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A village near the coast of Sumatra in ruins after the Tsunami struck on 26th December 2004

The Potential of Ecosan to Provide Sustainable Sanitation in Emergency Situations and to achieve "quick wins" in MDGs

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MSc Thesis
(MWI-2006-22)
March 2006

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Master of Science Thesis
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This research is done for the partial fulfilment of requirements for the Master of Science degree at the UNESCO-IHE Institute for Water Education, Delft, the Netherlands

Delft
March 2006

The findings, interpretations and conclusions expressed in this study do neither necessarily reflect the views of the UNESCO-IHE Institute for Water Education, nor of the individual members of the MSc committee, nor of their respective employers.

Abstract

Natural or man-made disasters such as earthquakes, hurricanes and war, cause emergency situations, which affect people's lives, the infrastructure that supports them and their natural environment. In developing countries, the existing infrastructure is often weak and insufficient to start with. For this reason, emergency situations in developing countries can usually be characterised by one or several of the following: disease outbreaks, insecurity, violence, and lack of basic services such as food, water and sanitation.

The aid agencies tend to implement sanitation systems that are well known and proven even if they may not always be long-term sustainable solutions. Currently the excreta disposal practices used in emergency situations in developing countries include open field defecation, shallow trench latrines and deep trench latrines for immediate to short term emergency situations, and simple pit latrines and pour flush latrines for long-term emergency situations.

Although some of the current methods exhibit good principles for managing human excreta i.e. isolation, containment and treatment, the practices are in most cases not environmentally sustainable. The most common technology used in emergency situations is the simple pit latrine. This can result in groundwater pollution (especially in areas where the water table is high), inconvenience for women and children (since they are built a distance from the households), nuisance due to odour and flies (or other insects) and also problems with not having sufficient space available to build or rebuild when full (especially in densely populated areas).

Ecosan is an alternative approach to conventional sanitation systems that promotes ecological and economical wastewater and waste management. Ecosan is based on the principles of containment, sanitisation and reuse ("closed-loop" ecological systems) (Werner *et al.*, 2003). The nutrients recovered from human faeces and urine produced can be used in agriculture, hence preserving soil fertility, ensuring food security and minimising water pollution. Despite the fact that reuse of sanitised wastes as fertiliser may not be possible in the immediate or short term of an emergency, the *potential* for reuse should still be evident within an ecosan approach to providing emergency sanitation.

To investigate the role ecosan can play in achieving sustainable sanitation in emergency situations, the main objectives of this research project were to:

- Analyse current practices in emergency sanitation and to describe their shortfalls.
- Establish the viability of ecosan at the different stages of emergency.
- Establish criteria that will determine the conditions under which introduction of ecosan practices would be beneficial in a given emergency situation
- Examine the relevance for the MDGs: if the approach to human excreta disposal in emergency situations was adjusted/changed, how would the same approach achieve "quick wins" for relevant Millennium Development Goals, namely: "Eradicate extreme poverty and hunger" (Goal 1), "Reduce Child Mortality" (Goal 4) and "Ensure environmental sustainability" (Goal 7).

This study was carried out as a desktop study with support from Médecins Sans Frontières (MSF)and the International Committee of the Red Cross (ICRC), who enabled me obtain the case studies used in this research. I have analysed three case studies from developing countries namely the case El Salvador after Hurricane "Mitch" in 1998, the Afghanistan environmental sanitation programme in 2000 and the Pakistan earthquake in 2005. For each

case study, i have analysed the existing water supply and sanitation situation before the occurrence of the disaster, the type of systems that were installed after the disaster, and examined whether ecosan could have been an appropriate solution.

The analysis has shown that the systems implemented in the long-term phase of the emergency are safe and sustainable in comparison to those used in the immediate to short term of the emergency. Also noted is that the toilets implemented in El Salvador and Afghanistan are ecosan compatible toilets.

The study has shown that for ecosan to be viable during emergency situations, specific criteria have to be in place e.g. for the essential criteria awareness and expertise among aid agencies, ease of transportation and quick installation of assembled units, availability of water, status of displaced people, stage and duration of emergency and the role of government in sanitation provision. And for the desirable criteria; awareness amongst the users, availability of land for reuse, collaboration between the different aid agencies. Other relevant criteria include existing sanitation system, food supply chain, expected life cycle of the implemented sanitation system, user's understanding of limited choices and coordination with other reconstruction projects.

Whilst ecosan approaches can include dry or wet sanitation systems, the focus in this thesis is on dry urine diversion (UD) toilets because in emergency situations in developing countries, there is usually a lack of water supply.

With regard to meeting the Millennium Development Goals (MDGs), the research has shown through use of a simplified approach that by achieving Target 10 i.e. using ecosan compatible toilets, Target 2 and 5 will automatically be achieved.

The results show that for Target 10 to be met over two hundred thirty seven thousand toilets are required for El Salvador, more than two Million for Afghanistan and approximately seven million required for Pakistan. This leads to an estimated total investment cost for these toilets amounting to about 4.3 million euros in order to meet the targets by 2015.

The challenge for emergency sanitation in developing countries is not just to provide sanitation services that deal with the problem of excreta disposal, but also to provide services that are sustainable (in all accounts) in the long term (i.e., an investment in sanitation for the future). Very often this means that we should provide services that are *better* than what was in place originally.

In this sense, a disaster may create an opportunity for a "quantum change" in sanitation practice that might otherwise not be considered. In other words, the disaster may be the catalyst for implementing new technology, which can be more than just temporary, but the first step towards a sustainable technology.

Acknowledgements

I wish to thank the Netherlands Government and the Watermill Programme for fully sponsoring my Master of Engineering and Master of Science studies at UNESCO-IHE Institute for Water Education in the Netherlands.

My special thanks go to my mentors Dr. Elisabeth von Münch, Dr. Annette Ochs and Mr. Jean Francois Fesselet of Doctors Without Borders – Holland (MSFH). They have enabled me to sustain this research to its successful completion, I could not ask for more.

I would also like to thank Prof. Gary Amy for guidance and time that he devoted to this study.

I would also like to extend my sincere thanks to all those who provided me with words of encouragement, support, relevant information and were always ready to help when contacted – I cannot mention all your names so thank you.

I will also take this opportunity to thank my brothers, sisters, relatives and friends in Holland and at home and to all those that I love dearly, for encouraging and believing in me always.

Finally, but most especially I wish to thank my parents Engineer and Mrs Valentine Mwase for all the support, encouragement, care and love shown to me in pursuing my career as an engineer. I love you.

God Bless you Always.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Abbreviations

ACF	Action Contre la Faim
DAFT	Dry, Alkaline, Family and Time
Ecosan	Ecological Sanitation
GB	Great Britain
ICRC	International Committee of the Red Cross
IDPs	Internally Displaced Persons
LASF	La Letrina Abonera Seca Familiar (Dry Fertilising Toilet)
MDGs	Millennium Development Goals
MSF	Médecins Sans Frontières
MSFH	Médecins Sans Frontières Holland
NGOs	Non-Government Organisations
PVOs	Private Voluntary Organisations
UD	Urine Diverting
UK	United Kingdom
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations International Children's Emergency Fund (now United Nations Children's Fund)
Volags	Voluntary agencies
WEDC	Water Engineering and Development Center

1 Introduction

The Millennium Development Goals (MDGs) have no direct reflection about disasters despite the fact that their occurrence has a significant impact on both the people's livelihood and the economy of the affected communities or country. This chapter introduces emergency sanitation and how its improvement could lead to achievement of the MDGs. It also highlights the dangers of poor human waste disposal and points out ecosan as a possible viable option for handling human excreta during emergency situations. Also outlined in this chapter are the goal and objectives of this research.

1.1 Background

"No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all" Kofi Annan (2003).

The eight Millennium Development Goals (MDGs) were set up by the world leaders at the Millennium Summit in September 2000. MDG number seven, target ten focuses on halving by 2015 the proportion of people without access to drinking water and basic sanitation (Millennium-Project, 2005a). The summit on sustainable development held in 2002 in Johannesburg, South Africa included targets on sanitation not considered at the earlier Millennium Summit (WSSD, 2002). The Watermill Programme is a contribution by the Netherlands government towards achieving the MDGs by increasing awareness through education. This MSc thesis was funded by this programme.

At least 2.4 billion people - about 40% of the world's population, lack access to adequate sanitation (Langergraber and Muelleger, 2004). As a result about 2.2 million people in developing countries, most of them children, die each year from diseases closely associated with lack of safe drinking water, and due to inadequate sanitation and poor hygiene (Matsuura, 2003).

This situation is made worse after the occurrence of a man-made or natural disaster, when diseases spread easily. Emergency situations, which are a result of occurrence of a disaster, can occur anywhere in the world, affecting human health, people's lives and the existing infrastructure. If the infrastructure was already weak before the disaster, then this makes the impact of the emergency even more severe.

In emergency situations, one of the major causes of diseases is due to lack of proper sanitation facilities: such as proper toilets, hand-wash facilities and bathrooms. The hygiene problems brought about by disasters have direct consequence on the health of the population affected. Yet, sanitation in emergency situations is often not given as high a priority as other humanitarian interventions such as healthcare, food and water supply.

This is so despite the fact that many of the most common diseases occurring under such scenarios are caused by inadequate sanitation facilities and poor hygiene practice (Treglown *et al.*, 2002). Emergency sanitation therefore requires higher prioritisation among other areas of humanitarian intervention if deaths related to inadequate sanitation are to be reduced. The facts about inadequate sanitation and disease occurrence during emergency

situations are well known and many aid agencies wish to increase emphasis on sanitation in general.

In emergency situations the immediate health risks can be lowered by rapidly addressing water and sanitation. However, even when safe water is provided, this leads to the production of wastewater (greywater)[1]. This wastewater if not dealt with properly could lead to contamination of ground and surface water sources, and stagnant pools that provide room for breeding of disease causing vectors such as mosquitoes.

In developing countries, provision of adequate sanitation for all is quite hard under normal circumstances. It proves even harder under emergency situations where the duration is not clearly known: short, medium or long term. Emergencies may last for a long time – up to a number of years, for example the Kony war in Northern Uganda that has lasted nearly two decades. The affected population rely entirely on aid from aid agencies resulting in excessive hunger and malnutrition especially among the children.

The challenge is therefore to provide sustainable sanitation systems that address all or most of these problems. The systems should be quick to install, cheap, safe and sustainable. They should also easily integrate with the existing infrastructure, if any exist. The systems should also offer conservation of the resources such as food, water and energy that are usually meagre especially during emergency situations. Appropriate solutions to this kind of sanitation situation are required – that provide environmental protection as well as better livelihoods of the people.

One of the possible sustainable options to address such circumstances is Ecological Sanitation ("ecosan" in short). Ecosan is an alternative approach to conventional sanitation systems that offers an ecological and economical sustainable wastewater management. Also referred to as "closing the loop", ecological sanitation means the separation of waste streams (often, but not always separation of urine and faeces), saving water and energy, nutrient recycling, cost efficiency and the integration of technology to environmental, organisational and social conditions (Jenssen *et al.*, 2004). The ecosan concept is gradually accepted all over the world and pilot projects are ongoing.

Ecosan has been identified as a system that could provide safe and sustainable disposal of excreta during emergency situations as well as achieving the MDGs.
If the time-bound and quantified targets set in the MDGs are to be achieved, sustainable alternatives to the traditional practices have to be addressed. This research investigates the role ecosan can play for emergencies situations in providing safe and sustainable excreta disposal practices and also in achieving the MDGs.

[1] Sanitation in emergencies is almost always dry sanitation, hence water is not used in toilets.

1.2 Problem Description and Scope of Research

Adequate sanitation involves: safe disposal of human waste, adequate water for bathing and washing, prevention of food contamination and health hazards (Chattopadhyay, 2001). Adequate sanitation is a fundamental human right together with provision and access to safe water. Safe excreta disposal is a major area of concern in emergency sanitation. This is because of the large amounts of pathogens present in human excreta, some of which include: parasites, worms, eggs, and other disease forming pathogens (Chattopadhyay, 2001).

Aid agencies tend to provide quick sanitation solutions such as pit latrines, which may not be sustainable in the long term. This lives the affected people in a situation that still requires further intervention making them dependent on aid for a long time after occurrence of the disaster. This is because of the continuous outbreaks of diseases brought about by poor excreta disposal methods. Therefore aid agencies need to focus on sustainable sanitation systems that can serve their purpose during emergencies and even in the long term.

This research is limited to developing countries. It is further limited to a specific area of emergency sanitation i.e. excreta disposal. Greywater treatment and hygiene promotion are not part of this thesis but are recognised as important for proper excreta disposal.

1.3 Goal and Objectives

The overall goal guiding this research is to:

- **Analyse the role ecosan can play in emergency sanitation and in achieving "quick wins" for the MDGs.**

To achieve this goal, the primary objectives of this research are to:

- Analyse current practices in emergency sanitation and to describe its shortfalls.
- Establish the viability of ecosan at the different stages of emergency.
- Establish criteria that will determine the conditions under which introduction of ecosan practices would be beneficial in a given emergency situation.

The secondary objective is to:

- Examine the potential for achieving quick wins for the MDGs: if improved human excreta disposal practises in emergency situations are used

2 Literature Review Part I: Existing Situation in Emergency Sanitation

Emergency sanitation is a broad field and for the purposes of this research, its areas of intervention will be defined. This chapter describes emergencies and their causes, the stages of emergency and the relief aid system. It also describes the selection of the type of disposal method to be used during emergencies.

2.1 Definition of Emergencies and their Causes

Emergency situations can be defined as conditions where there is a marked reduction in the ability of people to sustain their normal living conditions with resulting damage or risks to health, life and livelihoods (Wisner and Adams, 2002).

The cause of emergency situations is the occurrence of disasters. Disasters may embody many diverse types of events. The major characteristic of all of these events is their severity. These events become disasters when the extremes present themselves. They are usually categorised by their origin; natural or man-made. Disasters can be either sudden (quick onset) or develop over a period of time (slow onset).

Disasters, whether natural or man-made, may represent different types of events as shown in Table 2-1. According to literature, three different types of disaster exist: they are either related to weather, earth geology or man-made actions (Songer, 1999). Those related to the weather and earth's geology are the most widely recognised (Songer, 1999). However disasters are also brought about by man's activities e.g. industrial accidents - Bhopal. They can also be combinations, e.g. weather related and man made such as climate change.

Table 2-1 Types of Events and Disasters

	Type of Event	**Type of Disaster**
1.	Weather related	Floods, Hurricanes.
2.	Earth's Geology	Earthquakes, Volcanic Eruptions, Tsunamis
3.	Man-made actions	Industrial Accidents, War and Conflict.

The most common impacts due to occurrence of a disaster are:

- Loss of life
- Destruction of infrastructure.
- Contamination of water sources; and
- Air pollution

Although the loss of lives may not be directly linked to poor sanitation that arises as a result of the occurrence of the disaster, the absence of this infrastructure in the long term leads to an additional loss of lives.

2.2 Stages of Emergency

According to Harvey *et al.* (2002), an emergency may stretch from a period of days to years. And as such there are distinct phases in which emergencies may be divided as shown in Table 2-2.

Table 2-2 Phases in Emergencies and Activities Carried Out

Stage	Duration	Activities of Aid Agencies with Regard to Sanitation
Immediate term	1 – 2 months	• Concentrate on the causes of sanitation related diseases.
Short term	2 - 6 months	• To reduce mortality and morbidity rates and prevention of further disease.
Long term	6 months - several years	• To sustain health and well being of the population as well as promoting self-sufficiency.

2.3 The Aid Relief System

At the onset of a disaster, the affected population tries to deal with the situation as best as they can by themselves. However when a situation is declared an emergency, humanitarian assistance arrives to assist the affected population. The humanitarian assistance that is provided to people affected by disasters is channelled through a diverse system with assistance from relief workers (Davis and Lambert, 2002).

According to Davis and Lambert (2002), assistance can then be provided through a number of channels, namely:

- Neighbouring communities
- National or local governments
- Outside governments
- Multilateral agencies e.g. United Nations systems
- The Red Cross and Red Crescent Movement
- Local and international Non-Government Organisations (NGOs), including religious organisations
- The private sector and specialised institutions
- Military organisations.

Disaster management is mostly the responsibility of the government of the affected country, whether it is the country that has been affected or a nearby country which hosts the refugees (Davis and Lambert, 2002). The response could be carried out through a special forum. This comprises of members from government departments and sometimes other entities such as major donors, UN agencies, NGOs, and the Red Cross/Red Crescent Movement. The forum may deal with the formulation of long-term planning and preparedness measures (Davis and Lambert, 2002).

The United Nations systems on the other hand plays the role of providing aid for humanitarian relief and for rehabilitation, protecting and supporting those affected by disaster such as refugees, and preventing and resolving conflict (Davis and Lambert, 2002). Its operation is however dependent on the outcome of appeals for voluntary contributions

from government and private sources. Thus when disaster strikes it is not guaranteed that funding will be available from the UN agencies (Davis and Lambert, 2002).

Humanitarian agencies focus on two goals during emergency situations: firstly, to provide protection to those fleeing their homes, and secondly, to rapidly reduce mortality rates (Schlecht, 2003). In the case of refugees, security falls under the mandate of the United Nations High Commissioner for Refugees (UNHCR). Health interventions are coordinated by international organisations but usually implemented by local government and Non-Government Organisations (NGOs) (Schlecht, 2003). These agencies are responsible for providing humanitarian assistance as well as playing the role of advocate through attempts to influence governments, donors and other institutions to abide by their humanitarian mandates.

Regarding the International Red Cross and Red Crescent Movement, their components include:

- International Committee of the Red Cross responsible for protection and assistance of victims of armed conflict and civil strife, including prisoners of war and political detainees,
- International Federation of the Red Cross supports work of national societies and is responsible for provision and coordination of assistance at an international level to victims of natural disasters or epidemics – in particular assisting refugees outside conflict areas in cooperation with the UNHCR (Davis and Lambert, 2002).
- Furthermore, the Red Crescent Societies, National Red Cross and the Red Cross societies provide a range of activities in health care such as vaccination campaigns, social services and training for medical and social workers (Davis and Lambert, 2002).

With regard to NGOs, Davis and Lambert (2002) explain that these vary in size, expertise and funding, and range from large international organisations e.g. Save the Children, through to small indigenous community-based groups. They are also known as Private Voluntary Organisations (PVOs) or voluntary agencies (volags). NGOs have become very important in handling emergency relief and are therefore seen as quick and efficient in handling emergency relief funds (Davis and Lambert, 2002). The funding comes from voluntary donations, grants from donor governments and from multilateral agencies e.g. the United Nations or the European Union. Some of the key aid agencies offering these services include: Oxfam, Médecins Sans Frontières, Concern, Merlin, to mention but a few.

The private sector on the other hand can be involved in the relief system at different stages such as:

- Manufacturing and supplying equipment,
- Providing consultancy and training services; and
- As contractors in the field.

The military organisations usually have a wide range of expertise and equipment which can be used to support humanitarian relief efforts (Davis and Lambert, 2002). However, they can sometimes be inappropriate for civilian populations e.g. refugee camps.

From this description it is obvious that the number and type of actors that are involved in providing emergency sanitation is huge. Hence, to change or influence the type of

emergency sanitation to be provided, poses a very difficult task, which requires a lot of awareness raising.

2.4 What is Emergency Sanitation?

According to Harvey *et al.* (2002), emergency sanitation is considered to include the following areas of intervention: Excreta disposal, wastewater management, hygiene promotion, solid waste management, waste management at medical centres and disposal of dead bodies.

Out of those the aspects covered in this research are mainly excreta disposal, and wastewater management and hygiene promotion are discussed briefly. They are defined below.

2.4.1 Excreta Disposal

Excreta Disposal is one of the most crucial elements in emergency sanitation programmes. Safe disposal of excreta combats the transmission of excreta related diseases (Harvey *et al.*, 2002). Provision of appropriate facilities for defecation is key to ensure the communities' dignity, safety, health and well-being (Sphere-Project, 2004).

2.4.2 Wastewater Management

Wastewater comes from households and leaking toilets and the volume is increased from water points, rainwater or rising flood water (Sphere-Project, 2004). The health risks associated with wastewater management include: contamination of water supplies and the environment, and, vector breeding.

2.4.3 Hygiene Promotion

Hygiene promotion is defined as the mix between the affected people's knowledge, practice and resources and the agencies' knowledge and resources, which together enable risky hygiene behaviours to be avoided (Sphere-Project, 2004). Effective hygiene promotion relies on an exchange of information between the agency and the affected population. This is essential to identify key hygiene problems and to design, implement and monitor a programme to promote hygiene practices that ensures the best possible use of facilities and the maximum impact on public health (Sphere-Project, 2004).

2.5 Selection of Excreta Disposal Method

According to Harvey *et al.* (2002), simple pit latrines are by far the most common technology choice in most emergency situations. However, when deciding on a specific excreta disposal system, certain selection procedures are followed.

Since there are several options available for excreta disposal, the aid agencies usually carry out baseline surveys and rapid assessment of the situation for a better technological choice that ensures that the beneficiaries use the suggested facilities. This is done as soon as the emergency strikes. The duration of the exercise is dependent on how available the information is, as well as the cooperation received from the relevant members.
The rapid assessment stage is designed to facilitate speedy collection of relevant information that forms the basis of the initial assessment (Harvey *et al.*, 2002). Even when

the emergency is still at acute stage, an assessment is always carried out. The following are usually assessed although not all emergencies call for this (Bastable, 2000).

Health and hygiene issues:

- The Crude Mortality Rate (CMR) –number of deaths per 10,000 people per day. This is done through all the stages of the emergency.
- Causes of mortality and morbidity

Socio-cultural issues:

- Estimated population and population density
- Current beliefs and traditions concerning excreta disposal especially regarding women and children
- Availability of necessary material for anal cleansing and soap for handwashing
- Existence of facilities, whether they are in use, and also possibility of there extension
- Level of awareness of public health risks
- Assessment of defecation practices and if they pose any health risks
- Existence of public health campaigns, and the authority in charge
- Availability of promotion media, and its accessibility to the affected population
- Assessment as to whether the entire population can use defecation fields, communal latrines or family latrines
- Women and menstruation how they deal with it, and availability of materials
- Responsibility for construction, maintenance and cleaning of latrines (public and private)

Environmental and technical issues:

- Availability of space
- The topography and drainage patterns of the area; hilly areas and bed rock pattern
- The depth, softness and permeability of the soil
- The depth of the water table
- Availability of local materials for construction of latrines
- Availability of skilled labour to construct the latrines
- Seasonal occurrence of rainfall

The data on the above issues is collected using the following methods: historical/background information and data gathering from community members, questionnaires, interviews, observations, group discussions, mapping and measuring (Harvey *et al.*, 2002). With regard to interviews the information is obtained through key informants such as community leaders, teachers, people from ministry of health etc. Also for further information about practices and beliefs, community-mapping sessions are usually conducted (Baghri and Reed, 1998).

The data collection and analysis has to be done quickly. To ensure this, relevant checklists showing the general description of the existing systems, the quality and quantity required and the level of usage, are designed in a comprehensive but easy to follow style. After assessment, a brief report is then prepared. Although it does not include an outline plan, the recommendations made form the basis of any future plan (Harvey *et al.*, 2002).
In selecting *appropriate* excreta disposal methods, the following criteria are considered (Harvey *et al.*, 2002):

- Socio-political factors
- Social-cultural factors
- Availability of land
- Ground conditions
- Availability of water
- Anal cleansing material and method
- Menstruation practices
- User friendliness
- Time constraints
- Design life
- Mandate of Agency
- Financial constraints
- Availability of local materials
- Means of transportation
- Human resources
- Operation and maintenance

Any successful measure for managing human excreta includes the principles of isolation (separates excreta from humans), containment (contains it in container) and treatment (excreta is destroyed by a process of decomposition and die off of pathogens) (Wisner and Adams, 2002) [2]. As a result several excreta disposal options are used depending on how the situation develops. Some of these options can only apply in rural areas and others are strictly limited to urban areas.

During the initial stages of an emergency situation, the excreta disposal facilities built should have the following characteristics (Harvey *et al.*, 2004):

- Rapid to implement
- Simple and easy to understand and use
- Use locally available material
- Safely contain excreta and separate it from food sources and water and;
- Have minimal negative impact on future interventions and the environment.

On the negative side they may exhibit one or more of the following characteristics:

- Lack of privacy
- Potential to pollute groundwater
- Not sustainable/desirable in the longer term.

According to Harvey *et al.* (2004), the excreta disposal options during the immediate term include: open field defecation, shallow trench latrines, deep trench latrines (see Appendix I for details on each of these "technologies"). As the emergency situation advances the technology choices are further enriched to more long-term solutions, which are usually more expensive to construct, and their implementation is time consuming. These long term options include (see Appendix I for details) (Harvey *et al.*, 2004):

- Simple Pit Latrines
- Ventilated Improved Pit Latrines
- Pour-Flush Latrines
- Communal Aqua-Privies

[2] Note that the main ecosan principles are similar: containment, sanitisation/treatment and reuse (see Section 4.1)

2.5.1 Financial Considerations

According to my discussions held with staff from MSFH who are involved in emergency relief, money is not the limiting factor in choosing a sanitation system. The choice is mainly dependent on the:

- Speed of implementation of the system
- Existing system and the excreta disposal practices in the community
- Construction of a system which people can quickly adapt to (if unknown to them before) and use as well as; and
- Simplicity to manage and operate.

Money is less of a consideration because people's lives are at stake and decisisons have to be made quickly. This means that if we could develop an "easily-implementable" ecosan option (see Section 3.1.1), this could be attractive for aid agencies even if it may be more expensive that the commonly used pit latrines.

