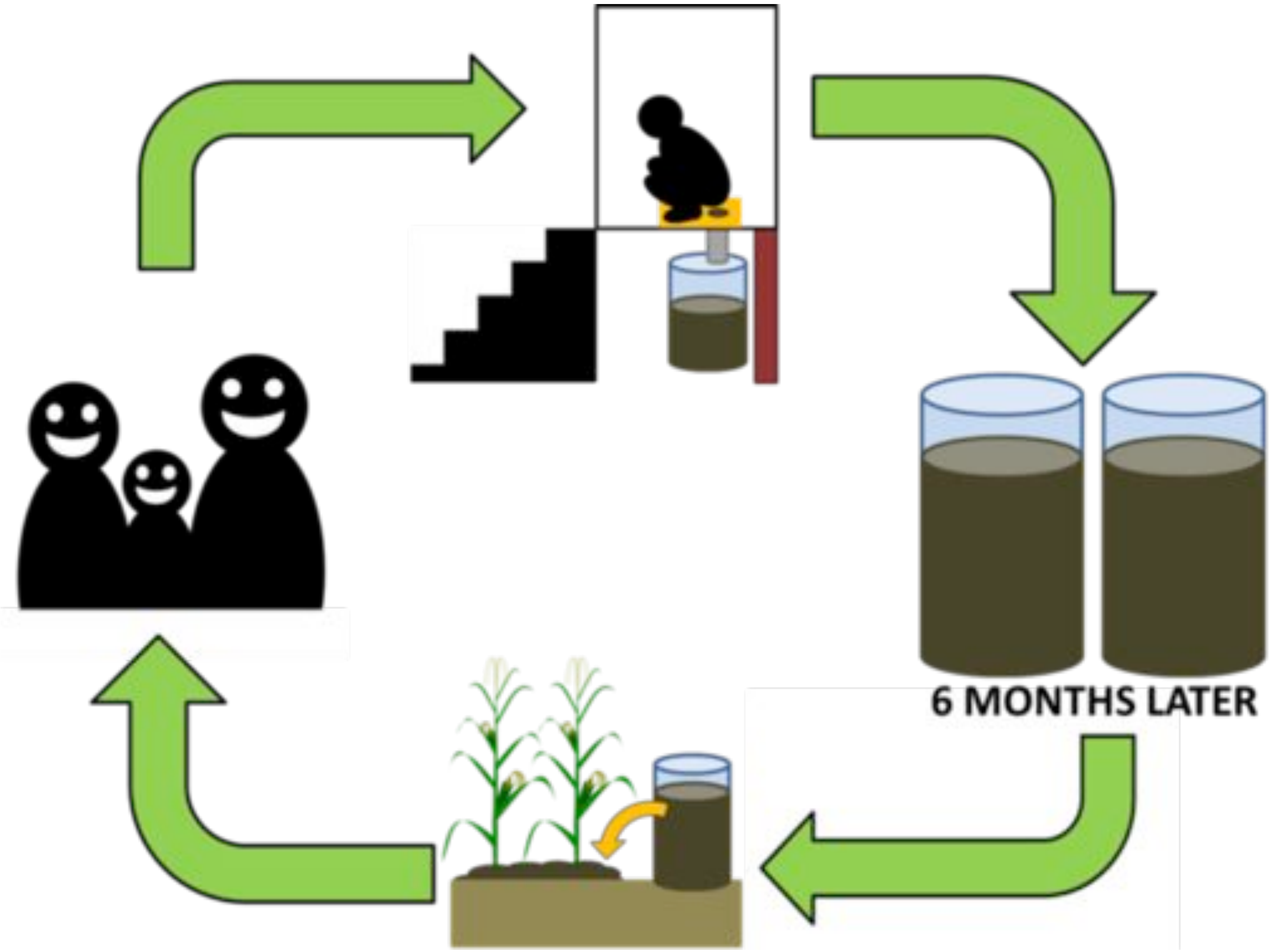

Figure 31. Poster promoting the use of composting toilets and showing the benefits of good sanitation practices.
(to be used during Phase 1 of the education program)

Phase 2: Construction and Adaptation

With the help of the pre-existing volunteer network in Codo, community leaders and any other willing community members, the construction of the toilets would begin at Phase 2. The construction of the toilets would be under the leadership of the local volunteers and community leaders however the whole community (particularly the men) would be encouraged to become involved in the building of the toilet facilities.

