Report

WaterAid

Assessment of urine-diverting EcoSan toilets in Nepal

WaterAid/Anita Pradhan

Photo: Research into the impact of urine on agricultural productivity

A WaterAid in Nepal publication

September 2008

Copy of the report can be downloaded from **www.wateraid.org/nepal**

WaterAid

WaterAid's mission is to overcome poverty by enabling the world's poorest people to gain access to safe water, sanitation and hygiene education.

Preface

Ecological sanitation (EcoSan) is increasing recognized as a realistic alternative to provide safe sanitation and to thereby reduce the health risks associated with poor sanitation. It has been found that it not only protects water resources and enhances soil fertility but also optimizes resources management.

Many organizations, including government and non-government agencies as well as some international agencies, are involved in promoting this technology and there is an increasing level of awareness on EcoSan and its benefits among professionals and policy makers. Despite positive development on this technology and its effective use, there remains a lot of work to be done before a real paradigm shift in sanitary provision can occur whereby people do not equate sanitation to merely access to toilets but rather to total and ecologically sound sanitation. It is in this context that WaterAid in Nepal and Environment and Public Health Organization conducted this study to assess the performance of EcoSan toilets, and to build awareness amongst sector professionals and users on the technical and financial aspects of EcoSan.

The study was carried out by a team consisting of Bhushan Tuladhar, Prem Shrestha, Mingma G. Sherpa, Prajwal Shrestha, Rajendra Shrestha, Ishwar Shrestha, Pragya Shrestha, and Punu Duwal. In addition Ms. Julia Schimdt also helped in finalizing the report. The study team also immensely benefited from the experiences of other organizations involved in promoting EcoSan in Nepal, including DWSS, D-Net, CIUD, Lumanti and NEWAH. Finally, we wish to thank all the community members who provided the study team with valuable information during the survey, field visits and focus group discussions. The collective contribution of all these individuals, one way or the other, played an important role towards the successful completion of this study.

WAN and ENPHO wish to acknowledge contributions by Dr. Roshan Raj Shrestha, Chief Technical Advisor of UN-HABITAT Water for Asian Cities Programme in Nepal and Kabir Das Rajbhandari, Urban Programme Manager, WAN for their input, support and guidance.

In view of 2008 being declared the International Year of Sanitation, we hope that this study will be used to enhance knowledge in the sector and, more importantly, to advance sanitation in Nepal.

Sanjaya Adhikary
Country Representative
WaterAid in Nepal

Bhusan Tuladhar
Executive Director
Environment and Public
Health Organisation

Table of contents

List of tables

List of photos

List of figures

Acronyms

AEPC	Alternative Energy Promotion Centre
BSP	Biogas Sector Partnership-Nepal
DVUD	Double Vault Urine-Diverting (latrine)
CDM	Clean Development Mechanism
CIUD	Centre for Integrated Urban Development
CODEF	Community Development Forum
D-Net	Development Network
DWSS	Department of Water Supply and Sewerage
EcoSan	Ecological Sanitation
ENPHO	Environment and Public Health Organisation
FGD	Focus Group Discussion
NARC	Nepal Agricultural Research Council
NEWAH	Nepal Water for Health
NGO	Non Governmental Organisation
NRCS	Nepal Red Cross Society
NRs.	Nepalese Rupees
PFL	Pour Flush Latrine
SOPHEN	Society of Public Health Engineers
SWOT	Strength, Weakness, Opportunity and Threat (analysis)
VIP	Ventilated Improved Pit (latrine)
WAN	WaterAid in Nepal
WHO	World Health Organisation

Executive summary

Across the world, ecological sanitation (EcoSan) is increasingly being seen as a serious and realistic alternative for providing safe sanitation, reducing the health risks associated with poor sanitation, protecting water resources and soil fertility, and optimising resources management. The main features of EcoSan are containment of waste, sanitisation and re-use as plant nutrients and soil stabilisers.

The re-use of human excreta and organic waste as fertiliser is not new in Nepal. However, the concept of EcoSan in its modern sense was first introduced in Nepal in 2002, and since then more than 500 urine-diverting EcoSan toilets of various models have been constructed in different parts of the country. Several organisations, including government and non-government agencies as well as some international agencies, are involved in promoting this technology and there is an increasing level of awareness of EcoSan and its benefits among professionals and policy makers. However, despite this positive development there remains a lot of work to be done before a real paradigm shift in sanitary provision can occur whereby people do not equate sanitation simply as access to toilets but rather to total and ecologically sound sanitation. In this context, the Environment and Public Health Organisation (ENPHO) has conducted a study, with assistance from WaterAid in Nepal, to assess the performance of urine-diverting EcoSan toilets in Nepal.

The study has found that, overall, the development and promotion of EcoSan toilets in Nepal has been very good. Although most of these toilets have been built in the Kathmandu valley, the application of this technology has been slowly spreading to other parts of the country as well. EcoSan toilet designs have been developed and improved over the years to suit the local context. Different designs have been developed to cater for different needs, and innovations such as Wet EcoSan and Indoor EcoSan have also been developed locally. The study has found that most of the EcoSan toilets are being operated and maintained in a proper manner and most of the toilets are clean and hygienic.

The social acceptance of the technology is also very high as most users are satisfied with the performance. More than 71 percent of users feel that the EcoSan toilet is good while 19 percent feel that it is ok, 9 percent feet it is good but a bit uneasy and only 1 percent feel it is bad. Even among neighbours, 44 percent feel that the EcoSan toilets are good and 36 percent feel that they are ok. In houses where EcoSan toilets have been established,

all family members are using it on a regular basis and they are also involved in cleaning it and managing the faeces and urine.

Although the initial cost of EcoSan toilets, which is about Rs. 16,500, is slightly higher than ordinary pit latrines or offset double pit latrines, EcoSan toilets provide benefits in terms of fertiliser. A financial analysis of cost and benefits of EcoSan toilets indicates that the pay-back period for an EcoSan toilet is 9.09 years and the Financial Internal Rate of Return (FIRR) is 8.11 percent.

The EcoSan movement in Nepal has benefited from the support provided by the government through the Department of Water Supply and Sewerage (DWSS) as well as the efforts of various national and international organisations. However, there is a need for coordinated efforts and a clear strategy for institutionalisation and scaling up of EcoSan in Nepal. In this context, the system used for promoting biogas technology in Nepal may be a good example of a model for promoting EcoSan in Nepal in a planned and coordinated manner.

The main problem observed with the EcoSan toilets in Nepal was that 29 percent of the EcoSan toilets were not equipped with a urine collection tank. There are also some problems related to proper storage and handling of urine. As utilisation of urine is one of the main principles of EcoSan, this weakness needs to be overcome with better monitoring and training. Additional effort should also be put into the proper utilisation of collected urine. Although many farmers who use EcoSan toilets appreciate the fertiliser value of excreta and are using the collected urine and faeces either directly in their farms or for co-composting, there is a need for additional research and training on urine application.

Based on the findings of this study, the following measures are recommended as a way forward for regulating and scaling up EcoSan in Nepal:

1. Institute regulated system for promoting EcoSan by designing a system to standardise designs based on local needs, develop a uniform financing system and ensure quality control.

2. Use the agricultural sector, including research institutions and the large network of extension workers, to further promote EcoSan throughout Nepal.

3. Demonstrate EcoSan in different areas outside the Kathmandu valley - particularly in communities where availability of water and fertiliser is a problem and use of human excreta is not a social taboo.

4. Include EcoSan promotion in existing sanitation and agriculture-related projects and programmes.

5. Promote urine utilisation by ensuring that a good urine collection system, with 100 litre plastic tanks, and proper training is mandatory for all EcoSan toilets.

6. Demonstrate the concept of a urine bank that collects urine from different EcoSan users or from places where urine is produced in large quantities and then stores it properly and distributes it when there is a demand for it.

7. Reduce the cost of EcoSan and introduce cost effective models.

8. Promote organic fertiliser

9. Build local capacity by providing training.

10. Raise awareness of EcoSan through mass communication as well as interpersonal communication.

11. Conduct regular research and monitoring on the performance of EcoSan toilets.

12. Build effective networks for learning and coordination among individuals and organisations involved in promoting EcoSan in Nepal.

1. Introduction

1.1 Background

Access to improved sanitation is a major concern in Nepal as only 39 percent of the population have toilets and even in houses with toilets, the management of human excreta is often not carried out properly. Only about 12 percent of people are connected to sewer lines (CBS, 2004) and almost all of the sewage is disposed of into water bodies without treatment. Even where on-site sanitation options such as pit latrines and Sulav toilets have been promoted, there are possibilities of groundwater contamination. In this context, ecological sanitation (EcoSan) toilets have been introduced in Nepal as an alternative sanitation system.

Across the world, EcoSan is increasingly being seen as a serious and realistic alternative for providing safe sanitation, reducing the health risks associated with poor sanitation, protecting water resources and soil fertility and optimising resources management. EcoSan is a concept that completes the nutrient and water cycles by recycling human excreta and organic waste in order to close the loop between sanitation and agriculture. The main features of EcoSan are containment of waste, sanitisation, and re-use as plant nutrients and soil stabilisers. It also eliminates the use of water for disposing of excreta. EcoSan is therefore an ecosystem approach that treats waste as a resource and closes the material flow cycle instead of following a linear path with expensive transport mechanisms and end of pipe treatment systems.

The re-use of human excreta and organic waste as fertiliser is not new in Nepal. Many communities have developed systems for containing waste and using it in their fields, but this practice is disappearing as people adopt modern systems of sanitation where waste and excreta are disposed of through sewer systems or other waste collection and disposal systems. The concept of EcoSan in its modern sense was first introduced in Nepal in 2002, and since then more than 500 urine-diverting EcoSan toilets of various models have been constructed in different parts of the country. Several organisations, including governmental and non-governmental agencies as well as some international agencies, are involved in promoting this technology. There is an increasing level of awareness about EcoSan and its benefits among professionals and policy makers.

However, despite this positive development there remains a lot of work to be done before a real

paradigm shift in sanitary provision can occur whereby people do not equate sanitation simply to toilets but rather to total and ecologically sound sanitation. In this context, there is still a need to optimise designs, raise awareness and develop systems to scale up the application of EcoSan. There is also a need to develop the economic arguments for EcoSan and illustrate that it does make economic and ecological sense to recycle human excreta and close

Photo 1.1: Interviewing an EcoSan user

the loop between sanitation and agriculture. Therefore, the Environment and Public Health Organisation (ENPHO) has conducted a study, with assistance from WaterAid Nepal, to assess the performance of EcoSan toilets in Nepal.

Objectives

The main objective of the research study was to assess the experience of EcoSan in Nepal over the past five years, analyse EcoSan toilets in Nepal from technical, financial and social perspectives and recommend measures to scale up the application of EcoSan in Nepal.

1.2 Methodology

The following tools were utilised in conducting this study:

Litreature review

Various published and unpublished pieces of literature including project/ research reports, articles, books and brochures, related to EcoSan and its application in Nepal, were studied to review and analyse available information on this topic.

Questionnaire Survey

Based on practical experience and litreature study, three types of questionnaires and checklists were developed for field study:

- Questionnaire for EcoSan users
- Questionnaires for the neighbours of EcoSan users
- Checklist to be used during the observation of EcoSan toilets

The questionnaires were tested among six households to assess the practicality of the questions and type of expected responses. The results of field tests were discussed with experts and team members. Keeping the objectives and goals in mind, the questionnaires were then revised to make them more practical and user friendly. It was decided that the survey would be conducted

for all households that have been using an EcoSan toilet for at least one month. It was also decided to survey the neighbours of one in every four EcoSan users (25% of EcoSan users).

To conduct the household survey, 22 enumerators from nine different project sites were selected. Before the commencement of survey work, training was conducted to orientate the enumerators. During the orientation, the intention of each question was explained and discussed in detail and a general standard for evaluation of various parametres was set. Some skills necessary for the conduction of a survey were also discussed. To gain confidence, some practical work in conducting surveys was also done during the orientation training.

The enumerators for the respective project sites conducted the survey work. The questionnaire survey was done for each household using the EcoSan toilets for at least one month; the observation sheet was filled out for each household surveyed. For every four EcoSan toilets, one neighbour was selected and interviewed about their perception of it. The team members supervised the enumerators and the forms submitted by the enumerators were checked daily and any discrepancies found were corrected immediately.

Field observation

The study team members also made household visits to some of the houses in the project area. During these visits, the team members interviewed the house owner about their use of toilets and observed the EcoSan toilets. These visits were made with the help of local promoters. The use of EcoSan toilets by children and their attitude towards these toilets was also studied during the house visit. The use of dry faeces and urine in agriculture were also studied during the visit. In addition, some of the farms, where urine and faeces were used, were also visited.

Focus group discussion

After the completion of the questionnaire survey, focus group discussions (FGDs) were organised in each of the project sites. Open discussion about the use, importance, advantages and disadvantages of EcoSan toilets were done during these focus group discussions. The preliminary results of the study in the respective project sites were also discussed. As well as going over the good and bad points of EcoSan toilets, there were very fruitful discussions about the steps to be

Photo 1.2: Focus Group Discussion in Siddhipur

taken in future in order to scale up the EcoSan toilets. The participants of these meetings gave some very important suggestions for the promotion of EcoSan toilets. Separate focus group discussions were also held with women and elderly users.

Interviews with key informants

People who are involved in the promotion of EcoSan toilets, people who have been using the EcoSan toilets for a long period, social leaders, some local level politicians, technicians, engineers and some sociologists were interviewed to gain their input on the use of EcoSan and strategies for its promotion.

The study team members also visited almost all of the organisations involved in promoting EcoSan toilets, such as national NGOs, international NGOs, donor organisations, Unicef and the Department of Water Supply and Sewerage (DWSS), to gain feedback on their experiences.

Analysis of data

After completing all of the above stated activities, the obtained data was tabulated and analysed to prepare the final report. The draft report was discussed with key stakeholders and finalised based on the comments received.

1.3 Descriptions of the study locations

The 517-EcoSan toilets identified during this study are distributed in seven districts of Nepal. Most of the toilets are concentrated in peri-urban areas of the Kathmandu valley. As well as the Kathmandu valley, Gorkha and Parsa are two major districts where EcoSan toilets have been constructed. This study assessed EcoSan toilets in the following locations:

Siddhipur

Siddhipur is a traditional Newar settlement located in Lalitpur district about five kilometres east of the town of Patan. The settlement is dense and houses are built in rows. More than 90 percent of the residents are Newar farmers who traditionally use urine in the fields. Many of the houses in Siddhipur have *Naugas* where urine is mixed with ash and composted. The first EcoSan toilets in Nepal were constructed in Siddhipur and now there are about 100 such toilets distributed throughout all the wards of the Siddhipur Village Development Committee.

Khokana

Khokana is another traditional Newar community located in Lalitpur district about five kilometres south of Lalitpur. Most of the residents of this little town are farmers and the town is also famous for its traditional oil production technologies. The sanitary condition of this community is moderate, with about 70 percent of households using the toilets and the rest using open defecation practices. This is also one of the first places where EcoSan toilets were constructed.