2.6 Sanitation-Related Diseases in Emergencies

The importance of safe and sustainable human excreta disposal cannot be over looked (Bastable, 2000). Several diseases are transmitted via the faecal-oral route such as diarrhoea, cholera, and typhoid. These account for up to 50% of all deaths in emergency, and research has shown that whilst availability of good quality water can reduce childhood diarrhoea by 15-20%, a much greater reduction is attributed to safe excreta disposal (36%) and hand-washing, food protection and improvements in domestic hygiene (33%) (Bastable, 2000).

Poor human excreta disposal such as use of unlined pit latrines and open field defecation lead to contamination of ground water and other sources of water supply and also promotes breeding of disease transmitting insects e.g. flies (see Figure 2-1 below).

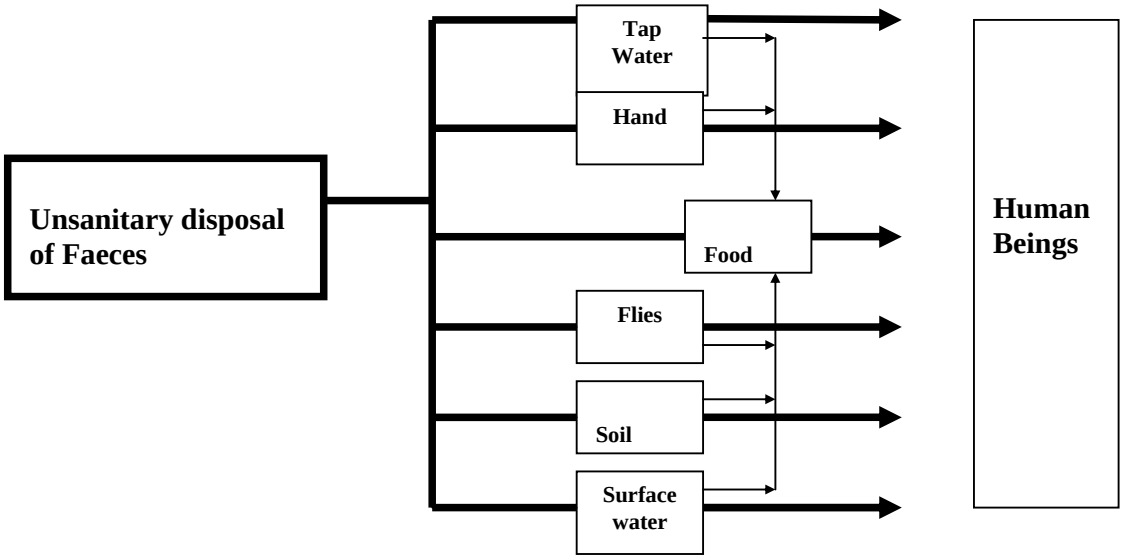

Figure 2-1 Faecal-oral disease transmission route (Chattopadhyay, 2001)

According to Wikipedia (2005), 30,196 deaths were confirmed in Sri Lanka after the island was hit by the Tsunami on the 26th of December 2004. The southern and eastern coasts were most affected and about one and half million people were displaced from their homes.

It further stated that the death toll continued to rise as the threat of infectious disease (cholera) breakouts turned into reality with doctors confirming the first cases of cholera at the start of the emergency. Cholera is mostly spread through drinking water contaminated due to improper sanitary conditions.

Furthermore, Claren and Smith (2005) report that at least five million people were affected by the Tsunami in Indonesia, Sri-Lanka, India, Thailand, Malaysia, the Maldives, the Seychelles, Myanmar and Somalia. They further add that the death toll as a result of the destruction exceeded 280,000 people and that more than one million people were displaced. Governments, NGOs and UN agencies urgently appealed for help to provide safe drinking water to the affected people to prevent deaths resulting from outbreaks of waterborne diseases such as: cholera, diarrhoea and typhoid.

3 Literature Review Part II: Ecological Sanitation in the Context of Emergency Sanitation

This chapter presents an overview of ecological sanitation and describes relevant ecosan compatible toilets. The relationship between water supply and sanitation, and the link to using ecosan facilities furthermore is discussed. Also comparison is also made of the most common existing excreta disposal system with a dry urine-diverting toilet.

3.1 Overview of Ecosan

Ecological sanitation systems focus on economically feasible and closed-loop ecological systems rather than expensive end-of-pipe technologies (Werner *et al.*, 2003). These systems are approaches that bring forth a new philosophy of dealing with what is regarded as waste and wastewater. They focus on the systematic implementation of the reuse and recycle of nutrients and water as a hygienically safe, closed loop and holistic alternative to conventional solutions (Werner *et al.*, 2003). It is an approach that puts economic, ecologic and social parameters into consideration through promotion of new sanitation principles and concepts (Mullegger and Lechner, 2004).
The nutrients recovered from human faeces and urine as a result of practising ecosan can be used in agriculture, hence preserving soil fertility, ensuring food security for generations, and minimising water pollution. These systems further ensure that water is used in an economical way and is recycled safely to serve purposes such as irrigation, groundwater recharge hence reducing water-related environmental pollution and health risks (Werner *et al.*, 2003).

If such sanitation systems are promoted – also in emergency situations - the result will be a better environment and hence improved livelihood of the people.

Ecosan can be defined as a sustainable sanitation system in all aspects, e.g. social, health, technical, financial, environmental and institutional. As such, it can use a water-based or non-water-based technology. It is a misconception that ecosan equals dry, urine diverting toilets. In emergency situations in developing countries however, usually only dry sanitation systems can be quickly implemented. Therefore, in this thesis the wide ecosan scope will be narrowed down to dry, urine-diverting or composting toilets.

The ecosan concept has been widely spread throughout the world and some of the leading developing countries (or countries in transition) practising ecosan include(Winblad *et al.*, 2004): in Asia: China, India and Vietnam; in Africa: South Africa, Zimbabwe, Tanzania and Uganda; in South America: Mexico, Bolivia. The situation in Uganda, as an example is explained in Appendix III.

Ecosan provides alternative sanitation solutions with or without using water while providing containment, treatment and recycling of excreta (Winblad *et al.*, 2004). This results in the protection of human health, and the environment, reducing of water use for sanitation systems and recycling of nutrients. The nutrients can be used as conditioners and fertilisers in agriculture, which if not could have polluted the environment; or/and cost millions of dollars to remove from the wastewater before discharge to the environment.

3.1.1 Ecosan-Compatible Toilets

Toilets to be used in the ecosan context are designed with the goals of: disease prevention by destruction of pathogens before the excreta are returned to the environment and recovery and recycle of plant nutrients and organic matter to close the nutrient cycle (EcoSanRes, 2005a). In the case of dry toilets water is conserved and pollution prevented.

All dry toilets are composed of a pedestal or squatting pan, a slab and a chamber and sometimes a superstructure (if the toilet is not built in the house). The components can be separate from each other or permanently attached to each other. The chamber(s) is situated below the slab and this is where excreta (separate or combined) are captured and stored. The chambers can be one or two and can be below or above ground and may be portable or permanently fixed. Countries such as China, Pakistan and India prefer the squat type toilet (rather than the sitting type) because they are considered cheaper and more hygienic. They are also more common amongst populations that practice anal cleansing using water. On the other hand, countries such as Malawi, Mexico and Zimbabwe prefer the pedestal type because they consider them more comfortable. Figure 3-1 below shows a schematic of a dry toilet.

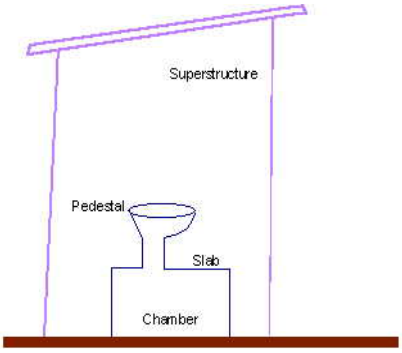

Figure 3-1 Schematic of a Pedestal Dry Toilet (The-Water-Page, 2000)

The following distinction can be made for dry toilets used in the ecosan concept (see also Appendix I on "composting latrines").

i) Urine diverting toilets
ii) Non-Urine diverting toilets (composting)

In urine-diverting toilets the pedestal or squatting pan is designed so that urine may be collected in a separate chamber or piped away from the toilet (for further information see technical data sheets for ecosan components (GTZ, 2005)). The faeces are sanitised through processes of desiccation, increasing pH or elevating temperatures.

In case of the population practicing anal cleansing using water, a washer hole or drain is included (see Figure 3-2 below) next to the hole that takes the faeces where the users can clean themselves. The wastewater from the washer is treated separately (e.g. together with greywater treatment). Figure 3-2 below shows an example of a pedestal and squatting pan UD toilet, the latter with a third hole for "washers".

For the non- urine diverting toilets (composting), the processes include composting of human excreta. Additional treatment may occur outside the chamber off site. Composting toilets are often considered more complicated to operate than dry UD toilets. They are hence not considered further in this research.

Figure 3-2 Urine Diverting Toilets, a Pedestal Type (left) and a Squat Type (right) with a Third Hole (at the back) for "Washers".

3.1.2 Agricultural Benefits of Ecosan

Reuse of sanitised excreta from ecosan compatible toilets in agriculture can lead to improved crop yields. Figure 3-3 shows improved agriculture production after using ecosan products.

Figure 3-3 Fine Tomatoes and Spinach Growing on Humus Derived from Excreta (Ecosanres, 2005b)

3.2 Water and Sanitation Practices and their link to Ecosan

The "lifeline" water requirement worldwide is nowadays often set at 50 litres of clean and safe fresh water per capita per day excluding water for food production and other economic activities (Gleick, 1996). The average amount of water used per capita per day for drinking, washing and cooking during emergency situations is 18-20 litres (Davis and Lambert, 2002). This amount varies depending on the climate, type of food available, amount of water available, human activity and cultural or religious practices such as anal cleansing with water.

Water supply and sanitation go hand in hand. Absence of adequate water supply limits the choice of sanitation options. In addition, the source of fresh water used by the affected population also affects the type of sanitation facilities built as well as their location. Some sanitation facilities require adequate water supply to function e.g. pour flush toilets, while others require little or no water for their operation e.g. simple pit latrines and ecosan compatible toilets.

Water supply and sanitation affect each other, and in order to combat disease occurrence amongst the affected population during emergency situations, provision of safe water to the affected population should be coupled by provision of safe and sustainable sanitation facilities. Given that clean and safe water is usually a meager resource during emergencies (especially at the onset), use of waterless or low water consuming facilities is often the only choice.

Supply of water to the affected population further leads to the production of wastewater (blackwater[3] and greywater[4]), and given that the population density is usually high – e.g. people live in crowded camps, decentralised wastewater treatment systems such as ecosan can be much more appropriate. Appropriate solutions for the greywater treatment must be found (less polluted than blackwater, so infiltration may be an option). However, this research is focusing on blackwater only and greywater treatment is outside its scope.

3.2.1 Comparison of the Simple Pit Latrine to the Dry Urine Diverting Toilet

Table 3-1 below shows a comparison between the most common excreta disposal system during emergencies (simple pit latrines) and ecosan dry urine diverting toilets.

[3] Blackwater is the mixture of urine and faeces – the main focus of this research.
[4] Greywater includes wastewater from the kitchen and bathroom and is not discussed in this thesis.

Table 3-1 Comparison between Simple Pit-Latrines and Dry Urine Diversion Toilets

Item	**Simple Pit Latrines** (Harvey *et al.*, 2004)	**Dry UD Toilets**
Distance from dwelling to minimise odour	Not more than 50 m from dwellings to be served	Since no odour and nuisance of flies and odour, it can be situated in the households.
Distance from water storage and treatment facilities	At least 30 m	Since no potential for groundwater contamination, it can be situated anywhere
Distance from surface water	At least 30 m	Since no potential for groundwater contamination, it can be situated anywhere
Horizontal distance from groundwater source	At least 30 m	There is no contact with groundwater, so horizontal distance is not important
Location of latrine from water sources and settlements	Should be downhill	Since no possibility of ground or surface water contamination, they can be situated upstream or downstream
Distance from communal food storage and preparation areas	At least 50 m	It can be situated anywhere
Accessibility to all users	Not always easy and accessible to all, i.e. the distance between toilets and dwellings	Easy and accessible to all because they can be built close to the dwellings or in the houses

The design of the pit latrines aims to retain only the solid components and infiltrates the liquid part into the surrounding sub-soil as much as possible (Werner *et al.*, 2003). During storage, decomposition of the organic substances (mainly solids) takes place under anaerobic conditions (Halls, 2000). The report further states that, it is the liquid part that seeps into the surrounding soil i.e. the sides and bottom of the pit and further decomposition of organic matter by soil bacteria takes place. Also, there is dying off of bacteria and viruses during storage and as the wastewater percolates through the soil. On the other hand, according to Werner *et al.* (2003) it is the liquid part that contains all the soluble elements, pathogens and viruses of the excreta - and as such this technology may be considered as a "highway to groundwater pollution".

On the other hand, it should be noted that not all pit latrines are prone to causing groundwater pollution. They however pose problems depending on the soil type, when the groundwater table is shallow and when the population density is high. Besides the potential for groundwater pollution, one of the main reasons for discarding the pit latrine technology should be the fact that nutrient-rich excreta is buried or left unused when it could have been re-used in agriculture to boost plant growth or as an alternative source of energy.

3.2.2 Comparison of the Most Common Excreta Disposal practices to the Dry Urine Diverting Toilet

Some of the most common excreta disposal practices[5] in emergency situations are as shown in Table 3-2 below and compared with excreta disposal principles of ecosan.

Table 3-2 Some of the Most Common Excreta Disposal Practices compared with Dry UD Toilets, + means it is achieved, - means it is not achieved and -/+ means sometimes it is achieved but not always

Type of excreta disposal	Isolation	Containment	Treatment	Potential for Re-use
Open Field Defecation	+	-	-	-
Shallow Trench Latrines	+	+	-	-
Deep Trench Latrines	+	+	+	-
Shallow Family Latrines	+	+	-	-/+
Bucket Container Latrines	+	+	-/+	-
Storage Tank Latrines	+	+	+	-/+
Packet Latrines	+	+	+	-
Chemical Latrines	+	+	+	-
Pour Flush Latrines	+	+	+	-
Septic Tank Latrines	+	+	+	-/+
Aqua Privies with septic tanks	+	+	+	-/+
Simple Pit Latrines	+	+	+	-/+
Ventilated Improved Pit Latrines (VIPs)	+	+	+	-/+
Ecosan compatible toilets (Dry UD or Composting)	+	+	+	+

As can be seen in Table 3-2, most of the common excreta disposal practises fulfil the principles of isolation and containment. This at least ensures that excreta are separated from humans and contained in some form. With regard to treatment, some of the practices satisfy this principle, but with regard to re-use of excreta this is generally not achieved. This could be attributed to the fact that the pits are too deep, in case of deep pit latrines and the excavation of the excreta is considered a cumbersome job. For the packet and chemical toilets, the use of chemicals mixed with the excreta makes the excreta unsafe for reuse in agriculture, in particular.

3.3 Advantages and Disadvantages of Ecosan for Emergency Situations

Advantages

The current practices of excreta disposal during emergencies uses mainly the “drop and store” technique, however there are several shortfalls with this method such as, possible ground water pollution, odour, and flies.

[5] Details of these practices/technologies are given in Appendix I

It is for this reason that ecological sanitation is introduced, since it solves most of the problems of these conventional methods, especially in emergency situations where most luxuries such as adequate water supply are meagre. Table 3-3 below shows the advantages of ecological sanitation and stage of applicability during emergencies.

Table 3-3 Advantages of Ecological Sanitation in the Context of Emergency Sanitation

Advantages (Werner *et al.*, 2003)	**Applicable to Stage of emergency (see Section 2.2)**
• Possibility to integrate on-plot sanitation into households, increasing user comfort and security for women and girls.	Short term
• Material-flow cycle instead of disposal.	Short term to long term
• Conservation of resources through lower water consumption, substitution of chemical fertilizers, minimisation of water pollution.	Short term to long term
• Improvement of health by minimising the introduction of pathogens from human excreta into the water cycle.	Short term to long term
• Promotion of recycling by safe hygienic recovery and use of nutrients, trace elements, water and energy.	Long term
• Preference of modular, decentralised partial-flow systems for more appropriate, cost-efficient solutions.	Long term
• Preservation of soil fertility through recovery of all nutrients.	Long term
• Improvement of agricultural productivity and hence contribution to food security.	Long term
• Promotion of holistic, interdisciplinary approach (hygiene, water supply and sanitation, resource conservation, environmental protection, town planning, agriculture, irrigation, food security, small-business promotion)	Long term

Disadvantages

Ecosan on the other hand exhibits some potential shortfalls or challenges, these include:

- Quick implementation may be difficult since it requires its awareness among the affected population
- The toilets may not work well if they are used by a large number of users (instead of just one family)

- Requires ready transportation of assembled materials.

The applicability of ecosan is currently under exploration within the environmental sanitation and hygiene improvement programmes of many governments and agencies in developing countries (Jackson and Knapp, 2005). However, acceptance of the technology is still limited despite the strong environmental and economic reasons surrounding it (Jackson and Knapp, 2005). Jackson and Knapp (2005), further states that one of the most important factors in assessing the potential for use of any sanitation technology is the degree of acceptance in a community, and the willingness to adopt or invest in it.

Ecosan can be applicable during emergency situation but given the novelty of the technology and approach it still requires awareness-raising among the affected population, especially if the technology is new to them. This, if not done could result in system failure and/or outbreaks of further disease, through misuse of technology. Criteria for the viability of ecosan in emergency sanitation are further discussed in Section 6.6.

4 Methodology

This study was carried out in the form of a desktop study. The methodology used in this research comprises of analysing three case studies, literature research from libraries and the internet, discussion on the ecosanres forum (see Appendix IV), discussion and dialogues with staff members working with aid agencies, as well as deriving information from the workshop on Sanitation and Waste Management attended in the United Kingdom (see Appendix II).
The case studies were selected based on considerations described in Section 5.1.

4.1 Data Requirements and Collection

The research was carried out in collaboration with Médecins Sans Frontières - Holland (MSFH), an international NGO that works in emergencies and on development projects.

They rendered their assistance by providing relevant reports and case studies that have formed the basis of this final report. I spent part of the research period (16 days) at their head office in Amsterdam. This enabled access to other relevant information that was required for this research. Table 4-1 summarises the methods that were used for this research.

Table 4-1 Methods Used for Research

Types of Data	Source	Organisation
Background information (ecosan, emergency sanitation, emergency situations etc)	Journals, internet, papers, reports, conference proceedings, books	N/A
Case studies of past emergency regions	Internet, reports	NGOs: MSFH, International Committee of the Red Cross
Studies of current emergency regions	Internet, reports	NGOs: MSFH
Existing practices	Dialogues, reports, books	UK workshop & MSFH
Information/Literature from similar research	Theses, reports	WEDC[6] - Loughborough University

As mentioned in Table 4-1, data was also collected through discussion with members from some of the key aid agencies during the workshop in United Kingdom. The workshop was focussing on Sanitation and Waste Management (see Appendix II) and it was organised by the Public Health Engineering Team from Oxfam GB, with the support of Waste Management in Emergencies Group. It included members from organisations such as MSF, Oxfam, ICRC, Concern and Save the Children among others.

Information was also obtained from WEDC - Loughborough University in the form of MSc theses and discussions with some of the members from the organisation in particular Peter

[6] WEDC: Water Engineering Development Center.

Harvey of WEDC, Daudi Bikaba of Oxfam GB and Steve Sugden of the London school of Hygiene and Tropical Medicine.

Also information for this research was obtained from the ecosanres forum (http://www.ecosanres.org), a closed discussion group with 190 members. The information obtained via this forum was incorporated particularly in Section 6.6.

4.2 Data Analysis

The data analysis was done as a **comparative study** of the collected information and also involved **developing criteria** for the applicability of ecosan in emergencies.

5 Case Studies Part A: Summary of Reported Information

This chapter presents a summary of three selected case studies. The first two case studies describe what happened after the emergency (Post emergency phase) and the third case study describes what happened during the emergency phase. The summaries are taken purely from what was documented without my own analysis. In Chapter six, analysis of these case studies shall be carried out.

5.1 Case Studies Selection

The following case studies were analysed for this research (Table 5-1):

Table 5-1 Case Studies Analysed for this Research

Name used in Thesis	Location	Disaster and Type	Aid Agency and Source of Report	Stage of Emergency
Case 1	El Salvador	Hurricane, weather related	MSFH	Long term
Case 2	Afghanistan	Civil War, man-made	ICRC	Long term
Case 3	Pakistan	Earthquake, Earth geology related	MSFH	Immediate – short term

It is important to note that the information is focused on what happened in the long term for the first two case studies whereas the Pakistan earthquake disaster (case 3) explains what happened in the immediate to short term of the disaster. What happened during the immediate to short term of the emergency for the first two case studies is not documented and can therefore not be analysed.

These case studies were selected because of the following:

- All the case studies occurred in developing countries.
- They represent the three types of disasters i.e. weather and earth related and man made actions
- In the case studies 2 and 3, the affected population practice anal cleansing using water, a reason sometimes cited as a disadvantage for practicing ecosan.
- Detailed reports for these case studies were available and discussion with staff members who were involved was possible i.e. the research was carried out in collaboration with MSFH who provided Cases 1 and 3; and from the workshop attended in the UK Case 2 was obtained from ICRC.

I would have liked to use the Indian Ocean Tsunami disaster from December 2004 as one of my case studies, but detailed reports were not available. This is a common problem with sanitation in emergency, where what is carried out during the emergency is only documented after a long time and usually does not include what is done during the early stages of the emergency.

However, some information on the Tsunami became available in March and is documented in Appendix VI. This was received after I had already finished most of my work.

The following questions aided in the analysis of the data (Table 5-2):

Table 5-2 Questions used in the Analysis of the Case Studies

Item	Question
1	How was the sanitation situation before the occurrence of disaster?
2	How much of the sanitation infrastructure was destroyed?
3	What was done after the event, at the different stages of emergency, and by whom?
4	Why was that particular infrastructures built?
5	What is the people's perception of the built infrastructure?
6	How could the new/re-built infrastructure have been better?
7	What alternative scenarios can be used or could have been used?
8	Was the re-built infrastructure temporary or permanent, and was it similar, worse or better than before the occurrence of the event?

However, not all the questions were answered during the analysis for all the selected case studies. This is because some of the information was not documented in the reports. These gaps shall be highlighted in the analysis, where they occur.

5.2 Case 1: El Salvador, Hurricane Mitch

Hurricane Mitch will always be remembered as the most deadly hurricane to strike the western hemisphere in the last two centuries (NCDC, 2006). Hurricane **Mitch** that hit Central America in 1998 is ranked the **second** deadliest hurricane ever recorded and directly killed about 11,000 people and the costs towards damages reached 5 Billion US Dollars (NCDC, 2006).

In comparison hurricane **Katrina** that hit the United States in August 2005 is ranked the **sixth** strongest Atlantic hurricane ever recorded (Wikipedia, 2006). Furthermore Wikipedia (2006), reports that the hurricane claimed about 1,418 lives and the damages caused were estimated at 75 Billion US Dollars making it the costliest hurricane ever in the United States.

The text for this section is summarised from the MSFH evaluation report on the Post Hurricane Mitch Project phase I - (AMBIENTEC-S.A-DE-C.V., 2000a) and phase II - (AMBIENTEC-S.A-DE-C.V., 2000b).

The Post Hurricane Mitch Project that was intended to implement water and sanitation projects was carried out in two phases:

- Phase I was carried out from December 1 1998 to– 31st August 1999, and
- Phase II carried on from 1st September 1999 to 31st of March 2001.

Phase II ended earlier i.e. 13th of January 2001 (due to the January and February 2001 earthquake) and continued later with rehabilitation works from June to December 2001.

Figure 5-1 shows the areas of operation in the project - Ahuachapan, Sonsonate, La Paz and San Vicente.