Alongside the construction of the toilets, community consultation would continue in order to address the issues that will be highlighted in the *Implementation Consideration* section of this report.

Community members would be encouraged to view and assist in the construction process for two reasons; to deepen their understanding of the toilet design and to ensure that the community members are involved in the project proposal. The overall objectives of Phase 2 are to establish a co-operative, participary approach towards ending open defecation and instil a sense of responsibility in community members to see the composting toilet as their own; this will be achieved through further education and involvement.

Phase 3: Education and Use

As the construction of the toilet draws to a close; an education campaign about the correct use of the toilets and a training program to educate about the maintenance of the toilets would begin.

Signs such as those seen in Figure 32, 33 and 34 would be erected around the village particularly around the toilet facilities to reinforce the appropriate use of the toilet and serve as a reminder of the importance of good sanitation practices. We are aware that the sample signs in Figures 31 and 34 are in English and would need to be translated into Fataluku, the native language of the Lautém region (this will be done with the assistance of the local volunteers and community leaders). It also must be noted that the signs are a temporary transitional phase of the implementation of the program; the signs will be removed when the behaviours shown in the signs become a natural practice of the community members. For this reason, it is impossible to determine a timeframe for the use of the signs.

The educational sessions as part of Phase 3 will be tailored for particular demographics to ensure the most effective education of particular community groups. Educational sessions will run in the following ways:

- Programs run at the local primary school, utilising the pit latrines already located there. Children would be encouraged to engage with their parents and family to transfer whatever knowledge they may already possess about the use of toilets
- Programs designed for women and girls to address issues relating specifically to them and to orient them towards the use of the toilets
- Engagement with religious leaders to facilitate meetings after church gatherings that address issues with the use and maintenance of the toilet

Also at Phase 3, the community volunteer group would be educated about the use of the compost as fertiliser. This training program would include the delivery of technical knowledge of the operation of the toilet including being able to identify that the recepticles are full, being able to identify that the compost is ready for use, being able to remove the fertiliser, being able to apply and use the fertiliser in the community and being able to rotate of the drums that collect the compost.

The overall objective of Phase 3 of the educaion program is to enhace the community's knowledge of the composting toilet and its product, particularly knowledge about the use of the toilets. This phase also places an emphasis on equipping local volunteers with the technical knowledge required to take responsibility for the ongoing maintenance of the toilet.

Phase 4: Education for the Future

During the final phase of the program, meetings will continue to be held to answer questions and address issues that may arise in the course of using the toilets. Phase 4 is community-led; no new information will be relayed to the villagers, rather it is about receiving community feedback. We anticipate that during Phase 4 the benefits of the toilet (health, social, economic and environmental) will begin to be recognised by the community, thereby encouraging the development of more toilets in Codo. If individuals are interested in developing toilets at a household level, this would be considered at this phase. The overall objective of Phase 4 is to track the progress of the project, to monitor transitions in behavioural practice and to determine the future direction of composting toilets in Codo.

Figure 32. Sample sign discouraging open defecation and encouraging the use of composting toilets

Figure 33. Sample sign encouraging the correct use of the composting toilets
(to be put around the village particularly the toilet blocks)

Figure 34. Sample sign encouraging the correct use of the composting toilets
(to be put around the village particularly the toilet blocks)

IMPLEMENTATION CONSIDERATIONS

Location

In our designing process we spent a lot of time considering where the toilets would best be located and whether or not they would work better if they were communal or used as one per household. We have decided on some recommendations, however, we acknowledge there will need to be a lot of community consultation in the decision-making process before any concrete conclusion can be reached. It is important to take into consideration community needs and opinions to ensure the community has some involvement with the project and to ensure that it becomes their own.

From our perspective, every household would benefit from a toilet. Although, considering that our proposal is really a 'first step' in trying to eliminate the practice of open defecation, it was decided that the best implementation strategy during the transitional phase from open defecation practices to the use of a sanitation system would be toilets at a community level. Our approach to the implementation of a sanitation system in Codo is a community-led total sanitation approach where the aim is to become open-defecation free rather than help individual households acquire toilets. One benefit of having communal toilets is the fact that initially, less people will need to be trained in the building and maintenance of the toilets. As mentioned in the education program, only the volunteer group, who will assume responsibility for the functioning of the toilets, will need to be trained, as opposed to one person in every household.