Tokha

Tokha is another Newar community and is very famous for the production of *Chaku*, a product of sugarcane. Tokha is the collective name for two Village Development Committees - namely Chandeshori and Sarswoti of the Kathmandu district. This community is about six kilometres north of the Gongabu bus park of Kathmandu. The culture, tradition and life style of the people is very similar to that of Siddhipur and Khokana. The sanitary conditions and water supply situation are also moderate. About half of the population use some kind of toilet and people have public stand posts for their water supply. The occupation of the majority is also agriculture and the cultivation pattern is totally traditional.

Thecho

Thecho is a traditional Newar community situated five kilometres from Lalitpur Sub-Metropolitan City. About 60 percent of households in this area have individual toilets. EcoSan toilets were introduced in Thecho in 2005. Fifty were built initially, now there are 90 EcoSan toilets. Some of these EcoSan toilets are located in the neighbouring Village Development Committees of Dhapakhel and Sunakothi.

Imadol

Imadol is located just three kilometres east of Lalitpur Sub-Metropolitan city. The settlement has many ethnic groups with the dominant group being Newar. The water supply situation is comparatively good in this area and toilet coverage is high compared to other communities.

Sunga, Thimi

Sunga is a poor and socially marginalised cluster within Madhyapur Thimi Municipality. Most of the house owners with EcoSan toilets in this location do not have any agricultural land.

Lubhu

Lubhu is a traditional Newar community located east of Siddhipur. The EcoSan toilets have been built on the outskirts of Lubhu. The water supply situation in Lubhu is comparatively poor with all of the people depending on the public standpipes for their water supply. However, the sanitation coverage is quite good - about 75 percent of households have access to toilet facilities.

Tigani

Tigani is an old Newar settlement located in the northern part of Thimi Municipality. This place is famous for the traditional skill of making beaten rice. There are about 100 households in this community. Most of the families are very poor and only about half of them own agricultural land. The water supply and sanitation situation is fairly good due to public stand posts provided by the Nepal Water Supply Corporation and about 80 households have access to toilets.

Duwakot

Duwakot is situated near the famous temple of *Changu Narayan*, a World Heritage Site. The community is of mixed type with different ethnic groups. The water supply and sanitation situation is moderate with about 75 percent of people having access to toilets.

Gamcha

This is a small Newar community located in the southern part of Kirtipur Municipality. The village is famous for *Sya baji,* a kind of beaten rice. The majority of the people in this cluster are poor and illiterate. The water supply and sanitation situation is moderate.

Shankhamul

This is a squatter settlement along the northern bank of the Bagmati River in Kathmandu Municipality.

Sabithawa, Parsa

The site for the urine diversion pour-flush toilets outside the Kathmandu Valley is situated in the Parsauni Birta Village Development Committee of Parsa district. Parsauni Birta Village Development Committee, located adjacent to Birganj Sub-Metropolitan city, has three villages – Sabaithawa, Parsauni and Itiyahi. Sabaithawa village, which is spread over wards 1, 2 and 3 of the Village Development Committee, has about 200 households dominated by Koire and Adhir ethnic groups. About 80 percent of the population rely on agriculture. The major sources of drinking water are tube wells and dug wells. Only 23 percent of all households have toilets, and open defecation is common.

Gorkha

The project area is in Bhuin Chaur Village Development Committee ward number 8 of Gorkha District. The community is homogenous and all the people in the project location are from the Chepang ethnic group.

Surkhet

The toilets are built within the Birendra Nagar Municipality in the Mid Western region for demonstration purposes.

2. Sanitation systems in Nepal

Nepal is one of the least developed countries in the world with about 85 percent of the total population still living in rural areas with very few modern facilities and little development. Physical infrastructure in rural as well as many urban areas is very poor and water supply and sanitation is no exception. Many people still rely on traditional systems for water and waste management and even where modern systems for water supply and waste management have been introduced, operation and maintenance of these systems remains a major challenge.

2.1 Traditional systems for human excreta and waste management

Most traditional communities in Nepal do not use toilets for defecation. As Nepal is predominantly a rural and agro-based country, people usually defecate in open fields, along river banks or in forest areas. As a practice, many people in rural areas of Nepal say "*pakha jane*" (going to field) or "*bahir jane*" (going out) for defecation. In fact, until 1990, it was estimated that only six percent of the Nepalese population had access to toilets. In the past, as settlements were thin and there were a lot of fields and forests surrounding the households, the risk of disease transmission was small. However, now, with increasing population and dense settlements, the risk of disease transmission due to unmanaged faeces has increased and there is a need to use toilets in households.

Although haphazard disposal of waste and open defecation is practiced in many communities, some communities in Nepal had developed systems for recycling their waste, including human excreta. The Newars of the Kathmandu valley and the Sherpas living in high mountain areas are examples of such communities.

Waste management in Newar communities

Newars are the traditional inhabitants of the Kathmandu valley who

Photo 2.1: *Nauga* in Siddhipur

developed very advanced systems for urban development, with well planned towns, beautiful architecture and well functioning water supply systems, hundreds of years ago. Newar communities lived in dense settlements normally built on elevated ground and row houses were built around courtyards to maximise the efficient use of space. Within this urban design, the Newars also built systems for waste management. This system includes '*Nauga*', '*Saaga*' and the use of compost, made from waste and excreta, for agriculture.

The area under the staircase on the ground floor was traditionally known as the '*Nauga*' which litreally means ash pit. Ash from the kitchen was placed there along with urine and some agricultural residue such as straw. The high nitrogen content in urine helps balance the high carbon content in ash and straw to produce good quality compost, which was harvested and used in the field.

Photo 2.2: *Saaga* in Siddhipur

'*Saaga*' literally means compost pit. Each household, even in urban settlements, used to have '*saaga*' in the courtyard or next to the house, where waste was composted. Every six months the compost was harvested and used in the fields. In the olden days, all the waste that was generated by the household was organic in nature. Therefore, all of it could be composted. Although the *saagas* did have some problems related to drainage and aeration, overall it was a good system for managing waste at the point of generation and recycling it for productive use.

Many households also sold their waste or human excreta to farmers. According to Nepali (1965), in his book on Newar society, Newars sold their waste for Rs. 0.50 per tin. The tin probably had a capacity of about 20 litres. This clearly indicates that in the traditional system, waste and human excreta had a value and the Newars realised that it had to be recycled for effective management. Furthermore, they also realised that the waste generators themselves were responsible for managing their waste.

With increasing modernisation, the traditional system of waste

management has almost disappeared from the Newar towns of the Kathmandu valley. Most houses now use pour-flush toilets connected to sewer lines or septic tanks and the garbage is usually left on the streets for collection by the municipal sweepers. As a result of poor management of excreta and waste, the rivers in the Kathmandu valley are now extremely polluted and farmers no longer benefit from the use of human excreta.

Excreta management in the Sherpa communities of Solukhumbu

A typical Sherpa home is two or three stories high with wooden floors and walls of stone and mud. The ground floor or basement usually has an animal shed and a storeroom while the first floor consists of a combined living room and kitchen, bedrooms and a separate prayer room. A house may also have an attic, generally used for storage. Usually, houses have a traditional composting toilet either attached to the house or somewhere very nearby. A traditional composting toilet can be either a permanent or temporary structure, depending on the family's economic status. Locally a toilet is called a '*Chyakhang*' where *Chya* means manure and *khangba* means house. Thus the Chyakhang is a 'house for manure production'.

A permanent composting toilet has walls made of mud and stone. The floor of the toilet is a wooden platform with a hole or holes resembling a squatting pan.

Underneath the platform is the vault for faeces collection. These vaults are large to allow for manure storage, with heights ranging from six to ten feet. Temporary toilets have platforms made of wooden planks spaced wide enough apart to serve as multiple pans. As with a permanent structure, there is an open vault used for faeces collection and manure storage.

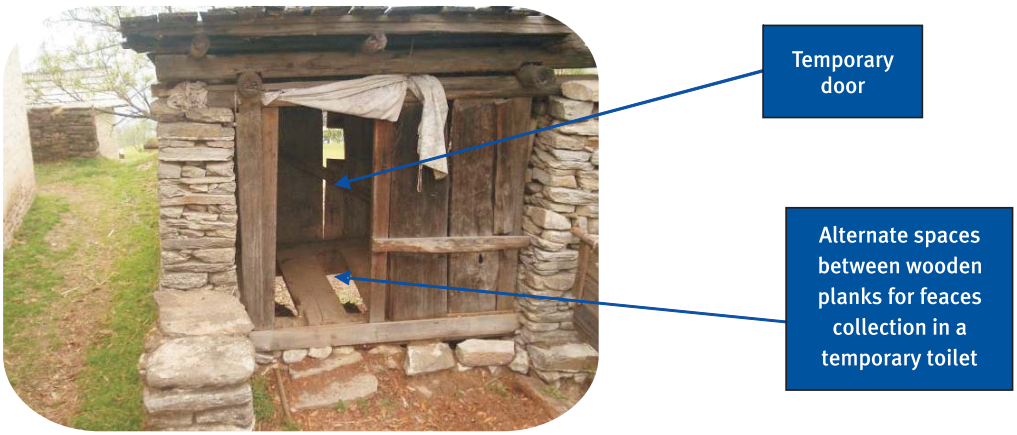
In the case of these traditional toilets, compost is made from human urine and faeces collected together with additives such as dried leaves, food waste and various green plant residues. After defecation or urination, dried leaves, locally known as '*sottar*', are added to the vaults. Once a month, an additional volume (1-2 *dokos*) of dried leaves is added to the vaults. Once or twice per year, green plants or '*titepati*', a locally available plant with medicinal value, is also added to the vaults. These additives help reduce foul odours and enrich the compost with additional nutrients. To maintain some moisture in the compost, food and vegetable wastes from the kitchen are added from time to time. In this area, compostable materials such as paper, leaves and corn shells are used for anal cleansing rather than water.

Compost preparation takes one year. The compost maturity coincides with the planting season for potatoes and maize in the autumn. About three or four weeks before planting time, the toilet is either not used or the manure is

removed from the vaults and piled up outside in the field. When fully matured and emptied from the vault, the compost is transported to the fields and mixed in with soil during field preparation. For mixing, the compost manure may be either ploughed or dug in with soil.

With tourism steadily increasing in the region, traditional composting toilets are slowly disappearing. Few

Photo 2.3: Traditional toilet in Solukhumbu



composting toilets are available in villages alongside trekking routes whereas villages untouched by trekkers still use them. Most houses in tourist areas now use pour-flush or flush toilets without any form of wastewater treatment. Lodge owners may have composting toilets for their own family's use, but expect that trekkers are more comfortable using flush toilets. The urine and faeces from flush toilets discharge directly into streams or groundwater and will eventually create unhygienic conditions and pollution of water bodies. Even without the influence of trekkers, traditional toilets are disappearing due to peoples' unwillingness to empty the vaults themselves, a diminishing interest in farming and the inability to find other people willing to perform such a job. Therefore, resourceful and environmentally-friendly traditional toilets are being replaced by modern 'sanitation' systems bound to disturb humans and animals living along the polluted water bodies.

2.2 On-site sanitation systems

In the absence of sewer systems, several types of on-site sanitation systems are being promoted in

Figure 2.1: Various types of latrines: Pit latrine, VIP latrine, offset pit latrine, EcoSan toilet

Source: DWSS Poster, 2006

Nepal. These include direct pit latrines, Ventilated Improved Pit (VIP) latrines, offset pit latrines, and flush toilets with septic tanks.

Direct pit latrine

Perhaps the simplest and least expensive form of toilet is the direct pit latrine. Construction requires digging a hole about one and a half metres deep and about one metre in diametre, then covering the hole with a slab made of wood, concrete, or other available material. The slab must have an opening somewhere in the middle so that a person may squat over the opening to defecate/ urinate. The pit itself may be lined with bricks, stones, concrete, or even bamboo, and the walls above the slab can be made of any material which would ideally ensure the privacy of the user. Once the pit is filled, the contents may be emptied and stored or buried in an appropriate place. Alternatively, the pit may be abandoned and the upper portion of the latrine placed over another pit.

Pit latrines are found throughout Nepal, particularly in places that cannot afford a more hygienic system. The direct pit latrine has the advantage of being economical, easily constructed from local materials and water conserving. However, these latrines can lead to serious health and environmental concerns. In areas with a high water table or where flooding is possible, including lowland areas of Nepal, pit latrines are likely to leak pathogens from faeces into the groundwater. Pathogens may include cholera, yellow fever, giardia, hookworm or other disease-causing viruses, helminths or bacteria. The pathogens can contaminate drinking or bathing water which may be pumped from groundwater wells or from groundwater that flows into surface water. Flies and other vectors (typically rats or insects) may spread disease from pit latrines by touching raw faeces and travelling around with pathogen contaminants. Another problem with pit latrines are odours that come from decomposing urine and faeces in a poorly ventilated environment. Such odours may make open defecation more attractive than using the latrine. Finally, these toilets make no use of the nutrients present in human excreta. This is wasteful and problematic in the long term.

Ventilated Improved Pit Latrine (VIP)

The Ventilated Improved Pit (VIP) latrine is a variation of the direct pit latrine. Constructed in a similar manner, the VIP latrine includes a ventilation pipe running from the pit to the outdoor air. Therefore, odours are reduced from this type of pit latrine but the problems of groundwater contamination, vector access and lack of nutrient re-use remain.

Offset pit latrine

Another kind of pit latrine that is more expensive but more aesthetically pleasing is the offset pit latrine, also known as the pour-flush toilet. In this system, the pit may be located a few metres away from the

squatting pan, with a pipe to carry excreta from the pan to the pit. Water poured from a small container is used to flush excreta into the pit, hence the name 'pour-flush' toilet. The excreta pipe should be short and steep enough that a minimal volume of water is needed for flushing. Some offset pit latrines have one pit, and others have two. For those with one pit, the pit must be emptied immediately when full. Given the high moisture content and the anaerobic decomposition process that has probably occurred in the pit, the odour may be extremely strong. Offset pit latrines with two pits are also referred to as '*Sulav*' toilets and are intended to be a sort of composting toilet. Once one pit is filled, it is closed off and the other pit is used for excreta. The contents of the full pit are removed after they have had time to further decompose into a material that is safe to handle.

This type of toilet is popular for people who are comfortable with 'flushable', water-consuming toilets in places with no available sewer system. However, the price of construction and maintenance cost associated with emptying the pits is high, especially compared with simple pit latrines. Also, this kind of toilet does not entirely deal with the problem of pathogens leaching into the groundwater. Unless the pit is completely waterproofed and sealed, a high water table will lead to contamination. Vectors are not a significant problem due to the air-tightness of a water-piped system, however, a lack of nutrient re-use with this system still exists. Some nutrients could be re-used with *Sulav* toilets if used appropriately.

Flush toilets with septic tanks

Septic tank-attached toilets are used in many parts of the world where sewer systems are not available. Septic tanks are similar to offset pits, except that they partially treat excreta by storing solid particles and allowing liquid to percolate through a soak pit. The toilet components include a squatting pan or commode and a built-in flush device.