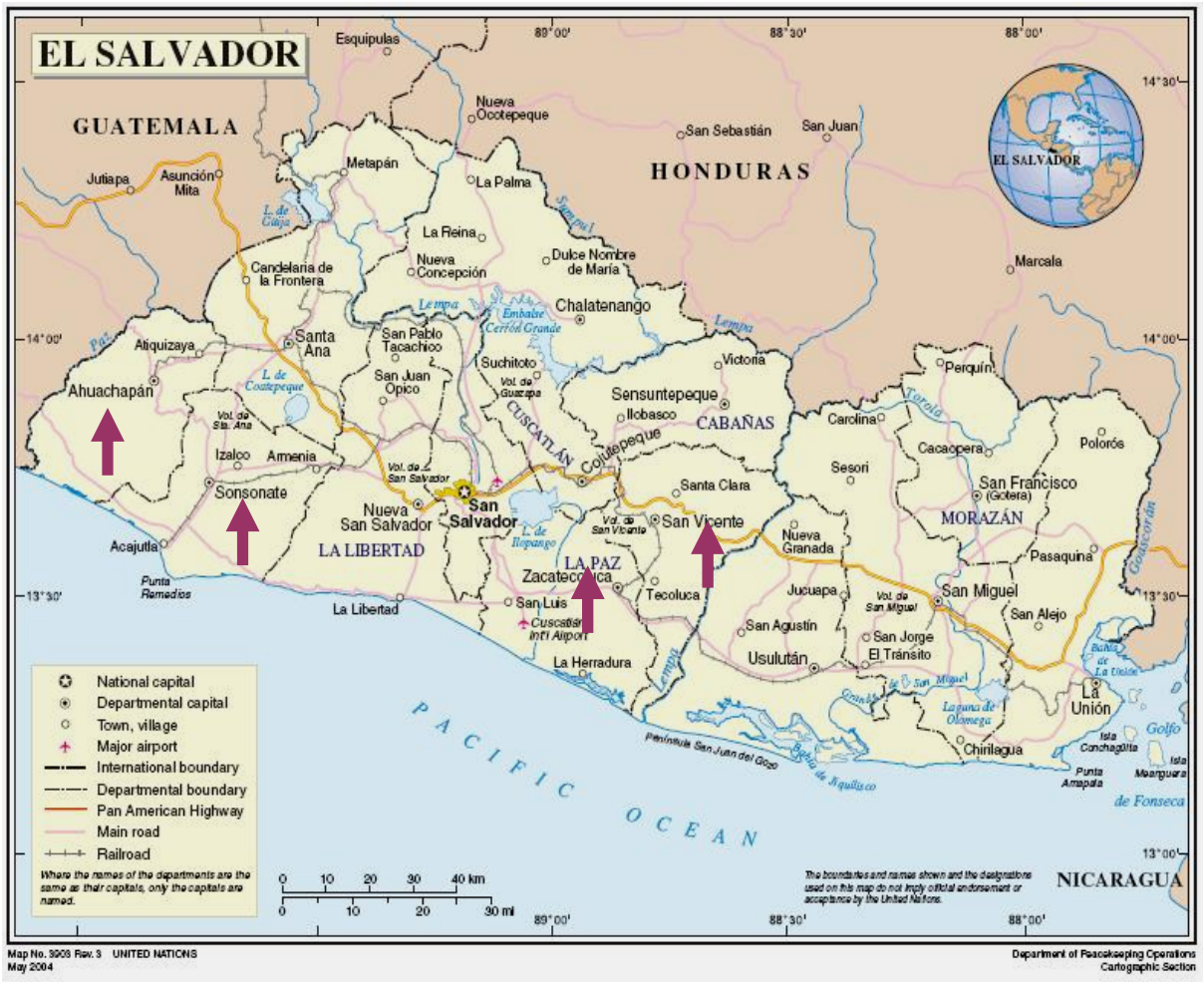

Figure 5-1 Map of El Salvador Showing Areas of Operation for the Project (UN, 2006)

The overall objective for MSFH in El Salvador was to carry out actions that would prepare the affected population in case of future emergencies (the area is prone to floods) and at the same time prevent water borne infectious diseases in Hurricane Mitch affected areas.

Phase I had a smaller scope of work mainly focussing on potable water, latrine systems and sanitation. Phase II on the other hand had a much broader scope of works including what was done in Phase I and rural aqueducts, sanitation in schools, sanitation education and home disinfections. It also took into account the outcomes of Phase I. The occurrence of the earthquake during Phase II resulted in rehabilitation of works done in Phase I. The same geographical area was maintained for Phase I as well as Phase II but for the latter, there was more effort in reaching more communities e.g. schools.

5.2.1 Post Mitch Phase I

Hurricane Mitch occurred in 1998 and struck the coastal regions of El Salvador. This caused many rivers to overflow leading to extensive flooding, which destroyed

infrastructure and disrupted people's livelihoods. The latrines were flooded and wells were contaminated.

The increase of flooded areas created favourable conditions for vector reproduction. Most of the water sources for human consumption were contaminated, sanitation conditions were poor, the population was vulnerable because of poor nutrition, inadequate sheltering and the stress of post emergency. In the emergency phase, the urgent needs e.g. food, shelter, sanitation and water supply were met.

In December 1998, after the emergency phase caused by Hurricane Mitch, MSFH developed a project called Post Mitch Phase 1, executed from December 1 1998 to August 31 1999 and focussed on environment sanitation in the coastal zones of the departments of Ahuachapan, Sonsonate, La Paz and San Vicente.

The project was executed by MSFH staff with support of and in coordination with the Ministry of Public Health and Social Welfare. The main components of the project were:

- Potable water; and
- Latrine systems

What was involved in the latter was not documented and is therefore not discussed. In general 780 wells were improved and equipped with shield and concrete covers with a perimeter sidewalk and a hemp manual pump. Also, 290 dry compost family latrines La Letrina Abonera Seca Familiar (LASF) were built of which 20 are solar (see Figure 5-2 below).

Figure 5-2 LASF Latrines; on the right hand side is the LASF with Solar (Adapted from MSFH Archives)

With regard to the latrine systems, each of the latrines constructed was at family basis and was designed for a density of 5.5 inhabitants per dwelling. The type of latrines constructed was the (LASF) also known as Dry, Alkaline, Family and Time (DAFT) toilets or Dry fertilising family latrines[7]. And out of the 290 latrines constructed, 88.3% are still in operation at the time the report was written i.e. 2000.

[7] I would call these latrines dry UD latrines

The LASF latrine consists of a seat and the faeces and urine are separated and given simple and adequate treatment (i.e. addition of lime or ash to the excreta), thus becoming useful products in the life cycle. The faeces fall to the bottom of the chamber and the urine goes through a tube outside of the chamber into a soak pit. The wiping material is deposited with the faeces (water is not used as anal cleansing material).

"This type of toilet can also be called an ecosan-compatible toilet. It is the same as a dry urine-diversion toilet. Further analysis of this case study is carried out in Section 6.1."

5.2.2 Post Mitch Phase II

Project Post Mitch Phase II was carried out by MSFH from 1st September 1999 to 31st March 2001. However due to the occurrence of the earthquake in January and February 2001, the project ended earlier, 13th January 2001 and another budget had to be opened to start rehabilitation works. The evaluation results obtained in Phase I allowed the formulation of Phase II, considering the need to implement a holistic intervention in order to benefit communities with water, latrines, a water disinfection program and sanitary education. Phase II chose to include communities that benefited in Phase I, with the aim to complete sanitary actions, and to increase water coverage and latrines in areas of flooding risk.

The intervention area was the same as that for Phase I except that more communities were reached. The project's main focus was:

- Rural aqueducts
- Sanitation in schools
- Well improvements and manual hand pump installations
- Home disinfections
- Latrines and
- Sanitary education

The earthquakes that took place in January and February 2001 led to further deterioration of infrastructure. As a result many areas were still at risk of infectious disease outbreaks brought about by:

- Housing vulnerability in rural areas, due to a low structural capacity
- Increased flooding areas, this creates suitable conditions for vectors
- Contaminated water sources (for human consumption)
- Poor water and sanitary conditions and lack of latrines and water systems
- Population vulnerability, caused by malnourishment, poor protection and the tenseness of a post emergency due to a natural phenomenon.
- The earthquakes created another emergency status. Most of the activities were suspended and rehabilitation actions were started.

The main focus of this research is sanitation and therefore the relevant components are discussed. Children were part of the water and sanitation educational programme under the sanitation in schools component. The schools located in the intervention area benefited in terms of manual hand pumps and in others latrines or both.

In general, 400 wells were improved with cleaning measures, shields and concrete lid construction, parametric fence and equipped with manual hand pumps. Of the 400 wells, 16 were located in schools, 367 in houses and the others in areas within the community agreed upon mutually.

With regard to home disinfections the strategy for this component was projected to strengthen the water-home disinfections program through the distribution of Sodium Hypochlorite 0.5%. Health promoters in each area coordinated the supply of the Sodium Hypochlorite in their respective communities. This was done to improve the water quality.

Sanitary education was strengthened during Phase II. It had three educators instead of one used in Phase I. They were responsible for planning all activities and the methodologies. All that was applied was based on previous experiences and knowledge acquired in former jobs with UNICEF, CARE, Save the Children, among others.

With regard to excreta disposal practices, 2,430 LASF latrines were constructed (9 of them located in the schools and 2,421 in homes). 92% of the population were using the latrines, credit being due to the education component, which was strengthened in Phase II. With water and sanitation interventions 77% of the polled population considered that diarrhoeal diseases have decreased in their communities. 86% of the polled population had been using their latrines for more than 6 months, of these 20% had used them for more than one year, and only **18%** was obtaining fertilizer. From the latter percentage, 56% use it in plants and agriculture, 28% buries it and 16%throws it away. The percentage of the population that obtained fertiliser from the excreta does not total up and what the 82% did with their excreta is not documented.

5.2.3 Issues not Addressed in the Report

The following areas are not addressed in the report and were important for my research. These include:

- The potential of groundwater pollution (e.g. nitrate) by discharging the urine to a soak pit
- The report did not state how much crop yields were improved for those farmers that used sanitized excreta as fertilizer; and
- What the remaining part of the population that did not obtain fertilizer from their excreta is not documented.

5.3 Case 2: Afghanistan Civil War

The summary for this section was obtained from the ICRC evaluation report of the Environmental sanitation programme in Kabul (Reed and Khan, 2003).

Afghanistan has since 1979 been in armed conflict. Due to intense fighting in its capital Kabul from 1992 to 1995, a lot of destruction took place. This affected about 40% of the houses and much of the water and sanitation facilities. Many of the inhabitants fled the city and the health of those that remained declined, particularly that of children. The fighting ceased in 1996 when the Taliban took over control of the city, but they were not prepared to allocate resources to water and sanitation rehabilitation.

The traditional latrines that were in use before the programme were unhygienic and presented a health hazard to the general community. They consisted of a raised platform of wood and mud over a container (called a vault) that had an opening onto the street. The excreta including urine fell through the hole in the floor into the container below. Sometimes urine diversion was envisaged to a pipe discharging to a street. The advantage of separating urine from faeces increases the time taken for the chamber to fill and reduces

the smell produced. The chamber/tank was emptied periodically, usually by farmers who used the waste as fertiliser. In hilly areas, the latrines did not include a vault below the platform, but instead the platform was fitted with a chute that directed the excreta into the street where it dried in the sun and was later washed away by the rain.

The fighting in the city had caused night soil collection to break down. This resulted in a build up of fresh excreta in the streets turning the latrines into a health hazard, contaminating the environment and attracting flies and other disease spreading vectors. Some vaults were below ground level because of the variations in street levels. This made them difficult to empty. Finally, if the excreta were collected it was used directly on crops as fertiliser, creating secondary health hazards to the workers, their families and consumers of the crops. What the people used for anal cleansing was not documented but given that this is mainly a Muslim country its expected that water is used for anal cleansing.

With regard to the water supply, most areas in Kabul are underlain by a relatively shallow aquifer (the actual depth to the water table is not documented). As a result, thousands of wells are dug by the residents. This means that there is no problem with accessibility to water but due to poor construction of the original latrines, the water quality from the wells was poor (the quality of the water is also not documented in the report).

A study carried out by Action Contre la Faim (ACF) in 1996 identified the main agent of disease transmission as poor sanitation facilities. ICRC recognised the problem and decided to investigate ways of improving domestic excreta disposal. The result was the launching of the environmental sanitation programme by ICRC targeting:

- Household latrine rehabilitation/construction
- Improvements to night soil collection
- Hygiene promotion and
- Improved communal water supplies

The programme objectives were to:

- Improve the health of the population of Kabul through the provision of 75,000 improved sanitary latrines, a safe community based water supply and hygiene promotion; and
- Set up a sustainable sanitation system for Kabul, from the latrine to the recycling of the night soil by the farmers.

The programme was divided into a number of projects each covering one of the main activities shown above. The latrine project started in September 1996 with construction of two latrines in District ten. After testing (it is not clear what the testing entailed) and adaptation to suit the beneficiaries' needs, a pilot project was then started which constructed a total of 453 latrines at household level (see Table 5-3 below). The design of the latrines was similar to those in existence except that:

- The size of the tank under the toilet was increased so that it could handle more waste ($1m^3$ or retention of 3 months)
- Installing of vent pipe to remove odour and reduce the number of flies and sealing of the emptying door so that the contents would not run into the street; and,
- Diverting of the urine to a soak pit was done so that the contents of the tank were relatively dry. (However, early designs used non robust materials and hence these had to be changed to stronger ones later on. Also blockages in the pipes are still a

problem and beneficiaries have removed the pipes and allow the urine to discharge into the streets.)

Table 5-3 shows the coverage of latrine construction from 1996 to 2003, and the layout of the improved latrine is as shown in Figure 5-3 below.

Table 5-3 Coverage of Latrine Construction in Kabul (Reed and Khan, 2003)

Year	District 1	District 2	District 4	District 8	District 9	District 10	District 11	District 15	Total
1996		90				363			453
1997		1627	3047			4740		820	10234
1998		1635	4897			482	414	6135	13563
1999		408	3339			2048	2485	1625	9905
2000	2924	274	828		2030	824	514	621	8015
2001	78		4		3183	5	1		3271
2002				277	983	2	1		1263
2003[8]				348					348
Total	3002	4034	12115	625	6191	8464	3415	9201	47052

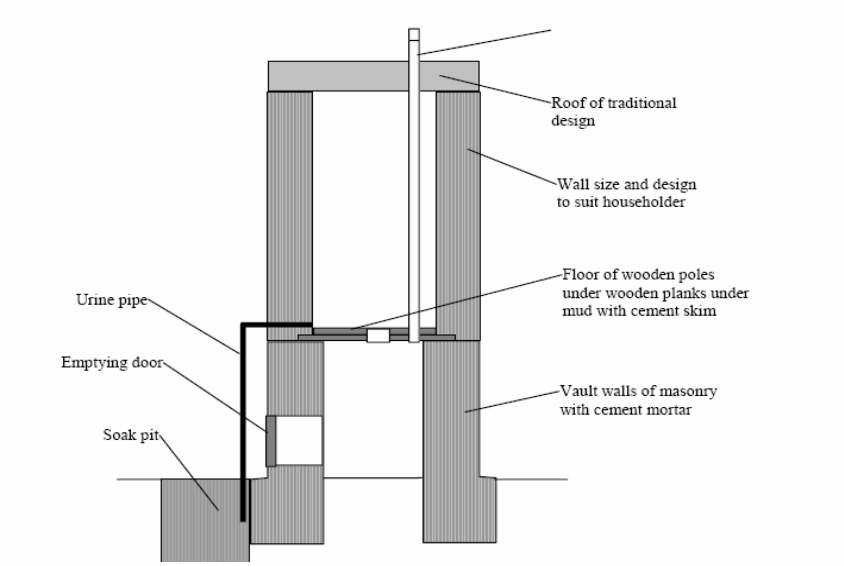

Figure 5-3 Vertical Cross-Section of the Improved Pit latrine (Reed and Khan, 2003)

The latrine designs used in Kabul are only effective if they are emptied regularly. This used to be done by farmers coming into the city at night to remove the sludge[9] for use as fertiliser.

This collection broke down completely during the intense fighting in Kabul from 1992 to 1995. Reinstatement of these services was encouraged by provision of subsidies to collectors to motivate them to restart collecting of the sludge. However when peace returned in 1996, the collectors quickly returned and normal unsubsidised sludge collection continued. This was because the farmers had returned to their agricultural land and needed

[8] Number of latrines constructed to 30th April 2003
[9] Sludge in this case means faecal matter not necessarily sanitised

this fertiliser. A management system was established (starting in district 8), where a local elder collects a regular contribution from each family in the area towards the cost of night soil collection. This type of contract has been agreed between collectors and the communities and has spread to other districts.

The major problem areas identified with the sludge collection system include:

- Lack of access to the hilly areas by the farmers; the project tried to solve this problem by creating collection points for the farmers,
- The increasing city boundaries and traffic, made sludge (faecal matter) collection by the collectors more cumbersome and uneconomical; for this problem, a model is being developed to link specific collectors to a specific area,
- The excreta collected by farmers is still relatively fresh[10] and hence could contain disease transmitting organisms; the project is making attempts to introduce a treatment system for excreta to try and minimise the problem.

A project of water supply improvement was incorporated in the programme to ensure that all the areas covered by the programme had access to at least one safe communal water source. This was achieved by either renovating an existing source in case of existence of one, or installing a borehole with a hand pump in case none existed. The sites selected for improving communal water sources were based on demand from the community and also in areas in which latrines were being constructed.

The project was jointly funded by ICRC and the community. The project provided the hardware and skilled workers and the community supplied the raw materials and the manual labour. On completion, the property was owned by the community.
The programme has been a success with nearly 48,000 family latrines being constructed. This has had a positive impact on sanitation related diseases amongst children and a major positive impact on the built environment. The technology has been widely copied in Afghanistan by other agencies and individual families.

5.3.1 Issues not Addressed in the Report

The following areas are not addressed in the report and were important for my research. These include:

- How the urine diversion was achieved and whether it was simply collected or infiltrated;
- The potential of groundwater pollution (e.g. nitrate) by discharging the urine to a soak pit;
- The kind of excreta disposal systems used in the wealthier areas i.e. at the embassies; and
- The kind of material used for anal cleansing (being an Islamic country, the material has been assumed to be water).

5.4 Case 3: Pakistan, Earthquake

In comparison to the Kobe earthquake that hit Japan in 1995, the Pakistan earthquake is considered to be the strongest earthquake in the past 100 years (Pararas-Carayannis, 2006).

[10] The excreta are relatively fresh because the collectors collect the faecal matter when the farmers need it.

The information in Table 5-4 below shows the magnitude of both earthquakes and the loss of lives involved (Pararas-Carayannis, 2006).

Table 5-4 Comparison Between the Pakistan Earthquake (2005) and the Japan Kobe Earthquake (1995).

Country	Magnitude on the Richter scale	Number of lives lost
Pakistan (2005)	7.6	More than 50,000
Japan - Kobe (1995)	6.9	Estimated at 6,430

The summary of text in this Section was obtained from the MSFH reports (MSFH, 2005a) and (MSFH, 2005b).

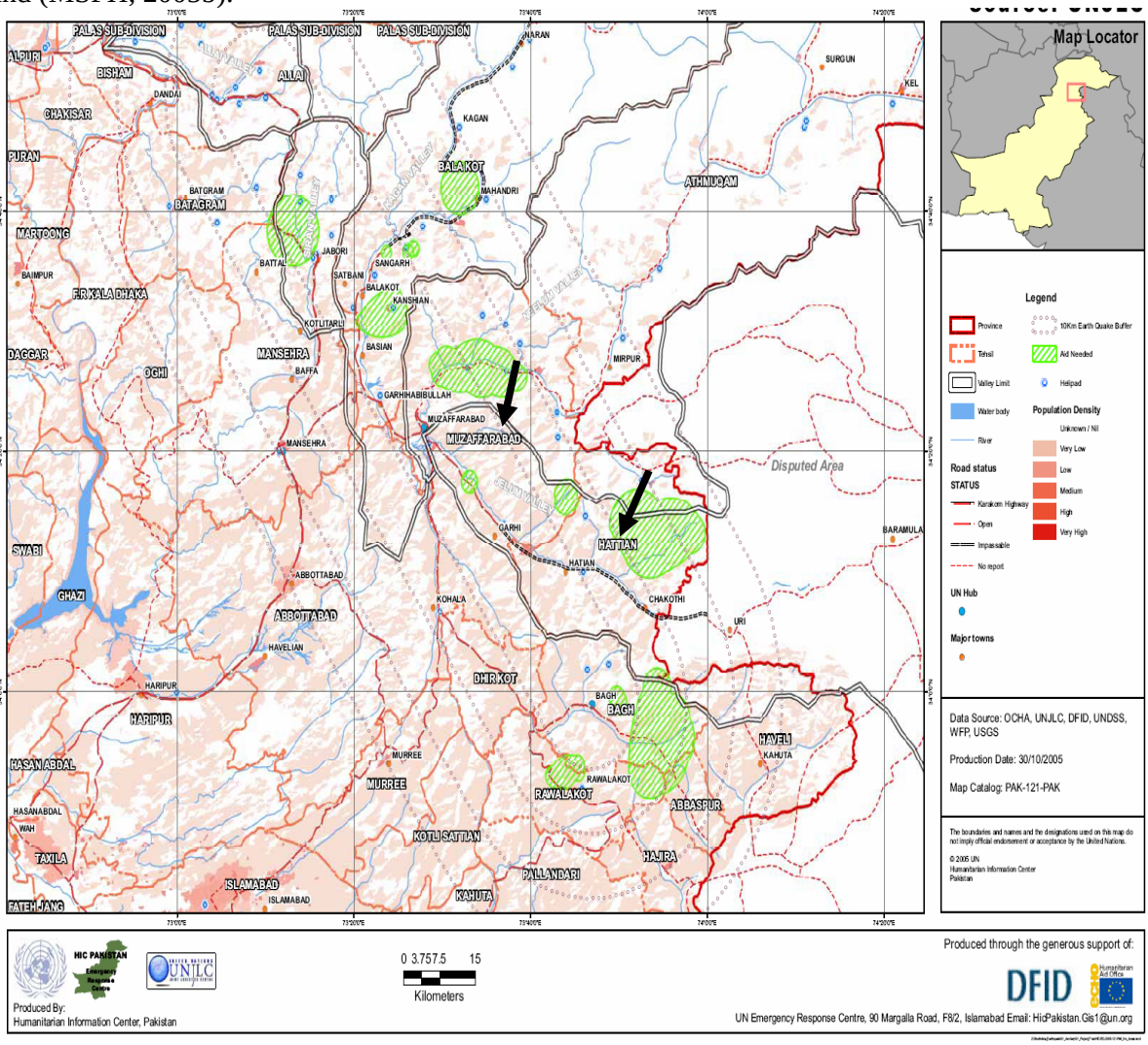

Figure 5-4 Map of Pakistan Showing Areas of Muzafarabad and Hattian That Were Hit by the October 2005 Earthquake (Lamnian is a Village that is not shown on the map)

An earthquake of magnitude 7.6 on the Richter scale hit Pakistan on the 8th of October 2005, and led to destruction of the existing infrastructure and also disrupted the people's

livelihood. Figure 5-4 above shows the area hit by the earthquake. The water supply and sewerage network was badly damaged and this made the affected population vulnerable to outbreaks of water related diseases.
MSFH operated in the towns of **Muzafarabad, Hattian**, (indicated by the black arrows in Figure 5-4) and the village of **Lamnian** (not shown on the map). The sanitation system before the disaster in the town of Muzafarabad was that of a sewer system without wastewater treatment and in the other towns it was use of septic tanks. Table 5-5 below presents a summary of the water supply and sanitation systems before and after the disaster for the three towns mentioned above.

Table 5-5 Summary of the Water Supply and Sanitation Systems Before and After the Disaster

Town	Water Supply System		Sanitation System	
	Before disaster	**After disaster**	**Before disaster**	**After disaster**
Muzafarabad	Town water supply system	Water trucks and springs within the town	Sewer system but without wastewater treatment	Pit latrines
Hattian	Gravity fed water supply systems from springs	Trucking and rehabilitation of the gravity fed system	Septic tanks	Pit latrines
Lamnian	Protected and non-protected springs	Protected and non-protected springs	Septic tanks	Pit latrines

5.4.1 Muzafarabad

In Muzafarabad, the main activities regarding water and sanitation after the disaster were to:

- Provide sanitation in the form of latrines where: the need was not covered, no aid agencies were present and in new camps where the capacity to intervene was possible.

The main actors were Oxfam, Islamic Relief/CONCERN and MSFH. With regard to sanitation, MSFH started by making pit latrines in the new University – this is where one of the big camps was. The first latrines constructed were only 1.5 meters deep as the Internally Displaced Persons (IDPs) were willing to work without payment as long as the digging was less than 1.5m. As the situation improved, MSFH started employing people to work on this and the pit latrines were made deeper (3m deep). More than 500 simple pit latrines were dug.

The MSFH set up two latrines for ten families i.e. one latrine for 25 to 30 people and it consists of one double pit, with one cubicle for women and children and the other for men. The latrines used initially were the shallow pit latrines (1.5m deep), and later the deeper ones of 3m. As the situation progressed, simple pit latrines were constructed.

- Provide washing facilities in long-term camps where latrines were installed with a target of one washing facility per 40 people. (The details of this activity were not documented).

- Ensure sufficient water (20 l/c/d) is available at the Internally Displaced Peoples (IDPs) camps.

With regard to water supply, just after the occurrence of the earthquake the system did not work as the majority of the pipe network was destroyed. The pumps were not functional due to shortage of electricity. At the start of the emergency, water trucks and/or springs that are situated all over the town were supplying most of the areas of the town. MSFH started its water supply activities with improving the water trucking to the town.

5.4.2 Hattian

In Hattian, the water and sanitation needs were less in comparison with Muzaffarabad. In and around Hattian, there are not many IDP camps and even where they exist, large portions of their tents were empty. The main activities regarding water and sanitation were to:

- Provide sanitation in the form of latrines where: the need was not covered, no aid agencies were present, and in any new camps where MSFH had the capacity to intervene.
- Provide washing facilities in long-term camps where latrines were installed.
- Rehabilitate gravity fed systems (for water supply) if needed.

Around Hattian, several villages had water problems due to the springs either being polluted or buried due to the earthquake and damage of pipes brought about by landslides and earthquakes. The water supply was tackled by the Canadian army, who later handed it over to ICRC then to MSFH who increased the storage capacity to have a buffer of three days.
With regard to sanitation, MSFH constructed simple pit latrines in the grounds of the Cuban hospital (were another camp was established), the MSFH paediatric ward and at the nearby IDP camp (Tali camp). About 250 pit latrines were planned for construction in and around Hattian.

5.4.3 Lamnian

In Lamnian, the area did not have an existing pipedwater supply system before the disaster occurrence. The people obtained water from protected and non-protected springs and continued to do this after the disaster occurrence. Diarrhoea cases were to be mapped to identify possible contaminated springs. The springs could be contaminated by the existing septic tanks. Water samples were to be taken from the nearby springs for bacteriological testing. There were no camps in Lamnian and since the people were living relatively far apart, there was no urgent need to start latrine construction. MSFH decided to give away latrine slabs to people who were interested in digging their individual pits.