Having shared toilets also promotes community-acceptance. It means that members of the community can teach and encourage each other to use the toilets. We anticipate that some members of the community might be reluctant to use the toilets initially but it is expected that as more people become comfortable with using them, negation towards the toilet system will decrease as community members will see that they are easy to use and that there are benefits for the community from using the composting toilets. Once the toilets have received acceptance from the general community, we anticipate that there will most likely be a demand for more toilets and we hope that community members would want to implement them on a household level. At this stage, community members might decide to build toilets for their own homes. In terms of where the toilets should be located, we recommend that they are placed in the most communal areas in Codo (for example: near the church, tap stands, the communal washing area and in community meeting places). We understand the toilets must be very accessible since open defecation is currently widely practiced and the toilets must be within a close distance to community members so as to encourage their use. We predict that toilets will be used more if they are located where the majority of the community can access them; community members are likely to be deterred from using the toilet facilities and revert back to open defecation practices if the composting toilet facilities are out of proximity. Therefore in deciding their best location, there would need to be a great deal of community consultation to determine which locations would be most appropriate and most accessible.

Quantity

In terms of how many toilets would be needed in Codo we predict that six would suffice to pilot the project for approximately a year. We anticipate that the need for more toilets will grow with time, however to start off people might be apprehensive about using them so we don't want to overwhelm the community with an abundance of toilets. We also concluded that establishing a large number of toilets in Codo at the onset of the project implementation may come across to the community members as forcing the toilets upon them. A small number of toilets to begin with allows the community members to become involved in the process and develops a sense responsibility for the toilet system, as discussed in the education program. Since the toilets would be placed in different locations we recommend that no less than four but no more than eight should be built; thus six toilets is ideal in light of the materials, cost and labour required for each toilet. We recognise that there are 419 people inhabiting the town of Codo, which means that approximately 70 people would be sharing one toilet, which clearly isn't enough. However, we don't expect that everyone in the community will take to using the toilets immediately and as previously mentioned, six toilets is the initial number to pilot the project so that the community can be involved and recognise the benefits of the composting toilets on their own. The most effective means of promoting behavioural change is empowerment, which will be achieved in this project proposal through community involvement and visible results. Success of the project proposal will be measured by latrine usage not number of latrines constructed. The demand for more latrines must come from within the community; it cannot be forced upon Codo. Six toilets is simply a starting point, not a long-term solution. As the volunteers in the community will have been trained to construct composting toilets, the community are able to construct more toilets as they require without relying on an external body. However, this number will need to be approved by the community. Finally, we recognise that with six toilets for 419 villagers, the drums that collect the compost will fill up at a rapid rate. We propose to have more drums than required for each toilet as a solution to this so that the operation of the toilets is not adversely affected.

Weather and climate

We have noted that the weather of Codo, particularly the region's monsoon season, might negatively impact the community's ability to use the compost. If it is especially wet in Codo, there could be issues with the compost staying on the garden or the crops where it is supposed to. In response to these potential problems, we recommend that there are extra drums to collect the compost readily available in the event that the compost needs to be stored for a longer period of time. This coincides with the need for extra drums for an increased population using the toilets (as discussed above).

The use of the compost

We have also considered that once the compost is ready for use, there will need to be a system in place that allows the compost to be fairly distributed. This will be largely up to the community; however we have made some recommendations.

The compost could be divided equally among the members of the community that use the toilet and this process could be managed by the volunteers who are responsible for the maintenance of the toilets. This would largely depend on whether everyone wants a share in the compost, but we will leave that up to the community to decide. Another idea is to sell the compost. The volunteers could be responsible for the money earned and it could go towards the maintenance and building of new toilets in Codo. An alternate suggestion is that a community vegetable garden is created and all the compost could be used there. The vegetables could be distributed throughout the community.

These suggestions will need to be considered in light of community needs and in consultation with the villagers in order to know what is most appropriate for Codo.

project review

STRENGTHS

The composting toilet design is most suitable for Codo and this is evident in the considerations presented in this report. We have tailored the design to suit the community's needs and circumstances. Our approach to the project brief has been a community-led total sanitation approach in which we consider it more important to shift behavioural practices away from open defecation rather than providing each individual or household in the community with a toilet facility. This mentality has framed our implementation strategy. In adopting a community-led total sanitation approach, we hope that the community will be empowered through education and involvement in the project to take responsibility for their health and sanitation and change their practices of open defecation.