While this system appears modern and is socially acceptable to all, there are some environmental deficiencies. The toilets, like all flush toilets, consume a great deal of fresh water which is quickly made dirty with urine or faeces. In septic tanks, pathogenic matter is not entirely removed from the liquid before it is released to the soak pit, leading to high water table groundwater contamination as in all previous systems. Also, after solids have built up in the septic tank to a certain level, the resulting sludge must be removed. This can be an expensive procedure that is environmentally harmful if sludge is not stabilised or treated before disposal into natural systems. Nutrients are not easily recoverable from the septic tank sludge once it has been stabilised.

Biogas-attached toilets

As of December 2006, Nepal had 157,675 domestic biogas plants. It is estimated that about 65 percent of

Photo 2.4: Newly constructed biogas plant with inlet for toilet

these plants are attached to toilets (BSP, 2007). Therefore, there about 100,000 toilet-attached biogas plants in the country. Almost all of these plants are of the fixed dome model. Most of the biogas plants (56 percent) have a 6 m^3 dome, but others can have a 4, 8, 10, 15 and 20 m^3 dome size. The toilets are similar to the pour-flush toilet with offset pit or septic tanks but the pipe from the toilet is connected to a biogas digester made of brick and cement. The biogas also has an inlet for feeding cattle dung. The gas produced due to anaerobic digestion of the dung and excreta is used for cooking or lighting while the slurry, which is removed from the outlet, is used as compost. As the system recycles human excreta as well as animal waste, biogas-attached toilets can be considered a form of ecological sanitation.

Biogas is an excellent system for sanitation as well as renewable energy because the organic waste is recycled to produce biogas as well as slurry compost. The system is relatively more expensive than ordinary toilets as a 6 m^3 plant in the hills costs about Rs. 31,515 (BSP, 2007). However, the government provides a subsidy of Rs. 9,500 per plant and the system has many benefits such as reduced cost of fuel wood and health benefits from improved sanitation as well as reduced indoor air pollution. Due to the relatively high initial investment and the need to have cattle as well, biogas-attached toilets are not appropriate for very poor families or for urban households. This system is also not very appropriate in water stressed areas as the dung has to be mixed with equal amounts of water before it is fed into the plant. This system is also not very appropriate for areas with a cold climate. However, for most rural households with some cattle, this type of toilet is a very good option.

2.3 Sewer systems

Perhaps the easiest form of toilet to operate, but also the most difficult and costly to install, is the flush toilet connected to a sewer system. The above-ground components are the same as with a septic tank flush toilet and have a squatting pan or

commode with a flush mechanism. Clean flush water is typically piped from the city water supply, and dirty water plus excreta from the toilet are flushed down a pipe leading to the larger sewer system. The sewage collected by the pipes is supposed to be collected and treated in large wastewater treatment plants. However, as establishment and operation of the wastewater treatment plants are difficult and expensive, raw sewage is often directly discharged into water bodies, thus causing water pollution.

As sewer systems require huge capital costs for corrosion-resistant pipes, excavation, pumps and wastewater treatment plants, they are not very feasible in areas with low population density. Some sewer systems have been built in urban areas of Nepal, but not all of them are functioning properly. Some of the most common problems associated with sewer systems are: high capital costs, poor design of the sewer network, clogging of sewer lines and discharge of raw sewage into water bodies.


ENPHO

2.4 EcoSan toilets in Nepal

In January 2002, ENPHO organised an interaction programme to raise awareness of Eco-san and explore the potential for its application in Nepal. Later that year, DWSS, together with D-Net, initiated a pilot project to construct ten EcoSan toilets in the community of Siddhipur in Lalitpur district and ENPHO, with support from WaterAid Nepal, initiated a similar project in Khokana, Lalitpur. Since then more than 500 EcoSan toilets of various designs have been established and there is growing interest in the technology.

This study found 517 EcoSan toilets had been constructed in Nepal by the end of 2006 out of which 487 were in operation. Most (93%) of the EcoSan toilets are located in the Kathmandu valley. The others are in Parsa and Gorkha with a few in Tumlingtar, Makawanpur and Surkhet.

Figure 2.2: Growth of EcoSan in Nepal

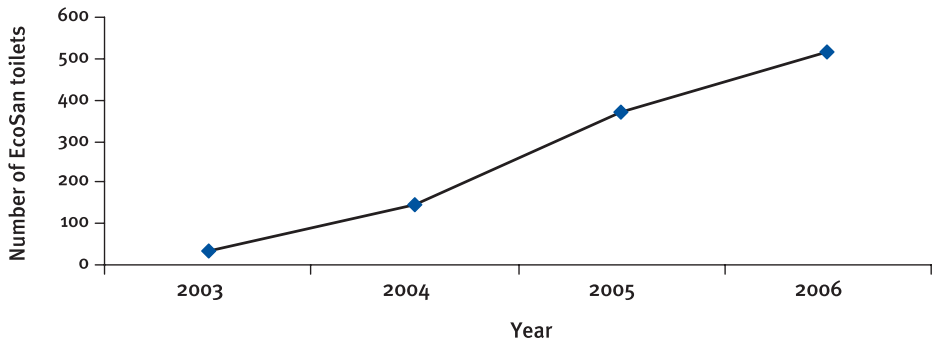


Table 2.1: Location of EcoSan toilets in Nepal

Cluster	Units in operation	Units under construction	Units not completed	Dismantled units	Units not in use	Total number of units
Siddhipur	95	-	1	-	-	96
Khokana	57	-	2	3	2	64
Lubhu	5				1	6
Imadol	12		1			13
Thecho	91					91
Gamcha	8					8
Sankhamul				2	2	4
Tokha	136	12				148
Bode	8			2	2	12
Thimi	4					4
Tigani	21					21
Duwakot	10					10
Private house/office	2					2
Gorkha	10					10
Parsa	20					20
Surkhet	2					2
Tumlingtar	4					4
Makawanpur	2					2
Total	**487**	**12**	**4**	**7**	**7**	**517**

Box 1: EcoSan champion: Gopal Dangol


ENPHO

Seventy year old Gopal Dangol proudly shows everyone the three 200-litre barrels filled with urine in his house. He has collected the urine from his EcoSan toilet and has borrowed some from high neighbours as well. He is saving it for use in his vegetable garden. Gopal lives in the small town of Khokana in the southern part of the Kathmandu valley where ENPHO, with support from WaterAid Nepal, initiated a pilot project to demonstrate urine-diverting EcoSan toilets back in 2002. Initially, ten demonstration toilets were constructed, but Gopal was not lucky enough to have one because of lack of space in his house. However, that did not stop Gopal from trying out the use of urine. He borrowed about 80 litres of urine from the people who had the EcoSan toilet and started using it in his own garden. From this he developed a urine collection system on his own. Since then, he has been a fan of EcoSan toilets and urine application and is a vocal advocate for EcoSan.

Gopal Dangol uses only urine, faeces and compost to grow potatoes and other crops and he has also allotted part of his farm for research into the impact of urine on agricultural productivity. He proudly says “I do not have to use chemical fertiliser and the potatoes are so good that people come in cars from far away just to buy my potatoes.” Now it is not just people coming to him for urine applied vegetables or advice - he is also often invited as a resource person to share his experiences during training and workshops related to EcoSan. He now speaks with confidence based on knowledge and experience and does not miss any opportunity to talk to people about EcoSan toilets. So far, 65 EcoSan toilets have been built in Khokana and Gopal Dangol was instrumental in motivating others to build the eco-friendly toilets.

3. Technical aspects of EcoSan toilets in Nepal

3.1 EcoSan toilets

Many of the toilets currently used in Nepal can contribute to the spread of disease. Toilets connected to sewage systems often empty directly into rivers and streams, while pit toilets can leach contents into groundwater, spreading pathogens from faeces and excess nutrients from urine into water bodies. Excess nutrients in water bodies can lead to excess algae growth which can deprive fish of oxygen and make water unsafe for human drinking or bathing. Pathogens from faeces can lead to disease for those bathing in, washing with and drinking contaminated water. For children and vulnerable individuals, diarrhoea and water-borne illnesses can lead to dehydration and death.

As an alternative to these harmful cycles, EcoSan's primary goals include:

- Prevention of disease
- Protection of the environment
- Recovery of nutrients

EcoSan stores faeces in a composting chamber where ash, lime or other additives are used to raise the pH of the waste and thereby break down pathogens. After about six months of storage without the addition of fresh faeces, the resulting material should be dry, rich, soil-like compost containing relatively few pathogens and may be used as a soil conditioner for agriculture. If EcoSan is installed and used properly, it assists in the prevention of disease.

Protection of the environment, the next goal of EcoSan, is accomplished on several levels. First, the use of urine as fertiliser rather than releasing it directly into the aquatic environments prevents problems such as eutrophication. Secondly, the environment benefits from the conservation of fresh water by not using water for flushing. Thirdly, the reduced need for chemical fertilisers when a family uses urine on their fields is beneficial to the environment. The minerals used to make fertiliser are typically mined and processed via environmentally destructive practices using large amounts of energy, water, explosives and harmful chemicals. Once produced, these fertilisers leak from

fields into ground and surface water, especially when applied in excess, and cause the same problems with excess nutrients as urine does in water. Finally, EcoSan users suspect that urine acts as a natural pesticide. By avoiding chemical pesticides, EcoSan plays a role in protecting entire food chains from the multiple ill effects of these chemicals.

The last important goal of EcoSan is the recovery of nutrients. Rather than the conventional linear path, where resources are continually used up and nutrients are disposed of into water bodies, EcoSan creates a renewable cycle of nutrients going from soil to plants to humans and back to soil again.

Ecological sanitation takes the nutrients present in human excreta and recycles them back into agriculture. This does not, however, mean applying raw faeces to crops. A key part of the EcoSan system is the destruction of most or all disease-causing pathogens before re-use of excreta as compost or liquid fertiliser. Results from scientific studies of pathogen destruction in EcoSan systems have provided us with guidelines for the treatment of urine and faeces before re-use as fertiliser.

Ecological Sanitation refers to the entire process of excreta containment, re-use and crop production. However, the physical component of EcoSan with which humans interact most frequently is the toilet. An EcoSan toilet must be carefully designed to accommodate the social and cultural norms for toilet design. It must make the user feel comfortable while still functioning to prevent disease, protect the environment and recover nutrients. There are multiple types of EcoSan toilets used in Nepal and still others used in other countries. The types can vary by design: type of pan or bowl, size/type of excreta chambers and component materials. These variations may depend on which materials are available, how much a family is willing to spend on the toilet, whether the family wants to use water for flushing or how often the family can fill and empty the faeces chambers. EcoSan toilets only make sense if a family is able to use or sell the faeces compost and urine fertiliser produced, if there are sufficient additives available for use in the toilet, if there is enough space inside or outside the house for construction and if the given location is warm enough to allow for sufficient drying of the faeces.

3.2 Types of EcoSan toilets

In general, two types of EcoSan toilets have been introduced in Nepal: urine-diverting dry toilets and urine-diverting wet toilets. Almost all of the EcoSan toilets constructed so far, except the 20 toilets in Parsa district, are dry toilets that have been based on the Vietnamese double vault model, with some modifications. Basic components of these toilets are two separate

watertight vaults with ventilation pipes for storage of faeces, a urine collection vessel and a system for diverting anal cleansing water. The vaults, which are separated by a brick wall, are constructed above ground level with brick masonry to avoid contact with ground water. The basic features of the dry toilets are presented below:

Vaults: In most cases, the volume of each of the vaults is 0.35 cubic metres and the height of the vault is normally two feet. The inner walls of the chambers are plastered with cement sand mortar.

Vault door: The vault door needs to be big enough to allow easy removal of the contents from the vault but it should not allow moisture to seep in. Several different options have been tried out for the vault door. In most toilets, a flush door of a size not less than 6"x 6" has been provided in one side of each of the vaults to facilitate the removal of dry content. The holes are closed with either a metal sheet, concrete slab or transparent PVC sheet.

Urine diversion system: A polythene pipe of 50 mm diametre is provided to divert the urine from the urine bowl to the urine collection vessel made of brick masonry, plastic tank or Jerry can. The size of the urine collection vessel varies from 20 to 100 litres. In the early days, a 50-litre capacity tank made of brick masonry was constructed at the side of each toilet to collect the urine. Nowadays, most of the toilets are being

Photo 3.1: DVUD EcoSan toilet

constructed with plastic urine collection tanks because they are inexpensive and there is less chance for leakage. The plastic tanks are generally of 100-litre capacity.

Anal cleansing: In the Dry EcoSan toilet, there is a separate hole for anal cleansing. The wastewater from anal cleansing is conveyed through a concealed pipe into a soak pit. Occasionally, the soak pit is also a small wetland with plants such as reeds planted on it.

Super structure: The outer size of the toilets is generally 5'x4'2" and all the brick walls are 4" thick.

The EcoSan toilets constructed within Nepal have some variation in design,

Photo 3.2: DVUD toilet under construction

construction materials and use. Some major designs are mentioned below.

Double Vault Urine Diversion toilets (DVUD)

The DVUD is a widely-used design of the EcoSan toilet. It is a modified version of a Vietnamese double-vault dry toilet and was used in the first EcoSan pilot project in Nepal. The DVUD has two separate watertight chambers for faeces storage with a ventilation pipe attached. There is one urine collection vessel, made of brick masonry, a plastic tank or a Jerry can. Newer versions often use a plastic tank (to prevent leakage) surrounded by bricks for support. The size of the urine tank varies between 50 and 100 litres, depending on the frequency of urine use as fertiliser. The faeces chamber walls are made of brick and plastered with cement and sand mortar in order to be water-tight. They have a masonry wall separating them. They are constructed above ground level to avoid seepage of faecal matter into the ground water even though the mortar should not allow it. Each chamber should have an internal volume of around 0.35 cubic metres with a height of only 0.6 metres (2 feet). An additional small chamber is made for the percolation of wash water. The outer walls of the toilet, placed above the chambers, are generally around 10 centimetres thick and made of bricks. The walls should enclose an area of 1.5 x 1.25 metres to allow enough space for the squatting pan and water bucket.

To facilitate compost removal from the faeces chambers, square openings of 6" x 6 " (or greater) are provided for each of the chambers. The openings are covered with a metal sheet, concrete slab, fiberglass, glass or transparent PVC sheet. Newer toilets use sliding-door style covers made of glass.

Near the urine storage tank there is a small soak pit for collecting anal cleansing water. This water is evaporated and disinfected by soil and by sitting in the sun.

Two-vault solar model

A few two-vault solar EcoSan toilets have been installed in Siddhipur and Khokana. The basic components are the same as the DVUDs except the faeces chamber access holes are kept at an inclined angle (rather than vertical) and chamber covers are made of sheet metal, painted black. When these black metal sheets are orientated towards sunlight, they heat up and cause the chamber temperature to rise as well. The black metal sheet covers are larger than

covers used for DVUDs because greater sunlight-exposed areas increase heating effects. With higher temperatures the faeces may dry faster, causing pathogens to die more quickly. Few of these models have been installed but they are comparable in price to DVUDs and are slightly more effective in drying faeces.

Single vault movable container type

The single vault movable container toilet is a dry toilet designed for indoor use. A plastic container mounted on a metal frame is placed directly below the squatting pan. This container stores faeces until it is full and then is replaced by a second container. The urine collection system is similar to that of a DVUD toilet and urine is diverted into a plastic tank. Anal cleansing water empties into another tank which must be poured into a soak pit periodically.