5.4.4 Issues not Addressed in the Report

The following areas are not addressed in the report and were important for my research:

- The results of the water quality tests for all the areas
- Where the faecal matter from the septic tanks was taken ; and
- Why the tents in Lamnian were mostly empty

5.5 Summary of Features of the Disasters described in the Case Studies

Table 5-6 presents a summary of what happened before and after emergency for the three cases in terms of water and sanitation.

Table 5-6 Summary of Features of the Disasters in the Three Cases

	Case 1 (El Salvador)	**Case 2 (Afghanistan)**	**Case 3 (Pakistan)**
Type of the disaster	Hurricane	Civil War	Earthquake
Stage of emergency	Long term stage	Long term stage	Immediate to short term stage
Water supply situation before the disaster	Wells	Hand dug wells due to shallow aquifer	Town water supply, protected and unprotected springs
Water supply situation after the disaster	Protected boreholes fitted with hand pumps	Protected boreholes fitted with hand pumps	Water supplied by trucks and from protected and unprotected springs
Sanitation situation before the disaster	Traditional pit latrines	Poorly maintained vault latrines	Sewer system and septic tanks
Sanitation situation after the disaster	LASF latrines – Dry urine-diversion toilets	Improved Vault latrines with urine diversion	Pit latrines

6 Case Study Part B: Analysis

This chapter analyses the case studies described in Chapter 5 with aid of the guide questions shown in Table 5-2. The purpose is to establish whether the implemented technologies are/were safe and sustainable excreta disposal systems.

6.1 Case 1 Analysis

Although the project was implemented in two phases, the analysis has been done jointly without separating the phases. The description of this case was provided in Section 5.2.

Before the occurrence of the disaster, the most common excreta disposal method was pit latrines despite the fact that this is a flood prone area. Consequently, most of the existing infrastructure was not up to standard i.e. it had problems with smell, flies and poor construction. Nevertheless, a majority of the population had access to these basic sanitation facilities.

The percentage of infrastructure destroyed by the disaster was not documented, but with regard to excreta disposal facilities (latrines), most of the existing excreta disposal facilities were flooded and inaccessible. At the onset of the disaster, existing latrines were flooded, and as a result water sources were further contaminated, shelter was inadequate and there was a lot of stress amongst the affected people. The immediate needs were met i.e. temporary shelter, water supply and waste disposal facilities - details of what exactly was done for each component is not documented.

Also not documented in the report was what was done after occurrence of the disaster at the different stages. However according to a discussion with Jean Francois Fesselet of MSFH, the type of toilets constructed/used during the emergency were latrines[11] with the pit raised above ground (see Appendix I, Figure 10-8) because the area was flooded. However in the long-term phase of the emergency, the LASF latrines (Figure 5-2) were constructed.

The LASF latrines were chosen because of the common flood conditions in the area and also because these types of latrines were already in use in several other parts of El Salvador (but not yet in the affected area). Also important to note is the fact that LASF toilets can also be used in hard rock areas and in high water table areas too.

The affected population (91%) embraced this technology and as of 2003 over 90% of the constructed latrines were still in operation. Of the population using the toilets, a small percentage (just over 18%) re-use the excreta, the other people bury it or simply throw it away.

The remaining part of the population (10%) that did not like the LASF latrines but were using them (though not following the required procedures) cited the following reasons: the use of ash after every use of the toilet was considered very cumbersome, they also pointed out that they had nothing to do with the excreta afterwards as they did not practice agriculture.

[11] They were not built as LASF latrines then.

In general, the re-built infrastructure is better than what was originally in use before the disaster. However, more awareness-raising is required about reuse of excreta. The system designed is satisfactory but the problem of excreta re-use seemed problematic for some parts of the population.

6.2 Case 2 Analysis

The kind of disaster experienced in Kabul was that of civil war and conflict. It is characterised by general system breakdown and lawlessness. Most of the facilities in existence continue to run, but because of increasing lawlessness, the systems usually break down over time. It is a special kind of disaster. The onset of this kind of disaster may not damage the existing infrastructure immediately or even at all, but due to difference in opinions and priorities of the new leaders, the result on the existing systems is often negative. The duration and intensity of the strife also plays a role on the damage of infrastructure.

In the case of Kabul, the armed conflict between the Anti-Communist Muslim Afghan Guerrillas (Mujahidin) and the Afghan government and Soviet forces started in 1979 culminating in intense fighting from 1992 to 1995. The existing sanitation systems then were in a very poor condition. They mainly consisted of a superstructure cast upon a container that had an opening to the street (see description in Section 5.3). Not documented in the report was what was done during the immediate and short term of the emergency.

According to Reed and Khan (2003), 40% of the existing houses, water and sanitation facilities were affected during the conflict. The environmental sanitation programme was launched by the ICRC targeting objectives as mentioned in Section 5.3. With regard to excreta and wastewater disposal, they embarked on construction of latrines. The activity commenced with the construction of two demonstration latrines; after successful use of these, construction of latrines for the entire community was started. The design was similar to those in existence except that the new ones had a larger size tank with the purpose of handling more excreta. Urine diversion was also incorporated to ensure dry conditions within the tank but exactly how the urine was separated was not documented. Also the emptying door was properly sealed to prevent contents of the container from running into the street.

This kind of toilet was used because:

- It was already in existence hence required less awareness-raising except the urine diversion part;
- The geology of the city in some areas is underlain by hard rock, so excavation is costly and cumbersome;
- In some areas the groundwater is low; therefore use of tanks for containment with a platform fixed above was preferable to deep pits; and
- In addition, the farmers were already reusing the excreta in their farms (although "fresh" i.e. not sanitised) hence requiring less awareness-raising about re-use of excreta (but they had to be encouraged to use the excreta after it had been sanitised).

The communities accepted the type of system because it was very similar to what was in existence before. The new infrastructure also reduced the nuisances of flies and odour. This has resulted in several aid agencies such as CARE, International Assistance Mission

and Medair, and families copying this system all over the rural and urban areas in Afghanistan.

The rebuilt infrastructure could have been improved by constructing double vault latrines (see Appendix I Figure 10-6) instead of single vault latrines to allow enough time for the drying and sanitising of the excreta before they are collected and used by farmers on their farms. Also the channelling of the urine - that is rich in nutrients - to the ground, presents a potential for groundwater contamination with nitrate; this should have been considered.

The rebuilt infrastructure is similar to what was in existence before. It is better managed now and several health concerns have been reduced through the modifications incorporated.

6.3 Case 3 Analysis

The situation for Case 3 was described in Section 5.4. It needs to be pointed out that the affected population is used to water borne sanitation, and is using water for anal cleansing.

After the earthquake struck, most of the existing infrastructure i.e. sewerage system and water supply system had broken down. The immediate intervention in the water supply and sanitation sectors was as expressed in Section 5.4.

Oxfam, MSFH and Islamic Relief in collaboration with Concern were the main actors at the start of the emergency. They equipped the communities with excreta disposal systems, initially constructing shallow pit latrines (1.5 m). This type of system was chosen because it seemed like the only viable option as the water supply system had broken down and hence dry sanitation was required. The Oxfam camp also tried to use the existing sewer system by building pit latrines over the sewer lines, but because of use of stones (due to water scarcity) as anal cleansing material, the sewer pipes were blocked and the toilet facilities closed.

As the situation progressed into the short term, the simple pit latrines were constructed 3 m deep. The ground water table in most areas is low so there is less risk of groundwater contamination. They were also chosen because of the ease of construction. They were not considered as long-term excreta disposal solutions, as the people would rather use water borne sanitation facilities when the situation normalises. The affected population accepted the technology because of the existing circumstances even though for the majority of the population, this kind of excreta disposal system (pit latrines) was new. A technology that could allow for use of stones for anal cleansing was selected as this was also used as anal cleansing material.

The sewage system that was in place before the earthquake hit was not providing any treatment to the wastewater. It merely provided a channel for its discharge into the river. The built (temporary) excreta disposal system of simple pit latrines is convenient for the given circumstances. But given the fact that the people practise anal cleansing using water (when it is available) this creates a likelihood of filling the pits faster. However this depends on the permeability of the soil. It poses a problem when the ground is impermeable. The technology also requires abundance of land (however this is not a problem in Pakistan) for construction of new latrines when the old ones fill up.

With regard to the future, the people are more inclined to going back to their original system of excreta disposal i.e. a waterborne sanitation. However, aid agencies are not keen to re-build the former existing system because of the large extent of damage to it that would require a lot of money to re-build it (let alone the fact that a wastewater treatment plant would have to be built to reduce environmental pollution).

This situation provides an excellent opportunity for implementing of a more sustainable sanitation systems such as ecosan.

6.4 Comparison of the Analysed Case Studies

The case studies show that in all cases the long-term emergency sanitation systems are safer and more environmentally sustainable compared to those in existence before the emergency.

The case studies also show that the sanitation systems implemented in the short to long term stage of emergency are to some extent (not always) more planned and take into consideration the long-term sustainability. On the other hand those implemented during the immediate stage of the emergency are usually short term - temporary options which are implemented in a hurry.

With regard to Case 1 and Case 2, the sanitation systems conform to what was already in place in the country, making it much easier in terms of education awareness and implementation. Also, implementation of these technologies took place a while after occurrence of the disaster (long term) – when the situation has normalised and people have returned to their usual lifestyle.

In addition, both case studies (Case 1 and Case 2) show government participation in the implementation of the excreta disposal facilities. This is very essential especially in developing countries where people tend to agree with programmes where the providers have government advocacy. Furthermore, the technologies introduced in Case 1 and 2 are similar to the existing practices of the affected communities. The idea of reuse of excreta was new for the people in El Salvador. Through awareness-raising, the practice of excreta re-use was started in Case 1 with 18% of the affected population using the LASF toilets now using the dried excreta as fertiliser.

In Case 2, the constructed toilet facilities are not strange or new, but awareness-raising was still required about proper excreta re-use. The technologies used also took into account the different social practices and as a result the facilities are still in use to date. It should be pointed out that reuse of excreta is not a pre-requisite i.e. the toilets would still function even without re-use of excreta.

In Case 3 on the other hand, the type of sanitation system used in the immediate to short term of the emergency is the pit latrines despite the fact that the existing sanitation system was a waterborne conventional sewerage system without a treatment plant. These people are experiencing a new kind of excreta disposal having been used to water borne sanitation facilities, namely pour flush latrines. The reasons to why pour flush latrines could not be used anymore are given in Section 5.3. However, even though the people are **new to the technology** and do not really favour it they are using it and managing it properly.

This situation sheds light on the introduction of more sustainable options such as ecosan. The challenge lies in identifying a suitable sustainable sanitation system, or in case of ecosan, a suitable ecosan compatible toilet (Section 3.1.1) to suit the people. Several other safe and sustainable excreta disposal methods exist that can address the problem other than the traditional pit latrine. Case 3 proves that new technologies can be introduced to communities during emergencies and if implemented properly can be promoted by aid agencies to the people for future use.

Although there was a sewerage system in place before the earthquake, its renovation and additional construction of treatment plant(s) is not recommended because it is expensive. Also in case of further disaster occurrence such as an earthquake it will lead to further breakdown and pollution of water resources.

In fact, disaster occurrences can sometimes become the necessary and pleasant driver of development especially in developing countries where most of the existing infrastructure is already poor. For instance if we consider Case 1, where the population was using pit latrines despite the fact that the area was flood prone, because of occurrence of hurricane Mitch, the resulting sanitation system is now safe and environmentally sustainable. Table 6-1 below shows a summary of the analysed case studies.

Table 6-1 Summary of the Analysed Case Studies

	Case 1 (El Salvador)	Case 2 (Afghanistan)	Case 3 (Pakistan)
Existing sanitation situation before the disaster	Traditional pit latrines	Poorly maintained vault latrines	Pour flush latrines and conventional sewer system discharging into a river without treatment.
Infrastructure destroyed	Not documented but a big percentage destroyed	40% of the existing infrastructure	Not documented but a big percentage destroyed
Infrastructure set up after the disaster	LASF (La Letrina Abonera Seca Familiar) also known as the Dry urine diverting Toilets	Better managed, improved vault latrines with urine diversion	Shallow, deep and simple pit latrines
Why was that type chosen?	Practice of LASF system in country already and area being prone to floods	Existing practice of excreta reuse and use of raised vault latrines with tank for containment within the country	Dry system required due to breakdown of the water supply system; also the ground water table is low, so little risk of groundwater contamination.
People's Perception	91% of the affected population appreciated it	Very much appreciated because it was similar to what was in existence before	The affected population would prefer water borne sanitation – pour flush toilets in particular
How could the new infrastructure be improved?	More awareness raising required encouraging those who do not like it to date. They should have identified another excreta disposal alternative for them. With regard to urine diversion the issue of possible ground water contamination should have been looked into.	More awareness raising is required as farmers still use fresh excreta on their farms. Also they should have built double vault latrines to allow enough time for sanitisation of the excreta. With regard to urine diversion the issue of possible ground water contamination should have been looked into.	Other alternatives should have been explored[12].
What else could have been done?		The volume of sludge increased, so land should have been allocated for disposal of the excess sludge produced and not used by the farmers on their farms.	Introduction of dry urine diverting toilets; since people are new to the pit latrines this would have served as a chance to introduce ecosan.

[12] The population uses water for anal cleansing hence enhancing the rapid filling of the pits (when water is available again).

6.5 Would Ecosan Have Been a Better Approach for the Three Cases?

As mentioned in Section 2.5, the most common method of excreta disposal during emergency situations is the simple pit latrine. This was also the case for Case 3. This practice involves digging new pits when they fill. The aid agencies construct these pit latrines with consideration of the slope of land, the ground water table, etc. When the emergency is over, people often continue to use the same system. However they carry out construction of these facilities without supervision and knowledge of what lies underground. This method is not sustainable in terms of environmental pollution and also it requires land to be available for location of a new pit when the old one fills. As a general guide, simple pit latrines are not appropriate for use as an excreta disposal system when the:

- Groundwater table is high;
- Area has a potential for flooding;
- Soil type is rocky i.e. hard to excavate or when the ground is underlain by pervious rock that could enhance the potential for ground water contamination;
- Population density is high; or
- Situation has lack of security (since pit latrines have to be built some distance from the settlements)

Therefore when such conditions present themselves i.e. when pit latrines cannot be used, ecosan could act as a fall back plan.

Depending on the type of emergency, the population density as well as the location, water supply is usually a big problem. Implementation of sanitation options that are water based is therefore not recommended during such emergencies (this was the case for all three cases studied in this thesis).

With regard to Case 1, due to the area being prone to floods, raised pit latrines were used instead of the usually implemented simple pit latrines (see Section 5.2). However, the principle of separation of waste streams was used in the long-term stage of the emergency. As a result, the affected population benefited in terms of re-using excreta on their farms (presumably resulting in higher crop yields, although this was not documented), protection of their water resources from pollution and improved health. Therefore, Case 1 already had an ecosan approach. However, the potential for groundwater pollution by urine channelled through the soakaways is envisaged.

For Case 2, the type of excreta system used before the emergency consisted of a vault latrine (see Section 5.3). The system implemented after the emergency was similar, however it included the separation of the urine from the faeces. This ensured the drying of the faeces in the vault before being removed by the farmers to use on their farms. The results showed improved health of the population and improved practices of re-use of excreta.

In Case 2 therefore, ecosan was already implemented. It should be noted that the authors did not use the term “ecosan” for Case 1 and 2, instead they called it the dry fertilising toilet/LASF and vault latrine respectively. But in fact the solutions for Case 1 and 2 followed the ecosan concept.

In Case 3, the population was used to water borne sanitation and was discarding the untreated waste into the river. During the immediate and short term of the emergency pit latrines were constructed. Given that the population is new to this kind of (dry) technology,

this would have been a good opportunity for introducing the dry urine diverting toilets, especially given that there was a problem of interrupted water supply. Since the population practises anal cleansing using water, the UD toilets would have been designed for "washers" to take care of this (see Section 3.1.1). Some of the benefits for using this technology for Case 3 are: permanent location of the toilets, absence of odour and flies, especially if managed well, and the promotion of a much more sustainable excreta disposal system.

Probably the main reason for not using an ecosan approach for Case 3 was lack of awareness within the aid agencies and lack of standardised ecosan technologies (see Section 6.6.1).

The advantages of ecosan have been discussed in Table 3-3. As long as there is awareness of ecosan amongst the affected population or within the country then ecosan based technologies should be implemented in emergency situations especially if there is no functional existing sanitation system in place. If they cannot be applied during the immediate stage of emergency, the technologies should at least be implemented in the medium to long-term stage of the emergency (e.g. as in Case 1 and 2). However, the education and awareness-raising component is required for those that do not know about the technology.

Use of ecosan facilities does not necessitate always re-use of excreta, especially if implemented in some emergencies where re-use of excreta may not be possible. Also the purpose is to integrate the ecosan concept of separation of waste streams into the excreta disposal practices. Therefore if ecosan facilities are implemented and the excreta are not re-used, a specific site can be identified and allocated for its safe disposal since it is no longer harmful to the environment and the people.

6.6 Criteria for and Viability of Ecosan in Emergency Situations

The **ecosanres forum**[13] provided the views of various international experts in ecosan. These were incorporated in this section (full text of responses to our initial posting is provided in Appendix IV).

Excreta disposal still remains a central issue in providing emergency sanitation. In many cases, ecosan may provide a more sustainable option compared to the current ones in use. The viability of ecosan is however dependent on the criteria which will be described one by one below. They are summarised in Section 6.6.11.

6.6.1 Awareness and expertise on ecosan amongst aid agencies

This is a very essential criterion for implementation of ecosan during emergency situations. As discussed in Section 5.2 and 5.3 for Cases 1 and 2 respectively, the ecosan concepts have been used in the implemented excreta disposal systems. Given the novelty of implementing such systems compared to the usual excreta disposal practices such as pit latrines, awareness and expertise within the implementing agencies is very crucial for their success.

[13] The forum http://www.ecosanres.org, founded on January 30th, 2002 is a closed discussion group with 190 members. Within the last three months it received 166 postings.

(Huba, 2006)) also states that the viability of ecosan is affected by the international toilet traditions brought in by the aid agencies operating in the disaster stricken area. If they have no idea about ecosan then they will continue to implement what they know, e.g. the pit latrines.

6.6.2 Easy transport and quick installation of assembled ecosan-compatible units

According to Madin (2006), for ecosan to be applicable in emergencies, it is recommended to have easy to assemble units equivalent to the "Oxfam slab" [14] available for quick installation and use at the disaster struck region. In this case a UD slab could be used with a squat hole with a separation of faeces and urine. A third hole would be at the back of the squat hole or a drain besides the squat hole where people who practice anal cleansing using water can use it. Even though these toilets may not be used with the intention to reuse the excreta, the concepts of ecosan shall be introduced to the affected people.

It was also pointed out that ecosan facilities are designed with a specific number of people per latrine. This may cause problems at the immediate stage of emergency when erection of such facilities has to be really fast and the number of users per latrine is much higher than its design value. The aid agencies could do it in such a way that they adapt the standards they usually use for implementing excreta disposal facilities in emergencies.

In general, aid agencies are used to implementing technologies that are already well established and can be obtained as a single unit e.g. the Oxfam slab/platform. However ecosan technologies on the market come in "piece meal". In the case of emergencies, ecosan type units that are easy to transport to the emergency areas are required. This is especially needed for the immediate and short-term stages of emergencies where practices such as non-sustainable shallow pit latrines and open field defecation are used. In such cases, the units should be able to be implemented very fast. Because they do not require a pit, they can also be removed and taken elsewhere later if needed.

6.6.3 Availability of water

The availability of water determines the type of excreta disposal facility to be established. If there is a limited supply of water – as is in most emergency situations, then the most suitable option would be a waterless excreta disposal facility such as ecosan compatible toilets. Its abundance however would present an opportunity of flexibility in the choice of the excreta disposal facilities.

6.6.4 Status of displaced people – people in camps or at home

According to Bracken (2006), the type of emergency can be distinguished between a disaster with a sudden onset such as an earthquake or a slow onset such as a drought. This will result in different impacts on the existing infrastructure.

Bracken (2006) points out that if people are displaced by the disaster from their own country, there is little interest in installing permanent infrastructure and instead they tend to use makeshift type of facilities. These facilities could be safe and sustainable such as ecosan but on the other hand, governments do not want refugee camps to become permanent fixtures, as well as being "too comfortable" by having sustainable sanitation facilities.

[14] Similar to that shown in Appendix II, under the heading of Ways Forward with Excreta Disposal

On the other hand, if the affected population is not displaced and are still in their own homes, but the existing infrastructure is destroyed, this provides an opportunity for re-building the community with safe and sustainable excreta disposal systems if such systems did not exist before.

6.6.5 Stage and duration of emergency

With regard to the stage of emergency, these range from the immediate stage through to the long term (Section 2.2). As such different interventions may be suitable depending on the stage of emergency reached. Ecosan may not be easily implemented in the immediate stage of emergency however with gradual progress to the long-term, this should be possible in most cases. Whatever is put in place in the immediate term should ideally be adaptable to ecosan to avoid having to install two systems.

6.6.6 Political will/role of government in sanitation provision

The role of government is important because people tend to rely on their governments when in need. The presence of government support in promoting certain sanitation technologies is necessary for their success. When refugees are involved in emergencies, the government may not be willing to participate in providing sustainable systems for the community (see also comments from Section 6.6.4).

Under emergency situations, money from donors is rapidly provided to improve the people's well being. Though sanitation does not take top priority during emergencies, the little money that is given to this task should be used on safe and sustainable sanitation systems. Aid agencies should keep this in mind because it would then also draw the attention of the respective country's government to the issue of sustainable sanitation.

6.6.7 Awareness of ecosan amongst users

It is easier to implement ecosan in those areas or countries where there is already knowledge of ecosan among the potential users. Section 3.1 provides an indication of countries where ecosan is relatively well known.

Changing people's sanitation practices may not always work out especially during or after a disaster when most of their property and loved ones are lost and their will to live is gone. If ecosan is to be used then it is easier (but not essential) if the selected technology should be in line with the current practices. Otherwise the affected people may always refer to the technology as strictly a disaster type of facility. Awareness of ecosan amongst users can be regarded as a desired criterion, but not an essential one.

6.6.8 Availability of land for reuse

The potential for reuse of excreta should be explored before deciding on the excreta disposal option. Rather than these communities relying entirely on aid throughout the emergency and possibly even after, the people should be prepared to face life afterwards with new skills that will improve their livelihoods.

Since most of the emergencies usually occur in rural areas, aid agencies should aim to implement during emergencies excreta disposal systems that enable reuse of excreta, since the people in rural areas usually practice agriculture, and are aware of (animal) excreta reuse. This in turn will help the affected population to increase their agricultural yields by using sanitised excreta as a fertiliser.

For ecosan to be applicable, land must be available to reuse the sanitised excreta or where it can at least be dumped such as a landfill. The most ideal case would be were the sanitised excreta can be used in agriculture. Ecosan is not limited to rural areas but it makes most sense when some agricultural reuse opportunities are in the vicinity (note the large extent of urban agriculture in many developing countries).

6.6.9 Collaboration between the different aid agencies

When an emergency strikes, several aid agencies and many volunteers move into the affected area to provide aid to the affected population. The aid agencies have knowledge of several excreta disposal systems and thus can implement what is appropriate for the people. However as observed in Case 3, the excreta method used was the pit latrine. Oxfam tried building them over the existing sewer pipes before resorting to digging of pits, while MSFH went straight to digging shallow and deep pits. The methods used by the other aid agencies were not documented, but this alone goes to show that there is probably no proper collaboration amongst aid agencies. For ecosan technologies to be used, it requires collaboration amongst the aid agencies and a common understanding. The volunteers also have to be given the right introduction.

6.6.10 Other Criteria

According to Huba (2006), the criteria considered for selection of ecosan systems should not only include the already usual ones followed during emergencies (section 2.5), but also other criteria such as **formerly existing sanitation system**, **food supply chain**, **expected life cycle** of the implemented sanitation system etc. This can help in implementing facilities that are more manageable, useful and sustainable for the people.

Another criterion is the issue of **coordination with other reconstruction projects**. This is because several NGOs are putting up new infrastructure for the people such as houses and schools. As such the principle of ecosan could be relayed to the people using the same platform i.e. this is the opportunity to incorporate ecosan in the new infrastructure for the people.

6.6.11 Summary of Criteria and Viability Analysis

In Section 2.5 I had listed criteria to be considered when selecting *appropriate* technologies during emergency situations. These are crucial considerations in achieving a sanitation option that is to be used by the affected population. Under normal conditions, criteria such as gender sensitivity, culture, soil types, availability of water and construction materials, population density and security are also considered. Table 6-2 shows a summary of the criteria (essential and desirable), explained above which should be considered when implementing ecosan technologies in emergency situations.

Table 6-2 Summary of Specific Criteria for Applicability of Ecosan During Emergencies

Specific Criteria	When Ecosan[15] Is a Viable Option	When Ecosan is not a Viable Option	Recommendation
a) Essential Criteria			
1.) Awareness and expertise on ecosan amongst aid agencies	Previous implementation of similar projects	Absence of expertise on ecosan in the agencies	Increase awareness amongst aid agencies through education awareness.
2.) Easy transportation and quick installation of assembled ecosan-compatible units	When materials are locally available or when they can be brought in quick for installation	Ecosan-compatible units not available	Develop standards of ecosan compatible toilets that are easy to install and quick to assemble for emergencies.
3.) Availability of water	Limited	In abundance	None
4.) Status of displaced people	Within home country	When out of own country	None
5.) Stage and duration of emergency	After awareness raising	At the onset of emergency	None
6.) Role of government in sanitation provision	Present	Absent	Increase advocacy within government departments to promote use of sustainable sanitation systems.
b) Desirable Criteria			
7.) Awareness of ecosan amongst users	Pre-existing	Existing negative attitude about ecosan or failed projects	Introduce the ecosan compatible toilets amongst the population.
8.) Availability of land for reuse	Excreta can be re-used	Excreta cannot be re-used and even no space for dumping	None
9.) Collaboration between the different aid agencies	Present	Absent	Encourage the donors to encourage aid agencies to implement sustainable sanitation systems.
10.) Other Criteria • Existing sanitation system • Food supply chain • Expected life cycle of the implemented sanitation system • Users' understanding of limited choices • Coordination with other reconstruction projects	When the existing system is destroyed and also when the food chain requires use of fertilisers on the farms. Required also when alternatives are very limited.	When the existing system is safe and sustainable.	Aid agencies should improve the existing sanitation systems to improve people's livelihoods through promotion of the activities they carry out such as agriculture. They should also introduce the new systems in the reconstruction projects they carry out.