The composting toilet design is a very simple design. The simplicity of the design was deliberate, as it makes the design easy to replicate and alter if needed; depending on the change of climate conditions or the changing availability and cost of materials. A simple toilet design also means that there isn't a large shift in behavioural practices from open defecation to using the toilet (in comparison to some of the more complicated sanitation systems presented in the *Design Options* section of this report). Therefore, the composting toilet is likely to be more culturally acceptable to the community.

To increase the success and appeal of the system we have also ensured that the proposed design is safe for users. Utilizing local materials in the construction of this toilet also accredits the design as it reduces the overall cost of the project.

The composting toilet design maintains a good cost-benefit ratio. Capital costs of the toilet may seem high, however, the composting toilet has a life-long capacity, provided that it is adequately maintained (ie. sufficient number of toilet drums per toilet structure and that these are rotated periodically as required). The proposed sanitation system also has the capacity to boost the local economy and make cost savings in healthcare by capping the spread of diseases and the frequency of illness caused by a lack of proper sanitation.

The composting toilet design is a very sustainable option for Codo. This design avoids the use of chemicals or harmful substances in its system. Additionally, the composting toilet does not consume any electricity or water it its operation. Furthermore, the composting toilet adopts an ecosystem approach to sanitation; as it recycles human excreta back into the environment, turning it into a nutrient rich fertilizer to benefit local crops and plants. By recycling the products of its system back into environment, the composting toilet contributes to economic and productive systems in the community. This contribution to the local industry could provide a source of livelihood for the community in Codo.

WEAKNESSES

For this sanitation system to truly be successful in Codo, community mobilisation is a prerequisite. The composting toilet design needs to have the support of all members of the community in two regards; in the construction and maintenance of the toilet and in the usage of the toilet and encouraging its use by other community members. This may prove the biggest challenge to our project however the *Implementation Strategy* proposed in this report will assist to overcome this issue. In addition to this, the challenge of community mobilisation and education could play to our benefit, as this will act to motivate engagement with the community to encourage their full involvement and co-operation in the delivery of the project.

Another challenge to this project is that it requires training and education and relies on the local volunteers to assume responsibility for the project. This challenge will be met by the proposed education package that is coupled with this project; however, it will require extra time and effort. While this may seem like a temporary shortcoming of the project, the long-term benefits of an education and training program will be invaluable to the community. We also recognise that relying on volunteers to run the project, and maintain the sanitation infrastructure after the delivery of the project, may seem slightly problematic as the volunteers are not trained professionals. Nonetheless, we believe that the involvement of the volunteers is essential to encourage community involvement. We are in agreement that the project will be more successful if it is facilitated by the local volunteers as opposed to an external body; the community is likely to be more responsive to the volunteers and adopt the project as their own.

NEXT STEPS

Evidently, our long-term and primary goal for Operation Sanitation is to provide a way to enable the village of Codo to become open defecation free. We propose that the 'first step' discussed in our implementation strategy operates for a minimum of twelve months so that the community are given the opportunity to pilot the initial six composting toilets and accordingly decide on the future direction of sanitation practices in Codo. We also suggest that twelve months is a viable timeframe for the benefits of the composting toilets to the health and welfare, the environment and the economy of the community to manifest to the people of Codo, such that the demand for composting toilets increases in the community.

We aspire to have one sanitation facility per five households in Codo post-2015. This is approximately 22 toilet structures for the entire village. We recognise that this long-term goal is consistent with, and helps meet, international sanitation goals. We are referring specifically to the 2011 consultation convened in Berlin by the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF), which set four targets to ensure that efforts to reach the Millennium Development Goals by 2025 are on track. Amongst these was a target to ensure a world that is open-defecation free by 2025. The Berlin consultation also discussed targets post-2015; amongst this discussion was the notion of 'adequate sanitation at home' which was defined as sanitation facilities shared between five households or less (WHO & UNICEF 2013: 11). In line with this, Operation Sanitation proposes that post-2015; there is adequate sanitation for all homes in Codo. We hope that the profits of the initial six composting toilets will assist to fund this development.

In the long term, we would like to see one composting toilet per household in Codo and toilet facilities in shared community spaces but even more than this, we'd like to see usage of these latrines by all members of the community. As previously discussed, we recommend investigation into the implementation of biodigester toilets in the long-term future following from the successful implementation of composting toilets in the near future. We recognise that when this stage is reached, the biodigester would need evaluation in light of community needs and values and its appropriateness for Codo at that time.

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