This model is ideal for households with limited space available for building construction. Currently there are five indoor EcoSan toilets of the single-vault moveable container type located in Siddhipur.

Urine diversion pour-flush toilets

The urine diversion pour-flush model, also known as Wet EcoSan, is essentially a modification of the double pit pour-flush toilet with an added mechanism for urine diversion. A special urine-separating pan must be used, as with other EcoSan models, and urine is collected in a separate container in the same way. The faeces, along with the water used for anal cleansing and flushing is, however, sent to a pit lined with precast concrete rings similar to a pour-flush toilet. After filling one pit, the other pit is used while the contents of the old one decomposes for six months. After a few years, the pit must be emptied. Unlike the dry toilets, anal cleansing water may be poured into the faeces chamber but urine is still collected separately.

Photo 3.3: Single vault EcoSan toilet

The pan for the Wet EcoSan is slightly different from the Dry EcoSan model as the pan is designed to collect water as well. Currently, two types of pans, one made from cement and another made from fiberglass are available in the Nepalese market. This type of EcoSan is especially useful in areas where plenty of water is easily available and handling of faeces is socially undesirable.

Currently there are 20 Wet EcoSan toilets in the Sabaithawa village of

Parsa District. In these toilets, urine is diverted into 20 to 30 litre plastic containers through a small rubber pipe while the faeces and the wastewater is carried by a 110 millimetre diametre polyethylene pipe to a distribution chamber and two concrete lined pits, which are four and a half feet deep.

3.3 Various components of EcoSan toilets

Over the last five years, various design changes have been made in the EcoSan toilets built in Nepal - based on experience and feedback from users. These changes have been made mainly to improve technical performance, increase user acceptance and reduce cost. This section will describe the various components of EcoSan toilets and analyse their performance.

Photo 3.4: Combined pan

Squatting pan

In Nepal, squatting pans are often preferred to commode-style toilets. Therefore, all except one toilet has used various types of squatting pans. To effectively separate urine and faeces, prevent cross-contamination, allow faeces to fall into one of the two tanks and still have an easy-to-use shape, a squatting pan must be carefully designed. Various models of squatting pan have been tested, including a combined pan with two holes for faeces and one hole for urine and a model with two separate pans, one over each faeces chamber. The benefits and drawbacks of each type of pan are shown below.

Combined pan

The combined pan has a urine hole in the middle and two larger holes on either end for faeces. Each faeces hole is located over one of the two faeces chambers, and each has a cover to prevent vector access and eliminate odours. The hole over the full chamber ought to be covered with a special sign or symbol to allow the chamber to sit for six months without the addition of fresh faeces. This type of pan may be molded out of cement or from polyvinyl chloride (PVC). PVC combined pans are widely used by Lumanti.

This pan design has some important advantages. It saves space compared to a two-pan design. The width of the

toilet floor need only be wide enough for one pan, although there must be additional room to allow for squatting in either direction over the two faeces holes. The design saves money by only requiring one pan, rather than two, and one urine diversion pipe. In most of rural Nepal, families and local communities as a whole do not have many spare funds: keeping costs low is crucial.

Unfortunately, this type of pan also causes a number of problems for users. Several users complained that it is easy for urine to enter the full vault since faeces hole covers are not completely sealed and splashing occurs. Also, the urine pipe often becomes disconnected from the pan and allows urine into one of the faeces tanks. (This can be fixed by using a threaded pipe connection into the pan and perhaps tightening the connection using Teflon tape). Any leakage of urine or water into the faeces tank will create excess moisture and prevent faeces desiccation so it is important to fix any pipe connection problems. Unless faeces are dry, large numbers of pathogens will remain in the excrement and later contaminate crops. One final issue arose with each faeces hole being located near the edge of the faeces chamber rather than in the centre of the chamber. As a result, excrement started to pile up along one side of the vault and it was difficult for users to push the pile over and spread it out.

Two pan system

The other type of pan, used more often in recent versions of EcoSan, is a toilet with two separate pans. Each pan has two holes, one for faeces and one for urine, and most pans have designated non-slip areas for foot placement. The faeces drop directly into the middle of the faeces chamber and urine is conveyed to the collection vessel via a small pipe. These pans are typically made of cement and polished with white cement. Lids to cover faeces holes are also made of cement. With this type of pan, if the faeces hole of the pan not in use is covered, the pot used for ash may be placed on it.

This system of pans is well-liked by users, and there were few problems encountered with the design. By placing the ash pot over the pan which is not in use, confusion over which pan to use is eliminated. This is a particular concern for guests or new users who aren't used to seeing two pans side-by-side. People like the appearance of

Photo 3.5: Pan for Dry EcoSan toilet

these pans in general. The one major problem area was the connection between the urine pipe and pan, as with the combined pan. Many toilets surveyed were found to leak at this point.

Pan for Wet EcoSan

Two types of pans have been developed in Nepal for Wet EcoSan

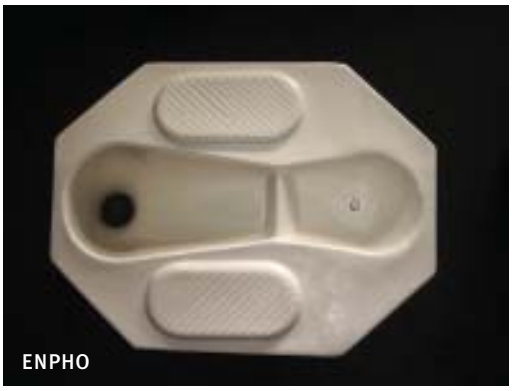


Photo 3.6: Pans for Wet EcoSan toilets made from cement and fibre glass

toilets – one made of cement and another made of fibre glass. Both the pans have two holes - one for faeces and one for urine. The area between the holes is sloped towards the faeces hole as the water is collected together with the faeces.

Pan cover

The faeces hole cover is a surprisingly important component of EcoSan toilets. If the lid is consistently placed over the hole, lifted only for use, and replaced afterwards, the likelihood of flies breeding inside the vault diminishes. Lids at the village sites were made of cement, metal, PVC, or plastic. During site visits, it was found that about 11 percent of the toilets had no lid, which is not satisfactory.

The lids made of PVC, plastic and metal were lightweight and did not always cover the faeces hole adequately. They were more easily knocked off of the hole, and were sometimes accidentally misplaced by users. Lids of cement were comparatively heavy and did not tend to move or get lost. Therefore, users preferred cement lids and perceived them as more practical. However, even cement lids could be improved because users complained about the need to bend over and touch the lid for defecation. A small hook rod could be added to the system so that the user can remove the lid while still standing.

Faeces collection chambers

The internal size of faeces collection chambers is more or less uniform for all EcoSan toilets observed in the field. The standard size (0.35 cubic metres) was adequate for most families. However, some toilets have chambers which are not located above ground which may allow water to enter the chambers and also lead to leakage problems in the rainy season. In those underground chambers, the plaster within the vault was no longer intact due to the entrance of water. As a result, all

future toilets ought to have above ground faeces collection chambers.

If space allows, it may be better in the future to make tanks larger so that faeces may be allowed more than six months to fully dry and allow pathogens to die. In cases where families are large and the normal tank size would fill in fewer than six months, larger chambers should be considered by the family and builder.

Urine pipes and the urine collection tank

Urine pipes posed a problem in many of the EcoSan toilets observed. As noted earlier, the joint between the pipe and the pan is often loose and may cause leakage. This is particularly bad in the PVC pans where the urine pipe does not have a proper connection mechanism and the pipe itself is often very short. Without adequate length, any movement in the pipe or pressure put on it may cause it to become disconnected from the pan. This is an easy problem to fix although a longer PVC pipe will be slightly more expensive than a shorter one. The size of urine pipes was sometimes a problem in certain toilets. Some were using 15 mm diametre HDP?? pipes which were easily clogged by salt precipitation from the urine. Therefore, urine pipes should not be less than 50 mms in diametre in order to prevent clogging.

In most cases, the urine pipe is placed so that urine flows freely into the tank unassisted. The end of the pipe must be submerged in urine inside the tank to prevent the air from reacting with urine and producing ammonia. Nitrogen is urine's most abundant nutrient and if ammonia is formed, part of the nitrogen will be lost when the ammonia escapes as a volatile gas. If the pipe outlet is placed near the bottom of the tank, at least halfway to the bottom, the problem of nitrogen loss should be minimal.

The size of the urine tank is another problematic point. Many toilets have tanks which are too small and don't allow urine to sit for a long enough time before being used. Although urine contains significantly fewer pathogens than faeces, it is still recommended that urine sit for at least one week before it is used as an edible crop fertiliser. Therefore, the urine tank should be at least 100 litres in capacity. The urine tank must always have an airtight cover to ensure that air doesn't react with the urine and cause nitrogen loss via ammonia volatilisation. However, in many toilets, including some in Thecho and Tokha, tanks are frequently kept open and precious nitrogen is lost.

Ventilation pipes

A ventilation pipe is another crucial component of the EcoSan toilet. Proper ventilation is necessary for the dehydration of faeces and for minimisation of odours inside the toilet.

During EcoSan site visits, some toilets were found that did not have a ventilation pipe or had a ventilation

pipe that was too short, clogged or had no cover on the top end. While these problems seem simple, they may cause the entire EcoSan system to fail and result in users losing faith in the technology as a whole. During construction, it is important that the ventilation pipe be tall enough to push odours outside. Pipes which are low to the ground leave EcoSan toilet interiors with a foul smell. Pipes ought to remain unclogged if they have a cover on top, although, if a clog occurs somehow, it must be fixed immediately. A cover over the ventilation pipe is essential to prevent rainwater from entering the faeces chamber. Once wet, the six-month period becomes inadequate for sufficient pathogen die-off.

Lighting

In Nepali households, toilets are not normally designed for comfort and accessibility. They often lack adequate lighting and ventilation. During EcoSan site visits, it was discovered that EcoSan toilets are treated no differently - most of the toilets have inadequate light and ventilation. Only small holes are made in the walls of toilets to allow light inside. The holes are usually not covered with fly screens although it is important to keep flies from breeding inside the toilet. The majority of toilets also do not have an electric lighting system attached for nighttime use. Whenever there is a lack of light, it becomes easy to misuse the EcoSan toilet. If the toilet room is dark, a user might spill anal cleansing water into the urine or faeces hole without noticing. They might not be able to see where to put ash, and might spill it or forget to use it entirely.

Access doors in vaults

Faeces chamber access doors must be properly designed so that vaults are easy to open every six months but stay tightly closed the rest of the year. The doors must allow faeces to be removed easily from the vaults twice per year. In most of the EcoSan toilets studied, access doors are made of metal, concrete, wooden planks, transparent PVC sheet and other materials. Hole sizes were not uniform: some were not large enough to allow easy access to the vault contents while others provided plenty of area for emptying.

Of all the materials used for access doors, metal sheet seemed to be the most problematic. These metal lids had corroded in a few toilets due to moisture from within the chamber and from the outside air. Rain can also lead to corrosion. Once the metal is corroded, doors may not shut properly and flies or odours in toilets can become a problem. Also, it is hard to open the corroded doors for chamber emptying. Users with concrete slab access doors seemed more satisfied but were not without complaints - water leakage from the slab joints were seen in many units.

The transparent PVC sheet seemed to work well and has an aesthetically pleasing appearance when first installed. Unfortunately, however,

many PVC sheet doors were placed in bright sunlight and began buckling over time. Once the doors are hot enough, they bend slightly and openings are formed for flies and rodents to enter the faeces chambers. Perhaps if lids were made of thicker PVC sheet they could more easily resist melting. Some newer EcoSan toilets were made with fiberglass or glass sliding access doors and seemed to have fewer problems than the other materials. Fiberglass is quite expensive as a material but glass is cheaper and more widely available. If concrete slab doors are preferred, it would be possible to design them so that the side of the slab is jointed with cement mortar after each time the vault is emptied.

Toilet superstructure

Door shutter

Toilets are places of privacy; the toilet user must feel safe, comfortable and unwatched. During field visits, 22 toilets were found without a real door. Instead, these EcoSan toilets used a curtain made of cloth or plastic. Although these allow for some privacy, they cannot be locked and lead to potential embarrassment for the user. To ensure acceptability of EcoSan technology, it is better to use a solid door made of wood or metal.

Height of toilet

EcoSan toilets, like any toilet, should allow any user to stand inside without hitting his/her head. While this is not typically a problem in the EcoSan toilets visited, a few toilets had a very low ceiling height. This can make using the toilet difficult and uncomfortable, so it is best for designers to create an interior height of around two metres.

Roof

EcoSan toilets are, at their essence, dry toilets: the faeces vault, urine tank and inner toilet area should be completely watertight. However, during field observations, 10 toilets were found without a complete roof and 21 toilets had a leaky roof. Any leakage in the roof may lead to dampness in the vaults and generally create an unpleasant or smelly environment within the toilet room.

Box 2: Roshan's Eco-Home

When Dr. Roshan Raj Shrestha decided to build his new home in 2002, he decided to use this as an opportunity to demonstrate several systems for sustainable water and sanitation. For Roshan, who was then the Chairman of ENPHO, this was the time to practice what he preached. The house is built on a small 135m² plot of land in the neighbourhood of Dallu in the western part of Kathmandu but within this small space he has managed to install systems for rain water harvesting, grey water recycling, drinking water treatment, waste composting, roof-top gardening, solar energy and, of course, a urine-diverting Dry EcoSan toilet. The house is in the middle of the city but it is neither connected to the city's water supply system nor the sewer system.

The Dry EcoSan toilet is attached to the master bedroom located on the second floor of his Eco-Home. It is connected to a bucket collection system located in the basement of the house. Ash is used instead of water after defecation and little (less than 100 ml) water is used after urination. The urine is collected in a 50 litre bucket and the faeces stored in an 80-litre plastic bin. The toilet is used by two people and when the faeces bin fills up once every four to five months, it is then replaced by an empty one. The collected faeces are left for six months before being applied to the garden. Part of the stored faeces is also mixed with kitchen waste compost for co-

composting. This toilet saves more than 40 litres of clean water per day as a flushing toilet consumes more than 10 litres of water every time it is used. Though the toilet is attached to the master bedroom, Roshan and his family never experience any bad odour.

Collected urine is diluted in a 1:10 ratio and applied to the garden (flowering plants) once every three to four weeks. In the case of other crops, urine is applied to the soil at a ratio of 1 litre/m^2 area of land. Excess urine is also mixed with compost to facilitate the composting process and produce a better quality product.

As the Eco-Home has limited space for a garden, Roshan has successfully established a terrace garden and small kitchen garden where urine and faeces are regularly applied as a fertiliser. The garden produces excellent quality vegetables such as tomatoes, radishes, beans, green salad, carrots and pumpkin. Urine and composted faeces are also applied to fruit plants like guava and citrus.