[15] For the purposes of this table, "ecosan" is meant to mean: dry urine diverting toilet or dry composting toilet, re-use of excreta is initially optional but possible.

6.7 Procedure for implementing Ecosan in Emergency Situations

Aid agencies should strive to implement sanitation solutions that are environmentally safe and sustainable in the long term. They should not only focus on the provision of sanitation services that deal with the problem of excreta disposal, but they should aim to implement services that take care of the excreta disposal as well as ensuring environmental protection and improved livelihoods of the people.

They should also endeavour to increase awareness and promote sanitation systems that are safe and sustainable in emergency situations and thereafter. If all or most of the criteria (see Table 6-2) are in place, and pit latrines cannot be used, (see Section 6.5) then ecosan technologies should be implemented following the flow chart as shown in Figure 6-1 below.

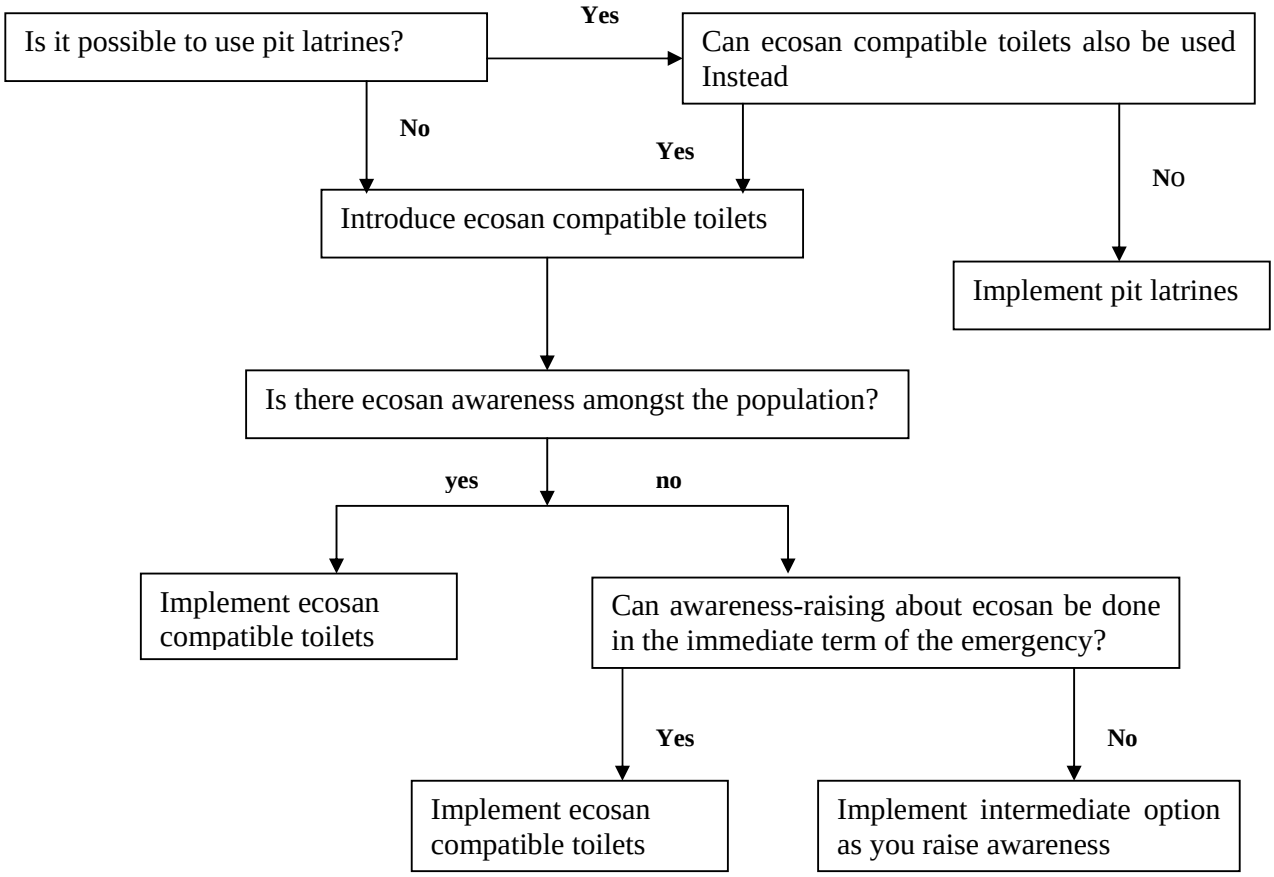

Figure 6-1 Decision Flow Chart for Implementing Ecosan During Emergencies

7 Impact of Research Findings in MDG Achievements

7.1 Relevant MDGs and Their Targets

"*The Millennium Development Goals (MDGs) are the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions - income poverty, hunger, disease, lack of adequate shelter, and exclusion - while promoting gender equality, education, and environmental sustainability"* (Millennium-Project, 2005a).

For this research the relevant MDGs are as shown in Table 7-1 (Millennium-Project, 2005a). The targets highlighted are the ones relevant to this research.

Table 7-1 The Relevant MDGs and their Targets (those shaded in grey are the ones relevant to this research)

MDG	Description	Target
Goal 1:	Eradicate extreme poverty and hunger	**Target 1:** Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day.
		Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
Goal 4:	Reduce child mortality	**Target 5:** Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate.
Goal 7:	Ensure environmental sustainability	**Target 9:** Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.
		Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.
		Target 11: Have achieved by 2020 a significant improvement in the lives of at least 100 million slum dwellers.

Broad regions are far off track in meeting the MDGs. The Millennium-Project (2005a) further mentions that, *"…. Sub-Saharan Africa has been in a downward spiral of AIDS, resurgent malaria, falling food output per person, deteriorating shelter conditions and environmental degradation so that most countries in Africa are far off track to achieve most of the goals."* The report further states that the situation could be worsened with climate change by increasing food insecurity, spreading of vector borne diseases, and increasing the likelihood of natural disasters. Also, most of the world is off track in reducing child mortality rates and reversing environmental resources (Millennium-Project, 2005a).

The estimated mortality rate due to hygiene and other water and sanitation related diseases was about 2.2 million in the year 2000 (Werner *et al.*, 2003). This is so despite the fact that

large sums of money have been sunk into water and sanitation projects worldwide over the past two decades.

Hygiene, safe water and sanitation are primary human rights. And now that sanitation has made it to the global agenda (MDGs), sustainable alternatives to conventional practices need to be addressed in order to achieve the MDGs (Rosemarin, 2003). Currently the percentage of people with access to improved sanitation services has risen from 49% in 1990 to 58% in 2002 (UNICEF, 2002). However, to halve the proportion of people without improved sanitation (majority of whom are the world's poorest), global coverage needs to grow to 75 per cent by 2015 and, if the 1991 – 2000 trend continues, then this target will not be met by 2015 (UNICEF, 2002). Therefore, solutions to the sanitation problem need to be identified if the MDGs are to be achieved, which will result in improved livelihoods of majority of the world's poorest people.

However as observed, there is no linkage of MDGs and disasters, despite the fact that they have a significant impact on both people's livelihoods and economics of the affected countries for example the Indian Ocean Tsunami disaster. Achievement of Goal 7 brings about achievement of most of the targets, i.e. child mortality is reduced by reduction of disease spreading vectors and diseases, the agriculture production can be improved through re-use of excreta hence reducing on the number of people suffering from hunger. Therefore a special target should be put under Goal 7 i.e. to improve the lives of those affected by disasters through promotion of safe and sustainable technologies such as ecosan.

7.2 "Quick Win" Solutions

It is the world's poorest that are most susceptible to disaster, and as such the MDGs can be achieved by improvement of sanitation in emergency situations through implementation of "**quick win**" solutions. The solutions to be implemented should be **cheap**, **safe** and **sustainable** and should be further used by the affected populations even when the situation returns to normal.

Quick wins are solutions that are cheap and can be implemented in a fast way in order to achieve positive outcomes that are safe, acceptable and sustainable to the communities they are intended for as well as improving their livelihoods and the environment in the long term. Examples of proposed "quick win" solutions relevant to this research are shown in Table 7-2 (Millennium-Project, 2005b).

Table 7-2 Proposed "Quick Win" Solutions and the Contribution via Ecosan for Emergency Situations

Proposed Quick Win Solutions (Millennium-Project, 2005b)	Contribution via Ecosan for Emergency Sanitation
Goal 1:	
➢ Providing impoverished farmers in Sub-Saharan Africa with affordable replenishments of soil nitrogen and other soil nutrients,	➢ Reuse of excreta by the farmers in their gardens
➢ Training large numbers of village workers in health, farming and infrastructure (in one year programmes) to ensure basic expertise and service in rural communities.	➢ Through awareness-raising about the use of ecosan compatible toilets, the people learn about the health benefits. The people benefit in terms of improved farming methods and yields which leads to capacity building at the lowest levels of society.
Goal 4:	
➢ Distributing free long lasting, insecticide-treated bed nets to all children in malaria endemic zones to cut decisively the burden of malaria.	➢ Use of ecosan compatible toilets reduces breeding of disease spreading organisms such as flies.
Goal 7:	
➢ Providing access to electricity, water, sanitation and the internet for all hospitals, schools and other social service institutions using off-grid diesel generators, solar panels, or other appropriate technologies,	➢ If the excreta are treated in anaerobic digestion systems biogas can be generated that can be used by households for cooking, lighting etc.
➢ Providing community-level support to plant trees to provide soil nutrients, fuel wood, shade, fodder, watershed protection, windbreak and timber.	➢ Use of ecosan compatible toilets provides protection of water resources as well as providing nutrients for the soil.

7.3 The Role of Ecosan in Achieving the MDGs

Ecosan is a paradigm in sanitation with a very good potential to eradicate problems related to the global water and sanitation crisis and to contribute to meeting the MDGs, in a safe and sustainable manner (Werner, 2004).

Through use of ecosan products i.e. the sanitised urine and faeces, soil nutrients can be replenished, saving on use of artificial fertilisers which are not only costly but also lead to further contamination of water bodies through run off (see Section 3.1.2). Use of ecosan as an excreta disposal system will also lead to a decline in child mortality rates given that it does not provide breeding grounds for disease spreading vectors such as flies unlike the other types of waste disposal such as pit latrines.

Also with proper training of the affected communities, ecosan technologies are favourable in such a way that they can be decentralised i.e. each household can manage their products. This could also be looked at as a business prospect with households buying and selling their sanitised excreta from each other for use in agriculture. This is a situation that is envisaged in the long-term and not during the immediate term or short term of the emergency.

7.4 Calculation of Number of Toilets Required to Meet the MDGs

Table 7-3 below shows the number of ecosan compatible toilets that have to be constructed in order to achieve the MDGs by the year 2015 for the analysed case studies of El Salvador, Afghanistan and Pakistan. In order to give a requirement of what is needed it terms of ecosan-compatible toilets to achieve the MDGs, an estimate based on a simplified analysis using the following assumptions has been carried out:

- The population growth between 2002 and 2015 for Goal 7 and between 1990 and 2015 for Goals 1 and 4 was not taken into account.
- The base year for Goal 7 was taken as 2002 instead of 1990 as the information for this year was much more clear for all the three countries considered.
- It has also been assumed that a typical household contains 5 people and each has (or will have) one toilet.
- Each household has been assumed to have two children below five years for each of the countries used.
- The under-five mortality rate is reduced to near zero for households that have ecosan compatible toilets because of reduction in the diseases that cause death among children such as diarrhoea, and dysentery.
- An ecosan compatible toilet classifies as “basic sanitation”.
- People no longer suffer from hunger once they have an ecosan compatible toilet in their household because they can reuse the sanitised excreta in their gardens.

Basing on the assumptions above the analysis was carried using the methods below.

- To obtain the number of facilities required to meet Target 10, the number of those without basic sanitation by 1990 is halved and divided by the number of people per household.
- To obtain the number of facilities required to meet Target 5, the number of under-fives in the population ($2/5^{th}$ of the population) is multiplied by the number of under-fives per thousand whose lives shall be saved by improving sanitation between 1990 and 2015. The product is then divided by estimated number of under-fives per household.

- To obtain the number of facilities required to meet Target 2, the number of those suffering from hunger between 1990 and 2015 is halved and divided by the number of people per household.

Table 7-3 Ecosan Compatible Toilets Required to Meet Each MDG Target for this Research (simplified analysis)

	Case 1 (El Salvador)	Case 2 (Afghanistan)	Case 3 (Pakistan)
Population 1990* (millions)	5.1	13.8	110.9
Total Sanitation Coverage 1990* (%)	51	Not given	38
Estimated Number of people per household (own estimate)	5	5	5
MDG Goal 7 Target 10			
Population 2002 Base Year for Goal 7* (millions)	6.4	22.9	149.9
Total Sanitation Coverage 2002* (%)	63	8	54
Number of people *without* access to improved Sanitation (millions)	2.4	21.1	69.0
Halve the number of people without improved sanitation in the base year (2002 in this case) (millions)	1.2	10.5	34.5
Required number of ecosan compatible toilets to meet the 2015 Target (thousands)	237	2110	6896
Anticipated Total Sanitation Coverage 2015 (%)	81.5	54	77
Target Number of people with access to improved Sanitation by 2015 (millions)	5.2	12.4	115.4
MDG Goal 4 Target 5			
Estimated under-fives in the population (own estimate) (%)	10	10	10
Number of Under fives in the population 1990 (thousands)	2.04	5.5	44.4
Estimated Number of Under fives per household (own estimate)	2	2	2
Under-Five Mortality Rate per 1000, in 1990*	52	260	140
Reduce by two-thirds the under five mortality rate between 1990 and 2015	17	87	47
Number of under-fives per 1000, whose lives can be saved by improving sanitation through use of ecosan compatible toilets by 2015	35	173	93
Required number of ecosan compatible toilets to meet the 2015 Target (thousands)	35	478	2070
MDG Goal 1 Target 2			
Population suffering hunger in 1990* (%)	33	50	25
Number of people suffering from hunger 1990 (millions)	1.7	6.9	27.7
Reduce by Half the proportion of people who suffer from hunger between 1990 and 2015 (millions)	0.8	3.4	13.9
Target population suffering hunger by 2015 (%)	16.5	25	12.5
Required number of ecosan compatible toilets to meet the 2015 Target (thousands)	168.6	690.0	2772.5

The items marked with an asterix (*) were obtained from (UN, 2004).

Table 7-3 shows that, by meeting Goal 7 Target 10, through provision of ecosan compatible toilets for each case, Target 2 and 5 shall in turn be met by the year 2015 as they require a lower number of toilets in comparison to Target 10.

To give a monetary aspect of carrying out the above-mentioned task (Table 7-4), a unit investment cost for double vault urine diverting toilets (as an example of an ecosan compatible toilet type) has been used as 465 Euros per toilet. The investment cost used has been obtained from (Mayumbelo, 2006). It should be noted however that more detailed cost estimates are outside the scope of this thesis.

Table 7-4 Investment Cost Required to Meet the MDG Targets Based on Simplified Analysis

Country	**Number of ecosan compatible toilets required (thousands)**	**Cost Euros (Millions)**
El Salvador	237	110
Afganistán	2110	981
Pakistan	6896	3,207
Total Cost Euros (millions)		**4,298**

Therefore improving emergency sanitation through promotion and use of appropriate and sustainable technologies such as ecosan may assist in providing quick win solutions, which will make a significant contribution to the achievement of the MDGs.

8 Conclusions and Recommendations

8.1 Conclusions

The world appears to be experiencing an increasing number of disasters especially in developing countries. These disasters create emergency situations, which have a devastating effect on the affected areas. As such, aid agencies are faced with a task of improving the affected people's livelihoods through provision of humanitarian assistance. One of the ways of improving the people's livelihoods is through improving sanitation during emergencies – in particular, the excreta disposal.

Since the sanitation situation in the developing countries is usually in a poor state (most of them using pit latrines, broken down sewer systems or simply the bush), emergency situations can be looked at as opportunity to re-build/introduce the affected communities with/to better sanitation technologies such as ecosan that improve people's living conditions as well as ensuring environment protection.

In general, ecosan has been applied in both developing and developed countries, and from the literature studied so far, it has not been applied during the immediate term or short term of the emergency situations[15]. However, its principles have been applied in long-term emergency situations.

This could be attributed to the novelty of the technology and approach and as such requires more awareness-raising especially if new to the affected people. It is also noted that water is usually scarce during emergencies. Ecosan provides sanitation options (urine-diverting and non-urine diverting toilets) that are water based and also waterless (the latter of which can be used during such emergencies) while fulfilling all the ecosan principles. For this thesis however cosan implies dry UD toilets, because of lack of water during emergencies and also because of the simplicity to manage dry UD toilets.

The case studies analysed have shown that in the long term of the emergency ecosan based technologies were implemented, i.e. the LASF latrines and the vault latrines both with urine diversion used in El Salvador and Afghanistan respectively. However during the immediate to short term of the emergency pit latrines were used i.e. for the case of Pakistan.

The viability of ecosan during the immediate and short term may pose big challenges but if specific criteria (essential and desirable) are in place then implementation of ecosan compatible toilets will be possible. The essential criteria are; awareness and expertise on ecosan amongst aid agencies, easy transportation and quick installation of assembled units, availability of water, status of displaced people, stage and duration of emergency and role of government in sanitation provision. The desirable criteria are; awareness of ecosan amongst the users, availability of land for reuse, collaboration between the different aid agencies.

In addition to the above other relevant criteria that can assist in implementing ecosan technologies are; the existing sanitation system, food supply chain, expected life cycle of

[15] Containment and sanitisation are practised but not always re-use

the implemented system, user's understanding of limited choices and coordination with other reconstruction projects.

It should be noted however that ecosan systems are very useful in flood prone areas and in areas where the ground is hard to excavate e.g. rocky areas. On the other hand they can also be used under normal conditions too.

As observed the main area of concern with the ecosan technologies is the potential of re-use of the sanitised excreta. Whereas this should not be used as a reason to limit its application in emergencies if there is no ready use, the affected population can be informed about excreta reuse as the emergency advances.

Ecosan technologies if used during emergency situations and thereon would result in numerous benefits for the affected community and the country and would also lead to the quick wins for the MDGs. Section 7.1 presents the MDGs that can be achieved if ecosan is used during emergency situations. The benefits include: food security, reduced child mortality rates and environmental protection.

Results in Table 7-3 reveal that by 2015 through addressing Goal 7 Target 10, with provision of ecosan compatible toilets for each country; El Salvador, Afghanistan and Pakistan, Target 2 and 5 shall in turn be met.

The results show that with regard to Target 10 over two hundred thirty seven thousand toilets are required for El Salvador, more than two Million for Afghanistan and approximately seven million required for Pakistan. This leads to an estimated investment cost for these toilets amounting to about 4.3 million euros in order to meet the targets by 2015.

All these benefits are inter-twined in such a way that, by use of safe excreta disposal methods such as ecosan (Target 10), re-use of excreta in agriculture can lead to an increase in food security (Target 2) for the community and this could lead to improved livelihoods of the people. Because ecosan is an environmentally friendly technology, this would lead to a decrease in contaminated water related diseases to which children are most vulnerable to, hence reducing child mortality (Target 5). Ecosan technologies also save on the amount of money that would be spent on repair/building of existing conventional wastewater systems.

Therefore use of ecosan compatible toilets during emergencies will lead to sanitation situations that are **better than before the event causing the emergency** hence leading to improved livelihoods of the affected communities, environmental conservation and achievement of the MDGs**.**

The point is therefore to use emergency situations as an opportunity to improve sanitation in developing countries (in a sustainable fashion) by replacing or rebuilding the existing sanitation systems with sustainable solutions

8.2 Recommendations

From the conclusions therefore, aid agencies should:

- Encourage capacity building in their organisations to broaden their expertise and awareness about new safe excreta disposal systems e.g. by enrolling in courses at relevant educational institutions.

- Ensure government in the affected countries are involved in their development projects especially the sanitation related projects

- Collaborate with each other in promoting sanitation systems that are safe and sustainable

- Also incorporate safe sustainable technologies such as ecosan in their development projects such as improving shelter and water supply

Research is required on the type of portable ecosan facilities that are appropriate for emergency situations and their cost. If ecosan compatible toilets are to be used during emergencies, then easy to assemble units should be available for installing as soon as an emergency strikes.

Also it needs to be investigated how the other areas of emergency sanitation i.e. wastewater management, hygiene promotion, solid waste management, waste management at the medical centres and disposal of dead bodies can be improved (in the context of an overall ecosan approach). The main concern in poor excreta disposal is the presence pf pathogens in human excreta that can lead to disease transmission. However, the other emergency sanitation areas if not considered can also cause the same disastrous effect or even worse. As such, research should be carried out to determine existing approaches and how the situation can be improved.

9 References

AMBIENTEC-S.A-DE-C.V. (2000a) *Post Mitch Phase I Evaluation of Water and Sanitation Activities - Doctors Without Boarders Holland-El Salvador*.

AMBIENTEC-S.A-DE-C.V. (2000b) *Post Mitch Phase II Evaluation of Water and Sanitation Activities - Doctors Without Borders Holland-El Salvador*.

Baghri, S., and Reed, R. A. (1998) Emergency Sanitation in Refugee Camps. *Sanitation and Water for all: Proceedings of the 24th WEDC Conference*, Islamabad, Pakistan, 23-26.

Bastable, A. (2000) *Guidelines for Excreta Disposal in Emergencies*, Oxfam, London, 1st Edition.

Bracken, P. (2006) *Ecosanres Discussion Forum - Personal Communication.* [Online] http://www.ecosanres.org [Access date: 24/02/2006]

Chattopadhyay, S. (2001) Sustainable Water Supply and Sanitation - City Planner's Role. *NASA - Nordic Association for South Asian Studies - Biannual Conference*, Voss, Norway, 20-22 September, 1-20.

Claren, T., and Smith, L. (2005) *The Drinking Water Resource to the Indian Ocean Tsunami, Including the Role of Household Water Treatment*. WHO. [Online] http://www.who.int/household_water/research/DW_response_tsunami.pdf [Access date: 11/02/2005]

Davis, J., and Lambert, R. (2002) *Engineering in Emergencies: A practical guide for relief workers*, ITDG in association with RedR, London, 2nd Edition.

EcoSanRes (2005a) *The EcoSanRes Programme for Improved Livelihoods Around the World. EcoSanRes*. [Online] http://www.ecosanres.org/PDF%20files?fact_sheets/ESR3lowres.pdf [Access date: 20th August 2005]

Ecosanres (2005b) *An Introduction: Understanding the Concept of Ecological Sanitation.* [Online] http://www.ecosares.org/PDF%20files/PM%20Report/Chapter%201%20Introduction%20a.pdf [Access date: 12/03/2006]

Gleick, P. H. (1996) Basic Water Requirements for Human Activities: meeting basic needs. *Water International*, **21**(1998), 83 - 92.

Graham-Harrison, K., and Low, M. (2005) *A review of Ecosan Experience in Eastern and Southern Africa* World Bank [Online] [Access date: 20th August 2005]

GTZ (2005) *Technical data sheets for ecosan components - Urine Diversion*. [Online] http://www.gtz.de/ecosan [Access date: 16/02/2006]

Halls, S. (2000) *International Source Book on Environmentally Sound Technologies for Wastewater and Stormwater Management*. UNEP. [Online] http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-15/2-4/4-1-1.asp [Access date: 13/02/2006]

Harvey, P., Baghri, S., and Reed, B. (2002) *Emergency Sanitation Assessment and Programme Design* WEDC Loughorough University, 1st edition.

Harvey, P., Bastable, A., Ferron, S., Forster, T., Hoque, E., Morris, L., Piano, E., and Smith, M. (2004) *Excreta Disposal in Emergencies: A Field Manual*, WEDC, Loughborough University, Draft.

Huba-Mang, E.-M., and Panzerbieter, T. (2005a) *"Water is Life, Sanitation is Dignity"*. World Toilet Organisation, Colombo.

Huba-Mang, E. M., and Panzerbieter, T. (2005b) *Mission Report*. World Toilet organisation, Colombo.

Huba, E.-M. (2006) *Ecosanres Discussion Forum - Personal Communication*. [Online] http://www.ecosanres.org [Access date: 26/02/2006]

Jackson, B., and Knapp, A. (2005) *Lessons from a Multi-Country: A Review of Ecosan Experience in East and Southern Africa*. Sanitation Connection. [Online] http://www.conference2005.ecosan.org/abstracts/b11.pdf [Access date: 22nd August 2005]

Jenssen, P. D., Heeb, J., Huba-Mang, E., Gnanakan, K., Warner, W. S., Refsgaard, K., Stenstorom, T. A., Guterstam, B., and Alsen, K. W. (2004) *Ecological Sanitation and Reuse of Wastewater - Ecosan: A Think Piece on Ecological Sanitation*. The Agricultural University of Norway. [Online] [Access date: 18th August 2005]

Langergraber, G., and Muelleger, E. (2004) Ecological Sanitation - a way to solve global sanitation problems? *Environmental International*, **31**(2005), 433 - 444.