4. Perception of users and neighbours

In order to gain information on social acceptance and the socio-economic aspects of EcoSan toilets, 440 EcoSan user families were surveyed about how they use their EcoSan toilet, what they like or dislike about the various aspects of using it and what they think could improve the EcoSan in future installations. Another group, consisting of 142 neighbours of EcoSan users, was surveyed to find insights into the perceptions of EcoSan toilets by the neighbours and surrounding community. Household visits and focus group discussions were used in addition to surveys.

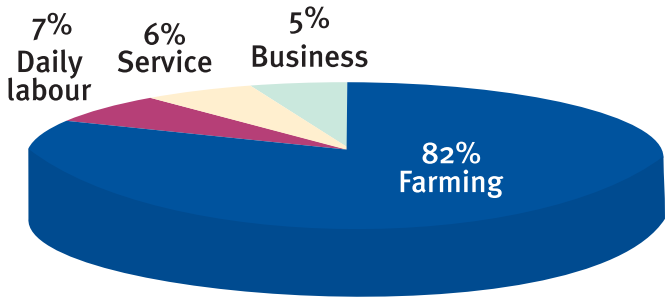
4.1 Perception of EcoSan users

Background information on users

Of the 440 households surveyed within the Kathmandu valley and Gorkha regions, 2637 people, including 371 children below the age of ten, are using the toilets. The average family size is approximately six persons. The smallest average family size, found in Bode, is four persons, while the highest, found in Thimi, is eight persons. Of all user households, 82 percent of them work in the agricultural sector. Labour occupies another 7 percent, with services making up 6 percent and business - 5 percent.

Though most respondents practice agriculture as their primary occupation, the majority own only a small area of cultivable land. About 8 percent of user households do not own any agricultural land while 19 percent of households own less than one ropani. The remaining 73 percent of households own greater than one ropani of agricultural land but very few of them have greater than five ropani. Therefore, almost all of the EcoSan users surveyed can be categorised as small farmers.

Figure 4.1: Occupation of EcoSan users



Other toilets used

About 91 percent of the survey respondents did not own any other toilet in addition to their EcoSan toilet. However, around 4 percent of households reported having a pit latrine as an alternative toilet, with another 4 percent having a pour-flush toilet and 1 percent having a modern flush toilet. Details of where these alternative toilets are located are shown in the table below.

toilets by neighbours who encouraged them.

Who uses it, and how?

Proper use of EcoSan toilets is essential for the production of useful fertiliser and safe compost for plants and for maintaining a pleasant smell and appearance within the toilet. Of the 440 total respondents, about 93 percent said that all family members are using the EcoSan toilet. About 3 percent said only adult family members use the toilet and presumably the children were using open places for defecation and urination. Another 3 percent of households reported that only the female family members use the EcoSan toilet. In these rare cases it is common for male family members to remain outside the home for work almost all of the time and only females spend time at home. During focus group discussions, when this issue was raised, participants of the discussion said that all family members, including children, are using the toilet. However, in some cases it was hard for children to keep

Table 4.1: Alternative toilets

Type of toilets	Tigni	Thimi	Bode	Siddhipur	Duwakot	Lubhu	Imadol	Khokana	Thecho	Gamcha	Tokha	Bhuin chaur	Total
No other toilets	19	4	8	10	73	4	42	10	84	7	129	10	400
Pit latrines					4		6		4		4		18
Sulav	1				3	1	8		3	1			17
Flush								2			3		5
Total	**20**	**4**	**8**	**10**	**80**	**5**	**56**	**12**	**91**	**8**	**136**	**10**	**440**

Motivation for using an EcoSan toilet

Most users mentioned several factors that had motivated them to install and use an EcoSan toilet. Almost 74 percent of respondents said the availability of fertiliser provided by EcoSan was the primary motivational factor, while 72 percent listed their need to have a toilet as the main factor. Seventeen percent of users said they were motivated by EcoSan's ability to protect the environment. Another 3.4 percent were attracted to the technology because of subsidies available. Approximately 9 percent of users were influenced to build these

urine out of the faeces hole due to the pan being too large for them. Additionally, it was stated that some elderly people were not using the toilets because they were not yet comfortable with this toilet system and prefer outdoor defecation.

When asked *how* they are using the toilets, about 98 percent of EcoSan owners said they were using their toilet for both defecation and urination. Only a small fraction of the population (about 2 percent) does not use these toilets for urination and use it for defecation only. This may be due to some trouble that males have trying to urinate in the standing position in an EcoSan toilet. However, when males were asked to confirm this difficulty in a focus group discussion, almost all of the participants denied the issue. They said there were no problems using EcoSan for either type of excreta.

Keeping it clean

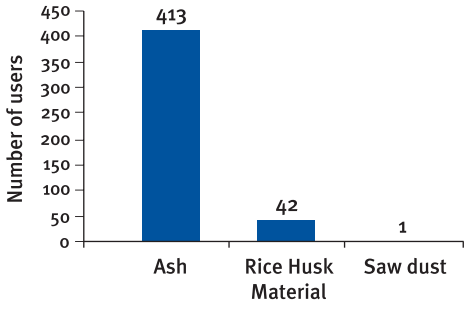
In Nepalese society, household jobs such as cooking, washing and cleaning are traditionally the responsibility of female family members. We asked the EcoSan owners who cleans the toilet on a regular basis. Responses were surprising, considering traditional viewpoints. About 63 percent of respondents said that cleaning the toilet is the combined responsibility of both male and female family members. Whichever family member has some spare time will clean the toilet. Twenty nine percent of the respondents said that toilet cleaning is the female family members' responsibility, while only 8 percent of respondents said that male family members are doing this job.

During household visits, it was observed that about 43 percent of the toilets were clean and about 50 percent moderately clean. Those which were only moderately clean often reflected the overall cleanliness level of the household. Only about 7 percent of toilets were found to be unclean. On the whole, users seemed concerned about the cleanliness of their toilet although standards of cleanliness vary.

Additive materials

Ash, rice husks and saw dust are the primary additive materials used for the EcoSan toilets. Of these, ash is the most commonly used with more than 96 percent of households using it. Depending on their availability, people may use more than one additive material. Since most EcoSan users are involved with agriculture and use firewood or other burning materials for cooking, they have plenty of ashes to use in toilets. However, 9 percent of users are using rice husks as additives and

Figure 4.2: Additives used in EcoSan toilets



some of those use husks in combination with ash. These users try to use ash as much as possible. Often their ash is produced from burning rice husks or saw dust in stoves. People are comfortable with this practice because ash is traditionally mixed with animal manure and compost to add to fields as a soil conditioner.

With time, life styles and practices are changing. The use of liquefied petroleum gas (LPG) and electricity for domestic cooking is increasing as the use of EcoSan increases - creating an adverse situation. The demand for ash is increasing while the supply is decreasing. Fortunately, there are still outside sources of ash available to most users who don't have adequate ash supplies. In certain areas of the Kathmandu valley, there are *chiura* mills (beaten rice mills) where risk husks and saw dust are used for burning and ash is produced in large quantities. Originally, it was easy for those needing ash to go to the mill and collect ash free of charge. However, once the demand increased, they started charging for it. The EcoSan users use their own ash as far as possible and they go to mills when needed. However, the availability of additive materials may become a significant problem in the near future.

As per the survey results, it was found that some 96 percent of EcoSan users use their own ash for most of the time but they also go to mills and neighbours to buy or borrow when they do not have enough of their own. There are no families who rely solely on an external source of ash. The external source is only supplementary for some days of the year.

The cost of ash in *chiura mill* is not very high; until recently it was free. The cost varies between NRs.10 to 50 per sack, depending upon the time and demand.

About 88 percent of the EcoSan users are not facing any problem with getting additive materials, but that leaves about 12 percent facing some kind of problem in getting them for some months of the year. The problem is going to be increased in the days to come. It is therefore of uppermost importance to find reliable alternatives for the ash as additives in EcoSan toilets.

Faeces management

All of the EcoSan toilets surveyed for the analysis are two vault urine diversion dry toilets. There are 20 urine diversion Wet EcoSan toilets in Parsa, but these toilets are not included in this analysis. The analyses of those toilets have been done in a separate section.

The vault sizes of almost all the toilets surveyed are 0.35 cubic metres. The chambers are made of brick masonry and the opening to remove dry materials is kept at the rear side of the toilets with the cover. To help the drying process and to reduce odours, there is a ventilation pipe in each vault. One chamber is used at a time. Once the chamber in use is filled up, it is closed and the

next is used. It was advised by the promoter to keep the filled chamber closed for at least six months or until next chamber is full, for the sanitisation of content.

Among the 440 respondents of the survey, 29 people were not aware of the filling time of the vault. Some 135 toilets are new and none of the vaults are full yet. We found 30 vaults filled within two to three months. In addition, 48 vaults were filled within four to five months and the majority - 129 (30 percent) of the vaults were filled within six to seven months period of use. Some 52 vaults or 11.8 percent lasted for more than seven months before becoming full.

The filling time of vaults may depend on many factors such as the population using the toilets, quantity of additives use, frequency of moving the piles, ventilation, temperature etc. In our study, the average family size is 5.99. With this population size, it was estimated that one vault would be enough for more than six months.

Time of emptying the vault

The promoters of the EcoSan toilet have suggested that the EcoSan user empty the vault only after six months of its closing. This is very important for sanitisation of the faeces. Studies have shown that storage for six months with a relatively high pH kills almost all of the pathogens in faeces.

In the survey we found that about 51 percent of all the EcoSan users remove the contents of the vault when the next vault is full. This means that there is no certainty of time - they have to remove the content once the other vault is nearly filled up. But in this practice, the time is more or less six months. There are some families who empty the vault immediately after filling - they handle the fresh faeces. We asked some of the respondents of these categories why they do so. Many of them answered that they want to mix the faecal matter with other compost materials. Likewise, there are some families who empty the vault as per their need - they take it out at any time they require it. Some 10.4 percent of all EcoSan users are doing it in this manner. About 13 percent emptied their content in around four months after closing the vault. Some 61 families have not emptied the vault - they have closed one vault and are using the next. The total respondents for the vault emptying time are 269. The detail is given in the table below.

Table 4.2: Emptying frequency of the faeces vault

Emptying frequency	HH numbers
Immediately after filling	18
When next tank is full	138
As per the need	28
Within 4 months of filling the tank	16
After 4 months of filling the tank	18
Not emptied yet	61
Total	**440**

Responsibility for vault emptying

Of the total respondents who had emptied the vault at least once, 39

percent said it is the responsibility of both male and female members of the family and they do it as per the need. But some 31 percent believe it is the male's job and they have to do it. On the other hand, some 30 percent said it is the responsibility of female members of the family and they have to do it.

When this issue was raised during the focus group discussions, the participants said that although they were initially worried about the time it would take to empty the vault, they do not have any worries now. The job is not as hard as it was initially considered to be. It is only a matter of one or two hours work and most users feel that anyone in the family can empty the vault and that gender is not a major issue in this case.

Conditions during the vault emptying process

It is a common belief among people that the faeces will smell strongly when taken out of the vaults and that the process of removing faeces from the vaults is a tedious and disgusting job. From a health and safety point of view as well, the faeces at the time of removal from the vaults need to be dry and stable, without any foul smell, in order for them to be considered safe for handling and use. Therefore, the condition of the faeces at the time of removal from the vault and the attitude of the users towards the vault emptying process are critical factors in the proper use and further promotion of these toilets.

Odours during emptying

Among the 218 EcoSan users surveyed who had experiences of vault emptying, only about 1 percent experienced a very bad smell during emptying. Some 61 percent of the respondents experienced a light smell whereas about 38 percent of respondents said there was no smell at all whilst emptying the vault. If the material in the vault is kept completely dry for about six months and an adequate amount of additives are used, there should not be any bad smell at the time of removal. Therefore, there must be some problems in the toilets of the eight users who reported a bad smell. During the study it was observed that some 158 toilets did not have proper ventilation. In these units, some ventilation pipes were broken, some were misplaced, some were clogged and in some toilets there were no ventilation pipes at all. The users who complained about bad odours had the units where the ventilation pipes were not properly installed.

Moisture in the content of the vault during emptying

Only three out of the 218 respondents complained about high moisture content in the faecal matter when the vault was emptied. About 61 percent of respondents said there was quite a normal moisture content and the rest - about 38 percent - said the content was completely dry with minimum water content and there was no smell at all. This shows that, if properly used, the moisture content and smell in the vault can be minimised to a large extent and it will

be easy to handle the content. After storage for about six months, the content is almost completely converted to inert material.

Use of dry faeces

Among 440 surveyed households, 218 have emptied their vault at least once. Among the users who have emptied the vault at least once, 19 percent said they take it straight to the field while about 54 percent said they stored the contents in the sun or a shed for a few days before applying it in the field. The rest of the households, or 27 percent of the total, said they mix the contents with other composting materials and put it in the compost pit for co-composting. Most of the families are aware of the need to store the content for a few days before applying it to the field but, due to various constraints, they are not following the rules. The major constraints are space and the need for manure.

Management of urine

Collection of urine and faeces separately is one of the main principles of EcoSan toilets. To close the nutrient loop, the urine collected should be recycled by using it in agricultural fields. Human urine is rich in nutrients that plants need. Proper management of this resource requires appropriate and properly functioning urine collection pipes and tanks, as well as regular use of the collected urine in the fields.

Urine collection tank

Although urine separation and collection is one of the main objectives of EcoSan, out of the 430 EcoSan toilets observed, 124 toilets (29 percent) did not have any type of urine collection tank. The majority of toilets in Thecho and Tokha did not have urine collection tanks. In Thecho, 60 out of 91 toilets did not have a tank, while in Tokha, 56 out of 136 toilets didn't have one. The users in these communities said that they use small jerry cans or mud pots for the collection of urine, but at the survey, these were not in use. This is one of the main problems observed with the EcoSan toilets. In other toilets that did have urine collection systems, the collection tanks are made of brick masonry, plastic tanks and jerry cans.

Figue 4.3: Capacity of urine tanks

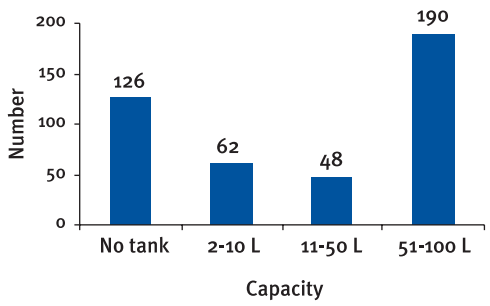


Photo 4.1: Effects of urine on composting

The size of the urine tanks varied from two litres to 100 litres. Some of the users are using small plastic jerry cans and mud pots while most of the newer toilets are using 100 litre capacity plastic tanks. The 100 litre capacity plastic tanks are used in Tigani, Siddhipur, Gamcha, Khokana, Thimi and Gorkha. Among the total of 316 toilets with urine collection tanks, some 20 percent have a capacity between two and ten litres. Similarly, 16 percent have a urine tank with 11 to 50 litres capacity and the remaining 64 percent of the toilets have relatively bigger sized urine tank capacities of 51 to 100 litres. Some of the older toilets in Siddhipur and Khokana had brick masonry urine tanks. The urine tanks made of masonry were found to be leaking in most cases and in many cases the covers on those tanks were not found to be placed properly. Similarly, the small jerry cans and mud pots used for urine collection were not working satisfactorily. Since the sizes of the urine collection tanks are very different, the time for filling the urine collection tanks also varies significantly (Table 4.3).

Table 4.3: Urine tank filling time

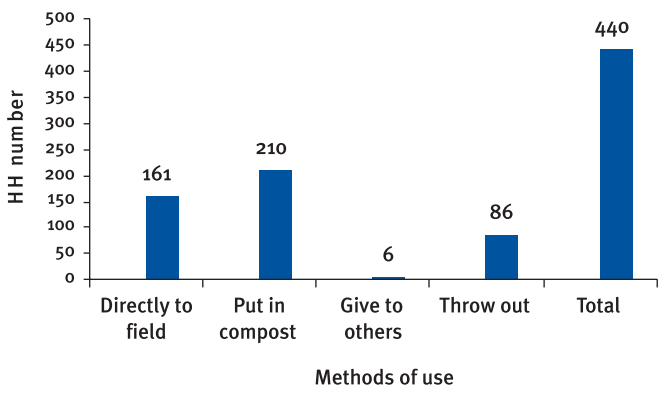
Time to fill the urine tanks	HH numbers
0 to 15 days	124
15 to 30 days	43
> 30 days	43
Do not know	107
No urine tank	123
Total	**440**

There is no uniformity in the pipes connecting the urinals and the urine tanks. Some pipes are connected openly with the tank and some are immersed in the tank. It is ideal to have an airtight connection between the pipe and the tank to reduce the loss of nitrogen from the urine.

Use of urine

Most of the EcoSan toilet owners are very much aware of the importance and nutrient value of urine. But unfortunately, in practice, proper use of urine is often not seen. About 37 percent of the respondents said that they use the collected urine directly in the field when needed while about 48 percent preferred to put the urine in the compost instead of taking the urine directly to the field. Some of the families do both direct application and co-composting. They take urine to the field when needed and they put it in the compost when they do not need it. About 20 percent of the total respondents did not hesitate to say that they pour the

Figure 4.4: Application of urine



urine down the drain when the tank is full and they do not need it for the field. A small portion of respondents have also given the urine to neighbours who need it.

The farmers are accustomed to and feel comfortable carrying solid materials, like compost, to the fields. However, they hesitate to carry the liquid urine. As a result many of them prefer to mix the urine with compost or other materials, like ash, for ease of transportation.

Table 4.4: Methods of using urine

Methods of using urine	HH numbers
Directly on field	161
Put in compost	210
Give to others	6
Throw out	86

Efforts to improve the collection, storage and use of urine are necessary in almost all of the project areas. Very few families are found to collect, store and use the urine in a manner that minimises nutrient loss. Toilet owners who do not have a urine collection tank, sometimes collect the urine in temporary urine collection vessels and take it to nearby fields. EcoSan toilet owners with permanent and relatively large urine tanks take the urine to any field they want, but most of the participants in the focus group discussions felt uncomfortable carrying the liquid urine over long distances. However, according to the users, the application of urine in various crops is increasing and the interest of farmers in using the urine is increasing.

The majority of farmers with EcoSan toilets - 70 percent - use the urine for their vegetable farming. However, urine alone is not sufficient for most families. About 22 percent of farmers are using urine in all kind of crops, while 6 percent use the urine in annual crops like paddy, maize, and wheat.

Lack of collection vessels of adequate capacity and transportation of urine to distant fields are some of the hindering factors for the optimal use of urine. There is also some confusion about the methods for use. Therefore, there is a need for appropriate guidelines for urine application directly in the field, as well as co-composting.

Effect of urine in agriculture

Most of the EcoSan toilet owners are well aware of the nutrient value of urine and most are confident that the production of crops will increase after the application of urine. About

Photo 4.2: Urine application

60 percent of farmers who used urine in their field said their yield increased after its use, while about 21 percent did not notice any change after applying urine and the rest did not know about the yields of crops. Some 56 percent of the urine users also said that the quality and taste of vegetables improved after applying urine. In response to questions regarding who uses urine in their field and the difficulties they experience because of it, only about 5 percent said they felt a little uneasy working when using urine as a fertiliser. The rest of the respondents (331) said there was no change when working with urine as fertiliser.

Social acceptance, satisfaction and comfort

According to the questionnaire survey, most people using the EcoSan toilet are happy and have a positive view of it. In response to the general question, "How is EcoSan?", 313 respondents or 71 percent said it is good, while 9 percent said it is good but not as easy to use as other toilets. About 19 percent of the respondents felt that the EcoSan toilets were neither good nor bad. The remaining one percent was not satisfied with the EcoSan toilets.

Based on the survey results, focus group discussions, household visits and interviews, it seems that people feel uncomfortable using their EcoSan toilets to start with, but after using it for some time they gain a sense of comfort with the toilet system and using it becomes habitual. EcoSan toilets clearly need some time for adjustment as users must adapt to the dry toilet system by being careful not to add water to the faeces chamber during anal cleansing. Furthermore, they must have a regular supply of ash or other additives and remember to add them regularly and they must also empty faeces vaults every six months. It is rare, however, for users to feel uncomfortable with these new practices in the long term.

During the focus group discussions, we also raised the specific issue of gender as related to users' satisfaction levels. When asked if females have any particular difficulties using EcoSan toilets, almost all participants said no. Similarly, the male participants did not mention any problems except that there is chance of urine splashing if standing during urination. Therefore, they suggested installing a male urinal (or urinating bowl) inside the toilets.

Major problems encountered

Among the 440 responding households, 209 or around 47 percent said there are no problems with EcoSan toilets. However, since this toilet is a little different from other conventional toilets, the people using it for the first time, such as guests, may have some difficulties. Of the total number of respondents, 137 or 31 percent, of the total expressed this as one of the major problems. Each guest has to be instructed before the use of the toilet which is not easy and sometimes it is also uncomfortable. Some people misused the toilets, thereby creating problems.

Smell, insects, cleaning and uneasiness are some of the problems that EcoSan users mentioned. But the number of people who mentioned these problems was comparatively small. Only 11 percent of the respondents complained about the problem of smell and only 12 percent mentioned difficulties in cleaning. People who are used to flush toilets, which are easier to clean, find the cleaning of EcoSan toilets to be a bit difficult as there is a risk of pouring the water into the faeces hole.

Perceived advantages of EcoSan toilets

Most of the users (86 percent) mentioned that the fertiliser value of excreta and nutrient recycling is one of the major advantages of the EcoSan toilets. It seems that most of the people were motivated to construct EcoSan toilets due to this fact. Water saving is another advantage of this technology with about 35 percent of the respondents motivated by this. Similarly, about 23 percent of the respondents said that the EcoSan toilets also helped to protect the environment. During the focus group discussions, many participants supported the argument of the fertiliser value of toilets. Most of the EcoSan users are from the farming community and for them this organic fertiliser has great value. At the same time, a large number of participants in the focus development groups, especially women, said that water saving is one of the main advantages of EcoSan toilets. This was mentioned in areas where water is not easily available and women have to carry the water from distant public tap stands. They said that it was very hard to fulfill the water demand in the household before the construction of EcoSan toilets but now that problem no longer exists.

4.2 Performance of Wet EcoSan toilets in Parsa

In 2005, DWSS with support from WHO, constructed a different type of EcoSan toilet in 20 houses of Sabaithawa village in Parsa district, which is located in the plains in the southern part of the country. The Wet EcoSan toilet is actually an improved version of the double-pit pour-flush toilet with a urine diversion mechanism added to it. In this type

Photo 4.3: Wet EcoSan in Parsa

of EcoSan toilet, the urine is collected separately while the faeces, together with the water used for anal cleansing and flushing, is collected in a pit. Except for the pan, where two separate holes are provided for urine and faeces, and the urine collection pipe and tank, all the components of the toilets are the same as those of the pour-flush toilets. This type of toilet is appropriate for areas where availability of water is not a major problem and faeces handling is a social taboo.

Photo 4.4: Urine collection tank

Photo 4.5: Pits for faeces collection

The EcoSan toilets were introduced in Sabaithawa after a training and exposure visit provided to the local community leaders. All of the EcoSan users built their toilets with the financial support of WHO/DWSS. Two major reasons for building EcoSan toilets were the need for toilets and the availability of fertiliser.

Although the sanitary condition of the village as a whole is not very good, all of the EcoSan toilets have been in continuous use since they were built. All family members, including the children, are using the toilets for both urination and defecation. However, some small children occasionally don't use the toilet. As per the responses of users and observations in the field, the use of toilets is found to be satisfactory and most of the toilets are clean and well maintained. The users do not have any complaints about the EcoSan toilets and they are generally satisfied.

Use of urine and faeces

One of the most successful aspects of Wet EcoSan toilets in Parsa is urine application. All of the EcoSan toilets have 20 to 30 litre capacity urine collection tanks made of plastic and all of the houses have experience of using urine in the fields. Some of the toilet owners said that the urine does not smell bad when applying in the field, whereas some of the owners did complain about the bad smell.

Urine is applied by mixing one part urine with three parts water. They have applied urine to potatoes and green vegetables as well as beans. Though the urine smelled bad at the time of application, the yield of the vegetables has increased considerably. Some of the EcoSan owners said the urine also works as pesticide - one said that the urine works as a pesticide in beans. The vegetables produced with urine application are also very good in quality. The vegetables are soft and have a good taste compared to those without urine. However, the urine collected in a household toilet is not sufficient for the vegetable fields. In this situation, some of the farmers started to borrow urine from others. We found an increasing demand for urine-diverting toilets due to the fertility value of urine in that area. All the respondents said that they will continue using the urine as it is beneficial to them.

Almost all of the toilets were constructed around May/June of 2005. After one year of use about 65 toilet owners are still using the first pit, while the rest have shifted to the second pit. No one has yet experienced removing the content of the pit or using the faeces.

Attitude towards EcoSan

We asked all the EcoSan users to give us their opinion of EcoSan toilets. In general, all of the users were happy with their EcoSan toilets. They are using it and are also recommending others to do so. Some of the main advantages of EcoSan toilets as mentioned by the users are as follows:

- EcoSan toilets give good fertiliser, which is a blessing for poor farmers.
- The toilet makes defecation very easy. It was very hard to go out during the night and on rainy days.
- The urine not only works as a fertiliser but also works as a pesticide.
- Prolonged use of urine and faeces in the field will increase production.

The main disadvantages of EcoSan toilets as mentioned by the users, based on their experiences, are as follows:

- The toilet is costly and poor people cannot afford it without financial subsidies.
- Carrying the liquid urine is difficult and it smells bad when it is applied.
- Eating the vegetables grown with urine feels a little strange. But some of the participants disagree with this statement as they feel that there is no difference between animal urine and human urine. They have been using animal urine for centuries.
- Removing the content of the vault will be difficult.

Overall, it can be concluded that the EcoSan users are satisfied and the technology is very appropriate for the village. Therefore, the application of EcoSan should be expanded with partial subsidies provided for poor families.

4.3 Perception of neighbours

Background of neighbours surveyed

Along with the survey of EcoSan toilet users, a group of neighbours from 142 households in eight project areas were also surveyed to assess the perception of neighbours who do not use the EcoSan toilets. Altogether, neighbours were selected from 33 percent of the households with EcoSan toilets. The minimum percentage of households in each project location was 25 percent and the households were selected randomly. The total number of people living in the 142 selected households was 833, including 427 women and 97 children under the age of 10.

The socio-economic background of the neighbours was fairly similar to the EcoSan owners. The main occupations of the families surveyed were agriculture (76%) followed by service and business (8% each). About 13 percent of the total households surveyed did not have any agricultural land and 9 percent own land of less than 1 ropani (508 sq. m.). The remaining 78 percent of households own agricultural land of more than 1 ropani.

The families working in agriculture have a tendency to use various fertilisers including chemical fertiliser, compost and chicken manure depending upon the availability and necessity. But the trend of using chemical fertiliser is increasing day by day. More than 88 percent of households use chemical fertiliser. In addition, about 66 percent of households said they use compost and about 15 percent said they use chicken manure as well. Urea, containing 46 percent nitrogen, is the most extensively used chemical fertiliser. The use of phosphorus and potassium is rare.

Access to toilets

Of the 142 households, 113 (80%) had access to some kind of toilet. The rest are practicing open defecation or go to traditional open toilets called '*Khikhamuga'* which are designated spaces for defecation. There are usually separate '*khikhamuga'* for women while the men go to the fields. The '*khikhamuga'* are generally not hygienic. Among the households with toilets, 65 percent own pour-flush latrines, while 31 percent own simple pit latrines. The remaining 4 percent use modern flush toilets. Nineteen of the 113 toilets are connected to some kind of underground sewage pipe, but the sewage systems do not have treatment facilities and they discharge the black water in nearby water bodies. Sixty two are connected to septic tanks, but most of these tanks are not properly designed and are merely a pit lined with masonry. Very few people have constructed watertight septic tanks where the anaerobic biological process can take place. Once the pits

are filled, the content is removed manually or by using a suction device. The content is usually discharged again into nearby water bodies without any kind of treatment.

Knowledge and attitude towards EcoSan toilets

Most of the neighbours are well aware of the EcoSan toilets. Out of the 142 households surveyed, 100 responded that they knew about the toilets in detail and 22 said that they had even used the toilets. Only one household had not heard about the EcoSan toilet, while 19 were aware of them but had not seen the inside of one.

About 98 percent of the respondents had a positive attitude towards EcoSan toilets. Only three households expressed their negative attitude. About 53 percent of neighbours surveyed said they never experienced bad odours from the EcoSan toilets in the neighbourhood. However, 29 percent said they occasionally experienced bad smells from a neighbour's EcoSan toilet, and 14 percent said there was a bad smell during the time of emptying the vault. These results clearly indicate that the people who are not using the EcoSan toilets are also positive towards the technology.

Attitude towards nutrient recycling

More than 87 percent of the respondents said that using sanitised human excreta as fertiliser is a good idea. However, 9 percent have doubts about it. They feel the consumers of the food may not accept the product, or the process of applying the excreta will be difficult and disgusting. Only 4 percent of the respondents said re-use of sanitised human excreta is not a good practice and is not suitable for modern society.

Sixty two percent of total respondents without EcoSan toilets have no experience of using human excreta in their fields, whereas 32 percent have some kind of experience. Amidst this situation we also asked the people if they would use human urine as manure in the field. As a response, 102 households said yes immediately but 12 respondents were not sure and 22 households or 15.49 percent do not want to use the urine as manure at all.

In total, 27 percent of the respondents think that the use of sanitised human excreta will reduce the use of chemical fertiliser to a great extent. But about 70 percent think it can only replace chemical fertiliser by a small portion. About 3 percent of the respondents do not believe in replacing chemical fertiliser with human excreta.