Madin, K. (2006) *Ecosanres Discussion Forum - Personal Communication*. [Online] http://www.www.ecosanres.org [Access date: 23/02/2006]

Matsuura, K. (2003) *International Year of Freshwater*. United Nations. [Online] http://www.un.org/events/water/brochure.htm [Access date: 8th August 2005]

Mayumbelo, K. M. K. (2006) *Cost Analysis for Applying Ecosan in Peri-Urban Areas to Achieve the MDGs - Case Study of Lusaka Zambia*, MSc thesis UNESCO-IHE, Delft.

Millennium-Project (2005a) Investing in Development, A Practical Plan to achive the Millennium Development Goals. Overview. United Nations Millennium Project, Washington D. C.

Millennium-Project (2005b) *UN Millennium Project "Quick Wins"*. United Nations. [Online] http://www.unmillenniumproject.org/press/press3.htm [Access date: 31/01/2006]

MSFH (2005a) *Draft Trip to Pakistan Report Public Health Department - Internal Report*

MSFH (2005b) WATSAN UPDATE for Pakistan - Internal Report.

Mullegger, E., and Lechner, M. (2004) *Ecological Sanitation a Sustainable Approach to the Future*. Austrian Development Agency. [Online] http://www.ada.gv.at/up-media/989_eza_sanitation_7_7_.pdf [Access date: 31/01/2006]

NCDC (2006) *National Climatic Data Center - Hurricane Mitch*. [Online] http://lwf.ncdc.noaa.gov/oa/reports/mitch/mitch.html#INTRO [Access date: 20/02/2006]

Pararas-Carayannis, G. (2006) *Earthquakes Page*. [Online] http://www.drgeorgepc.com/EarthquakesJapan.html [Access date: 20/02/2006]

Reed, R., and Khan, M. (2003) *Evaluation of the ICRC Environmental Sanitation Programme in Kabul, Afghanistan*. Loughborough University, Loughborough

Rosemarin, A. (2003) EcoSanRes - a Swedish International Ecosan Programme. *Proceedings of the 2nd International Symposium on Ecological Sanitation incorporating the 1st IWA specialist group conference on sustainable sanitation* Lubeck, 7th -11th April 2003, 83 - 91.

Schlecht, J. (2003) *Migration Information Source*. Migration Policy Institute [Online] http://www.migrationinformation.org/Feature/print.cfm?ID=151 [Access date: 10th August 2005]

Songer, T. (1999) *Epidemiology of Disasters*. [Online] http://www.pitt.edu/AFShome/e/p/epi2170/public/html/lecture15/index.htm [Access date: 2nd November 2005]

Sphere-Project (2004) *Humanitarian Charter and Minimum Standards in Disaster Response*, The Sphere Project, Geneva, 1st Edition.

The-Water-Page (2000) *Toilet Designs and Operation*. Water Policy International Ltd. [Online] http://www.thewaterpage.com/ecosan_design.htm [Access date: 13/02/2006]

Treglown, S., Harvey, P., and Reed, B. (2002) Planning and Management of Emergency Sanitation. *Proceedings of an International Conference, WEDC, Loughborough University, UK* Loughborough University, 10th - 12th April 2002, 1-123.

UN (2004) *United Nations Statistics Division Millennium Development Goals Indicators Database*. [Online] http://millenniumindicators.un.org/unsd/mi/mi_results.asp?crID=586&fID=r15 [Access date: 10/03/2006]

UN (2006) *El Salvador*. [Online] http://www.un.org/Depts/Cartographic/map/profile/elsalvad.pdf [Access date: 24/02/2006]

UNICEF (2002) *Meeting the MDG Drinking Water and Sanitation Target - A Mid Term Assessment of Progress* World Health Organisation. [Online] http://www.unicef.org/wes/mdgreport/sanitation0.php [Access date: 26th August 2005]

Werner, C. (2004) *Ecosan GTZ Background*. GTZ. [Online] http://www.gtz.de/en/themen/umwelt-infrastuktur/wasser/8528.htm [Access date: 20th August 2005]

Werner, C., Fall, P. A., Schlick, J., and Mang, H.-P. (2003) Reasons for and Principles of Ecological Sanitation. *Proceedings of the 2nd international symposium on ecological sanitation incorporating the 1st IWA specialist group conference on sustainable sanitation 7th - 11th April 2003*, Lubeck, Germany, 7th - 11th April 2003, 23 - 30.

Wikipedia (2005) *Humanitarian response to 2004 Indian Ocean earthquake*. Wikipedia. [Online] http://www.en.wikipedia.org/wiki/Humanitarian_response_to_the_2004_Indian_Ocean_earthquake [Access date: 30th August 2005]

Wikipedia (2006) *Hurricane Katrina*. [Online] http://en.wikipedia.org/wiki/Hurricane_Katrina [Access date: 20/02/2006]

Winblad, U., Simpson-Hebert, M., Calvert, P., Morgan, P., Rosemarin, A., Sawyer, R., and Xiao, J. (2004) *Ecological Sanitation*, Stockholm Environment Institute, Stockholm, 2nd Edition.

Wisner, B., and Adams, J. (2002) *Environmental Health in Emergencies and Disasters: A Practical Guide*

World Health Organisation. [Online] http://www.who.int/water_sanitation_health/hygiene/emergencies/emergencies2002/en/ [Access date: 04th August 2005]

WSSD (2002) *Report of the World Summit on Sustainable Development*. United Nations, Johannesburg, South Africa.

10 Appendices

Appendix I – Common Excreta Disposal Practices During Emergencies

The following information is taken from (Harvey *et al.*, 2004).

- **Open Field Defecation**

An area is set aside sufficient to accommodate 0.25 m^2 per person per day excluding access paths. Separate areas for men and women are usually selected. The area is situated at least 30 meters from other camp facilities. The soil has to be soft enough to dig easily in order to cover the excreta. Figure 10-1 below shows a typical layout for open field defecation

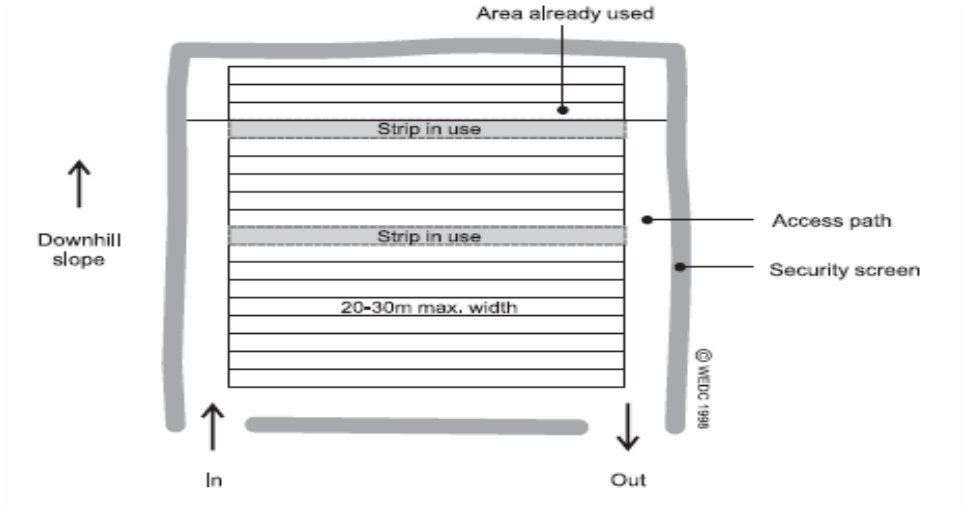

Figure 10-1 Layout of land for Open Field Defecation adapted from (Harvey *et al.*, 2004)

Advantages: They are rapid to implement, require minimal resources and they minimise indiscriminate open defecation.
Disadvantages: There is lack of privacy, a substantial area is required, they are difficult to manage, there is tendency of cross contamination of users and they are only suited for regions with a hot and dry climate.

- **Shallow Trench Latrines**

In this case the faeces are buried and far better contained than in a defecation field. To serve a population of about 100 people a typical measurement of about 3-5 meters long, shallow trench is sufficient. The trenches are not used for more than a week, before they are filled, compacted and replaced by new trenches. The location is similar to that of defecation fields. Figure 10-2 below shows a layout of shallow trench latrines.

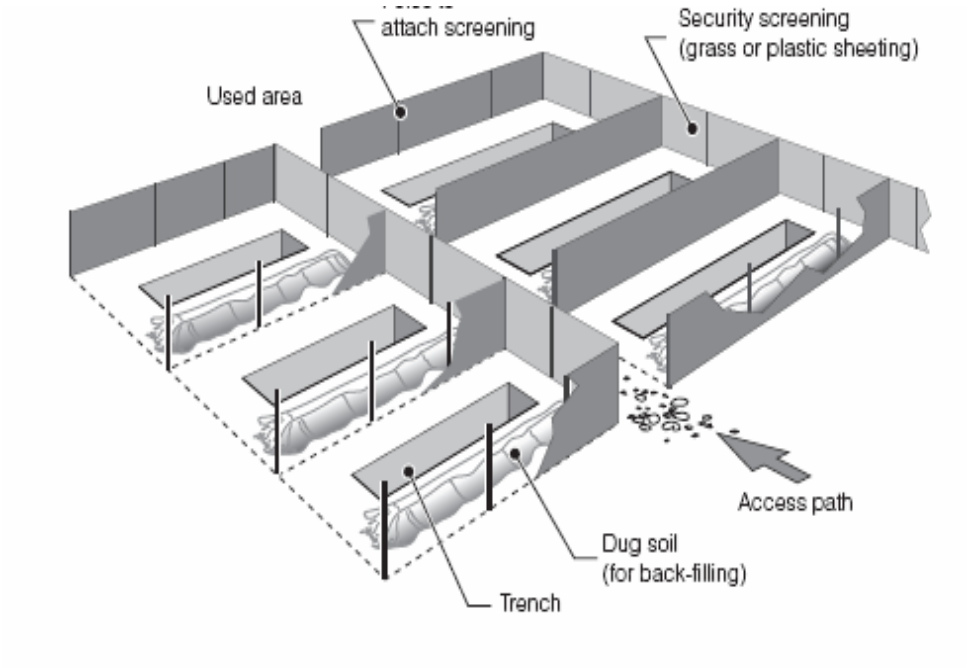

Figure 10-2 Layout of Shallow Trench Latrines (Harvey *et al.*, 2004)

Advantages: They are rapid to implement, and the faeces are covered.
Disadvantages: There is lack of privacy, a substantial area is required, and they have a short life span.

- **Deep Trench Latrines**

Deep Trench latrines are deeper, longer and wider than the shallow trench latrine, and can last to up to 1 –3 months.

Advantages: They have a longer life span, and the faeces are covered.
Disadvantages: They require tools, labour and materials for construction.

- **Shallow Family Latrines**

Shallow family latrines are individual simple latrines either hand dug or drilled. These are common when there is a low population density, and also for long-term emergency settlements. Family latrines are usually preferred as they are more hygienic than public facilities coupled with the long-term benefits in terms of maintenance.

Advantages: There is adequate privacy, they are rapid to implement, and a reduced requirement for labour.
Disadvantages: There needs to be willingness and ability of the family to construct their latrine, and it is difficult to manage siting and backfilling of pits.

- **Bucket Container Latrines**

When there is limited space, it is appropriate to provide buckets or containers in which people defecate. These have tight-fitting lids and should be emptied at least daily. Disinfectant may be added to reduce odour and contamination. The containers can be emptied in a sewerage system, landfill or waste stabilisation ponds. These are appropriate when there is no other immediate option and where users find the method acceptable.

Advantages: The defecation containers can be produced and transported easily and they can be used in flooded areas.
Disadvantages: Large quantities of containers and disinfectants are required, there is need for education regarding final disposal and the containers may be used for unintended purposes.

- **Storage Tank Latrines**

In case of flooded areas, or where ground excavation is difficult, large storage tanks can be situated above the ground with platforms and a simple superstructure fitted above. In this case, steps are constructed for it to be accessed by the people and the effluent is collected in the tank. The tank requires regular emptying. These latrines are suitable as immediate or short-term measures only.

Advantages: Large storage tanks are often available in relief shipments, they are rapid to construct and can be used in rocky or flooded areas.
Disadvantages: Regular emptying of tanks to clearly designated areas is required, a large number of tanks is needed (these could be used for other purposes) and they require appropriate material for building the steps and the superstructure.

- **Packet Latrines**

Some emergency situations make use of disposable packet latrines. These are plastic packets in which the user can defecate. They contain a blend of enzymes, which breaks down excreta and is disposed of safely clearly designated areas.

Advantages: These are lightweight packets and easy to transport, and are useful when there is no space available.
Disadvantages: The method may not be acceptable, and the final disposal site must be clearly marked, accessible and used.

- **Chemical Toilets**

These are typical in developed countries. They are single prefabricated plastic units incorporating a sit-down toilet, lockable door, hand wash basin and effluent tank containing chemicals to aid digestion and reduce odour.

Advantages: They are hygienic and the odour is minimised.
Disadvantages: They are very expensive, difficult to transport and require regular emptying to an appropriate treatment facility, as well ensure availability of chemicals for use. Not usually appropriate for developing countries.

- **Upgrading of Existing Facilities**

Sometimes emergency situations occur in areas where there sanitation facilities exist e.g. in urban areas. These could have been damaged due to circumstances brought about by the disaster occurrence and fuelled by inadequate water supply and power cuts. In such cases, repair or upgrading of the existing facilities is done but it depends on how quickly this can be done. Figure 10-3 below illustrates an example of upgrading to an existing system.

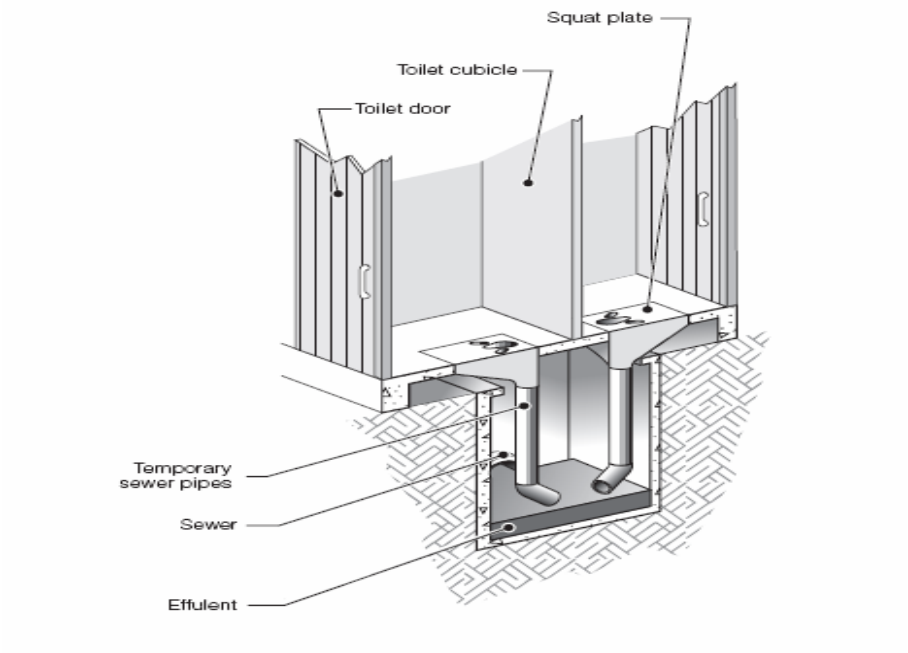

Figure 10-3 An Example of Upgrading to an Existing System (Harvey *et al.*, 2004)

Advantages: The existence of basic infrastructure and use of local materials and technologies is advantageous.
Disadvantages: There are limited expansion possibilities. Also, repair and upgrading may be time consuming.

- **Other Latrine Options**

Several other pit latrines are used during emergency situations, these include: Ventilated Improved Pit (VIP) Latrines, Double Pit latrines, Composting latrines, and Simple Pit latrines among others.

Simple Pit Latrines: This latrine is about 2 meters or more deep and is covered by a latrine slab. It is usually lined about 1m below the ground. A squat hole is provided in the slab, which allows excreta to fall directly into the pit. A removable lid to minimise flies and odour must cover the hole. The super structure can be made of locally available materials such as wood, mud or grass or it can be a more permanent structure of bricks and mortar.

These types of toilets are cheap, quick to construct and operate without water. They are also easily understood and appreciated by the people.

However, they are unsuitable where the water table is high and also where the ground is rocky. Figure 10-4 below shows a typical layout of a simple pit latrine

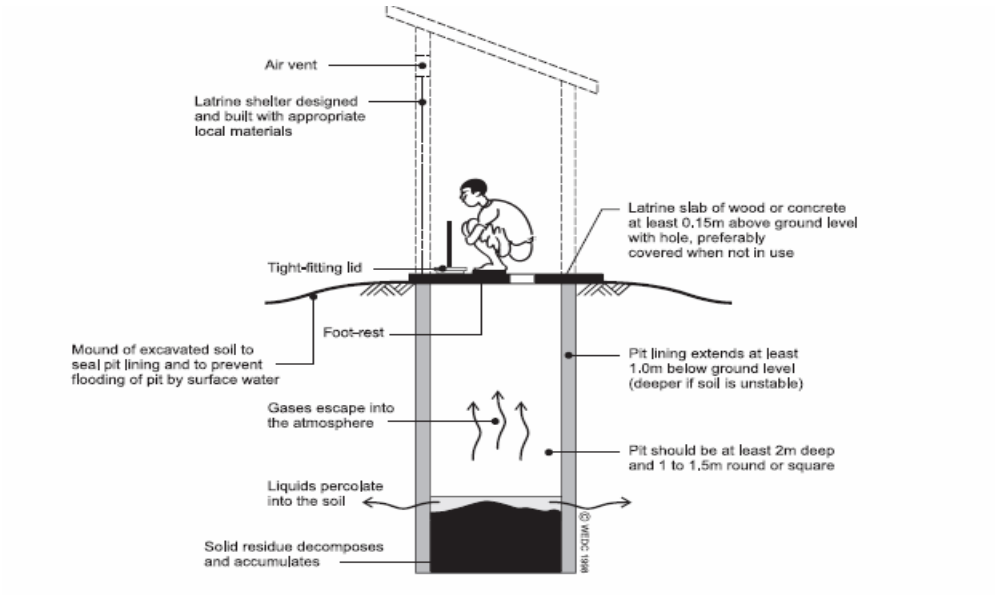

Figure 10-4 Shows a Typical Layout of a Simple Pit Latrine (Harvey *et al.*, 2004)

Ventilated Improved Pit Latrines (VIPs): These are improved pit latrines designed to minimise odours and flies. A vent pipe is installed into the slab through the roof to remove odours from the pit. The vent pipe end is covered with a gauze mesh to prevent flies from entering the pit and also to trap flies trying to leave the pit. The interior of the toilet should be dark. The other important criteria for this technology are: the size of the vent pipe, the length of the vent pipe and the sitting of the VIP latrine.

With this technology, odours and flies are reduced. This technology is also a good quality long-term solution. Figure 10-5 below shows an example of a VIP Latrine.

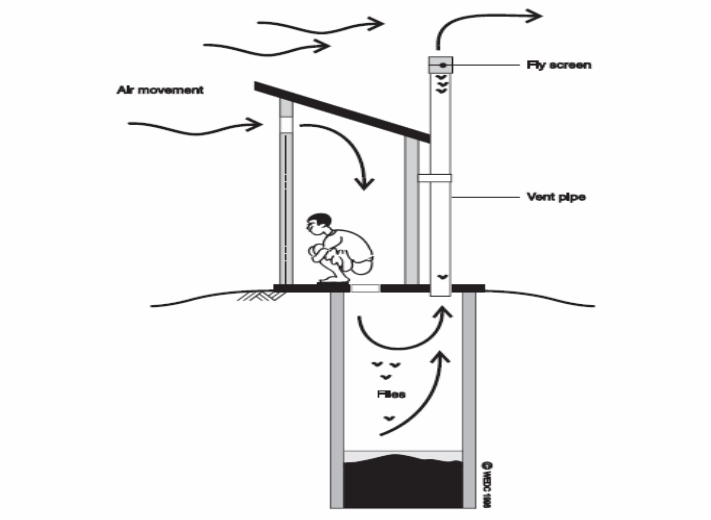

Figure 10-5 An Example of a Ventilated Pit Latrine (Harvey *et al.*, 2004)

However it is very expensive to construct and the design and operation are not often fully understood. Construction may take time and the dark interiors recommended may prevent

children and sometimes adults from using it. Also like most latrines, it poses a potential for groundwater contamination.

Double Pit Latrines: When it is not possible to dig deep pit latrines, it is easier and cheaper to dig two shallow pits side by side. The concept can be applied to simple pit latrines, VIPs, and all the other pit latrines types. One pit is used until it is full after which it is sealed off and the second one is used. If the contents are left to stand for about two years, most of the pathogens in the excreta are destroyed and the waste can be relatively easy to handle and can be used to improve the quality of the soil. Figure 10-6 shows an example of a double pit latrine.

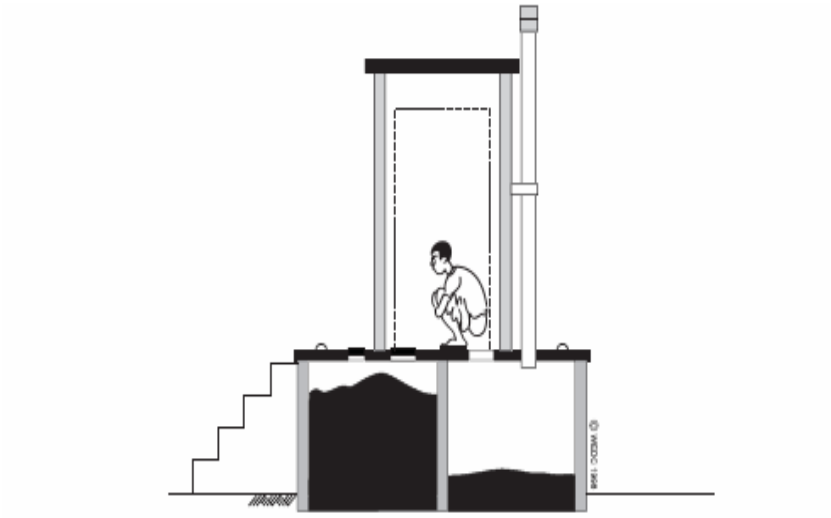

Figure 10-6 An Example of a Double Pit Latrine (Harvey *et al.*, 2004)

Composting Latrines: They are two types of composting latrines: the anaerobic and aerobic[16].

With the anaerobic type, the method used is a dry disposal system, in which urine and faeces are managed separately. The faecal matter is dried by exposure to heat/sun and the addition of: lime, saw dust or ash help in controlling the moisture content. Vegetable waste or other organic wastes can be added to control the chemical balance. The contents are then isolated from human activity to allow for destruction of pathogens in order to make the excreta safe for handling. After a period between ten months to two years, the waste can be used as a fertiliser or as a fuel. Figure 10-7 below shows an example of the anaerobic type of composting latrine.

The technology needs to be adapted if people practising anal cleansing using water e.g. some Muslim cultures (normally done with a third drop hole).

For the aerobic type, the principle is the same as the above, except that the faeces and urine are not separated. In this method, new waste must be separated from old waste and air must be able to circulate freely. In this process, bacteria, worms and other organisms are used to

[16] Harvey *et al*. Calls this an anaerobic composting latrine; other authors refer to this type of toilet as "dry urine-diversion toilet", which is a more accurate description in my opinion.

break down organic matter to produce compost. Vegetable waste can also be added to the toilet chamber. The resulting compost can be used as a fertiliser for agricultural purposes.

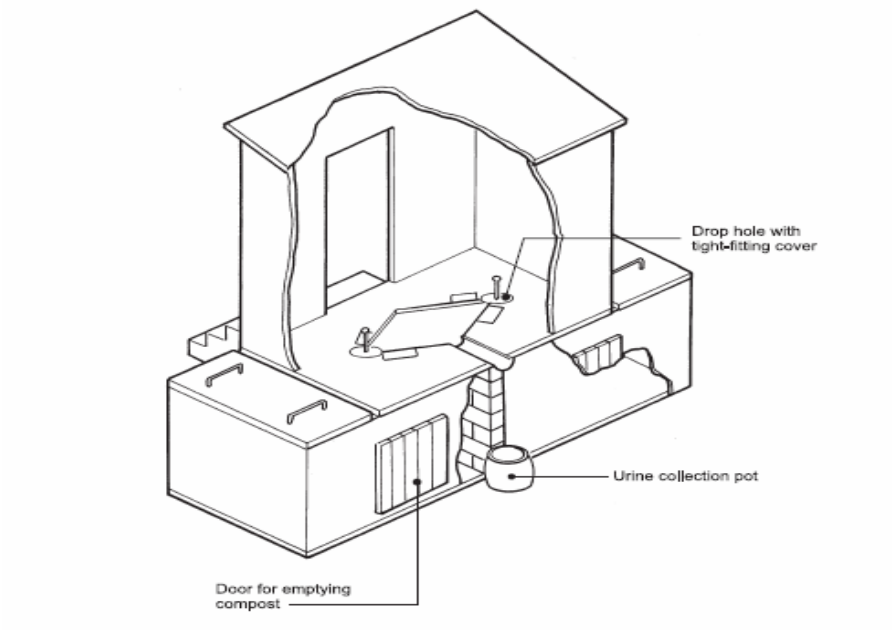

Figure 10-7 Example of Anaerobic Composting Latrine (Harvey *et al.*, 2004)

This technology is expensive to construct, and user awareness and understanding is required.