Willingness to build toilets

When the households without toilets were asked which type of toilet they wanted to build, one preferred the pit latrine, two mentioned the pour-flush pit latrines (Sulabh), seven showed interest in the septic tank system

and 19 households showed an interest in EcoSan toilets. In total, 57 of the 142 households, including several households that already had a toilet, expressed their willingness to install EcoSan toilets in their houses. This indicates that the EcoSan toilets have a good image in the community. Another 37 households expressed conditional willingness - they want to install the toilets if subsidies are available. They are not ready to invest in the full cost of the toilets. In fact, very few people showed an interest in investing the required amount in this toilet. Among the 29 households without latrines, about 55 percent are ready to invest less than Rs. 2000 for toilet construction, while 17 percent are ready to invest between Rs. 2000 and 5000 and 21 percent are not willing to invest anything at all. Only 7 percent of the households were ready to invest more than Rs. 5000. On the one hand these results are encouraging because more than 65 percent are willing to built EcoSan toilets, however, very few people are willing to invest in the toilets.

Attitude of neighbours as perceived by EcoSan users

When the EcoSan users were asked how their neighbours, who don't own EcoSan toilets, perceived their EcoSan toilets, 57 percent said that their neighbours appreciate the EcoSan toilets very much. About 32 percent of the respondents said their neighbours are positive towards the EcoSan toilets. But about 8 percent of the respondents felt that their neighbours are not very happy with their EcoSan toilets. They think the toilet is of inferior quality. In focus group discussions and interviews, the participants said that many of their neighbours are very interested in the technology and want one too. They said their neighbours are very interested in the fertiliser use of the toilets and its water saving nature.

Box 3: Manju's journey from diffidence to determination


ENPHO

Manju Maharjan, a young 20 year old member of the Sanitation & Hygiene Education (SHE) team in the village of Siddhipur, was deprived of toilet facilities until recently. She, like many other girls in Siddhipur, was forced to defecate in the unsanitary *Khichamuga* (open areas designated as communal toilets for women) to her shame and embarrassment. Boys had an alternative: they would defecate right alongside the roads. Manju says, "It didn't affect them at all when we [girls] walked past. Instead, we would cover our faces with our shawls, ashamed at the sight." Manju made herself even more vulnerable to disease because, mortified that boys would notice her, she wouldn't even take a bottle of water with her. "I wouldn't wash myself in the *Khichamuga*. Instead, I would wear my pants way below my waist and return home dirty. Only when I was satisfied that I was away from prying eyes would I wash myself. I did the same whenever I was menstruating." It wasn't just the fear of being watched that shattered Manju's self-esteem, she also feared being an outcast among her friends. "I was scared that my friends might need to use the toilet when they came over."

Finally, after becoming a SHE Team member, she managed to convince her parents to construct a toilet at home. She countered all their excuses of not having enough money saying, "When it comes to going to a *bhoj* [traditional feast] you always seem to have money. How can you say there isn't enough for a toilet?" Not taking no for an answer, Manju took advantage of the 60 percent subsidy provided by UN-HABITAT/ENPHO to make an EcoSan toilet, which collects urine and faeces separately so that they can be recycled as organic fertilisers. Now she not only has a toilet, but she has also turned the waste into valuable manure for the field. Manju feels that the training she received has made her much more outgoing and confident. She's also relieved that it's so easy to use the toilet and she can save time: "When you're in a hurry, even a minute seems like forever".

Source: UN-HABITAT/ENPHO/SWSUC, 2006: "Unheard Voices: Tales of Women's Struggle for Toilets in Siddhipur."

5. Financial aspects of EcoSan toilets

Costs and financing play an important role in planning sanitation schemes and selecting appropriate technologies. A few studies have been done to assess the financial aspects of EcoSan toilets and to compare them to other toilets, but as there are many different types and variations of toilets and the cost of materials vary according to time and place, a direct comparison of results from different studies is difficult. Furthermore, while construction costs may be fairly straight forward, operation and maintenance costs and benefits are difficult to estimate. This section summarises some of the studies related to the financial aspects of EcoSan toilets and presents a financial analysis for EcoSan toilets in Nepal.

Normally, financial aspects of projects are assessed using financial or economic analysis. Financial analyses assess the costs borne by the end users and the direct revenue from the project, while economic analyses also assess the overall costs and benefits to the society as a whole. The analysis is done over the expected lifetime of the facilities. There are several methods for financial analysis. These include Net Present Value, Cost-Benefit Analysis, Least Cost Analysis and Cost-Effectiveness Analysis.

Rockström et al. (2005) modified the 'sanitation ladder' originally produced by van de Guchte and Vanderweerd (UNEP, 2004) by including the cost of EcoSan toilets within it in order to compare the cost of various methods of conventional and ecological sanitation. Based on secondary information from several pilot projects, the analysis showed that in the urban context, conventional systems, with sewer connection and treatment, cost about two times more than EcoSan systems. In rural areas with on-site sanitation systems, conventional systems with septic tanks cost 15 to 20 times more and pour-flush latrines cost five to eight times more than EcoSan toilets.

The EcoSan Club (2003) compared the costs of flush toilets with mechanical and vertical subsurface constructed wetland treatment with urine diversion EcoSan toilets, and a horizontal subsurface constructed wetland system for a school in rural Uganda. They showed that the conventional system was 60 percent more expensive than the EcoSan alternative.

Holden et al. (2004) estimate that urine-diverting EcoSan toilets are inexpensive compared to other alternatives in South Africa as they have lower capital costs (1500 ZAR

for EcoSan; 2000 ZAR for VIP; 10,000 ZAR for waterborne systems)and running costs (0 ZAR for EcoSan; 200 ZAR/yr for VIP; 1200 ZAR/yr for waterborne systems).

In Nepal, Thapa (2004) compared the cost of three different types of toilets – VIP latrines, pour-flush latrines and EcoSan toilets in Kathmandu, and found that although the initial cost of the EcoSan toilet is slightly higher than the pour-flush latrines (PFL), the future monetary value of EcoSan toilets would be equal to the PFLs within five years and the VIP toilets within seven years. The study assumed that the initial cost of the EcoSan toilet was Rs. 17,144.35 while that for a PFL was Rs. 12,710.15 and for VIP latrines it was Rs. 5078.36. The study estimated the benefits of EcoSan toilet to be equivalent to Rs. 1633.03 per year. Analysis done for this study, however, is almost the same as that for PFL (see Table 5.1).

5.1 Cost of EcoSan toilets

The cost components that are normally considered in financial analysis are as follows:

- Investment or capital cost
- Running or recurring cost
- Opportunity cost of capital

In Nepal, most people tend to think that EcoSan toilets are more expensive than pit latrines or double pit pour-flush latrines (also known as Sulav toilets). The initial cost of EcoSan toilets is slightly higher than simple pit latrines but this cost is similar to a Sulav toilet. Furthermore, the cost of a Wet EcoSan and Dry EcoSan toilet is almost the same. The slightly higher initial cost is generally due to the need to construct two water-tight vaults and urine collection system above ground level. Furthermore, almost all of the EcoSan toilets that have been constructed so far in Nepal have been built with a brick and cement super structure which is normally more durable but also more expensive than those made from local materials such as bamboo and straw. Therefore, the cost of EcoSan toilets in Nepal seems a bit high because it generally includes the cost of a relatively expensive superstructure.

The cost of a DVUD EcoSan toilet with brick cement super structure in the Kathmandu valley is about Rs. 16,500. Out of this cost, about Rs. 10,000 is for the construction up to pan level, including the vaults, while the remainder is for construction of the super structure. In comparison, a double-pit Sulav toilet with similar super structure in Kathmandu would cost Rs. 15,775, while the cost of a double pit Wet EcoSan with similar super structure is about Rs. 16,155 and the cost for a toilet with a septic tank is about Rs. 18,000. Therefore, the initial cost of a Dry EcoSan toilet is about 4.5 percent and the initial cost of a Wet EcoSan is only about 2.4 percent higher than a double pit sulav toilet. But the cost of an EcoSan toilet is lower than a septic

Table 5.1: Comparison of investment costs for different types of toilets

S.N.	Description of work	Quantity			Unit	Rate (Rs.)	Amount		
		Dry EcoSan	Double pit PFL	Double pit wet EcoSan			San Dry Eco	Double pit PFL	Double pit wet EcoSan
1	Bricks	1050	650	650	nos	3.5	3675	2275	2275
2	Cement	5	3.5	3.5	bags	550	2750	1925	1925
3	Sand	30	20	20	cuft	22	660	440	440
4	Aggregate	12	5	5	cuft	33	396	165	165
5	MS bar	10	-	-	kg	48	480	-	-
6	Mason	7	4.5	5	nos	250	1750	1125	1250
7	Labour	9	7	7	nos	150	1350	1050	1050
8	Pan	2	1	1	nos	400	800	400	400
9	Slate	2	-	-	nos	75	150	-	-
10	Roofing work	1	1	1	job	1000	1000	1000	1000
11	Door and window	1	1	1	job	2500	2500	2500	2500
12	Concrete Rings	-	8	8	nos	350	-	2800	2800
13	Ring Cover	-	2	2	nos	500	-	1000	1000
14	Pipe and Fittings						-	-	-
	* 4" Poly pipe	-	10	6	rft	70	-	700	420
	* 3" Poly bend	1	-	1	nos	55	55	-	55
	* 3" Poly tee	1	1	-	nos	60	60	60	-
	* 3" Poly cowl	1	1	1	nos	55	55	55	55
	* 3" Poly pipe	6	10	10	rft	28	168	280	280
	* 11/2" PVC tee	1	-	-	nos	20	20	-	-
	* 11/2" PVC bend	3	-	1	nos	60	180	-	60
	* 11/2" PVC net cap	2	-	1	nos	41	82	-	41
	* 11/2" PVC pipe	1	-	3	rm	15	15	-	45
	* 1/2" GI nipple (6")	1	-	1	nos	39	39	-	39
	* 1/2" GI tank nipple	1	-	1	nos	45	45	-	45
	* 1/2" GI socket	1	-	1	nos	25	25	-	25
	* Plastic tap	1	-	1	nos	25	25	-	25
	* 60 ltr plastic container	1	-	1	nos	260	260	-	260
	TOTAL						**16540**	**15775**	**16155**

Note: Rates are based on prices in the Kathmandu valley in 2006/07

tank toilet and about half that of a biogas-attached toilet. The materials required for construction of the Dry EcoSan toilet, Sulav Toilet and Wet EcoSan toilet in Kathmandu and the associated costs are presented in Table 5.1.

The operational cost of the EcoSan toilet is also similar to the Sulav toilet. The EcoSan toilet requires the addition of additives such as ash, which may require some cost, but the Sulav toilet requires more water for flushing. Thapa (2004) estimates the

operational cost for EcoSan to be Rs. 251.44 year and assumes that the operation cost for PFL is 0.1 per cent of the capital cost or Rs. 127.10 per year. This cost is considered to be affordable for the families with EcoSan toilets as it represents only 0.35 percent of their income. Financial analysis done for this study estimates that the annual operation and maintenance cost for EcoSan toilets will be Rs. 570 per toilet per year.

5.2 Financial benefits of EcoSan toilets

Unlike conventional toilets, urine-diverting EcoSan toilets generate benefits, primarily in the form of organic fertiliser that can replace chemical fertilisers. Experiments done by ENPHO have shown that urine can replace the use of chemical fertilisers and it can also significantly improve the quality of compost if it is added to compost piles. When users of EcoSan toilets were asked if there was any reduction in use of chemical fertiliser after constructing the EcoSan toilets, about half of the respondents said “yes, there is a reduction”. But they could not answer about the amount saved. This may be due to the fact that Nepalese farmers do not usually keep any records of income and expenditures. Therefore, although many farmers see a financial benefit from using the EcoSan toilets, the benefits are difficult to quantify based on their experience. Ranjit & Heijnen (2006) estimate that the farmers in Sabsithuwa village, where Wet EcoSan toilets were introduced, could save NRs. 2500-3000 per year from using urine as fertiliser. Financial benefits can be estimated based on the nutrients present in the urine. This study estimates that the financial value of nutrients in urine produced by one family is equal to NRs. 1575 per year.

5.3 Financial analysis

On average, an adult produces 550 litres of urine annually. The volume of the urine contains four kgs of nitrogen, 400 grams of phosphorus and one kg of potash. Faeces has similar nutrients and effects in soil as that of compost. The nitrogen, phosphorus and potash contents of urine and faeces increase productivity of crops and vegetables. Thus they bear certain financial values and hence, a financial analysis has been carried out to examine financial viability of an EcoSan toilet and the pay-back period.

The following key assumptions are made for financial analysis:

- The construction time for EcoSan toilets is less than one year.
- All costs and benefits are expressed in April 2007 prices.
- The generation of benefits are the values of urine and faeces collected in the toilet.
- Financial analysis of the toilet is carried out over a period of 20 years.
- The residual value of the civil structure of the toilet is assumed to be 60 percent of initial cost in the twentieth year.

Project costs

Fixed investments

The total construction cost, based on market prices in April 2007, is estimated at Rs.16500.00.

Operation and maintenance costs

The operation and maintenance costs of the toilet include operation costs, depreciation and salvage value of the toilet. The operation costs include the cost of additives and labour wages for removing faeces from the tank of the toilet. Every time after use of the toilet certain additives (ash or rice husk) should be sprayed. The total cost of the additives is estimated at NRs. 240 per annum. In addition, faeces should be removed from the tank of the toilet every sixth months. The total cost of the activities is estimated at NRs. 150. The depreciation costs include the depreciation value of the toilet as a whole. The depreciation value is estimated at two percent of the total investment cost. The estimated value is NRs.300. The salvage value of the infrastructures in the twentieth year of operation is estimated at 60 percent of the present value of the infrastructures.

Benefits

Benefits from the use of urine as fertilizer

An average person produces 550 litres of urine per year. The volume of urine contains, on average, four kgs of nitrogen, 400 grams of phosphorus and one kg of potash. Thus an average family of six members produces 24 kgs of nitrogen, 2.4 kgs of phosphorus and six kgs of potash. The average prices of nitrogen, phosphorus and potash on the market in April 2007, as calculated based on their contents in urea, DAP and muriel of potash are NRs.47.82/Kg, NRs.60.90/Kg, and NRs.46.75/Kg respectively. Therefore, the total annual value of urine produced by an average family is estimated at NRs.1575.00.

Benefits from the use of faeces as compost

Annual production of soil conditioner (from faeces) from an EcoSan toilet is estimated at 100 kgs. The value of soil conditioner (compost) in Kathmandu is estimated at NRs. 5/ kg. Therefore, the annual total estimated value of the soil conditioner is NRs. 500.00.

Financial evaluation

Financial analysis considers the costs and benefits for individuals rather than society as a whole. Therefore, the benefits to society due to a clean and hygienic environment are not considered. The general approach used for financial evaluation in this study follows conventional financial appraisal methodology for project schemes. The methodology takes into account factors such as initial costs, maintenance costs and potential benefits in terms of savings and residual value of the project investments. Annual costs and benefit streams are considered for the next 20 years. Costs and benefits are estimated at market prices which include government taxes, duties and subsidies.

WaterAid/Marco Betti

Two indicators of financial viability, namely: 'Pay Back Period' and Financial Internal Rate of Return (FIRR), are calculated to test the viability of the project. The 'Pay Back Period' indicates when the investors will obtain their investments from the operation of the project. The FIRR is the discount rate at which the present value of costs is equal to the present value of benefits. If it exceeds the required rate of return, then the project is considered viable.