Raised Pit Latrines: When the ground water table is high i.e. a few meters above ground, or when the ground is extremely hard, this type of latrine is usually constructed. It has the same form as a simple pit latrine or any other latrine except that the pit is built upwards above the ground. The example in Figure 10-8 illustrates.

Figure 10-8 An example of a Raised Pit Latrine used in Tanzania (Harvey *et al.*, 2004)

Advantages: This type of toilet prevents ground water contamination.

Disadvantages: It is expensive and takes time to construct also the place for depositing of the excreta has to be designated.

Septic Tank Latrines: A septic tank is designed to collect and treat all wastewater. It is most appropriate where the volume of wastewater is too large for disposal into a pit latrine and when water borne sewerage is uneconomical or unaffordable. Figure 10-9 below shows a typical example of a septic tank latrine.

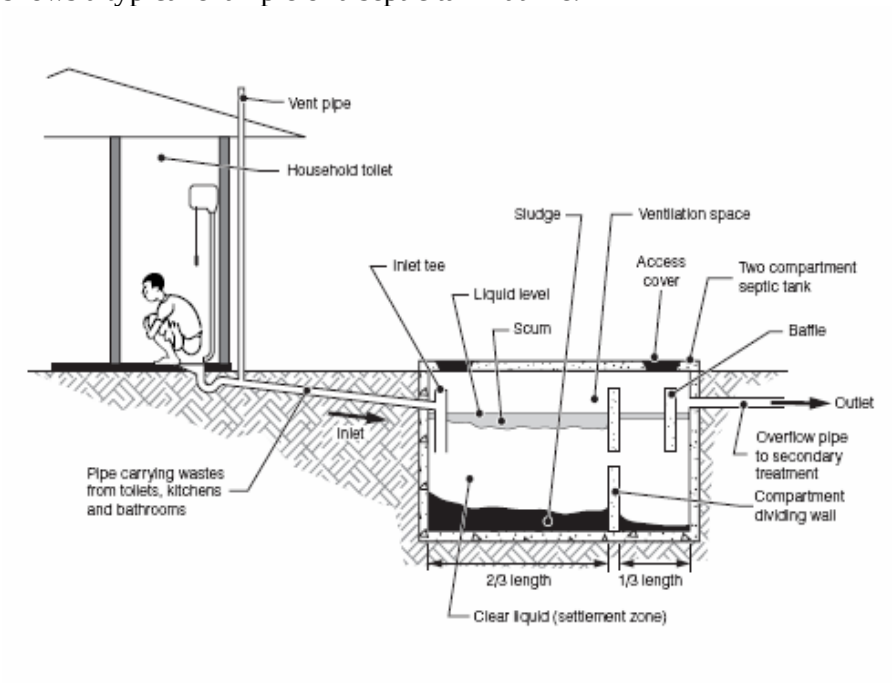

Figure 10-9 Shows a Septic Tank Latrine

Advantages: This system is appropriate where water is used for anal cleansing
Disadvantages: It is a very expensive system and construction is also time consuming. The system also requires availability of water supply.

Aqua Privies: An aqua privy is simply a latrine constructed over a septic tank. Figure 10-10 below shows an example of an aqua privy.

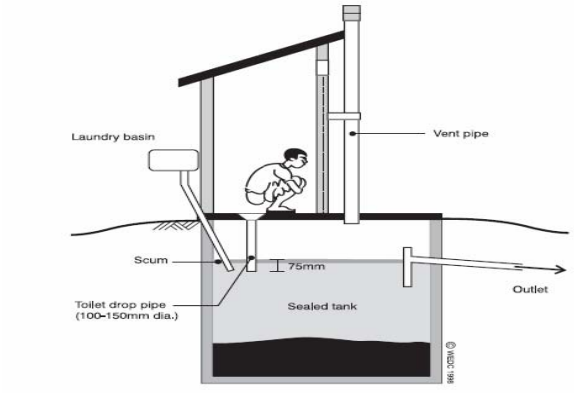

Figure 10-10 Example of an Aqua Privy (Harvey *et al.*, 2004)

Advantages: It is good for communities where pit latrines are socially or technically not known to them and undesirable. They are also odourless and require a very small amount of water because of their location. It is also very convenient for people who practice anal cleansing using water.
Disadvantages: They can be used if the amount of sludge production is small i.e. they cannot handle high population usage. There must also be availability of water supply. The tank of the aqua privy must be watertight to maintain a constant liquid level in the tank.

Pour Flush Latrines: Pour flush latrines rely entirely on water. The water acts as a hygienic seal and helps to remove excreta to a wet or dry system. The simplest pour flush latrine includes a latrine pan incorporating a U-bend, which retains the water. Figure 10-11 below show an example of a pour flash latrine.

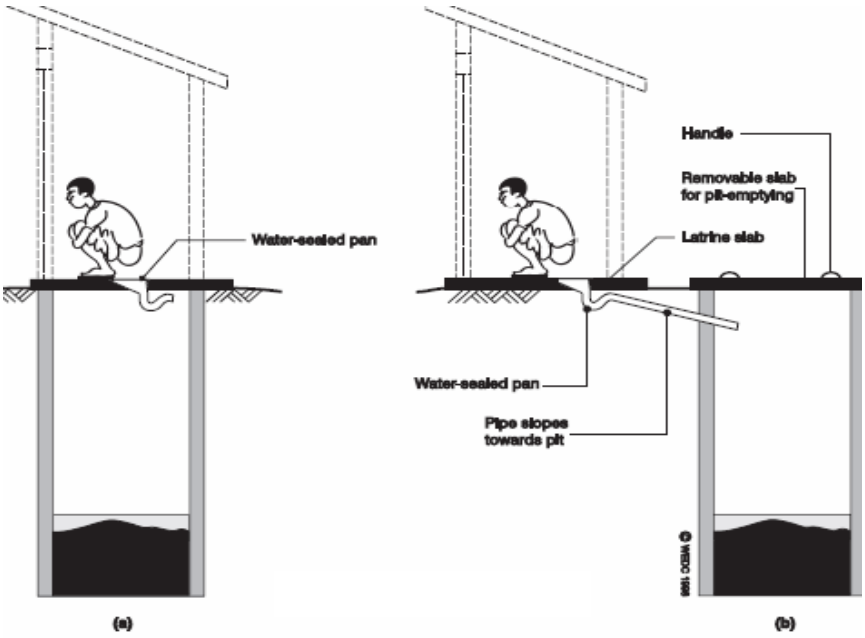

Figure 10-11 Example of a Pour Flush Latrine (Harvey *et al.*, 2004)

After defecation, a few litres of water **must** be poured into the bowl to flush the excreta into the pit in case of dry pit system and into the sewerage system in case of wet disposal system. They can be constructed directly above a pit Figure 10-11(a) or offset where the waste travels through a pipe to a pit or septic tank Figure 10-11(b).

Advantages: The system is odourless and is very easy to clean. It is also very convenient for people who practice anal cleansing using water.
Disadvantages: Use of solid anal cleansing material may cause blockages to the system. The system is very expensive to construct and requires a stable supply of water for proper use and maintenance.

Over-hung Latrines: The principle used here is similar to that used for the simple pit latrine except that in this case, the superstructure and floor are suspended over water. Figure 10-12 below shows an example of an over-hung latrine.

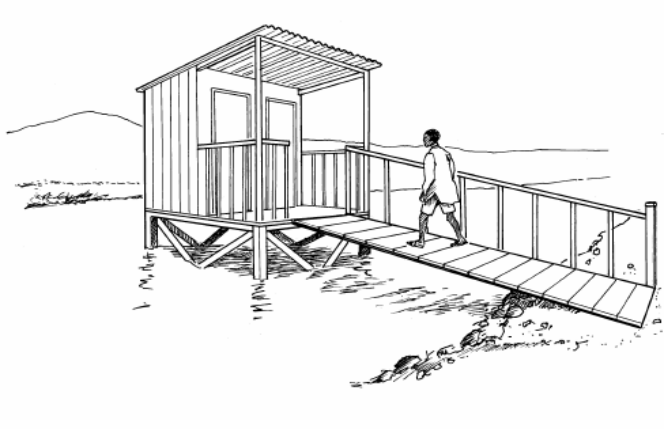

Figure 10-12 Example of an Over-hung Pit Latrine

Advantages: This maybe the only option in flood areas.

Figure 10-13 Over-hung Latrines Used in Bangladesh (Harvey *et al.*, 2004)

Disadvantages: This system is used only when the contamination of the watercourse has no adverse effect downstream and on water bodies where human activity is not envisaged. The super structure must be well constructed and safe for the users.

Appendix II – Sanitation and Waste Management Workshop Sept. 2005

The workshop summary was provided by Oxfam GB.
DAY 1 – Safe Excreta Disposal

Sanitation Ramblings - Key Note Speech: Steve Sugden (LSHTM)
Steve started by comparing internally displaced people (IDP's) and slum dwellers, identifying similarities and differences. IDP's contribute to urban population growth, lessons need to be learnt and shared between urban sanitation and requirements for IDP's. He looked at the meaning of sustainable sanitation and the concept of marketing sanitation as something demand driven, with customers rather than beneficiaries, and how toilets are marketed in developed countries. A dependency mechanism is often associated with freely provided latrines slabs. Health issues, normally endorsed by aid and development workers to promote latrines, are often well down the list of the user's priorities. Building a latrine is also associated with many uncertainties and risks; including high costs; unfamiliar materials; poor quality construction; etc. Steve stated our role as promoters of sanitation was to understand, enhance and develop systems that help families gain a latrine. The private sector role is to promote lifestyle and value, but also to make a profit. The private sector in particular includes small-scale providers.

Steve concluded, touching on the issue of emptying services in urban areas. Queries included contract type, which is as yet unclear. Steve is looking at service type contracts in the West and seeing what may be applicable? On marketing, the requirement for speedy implementation in emergency situations can make things difficult, but there is a need to understand where the customer is coming from.

The relationship between sanitation and health promotion was discussed. Are the two mutually inclusive? Or can sanitation be marketed irrespective of health promotion?

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Biogas in Rwanda: Patrick Kilchenmann (ICRC)
Patrick started by providing the historical context of prison interventions in Rwanda. The case study presented a biogas unit, both for excreta disposal and as a source of bio fuel in the prison kitchens, to reduce dependency on firewood. Details were given of the specifications of the design and the adopted technologies. The considered advantages over the alternative of septic tanks were primarily biogas production, higher efficiency in treating concentrated effluent, straightforward operation and maintenance and longevity.

After 20 days, 60% dry material reduction was achieved with some pathogenic destruction. Varying amounts of firewood were saved, at best around 30 - 50%, but more realistically around 10 - 15%. The digester cost was around $\$300/m^3$, including all pipe work and ovens. This compares with $\$25/m^3$ for a family-size digester in China and $\$96/m^3$ in Switzerland.

The advantages of introducing animal manure to aid gas production were discussed.

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Pour Flush Plastic Slabs:
J-F Fesselet (MSF-H).

Based on experiences in Aceh where the water table was exceptionally high and culturally there was need for pour-flush latrines.

The pre-tsunami norm, (porcelain pour-flush & shower, with side water tank), was the base model. A temporary solution needed to be found, with a minimum life of at least 3-months. Locally purchased plastic "bowl & pour-flush" unit offered a cheaper, lighter and easy-to-install solution. A timber superstructure was built over this. There were concerns over the small local concrete ring "Chin Chin" septic tanks, which were later replaced with more conventional septic tanks. Desludging was frequently required.

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Post Disaster Latrine Reconstruction - Gonaives, Haiti: Tim Forster (Oxfam)
The case study highlighted a response in a high-density peri-urban area with little space between houses, following hurricane Jeanne in 2004. An emergency programme was initiated and included water supply, excreta disposal but not waste management (Cash-for-work was not possible for security reasons). Existing latrines (if existing) were generally poor, many being pit latrines, in spite of the high water table.

Activities were directed at rehabilitating and reconstructing mainly school latrines, often better than those existing pre-hurricane. The aim was to meet Sphere standards, but this was not always possible due to limited space available. A standard design was developed using a raised chamber with simple pedestal toilet and composting tank. The latrines were designed for emptying every 1 - 8 years. Hand washing facilities were provided. Public health promotion (PHP) was undertaken using locally made posters, discussions with staff, and some child-to-child activities. The latrines were monitored 2-months after the project ended, with many units found to be nearly full?

Problems included; poor calculation of latrine life; maintenance problems; and lack of control over use. Many problems were attributed to lack of "ownership" by schools. There were no cleaners and a lack of user care. The poor quality of pedestal surfaces exasperated the cleaning problems. A lack of fences around schools meant everybody used the latrines. There were also problems with access to girl's latrines, which were often locked, keys being mostly held by male teachers. In general, soap for hand washing, was not provided by schools, this being considered an unnecessary expense.

A one-year monitoring programme was set up in June 2005, visits taking place every 3-months. PHP activities will take place with staff and children to try to overcome the difficulties.

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Post Disaster Latrine Reconstruction - Tsunami Toilets: Andy Bastable (Oxfam)
The presentation focused on excreta disposal in high water table environments following the Asian Tsunami, December 2004. Andy provided an overview of the initial emergency situation and constraints encountered with rapid latrine installation: peoples disliked direct drop latrines; need for sufficient clean-water (flushing and anal cleansing); need for frequent desludging (exasperated by high water tables); and access difficulties due to poor drainage. The aim was to meet Sphere standards.

Comparisons were made with other situations, i.e. Chad and Darfur, where the challenges are mostly around lining techniques in unstable soils rather than high water tables. In Aceh various types of U bend were tried. There were also debates about septic tanks and drainage fields infiltrating into the water table. Many "sealed" boxes were called septic tanks? Public health awareness in both Aceh and Sri Lanka was high. Latrines were later assigned to a few families to facilitate their cleaning and use.

The discussion included queries on progress to redesign the emergency plastic slab? Oxfam is looking at cheaper, lighter slabs made in India (including a water seal insert).

There was discussion over why a pedestal was chosen in Haiti? This was a community choice, as the pedestal model already existed.

Questions were raised about over what happens after desludging? Sludge disposal is something that needs to be considered in the design.

abastable@oxfam.org.uk

Septic Tanks for Emergencies: Bob Patterson & Raymond Gouck (BIPU)
A flat pack septic-tank system developed for the Australian army and used by Oxfam in Indonesia. BIPU was designed for use with pour-flush toilets and to provide safe effluent disposal to Australian primary treatment standards.

This is achieved through retention and digestion of solids within the BIPU tanks (at 30°C for 24hours, 90% solids retention is possible). BIPU's advantage is ease and quickness of assembly, particularly in high water tables. BIPU tanks are connected to an absorption trench, the design depending on site conditions. A site evaluation considers; area available; soil depth & permeability; seasonal ground water fluctuations; and climatic conditions (evaporation & transpiration). Alternative trench areas may also need to be designated.

BIPU uses 3 types of absorption trench: a Standard Absorption Trench (SAT), a Modified Absorption Trench (MAT(G)), and a Modified Adsorption Trench (MAT(E)). MAT (E) is useful in high water tables but does require a pump.

robpatterson@iprimus.com.au

Treatment Systems for Disaster Relief: Edoardo Piano (Arups)
The issues associated with wastewater treatment systems in disaster situations were outlined. These include limitations in space, long-term disposal, soil conditions and high water tables. The requirement for this project was for safe excreta disposal for 5000 people.

Various options were explored with a hybrid system of on-site "septic tanks" and off-site treatment consisting of trickling filter and activated sludge system contained within Oxfam type tanks. Results showed good organic removal, some solids removal, and disinfection by adding small doses of chlorine. The system recovered quickly from upsets & interruptions.

It is hoped is to develop the project further into a full-scale unit and perform field tests. The main system cost was estimated at £30 - 50k for 5000 people with £2k per month operation costs. This compares with £250 - 500k for a conventional package plant.

The appropriateness of such a plant, given it requires an existing sewer network, was discussed. Also, are relief agencies concerned about environmental pollution or more worried about disease pathogens?

Edoardo.Piano@arup.com

Public Health Promotion in Emergencies – Beyond the Hardware: Sally Crook (Oxfam)
What has to go with the hardware to facilitate appropriateness and sustainability? Sally provided examples of where PHP was used to improve and/or change the use of hardware.

Problems were linked to communication issues at project, programme and policy level. Three linked communication fields were identified to provide an information and dialogue-rich enabling environment: structural and "environmental" factors (policy issues), shaping the wider information environment, and community participation, dialogue and learning support. Policy issues include political commitment and social movements. Public information and peer pressure - do we reach into these opportunities when people's situations change, e.g. when they become IDP's? Community participation - how do we have discussions with people in emergencies? Dialogue and debate is difficult with short time scales. Who are we communicating with and how? Are we inclusive – women, disabled, elderly, etc? Delivery of messages needs to be emphasised without being top-down.

Finally, the importance of communication within organisations and across professional barriers was discussed. Gender was highlighted as being an issue still.

scrook@oxfam.org.uk

Excreta Disposal in Emergencies: Peter Harvey (WEDC)
An up-date on the Inter-agency project for a field-manual. The aim is to provide agency practitioners, both technical and non-technical, with practical solutions adapted to the emergency context, focussing on difficult environments. Based on the MSF public health engineering format, physical designs and bills of quantities will be provided. Feedback has been given by a number of NGOs. Expected completion date is June 2006.

Peter requested further case studies, based on field experience. Photos are needed, as are different designs, etc. Examples don't have to be fully proven or supported by research.

p.a.harvey@lboro.ac.uk

Ways forward with excreta disposal: Andy Bastable (Oxfam) facilitated the day's final session, collating thoughts on appropriate ways forward for excreta disposal.

- Direct drop and water seal slabs – to be discussed at the next Inter-agency meeting. Please provide comments to Andy Bastable or Joos V d Noortgate (MSF).

abastable@oxfam.org.uk
Joos.van.den.noortgate@brussels.msf.org

- BIPU – Brian Clarke from Surrey University will test the units. Oxfam are monitoring units in Indonesia and will report back.

- Experiences in Aceh and Sri Lanka revealed differing latrine designs. It was suggested these should be reviewed, looking at design quality and the consultation process.

- Coordination was recognised as a major issue. UNHCR and UNICEF have a mandate to co-ordinate in emergencies, and are currently analysing this role, as well as ways of actively doing it better.

vtobin@unicef.org

- Wastewater treatment will be looked at with support from Thames Water. Those interested in being part of a group looking at this should contact Tim Forster.

tforster@oxfam.org.uk

- Public Health Promotion – a need was identified to find different methods of communicating, different medias, how to do this better?

scrook@oxfam.org.uk

DAY 2 – Waste Management

Threats, challenges and opportunities: Martin Petersen (Golder Associates)
Martin looked at the composition of waste and what happens after a disaster. Some disasters produce large quantities of waste, e.g. several million tonnes in Aceh in one day. Enormous problems are created: waste piles up in streets; infrastructure is damaged or destroyed; staffs are new or inexperienced equipment is lost; Waste is low on the agenda!

Problems include: vermin; waste burning (acceptable short-term); and children playing with waste. When systems breakdown, dumping takes place in uncontrolled areas with potential for ground water pollution. Scavenging takes place, which is acceptable but there are health issues involved. Additional hazards include: non-separation of hospital wastes; risks posed by uncontrolled operation of plant; psychological problems associated with damaged buildings; and rubble lying around reminding people of what happened. Health and safety issues are also associated with handling waste, as well as local and global environmental issues.

There are negative livelihood issues: waste can impede reconstruction; drains and wells get blocked; waste is often taken out of town and dumped on agricultural land. Legal issues need to be considered – who owns the waste, what is the existing legislation?

Opportunities exist: in terms of recycling and income generation. Potentially, money can be made from waste, e.g. recycled demolition waste can be used for roads or for building blocks. Emergencies can create opportunities to improve on existing waste management systems, in particular hazardous wastes.

Challenges include: co-ordinating agencies doing similar things; sufficient human resources; logistics - particularly outside urban areas; awareness on dealing with waste? Strategically, what happens on day-1 should be considered to ensure it fits the medium/long term plan.

The Waste Management in Emergencies Group (WMinE) was set-up in 2002 and aims to become an operational NGO. WMinE provides free e-mail advice; a register of professionals; and is developing guidelines.

The importance of disaster preparedness was discussed. In some countries, (e.g. Caribbean), where extreme weather is common plans are already in place to deal with disaster waste. More often than not, however, such plans do not exist? Discussion followed on how plans could be developed? Moreover, WHO emphasises the need for quick waste clean up campaigns to raise people's moral.

mpetersen@golder.com
www.redr.org/WMinE

Waste Management in Sir Lanka after Tsunami: Claus Lillemark (Ramboll)
Claus provided a brief overview of the Tsunami in December 2004 with an emphasis on Sri Lanka. Ramboll's contribution to the waste management process was to assess: where funding was coming from; who was working in the waste sector; what the legal framework was; who were the local partners to work with; and what permission was required. Assessments were carried out in a 250km strip of coastline and landfills in southwest Sri Lanka.

A proposal, including a work plan for the clean up, media dissemination on waste issues (TV, radio and direct contact) was written. Initially, Sri Lanka employed a range of contractors and local labours, to inject money into the local economy. Activities were coordinated with the regular service providers, and health and safety training was given. Landfill sites were to be cleaned, waste being sorted into: compost material; items for recycling, e.g. tiles, bricks, etc; and disposable fractions. Collection centres were planned, final disposal taking place at existing landfill, or at temporary or new permanent sites. An exit strategy was required to consider what to do with plant and trained personnel?

CLL@ramboll.dk

Case Study – Post Tsunami in Indonesia: Martin Petersen (Golder Associates)
In Aceh, Tsunami waste was predominately organic, with some roofing asbestos, small quantities of industrial wastes, and bodies. Tsunami waste was mixed, resulting in a lot of double handling. Waste firstly being dumped in one area (often on agricultural land), before being moved to a new location later. Local government capacity was decimated in terms of staff and plant. Replacement plant is better sourced locally or nationally, as internationally donated equipment brings the obvious maintenance problems. A pre-tsunami informal recycling sector existed, so it was necessary to look at ways of getting waste to recycling centres. Cash-for-work paid people to clean up, but it often stopped there.

There was a general lack of co-ordination in relation to solid waste. NGOs duplicated or contradicted each other's work in the same communities. Rivers were used as dump sites, with obvious impact downstream. Awareness of effects on downstream livelihoods needed to be linked to upstream dumping.

In Banda Aceh, landfill was the best option early on but there was a lot of fly tipping at the city outskirts. Waste was mixed, clinical waste being mixed with normal waste. Legislation exists for hazardous waste in Indonesia but local authorities don't necessarily know about it (written in Jakarta). In a disaster, it's not always possible to separate waste early on, so dispensation from legislation may be required.

mpetersen@golder.com

Composting in Emergencies: Claus Lillemark
Organic waste can be composted to reduce overall volume, create a resource, and reduce the use of inorganic fertilisers, and potentially make money. However, quality is crucial, the benefits of compost are well known. Composting requires oxygen, mostly early on and less in the stabilisation period. High temperatures can be achieved early on. An 8 - 12 week maturation period follows stabilisation. During the composting cycle moisture content is reduced.

Shredding material accelerates the composting process as long as particles are of optimum size. Aeration is required early on to provide oxygen. Moisture must be sufficient so the process does not slow, but not excessive to avoid turning anaerobic. Mixing accelerates the process and weather can affect it too – not too wet, not too dry. The C:N ratio is important in the final product. Uncontrolled "back yard" composting is normal natural degradation but produces leachates. Medium sized windrows accelerate the process by controlling oxygen, moisture, and C:N ratio, giving quality end products.

Waste in the Maldives included both Tsunami and other wastes. In Hithadhoo, composition differed in urban and rural areas, rural waste having a higher organic content. Source materials were shredded, and then mixed with water and septic tank sludge. Phase-1 involved turning and adding water. In the reduction phase, water content is reduced. Final sieving and maturation follow the stabilisation phase. Larger fractions are re-composted. Log records assist process control.

The discussion highlighted the need to share experiences of composting and whether vermin were a problem? It was emphasised that with controlled composting, high temperatures are obtained; hence problems with rats or flies should be avoided. Pathogens in composting sewage sludge and excreta were discussed. It was recommended not to use sludge or excreta in low level "backyard" type composting, as pathogen destruction cannot be guaranteed.

CLL@ramboll.dk

Case Study – Health Care Waste: Dr Peter Lingwood
The composition of clinical waste includes all products of health care, including compressed gas cylinders. In a non-emergency situation 80% of clinical waste is non-infectious. Infections from contaminated equipment accounts for 1.3 million deaths worldwide. Often, there is an inadequate, or no system, to deal with clinical waste in many developing countries. The amount of waste will depend on where you are in the world. Separation at source is essential, as mixed waste is useless.

In emergency situations, normal structures breakdown. Waste from locations such as hospitals needs to be separated and stored securely. For example, a 3-bin system was set up in Banda Aceh, including a sharps box. Different colour plastic bags were used for different types of waste. Waste can then be stored in clearly marked, sealed oil drums. The best method of final disposal is a batch incinerator, ideally with ash collection.

In Kosovo, doctors were collecting their own clinical waste but had no method of disposal available, so did so in their gardens. The idea was to collect clinical waste from towns and take it to regional centres, where it could be incinerated at town hospitals, but logistical problems hampered this. A particular problem in Pristina was, hospitals had to destroy pharmaceuticals sent from the West, which had all passed their sell by date!

The discussion highlighted the need for care in incinerating expired drugs because of toxic fumes. There is a checklist on WHO website.

info@ceconsultants.co.uk

Linking Sustainable Waste Management to Development: Dr Monsoor Ali (WEDC)
Monsoor gave an overview about the lack of waste management in most urban areas in developing countries, in particular slums. Affordability and cost are big issues.

In Kukes, Albania, the population suddenly increased due to refugees arriving. This placed a huge burden on infrastructure including waste management. Composition of waste changed and waste picking started. Tearfund, EU and others assisted by; increasing plant and bin capacity; training; and community education. However, municipal capacity was lacking and the city council showed little interest in running things. There was no opportunity for any cost recovery as 80% population were unemployed. EU standards could

not be met due to lack of capacity, and there was political pressure in relation to tendering contracts.

The key lessons were; the need to think about affordability in the long-term; the need to involve local agencies at the beginning; and to develop partnership but avoid dependency.

The discussion highlighted using emergency situations as a motivating factor to improve solid waste management services.

s.m.ali@lboro.ac.uk

Drum incinerator for sharps in rural areas and composting toilets in Surinam: Adrianus (Ton) Vlugman (PAHO)
Ton described a drum incinerator that reaches 700 - 900°C. Ash production is limited and combustion is good without smoke. The design has been improved with a cut out top and bottom so ash can fall into the pit below and can eventually be covered.

Composting toilets: Designed for excreta only, urine is separated out and can be used as fertiliser. Solids are collected in the drum, and either woodchips or sawdust is added. Drum contents are then added to a live compost heap, so sanitizing the compost (although this has not been tested). Final product is a good soil conditioner, helping reduce slash and burn.

vlugmana@sur.paho.org

Healthcare waste management manual: Joos v. d. Noortgate (MSF Belgium)
In reality, health care waste is either burnt or buried in a hole. A number of MSF publications were developed to provide information on ways of managing health care waste, from the acute phase to the stabilisation phase. Publications contain software and hardware Sections:

- Essential Water & Sanitation Requirements in Health Structures
- Health Care Waste Management in Low-income Countries

Both publications promote participatory methods and waste separation. A separate manual exists for incineration, based on the modified De Montfort model.

- Incineration in Health Structures of Low-income Countries

Other manuals include:

- Safety-box Reducer – Construction and Operation Manual
- Waste Zone operators manual

For Hazardous wastes such as expired medicines and chemicals

- Hazardous Waste Management within the Health Structures of Low-income Countries

All drugs used by MSF (French & English) are listed and 4 - 5 disposal options are given. Publications provide general recommendations but need to be adapted to legislation, cultural and local constraints.

A CD-Rom of manuals can be obtained from:

Joos.van.den.noortgate@brussels.msf.org

Waste Management in Grenada post Hurricane Ivan: Tim Forster (Oxfam)
The aim was to improve access, clear roads of hurricane debris, provide a feel good factor, reduce disease vectors, and to inject cash into the community. WMinE Group provided

advice. Corrugated sheets, masonry, asbestos sheets, and vegetation were separated. Cash-for-work injected money into the local economy.

An evaluation found that the communities, the local authorities, and the donors appreciated the programme. The watsan committee was based around waste not water. A high proportion of participants were women.

Information about this case study will be placed on the workshop CD-Rom.

tforster@oxfam.org.uk

Solid Waste Management Inter-Agency Cooperation: Martin Petersen (Golder)
Martin's focused on looking for a way forward with waste management in emergencies. Waste was described as a killer and all actors need to be involved getting waste higher on the agenda. Timely and sufficient resources are required and there is a need to look longer term when dealing with emergency situations.

There are a lot of guidelines out there: MSF, Oxfam, WHO, Sphere, World Bank Technical papers, etc. They need to be disseminated and used. Watsan has come a long way and waste has to catch up. Preparedness is all-important; we know certain disasters are going to happen.

A lead agency needs to call waste co-ordination meetings. A generic plan needs to be agreed; to conduct assessments; hazard ranking; options; design and implementation. Inter-agency emergency waste management guidelines are required along the lines of MSF manuals.

mpetersen@golder.com

Where to now? Dr Peter Lingwood
Peter reiterated the messages of the previous session - a need for heightened awareness and to bring waste management into emergencies at an earlier stage. There is a need to lobby for better co-ordination and to address local governments on waste issues in country. Guidelines should be limited to emergency situations but need to take you further. Proposed guidelines need to look at assessment, resource evaluation, prioritisation, uses of different wastes and accessing funds.

info@ceconsultants.co.uk

End Discussion:
The day was rounded up with a look at ways forward in waste management:

- Target – technical guidelines. Look at different scenarios and contexts, generic processes. OK for implementers (NGOs and staff) but donors may require a different format? Useful to know what to look for in terms of hazardous wastes?

- Core emergency work is not around natural disasters. Focus should include our more usual work including urban and peri-urban contexts.

- Need for preparedness, to enable a more rapid response. Also need to link to long-term development so there is a better chance of success.

- Waste management is an integral part of watsan programmes. A need to make practitioners more aware of WM and more training required, e.g. Red R.

- Next step: round robin email for suggestions and inputs Draft one page proposal for WM guidelines, develop working group and feed in practical case studies.

www.redr.org/WMinE

For copies of workshop presentations go to:

http://oxfam.org.uk/what_we_do/emergencies/how_we_work/manual_excreta.htm

Appendix III – A Review of Ecosan in Uganda

Ecosan practice in the south-western part of Uganda (Graham-Harrison and Low, 2005).

Excreta reuse is not a new concept in Uganda as food cropss have been planted on filled traditional pits. The ecosan concept as it is known today was however started in 1997 with the South-Western Towns Water and Sanitation Project (SWTWSP). This concept is promoted by government as an option for problematic environments such as collapsing soils, high rock or water table.

The government of Uganda through the ministry of Water, Lands and Environment is playing a leading role in promoting urine diversion toilets as a means of protecting ground water. It has constructed a number of urine diversion toilets countrywide. For health reasons and to prevent pathogen transfer, reuse of faeces has however not yet been promoted until proper handling systems are established and widely disseminated.

About 506 "ecosan toilets" – urine diverting dehydration toilets were constructed in this part of the country by May 2003. Out of these, 437 are at household level, 36 are at institutional level and 33 are public facilities. Most users chose ecosan technology because it is hygienic (if used properly) and also because it does not require large amounts of water for its operation. In addition, it can be situated in the house and it is cheap to run.

The idea has been copied by other institutions e.g. nursery schools and petrol stations and has also been developed on individual initiative. However, a majority of the users comment that they built the toilets strictly as a sanitation facility and not for supporting agriculture practices. But this may well change over time so it is a good step in the right direction.

Appendix IV –EcoSanRes Yahoo Groups Discussions

This was the first posting to the ecosanres forum asking for information.
*/**Elisabeth von Muench** <stevenhorn@planet.nl>/* wrote:

Hi,
I am posting this on behalf of another MSc student of mine, who is due to finish next month:
==========
My name is Helen Mwase, I come from Uganda and I am currently carrying out a research for my postgraduate degree (MSc) at UNESCO-IHE in the Netherlands (thesis title along the lines of "the potential of ecosan to provide sustainable sanitation in emergency situations focussing on developing countries").

Ecological Sanitation is being practiced in a number of developing countries but has generally not been applied during (or immediately after) emergencies in those countries. I am collecting case studies from developing countries - analysing the excreta disposal facilities built immediately after the desaster/emergency and whether ecosan would have been a better option or not. I have so far studied the case studies of El Salvador i.e. the post hurricane Mitch project carried out by Doctors without borders Holland, the Afghanistan Kabul environmental sanitation programme by the International Committe of the Red Cross (ICRC), and the recent Pakistan earthquake disaster by Doctors without borders Holland. The information I have obtained so far points at implementation of ecosan-compatible facilities after emergencies i.e in the case of El Salvador after Hurricane Mitch, and for Kabul. In brief the observations show that for the case of Kabul the people were using a similar kind of technology (although poorly managed) before the disaster and this made it faster for implementation/improving the technology for the people. In case of El Salvador the people were using pit latrines before the disaster but because of awareness-raising and also because some parts of the country were using ecosan-compatible toilets (Le Latrine Abonera Seca Familia - LASF) the people warmed up to this kind of technology. In the case of Pakistan, the people are used to water borne sanitation, however because of disruption in the water supply brought about by the earthquake, aid agencies constructed the traditional pit latrines - and people are now using them.

Does anyone have any information / reports of any region in the developing countries where ecosan has been applied in emergency situations or where conventional solutions have been applied but where ecosan would have been better? - I have been trying to get some case studies on the *Tsunami disaster* but in vain! Does anyone have any information with regard to the post-Tsunami emergency sanitation facilites used and why. Due to the high groundwater table in many affected areas, the practice of quickly putting pit latrines in place may be particularly worrysome (?).

In trying to implement ecosan during emergencies, I have established a few criteria that should be considered for its quick implementation (or for deciding against ecosan). These include: ground conditions, level of water table, awareness amongst the affected population, population density, type of emergency, and location of emergency. Does anyone have further suggestions or comments about these criteria. I am also still trying to come up with realistic limits to some of the criteria for instance population density, does anyone have any comments or ideas about it?
I look forward to hearing from you. Helen (and Elisabeth)

-------- Original Message --------
Subject: Re: [EcoSanRes] Sanitation in emergency situations (developing countries) - what role could/should ecosan play?
Date: **Fri, 24 Feb 2006** 23:25:10 +0800
From: **heinz-peter mang** <heinz-peter@worldtoilet.org>
Reply-To: ecosanres@yahoogroups.com
To: ecosanres@yahoogroups.com
References: <20060224050131.47236.qmail@web51507.mail.yahoo.com>
<20060224144752.94560.qmail@web31105.mail.mud.yahoo.com>

Dear all,

working in emergency situations for sanitation is looking for today and the future at the same time.

All what is/was constructed as an emergency shelter should be rapidly decommissioned after some time of use, without danger for groundwater, nature, environment and future use of the area. This is another view of sustainablility. That means also here the sanitation loop has to be closed, but the fruits of reuse could often not be earned by the same users.

In transitional shelters people staying sometimes for years, but they have often no future at the same place, and therefore often humans are not willing to care about the environment as they have no identification with it and no ownership. Ecological sanitary solutions should respect this type of public ownership and look for individual and group benefits of clean and healthy public toilets. Happy toilet, healthy people!

When permanent shelters are designed and operated, than no other criteria as applied for 'normal' settlement planing should to be considered. Ecological sanitary solutions should respect housing density, gardening space, agricultural relationship, landscaping aspects, culture, overall health and hygienic criteria, gender, practicability, economy and so on ..... to be sustainable, too.

For all three levels ecological sanitation solutions are available, but - as Arun wrote - they are often not known and experienced by the impatient designers and architects of such shelters.

Therefore, WTO with their World Toilet College started last year to be a multi-cultural & mobile train-the-trainers insitute to cooperate with all willing international and national emergency organizations and responsible governmental bodies to take over responsible steps for the introduction of sustainable sanitation for all people, also in emergency situations.

There are many open questions, let's cooperate!

Toi toi toilet ..., Heinz-Peter Mang
Principal of the World Toilet College (WTC) & Bio-Energy and
Eco-Sanitation Expert at the Chinese Academy of Agricultural
Engineering

Ina Jurga <inajurga@yahoo.com> wrote:

dear elisabeth, dear all!

for other case studies and discussion about this topic, pls contact Elisabeth Huba elisabeth@wolrdtoilet.org working in the international team of the WTO , introducing and implementing ecological sanitation in tsunami regions of Sri Lanka and Indonesia- Banda Aceh and Meulaboah .

(i mailed this information to your colleague
Annette before, but your student seem not to have
contacted Elisabeth yet ....)

greetings
INA JURGA
>----------
Chinese Academy of Agricultural Engineering
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jurga@ieep.net

RS Arun Kumar
MSc (Environmental Management)
National University of Singapore
Singapore

Archives are available at http://groups.yahoo.com/group/ecosanres

Subject: Re: [EcoSanRes] Sanitation in emergency situations (developing countries) - what role could/should ecosan play?
Date: **Fri, 24 Feb 2006** 15:50:11 +0000 (GMT)
From: **Patrick Bracken** <pocb123@yahoo.com>
Reply-To: ecosanres@yahoogroups.com
To: ecosanres@yahoogroups.com

Dear Helen (and Elisabeth),
I find this topic to be particularly interesting and would like to thank you both for bringing it up. Having had a very slight brush with emergency sanitation before I heard of ecosan, ecosan in emergencies is

something I have thought about quite a bit.
I think that before launching into the general discussion of site specific criteria however it is important to look at the broader boundary conditions. 2 things here would seem to me to be very important:

1) The type of emergency (which you mentioned)
Is it of sudden on-set (an earthquake), or slow on-set (drought)? Are people displaced or still in their own homes (or what remains of them)? What was the effect of the emergency on the existing infrastructure etc.
In many cases, particularly if displaced people are involved and perhaps
even more so when they are no longer in their own country, there is often very little interest to install any infrastructure whatsoever – or only the most makeshift. Governments do not want refugee camps to become permanent fixtures, let alone to avail of sustainable sanitation facilities. This is one of the reasons why even relatively old camps of displaced people do not avail of permanent facilities. On the other hand, if people are in their own homes, but the existing infrastructure is destroyed, there is a clear opportunity to rebuild and to already begin installing sustainable systems in the direct aftermath.
The type of emergency (and maybe even more so the status of those affected) will therefore in my opinion influence the final choice of sanitation system. Even if ecosan makes more sense, political will may not be in favour.

2) The phase of the emergency
Emergencies generally run their course from an immediate, urgent phase, through a stabilisation period, to a recovery and eventually a resolution phase. In my opinion it would be a fair argument to say that at different phases, different interventions may be more suitable, depending on the context. Therefore, in the initial, panic phase, time is off the essence – rapid, cheap, and effective measures are essential to ensure that in the hours and days following the emergency (assuming it is a sudden event) excreta and wastewater is safely managed. A possible first response, even before pit latrines, is the identification of a defecation field – with the field simply being filled, according to a grid, with excreta, which is deposited in a hole and covered.

I could therefore imagine that in the situation where tens of thousand are suddenly homeless, it would prove extremely difficult to rapidly install sufficient UD toilets, set up the logistics chain to ensure regular emptying and sensitise people as to their proper use if needed, and ensure a safe and productive end use. However, as time goes on and a more measured programme can be planned, more sustainable systems could be introduced. I think this would be the moment to introduce pre-fabricated kits or similar and to begin planning the new system.

With regard to your other criteria, it could be well worth taking a look at a book published by WEDC in 2002 – "Emergency sanitation assessment and programme design". Its also available on CD. It has a Section on selection criteria for excreta disposal systems – all conventional, but very well thought out. Another book that is definitely worth getting hold of from an engineering perspective is Engineering in Emergencies; A practical guide for relief workers, J. Davies & R. Lambert (1995) Intermediate Technology Publications Ltd.

Before I forget – regarding ecosan in Zambia and the existence / non-existence of urban agriculture there. When I was there I did notice that every green area was planted, at the very least with maize, although I was told that the people had no interest in UA. As I did not spend any real time there I left the country very unsure about the whole thing. However I found a study by Axel Drescher (Uni Freiburg, Germany) which seems to confirm my impressions. The study is called "Urban Agriculture in the Seasonal Tropics of Central Southern Africa: A Case Study of Lusaka, Zambia" and is on the net.
Good luck with the study and all the best,
Patrick

-------- Original Message --------
Subject: Re: [EcoSanRes] Sanitation in emergency situations (developing
countries) - what role could/should ecosan play?
Date: **Fri, 24 Feb 2006** 06:47:51 -0800 (PST)
From: **RS Arun Kumar** <arunrs123@yahoo.com>
Reply-To: ecosanres@yahoogroups.com
To: ecosanres@yahoogroups.com

Dear Elisabeth

I would like to put in my thoughts in to the discussion of the role of Ecosan in emergency situations.
I feel that during emergencies say like after earthquake and tsunami, the scenario is totally devastating. worldover, all NGOs pour in their resources and help in rebuilding life and livelihood. Ecosan has a very bigger role to play. Let me explain how:

1. Before the disaster, the system of sanitation is set in to the traditional way. But after the disaster, things are getting into place from scratch. This is a very viable and potential opportunity to put forth the principles of ecosan onto the people. NGOs are rebuilding houses, and a slight shift in thinking beyond the conventional sanitation system would do a great deal of impact in the long run.

2. During emergencies, the priority is to build lives and livelihood. There is no or very little opportunity to try and change the practices they have been following all these years and before the disaster. The mindset is just not there. They find their homes destroyed and the least they want is a shelter on thier heads. Thereby, the ecosan system should be inline with their practices. Given the range of technologies in ecosan, this should not be a big issue. But I stress that this situation is not ideal for trying out to change the mindset of people.

I write this because I am working as Research Manager at World Toilet Organization and am a part of the Ecosan Team working in the tsunami affected areas of Meulaboh and Banda Aceh in Indonesia.

The other pathetic situation I felt is that all the "infamous" world organizations working towards relief do not have any idea about what to do towards blackwater management, and honestly, they want to come back to Meulaboh and Banda Aceh and to all the other places they are presently providing relief, to provide medical relief for people suffering from endemics. I am sorry if I have sounded a little too disheartened. That's not the case. Instead, I feel the kind of opportunity missed out in providing proper sanitation thereby reducing the no. of people without sanitation by a few thousands.

Every drop counts, every toilet counts!!!

Thank you

With warm regards

Arun

-------- Original Message --------
Subject: Re: [EcoSanRes] Sanitation in emergency situations (developing countries) - what role could/should ecosan play?
Date: **Thu, 23 Feb 2006** 13:47:38 -0800 (PST)
From:**Kent Madin** <rett139@yahoo.com>
Reply-To:ecosanres@yahoogroups.com
To:ecosanres@yahoogroups.com

Hi Elisabeth,
I think that what you propose in terms of guidelines or even "kits" for installing emergency UD toilets makes lots of sense. If done right, just the positive association with them as part of the solution to a disaster would help with ongoing local acceptance and integration of the idea.

The reason I asked is that there are so many variations on the actual UD toilet. Some people create toilets using outhouse like "bench" seats with a hole cut out and cut off plastic bottles as the funnels, others have fiberglass molds to make either fiberglass or cement toilets. From China you can get the plastic squat type that were tried (with

little success) in Mongolia even though the cost was just $5 US per unit.

It seems to me that coming up with a standardized and already mass produced toilet (We call the kind you sit on that are sort of straight walled and round, like in an outhouse in US Parks a "riser") is critical to what you are proposing for emergency use. Having a good supply of the toilets already to go, plus a very simple design for the vault/toilet enclosure seems critical.

We have been hunting about for suitable risers to use in Mongolia. I attach photos of the best we have found so far, manufactured in South Africa. We would like to encourage the Chinese, who have the plastic molding capacity, to make a similar UD toilet. But to accomplish what you are talking about, using UD toilets in an emergency as both the best public health solution but also the best way to introduce the concept, seems to me to pivot on having a lot of standardized toilets staged with emergency relief supplies.

One idea we have for the city use is to see if we can convince some Chinese plastic molders to build a vault which integrates a hole for the vent, a hole for the riser, a door for accesing the faeces container and a holding tank for the urine. This would be following the model of companies like Romtec in the US who sell what are essentially VIP toilets, (not UD) for National Parks and other remote public installations which are still accessible by tank truck for periodic removal. Romtec (www.romtec.com <http://www.romtec.com/>) makes "kits" that include a rotomolded vault which is then buried with a backhoe. The vault has all the fittings to attach vent pipe and toilet and a variety of choices for the actual toilet house. But Romtec doesn't make a UD toilet riser and apparently has never heard of the concept.

So I guess I am saying that there may be some synergy here between finding applications for, for instance the "ger neighborhoods" in Mongolia and the need to develop and refine a "kit" that could be used in emergencies. If a system could be developed that has the capablity to store the urine (or run it out into a drain field), integrated with a UD toilet and a simple way to remove the faeces container (like half a 50 gallon steel drum) and then just pour some fuel on it and incinerate it (in emergency conditions) it would potentially work for both single families and emergencies.

But the key seems to me to get a standardized toilet/riser with UD capability designed and then mass produced for cheapness. The toilet from South Africa is only about $24 dollars (I realize that is still a lot) but much cheaper than what is made in America. The Chinese are making the plastic squat toilets for about $5 per unit if I recall correctly. Perhaps they can be encouraged to see how cheaply they can make a riser version of the UD toilet.

anyhow just some thoughts.. Kent

Kent Madin wrote:

Dear Elizabeth,
What kind of UD toilets would you envision using in emergency situations and where would you get them? I mean the actual seat/riser
with the ability to seperate the urine.
Kent Madin

/Elisabeth von Muench <stevenhorn@planet.nl>/ wrote:

Dear Kent,

We don't really have a particular toilet in mind for our research (although, I guess that for many emergency situations in developing countries, the dry urine-diversion toilet might be most appropriate - assuming there is a lack of water). The toilet could be of the squatting or seating type. Whatever is most appropriate for a given country could be used (why did you ask about the seat/riser?).

The underlying larger issue of our research is this: if the aid agencies are rushing in after an emergency and are quickly putting in a sanitation solution (most of the time pit latrines) could there be scenarios where they could instead install e.g. UD toilets and work towards an ecosan solution? I mean if there is money for sanitation suddenly available then maybe it should be invested in something sustainable - especially given that these "make-shift" solutions that are put in after an emergency may be used for many months (sometimes years!) to come (people sometimes stay in these transitory camps for a long time; e.g. I read today that there are still people after the Indian ocean tsunami in temporary housing to this day).

We hope that maybe we can come up with practical guidelines for these aid agencies so that they can make quick decisions on the most appropriate sanitation type for a given situation rather than just putting in what they have always put in (i.e. pit latrins in most cases). We are working together with Doctors without Borders Holland on this one (MSFH). - So hence my question about case studies or experiences (or thoughts) that anyone in this group might have in that respect.

Regards,
Elisabeth

-------- Original Message --------
Subject: Re: [EcoSanRes] Sanitation in emergency situations (developing countries) - what role could/should ecosan play?
Date: **Thu, 23 Feb 2006** 19:36:12 -0800
From: **Larry Warnberg** <warnberg@pacifier.com>
Reply-To ecosanres@yahoogroups.com
To: ecosanres@yahoogroups.com
References: <20060223143049.38024.qmail@web52005.mail.yahoo.com> <43FE1E0C.5030509@planet.nl>

Practical guidelines are needed for aid agencies to introduce Eco-San in emergency situations. After the Indonesian tsunami I saw photos of materials packaged in colorful red and blue 5-gallon poly buckets. Basic cooking and eating utensils were included in the container, which could also serve as a tool for various functions. I wrote to the UNDEP, WHO, and others suggesting that simple pictorial instructions could be included to show how the bucket may be used to safely collect, contain, and recycle through composting a family's urine/feces. No need to buy buy or build a riser, UD, or dig a hole. So far there has been no response from more than two dozen agencies I contacted. I did learn from this exercise that many agencies have emergency sanitation plans, written by engineers, funded by pump manufacturers, and encouraging centralized systems of collection and treatment for disposal. No mention of sustainability, conserving

water, recycling nutrients, or preventing pollution. It would be great to see Eco-San incorporated into guidelines for emergency situations.
Larry
www.solartoilet.com

Archives are available at http://groups.yahoo.com/group/ecosanres

Appendix V –Reports on Tsunami in Sri Lanka by the World Toilet Organisation

The following information is summarized from the mission report by the World toilet organisation (WTO) (Huba-Mang and Panzerbieter, 2005b) and (Huba-Mang and Panzerbieter, 2005a).

The WTO in cooperation with Habitat for Humanity Sri Lanka sponsored by the Lien foundation Singapore set out to establish 50 ecologically and economically sustainable toilets in the Galle region.

There was a wide range of technological sanitation options to be considered for each location.

In Thotagamuwa

For areas with high ground water, the system consisted of a toilet house, plastic septic tank and a vertical filter. Four steps to gain distance from the water table level to provide adequate treatment in the vertical filter elevated the toilet house.

The vertical filter has a surface area of 1.2 by 2.2 meters and a depth of about 1.25 from the groundwater level. The walls are made form concrete blocks with waterproof layers of plaster on both sides. Water is then distributed to the filter through three perforated pipes. A gravel cover of about thirty centimetres covers the perforated pipes to prevent smell. The filter bed is composed of rocks and gravel in the top half and is separated by a geo-textile from the sand in the lower half.

For areas with an even higher water table, the toilet is not elevated since the filtering of the septic tank effluent is performed in a long gravel bed, embedded in the top layer of the soil. To prevent infiltration of this water into the soil and flooding during rain, the gravel bed is wrapped in plastic sheets from bottom and top sides. The filter bed leads to an infiltration point where large plants withdraw some of the water and nutrients for growth.

In Mandana

The options included;

- Urine diversion dry toilets
- Household septic tanks with or without biogas production
- Small treatment plants with/without biogas generation, connecting the houses with a small sewer network; and
- Water and air tight septic tanks per household, emptying service (truck), treatment plant with/without biogas.

In Batticaloa

The existing system at the boy's orphanage of Ramakrishna Mission consisted of urinals with the urine collected through a ten meter open channel to a centralised partly covered collection pit to be used as fertiliser on their vegetables and fruits. Much of the urine was

not collected due to evaporation. Also the collection pit was used as a dump for other waste too.
The design was improved by constructing ten porcelain urinals on a wall over the existing channel. The urine is then led to airtight collection containers e.g. jerrycans through a pipe. The facility was roofed to protect the children form the sun and rain during use. Storage times are also considered before use as liquid fertiliser.

In general it was noted that;

- More care should be taken in positioning of the toilets, graves and wells
- Grey water must be considered within the wastewater concept – if the opportunity for reuse is limited
- If the community is used to sharing facilities a shared facility seems to be feasible
- Urine can be stored in jerrycans and carried to a storage tank before application to farms