The 'Pay Back period' for investment in an EcoSan toilet comes to 9.09 years. i.e. the investor in the EcoSan toilet gets back all his investments (NRs.16500.00) within a period of just over nine years. The calculated FIRR is 8.11 percent. The investment is worth it since the present average interest rate for a commercial bank home construction loan is 7.50 percent. This means that the family who construct an EcoSan toilet from a bank loan will be able to pay the loan if the family sells urine and soil conditioner at market value.

6. Promotion of EcoSan toilets

The Department of Water Supply and Sewerage (DWSS) and several national and international non-government agencies as well as some UN agencies are involved in promoting EcoSan toilets in Nepal. DWSS initially worked with D-Net, a private company, to introduce EcoSan toilets in Siddhipur. Similarly, ENPHO, with support from WaterAid Nepal, initiated a demonstration of EcoSan toilets in Khokana. With the success of the pilot programmes, the ECOSAN latrine technology was gradually promoted to various other parts of urban and peri-urban areas of Nepal by WaterAid in Nepal through its partners like ENPHO, LUMANTI (Support Group for Shelter), Centre for Integrated Urban Development (CIUD), Nepal Water for Health (NEWAH); and by other leading organizations like the DWSS, the UN Agencies, the Practical Action Nepal, and the Nepal Red Cross Society etc..

ENPHO with the support of WaterAid in Nepal has also conducted several research projects related to EcoSan toilets for their promotion through wider application and evidenced based awareness raising. These include pathogen die-off in faeces stored in EcoSan, urine application in compost piles and impact of urine in the productivity of various crops and vegetables. Similarly, students from Tribhuwan University and Kathmandu University have also done some research on this topic.

6.1 Major stakeholders involved in the promotion of EcoSan

Some of the main organisations involved in EcoSan promotion are as follows:

Government organisations/ projects

Government organisations are key stakeholders for policy development and the institutionalisation of the promotion of various technologies. There are several government organisations involved in the water supply and sanitation sector but among these, the Department of Water Supply and Sanitation (DWSS), is probably the most important organisation.

Department of Water Supply and Sewerage (DWSS)

DWSS has been the main government organisation promoting EcoSan in Nepal. It has conducted pilot projects in Siddhipur and Parsa

and it has also been promoting EcoSan as one of the options for sanitation in Nepal. DWSS has also organised various workshops to promote EcoSan. DWSS is a key stakeholder for promoting sanitation in Nepal and its interest in promoting EcoSan is praiseworthy. It can play a very important role in further promoting EcoSan by providing institutional support as well as mobilising resources and developing human resources in this sector.

Small Town Water Supply and Sanitation Project

This is an ADB funded government project, designed to provide water supply facilities in emerging and small towns of Nepal. The project has also initiated construction of some EcoSan toilets as demonstration units. Two such toilets have been built in Surkhet. As this is a large project that is being implemented in many towns, it has the potential to spread the technology throughout Nepal.

Local non-governmental and private organisations

Local non governmental and private organisations involved in the water and sanitation sector play an important role in research and development, demonstration and local level promotion. Many NGOs are working closely with local communities and local governments and they can therefore promote the technology at the local level.

Centre for Integrated Urban Development (CIUD)

CIUD, a local NGO that is involved in urban planning and development, is promoting EcoSan in Tigani and Gamcha settlements in the Kathmandu valley. CIUD also has the capacity to carry out research on EcoSan and other eco-friendly technologies.

Community Development Forum (CODEF)

CODEF is a local NGO which has successfully implemented a pilot project on Wet EcoSan toilets in Parsa district. With the encouraging results of the project, CODEF is planning to extend the program, with a target of converting the whole village to an eco-friendly village.

Development Network (D-Net) Pvt. Ltd.

DNet is one of the pioneering institutions that introduced EcoSan toilets in Nepal. In 2002/03, D-Net, with support from DWSS and WHO, constructed ten EcoSan toilets for the first time in Siddhipur. The organisation has well-trained experts who are capable of doing research and promotion for EcoSan.

Environment and Public Health Organisation (ENPHO)

ENPHO is a research-based NGO dedicated to developing and promoting appropriate technologies to enable communities to become eco-friendly. It has been working on water and sanitation related issues

since its establishment in 1990 and it is one of the pioneer institutions for research and promotion of EcoSan technology in Nepal. ENPHO has promoted EcoSan in Siddhipur, Lubhu, Imadol, Khokana, Duwakot, Gorkha and other parts of the country and it has conducted research on issues such as pathogen die-off in EcoSan, urine application in compost and the effect of urine application in crops. ENPHO's strength is its capacity to do research, promotion and training on EcoSan and related topics.

Lumanti
A NGO dedicated to serving the urban poor on issues such as housing, water supply and sanitation and community development. Lumanti is a well established organisation that has been assisting in the construction of EcoSan toilets in several communities in the Kathmandu valley, including the Sankhamul squatter settlement, Thecho, and Tokha.

Nepal Water for Health (NEWAH)
NEWAH is a large NGO that was established in 1992 with the goal of improving the quality of life of the Nepali people by contributing towards safe water, health and sanitation services for those in greatest need. NEWAH has installed a few EcoSan toilets in Tigani of Bhaktapur and it has the capacity to do large scale scaling up of this technology as it has many trained staff involved in many sanitation projects throughout the country.

Nepal Red Cross Society (NRCS)
NRCS is a humanitarian organisation that is also working in the field of water supply and sanitation. The organisation has also launched a few EcoSan toilets in eastern Nepal. As NRCS has offices in all districts of Nepal, its network can be used to further promote EcoSan.

Society of Public Health Engineers Nepal (SOPHEN)
SOPHEN has been involved in raising the awareness and capacity of EcoSan by organising workshops on this topic. As this is a professional body with many engineers as members, SOPHEN can be involved in human resource development related activities.

International organisations

International organisations have played an important role in supporting the development of EcoSan in Nepal. They have provided much needed technical and financial support for all except three of the 517 EcoSan toilets that been constructed in Nepal so far.

Plan Nepal
Plan is a large international NGO working on community development as well as water supply and sanitation. It has installed a few EcoSan toilets in Makawanpur district as demonstration units. As Plan Nepal has been involved in water supply and sanitation for a long time and has many projects in this sector, they can play an important role in scaling up the application of EcoSan.

Practical Action Nepal
Practical Action, formally known as the Intermediate Technology Development Group, is a UK-based NGO promoting various appropriate technologies for community development. It supported the construction of ten EcoSan toilets in a Chepang community in Gorkha district. As Practical Action is a fairly large organisation that is involved in several projects in Nepal and has a special interest in innovative and appropriate technologies, it can be involved in further promotion of EcoSan in its project areas.

UN-HABITAT
The Water for Asian Cities Programme of UNHABITAT has been promoting EcoSan as well as various other innovative technologies and practices in urban water and sanitation for the poor.

WaterAid in Nepal
WaterAid in Nepal is one of the pioneer organisations to support the development of EcoSan toilets in Nepal. It has provided support to several of its partners, including ENPHO, Lumanti and CIUD to promote this technology in Nepal and it has also supported various research projects on this topic. As WaterAid in Nepal is dedicated to supporting the water and sanitation sector in Nepal and has several different projects in this sector that are implemented through various partner organisations, WaterAid in Nepal can definitely play a very important role in further scaling up the promotion of EcoSan in Nepal.

World Health Organisation (WHO)
The World Health Organisation has assisted DWSS in promoting EcoSan technology by providing funds for demonstration projects as well as workshops. WHO can also play an important role in the future in areas of technology promotion and capacity building.

6.2 Institutional framework for promoting EcoSan

Although there are several organisations promoting EcoSan toilets in Nepal and more than 500 toilets have been established, there is still a lack of a proper mechanism for scaling up the promotion of these toilets in a strategic and sustainable manner. Most of the work that has been done so far has been done on an ad-hoc basis without proper policies or long term strategies for research, promotion and monitoring. Although most of the organisations involved in promoting EcoSan in Nepal are aware of each other's activities, there needs to be more coordination among organisations promoting EcoSan and the promotion of this technology needs to be mainstreamed and institutionalised so as to ensure wide scale application throughout the country.

In this context, the institutional framework and mechanisms used for

promoting biogas technology are an interesting model that can be replicated with necessary modifications for promoting EcoSan.

The biogas model, which has been successful in promoting biogas technology in Nepal, is described in Box 4.

Photo 6.1:
Poster used for promoting EcoSan toilets

Box 4: Biogas promotion in Nepal - a model for EcoSan promotion?

In 2006, Nepal had more than 150,000 household biogas plants spread over 65 districts throughout the country and it had institutionalised a unique model for promoting biogas in the country. The system has received several prestigious international awards and is now being replicated in several other countries. This system includes standardised technical designs, clear division of responsibilities between relevant government, non-government and private organisations associated with biogas promotion, a uniform financing system and a strong quality control system. The system for scaling up biogas in the country consists of the following components:

- ***Policy framework:*** Several national policies including the tenth Five Year Plan (2002-07) and the Rural Energy Policy2006 have established biogas promotion as a priority activity and provided the foundation for promoting biogas in the country.

- ***Institutional framework:*** The Biogas Coordination Committee, with the Executive Director of Alternative Energy Promotion Centre (AEPC) as its chair person, is responsible for overall coordination, guidance and monitoring of the biogas promotion programme in the country. The Biogas Sector Partnership-Nepal (BSP), which started as a SNV supported programme in 1992 but established itself as a NGO in 2003, is the main organisation responsible for implementing the biogas promotion programme in Nepal. BSP works with certified private companies who are responsible for constructing the biogas plants.

- ***Financing mechanism:*** The government has a standard subsidy policy that has fixed the subsidy rates for different size plants in different areas of the country and the subsidy delivery mechanism is also fixed. In 2006, the subsidy ranged from Rs. 6,000 for a 4 or 6 m^3 plant in the Terai region

to a Rs. 12,000 for a 4 or 6 m^3 plant in remote hill districts. AEPC has also established a Biogas Credit Fund that provides loans through micro-finance institutes (MFIs). Over 130 banks and MFIs are currently providing credit for construction of biogas plants. The AEPC also receives funds through government, donor agencies as well as the sale of emission credits through the Clean Development Mechanism (CDM).

- ***Standard design:*** The government subsidy is only applicable for GGC 2047 fixed dome model biogas plants with a size ranging from 4 to 10 m^3.
- ***Quality management system:*** Only licensed companies – there were 65 such companies in 2006 – are allowed to construct biogas plants using trained masons and specified materials and appliances. The Quality Standard Document, published in 2004 has 82 criteria that all companies have to follow. All companies have to give at least a one year guarantee on all appliances and a three year guarantee on all structures and provide one maintenance visit per year during the guarantee period.
- ***Monitoring and evaluation:*** AEPC and BSP keep records of all plants constructed and at least five percent of all new plants are monitored in the field, through random sampling, for quality assurance. All companies are required to submit completion and annual maintenance reports.

Overall, the system for promoting biogas in Nepal is working quite well and it could serve as a model for EcoSan promotion as well.

7. Conclusions and recommendations

7.1 Conclusions

A Strength, Weakness, Opportunity and Threat (SWOT) analysis has been done, based on the findings of this study, to draw conclusions on the current status of EcoSan promotion in Nepal and explore future options for scaling up the application of EcoSan in Nepal.

Strengths

The main strength of the EcoSan toilets and the system for its promotion in Nepal are listed below. Future programmes to further promote EcoSan in Nepal need to build on these strengths.

- The number of EcoSan toilets has grown steadily over the past five years with more than 500 such toilets established in the country. Although most of these toilets have been built in Kathmandu, slowly the application of this technology has been spreading to other parts of the country as well.
- Most of the EcoSan toilets are being operated and maintained in a proper manner and most of the toilets are clean and hygienic.
- EcoSan toilet designs have been developed and modified over the years to suit the local context. Several different designs have been developed to cater to different needs and innovations such as Wet EcoSan and Indoor EcoSan have also been developed locally.
- Several different types of pans have been manufactured locally to suit local conditions, ensure regular supply and reduce the price of EcoSan toilets.
- Several organisations are involved in the promotion of EcoSan and there are many locally trained experts. These include international as well as local organisations and universities that are involved in a various activities related to promotion, capacity building and research.
- Some organisations have also conducted innovative research on issues such as pathogen die-off, application of urine on compost and the effect of urine application in crops.
- The technology has been endorsed by the Government of Nepal and DWSS is involved in its promotion as well. EcoSan has been listed as one of the on-site sanitation measures suitable in the Nepalese context.
- The social acceptance of EcoSan is very high. Most users of EcoSan are satisfied with the performance of this technology and they are


WaterAid/Anita Pradhan

recommending it to others as well. In houses where EcoSan toilets have been established, all family members are using it on a regular basis and they are also involved in cleaning it and managing the faeces and urine.

- Women and children are also quite comfortable using the EcoSan toilets. Therefore, there are no gender related problems in the toilets.
- Many farmers who use EcoSan appreciate the fertiliser value of excreta and are using the collected urine and faeces either directly in their farms or for co-composting. Most farmers have also said that the use of EcoSan products has increased their yields, especially of vegetables.

Weaknesses

The main weaknesses of the EcoSan toilets and its promotion in Nepal are as follows:

- Although urine collection and recycling is one of the main principles of EcoSan, 29 percent of the EcoSan toilets did not have containers for urine collection. Even when urine is collected, in many places the collection vessel is too small. Similarly, in several toilets the urine is not collected and stored properly - resulting in excessive loss of nitrogen as well as a foul smell.
- As the demand for fertiliser is seasonal, while the supply of urine is continuous, storage of urine is difficult.
- Transportation of urine to the field is difficult, especially in areas where the fields are very far from the homes.
- Many of the farmers are not aware of urine application rates for different crops.
- EcoSan toilets are slightly more expensive than ordinary pit latrines or offset double pit latrines. Although EcoSan toilets also provide some benefits in terms of fertiliser, the benefits are difficult to quantify and the high initial cost is a barrier for most poor families.

Opportunities

The current scenario in Nepal provides several opportunities for

further promotion of EcoSan, which are listed below. These opportunities must be capitalised to scale up the application of EcoSan in Nepal.

- As over half of Nepalese households still do not have access to toilets and the access to sewer lines is also very low, the potential for promoting EcoSan, as well as other sanitation options, is high.
- Many communities in Nepal traditionally use excreta in their fields and therefore, in these communities, the use of EcoSan products will not be a social taboo. So far the application of EcoSan has mostly focused in Newar communities in Kathmandu, but the potential for using EcoSan in other communities such as Sherpa communities, remain untapped.
- The demonstration of EcoSan and urine application in Parsa has shown that even in communities that traditionally do not use excreta in their fields, the acceptance of urine as a fertiliser can be very high once the benefits are demonstrated.
- EcoSan is suitable for many areas in Nepal. As many communities in Nepal, especially in the hills, face water shortages, these communities may be attracted to EcoSan technology as it conserves water. In the Terai, floods and water logging due to a high ground water table is a problem in many areas. In these areas as well, EcoSan can be a good option.
- Although Nepal is predominantly an agricultural country, access to chemical fertiliser is difficult in many areas of Nepal. Most of the users of EcoSan toilets that have been established so far have appreciated the use of urine as an organic fertiliser. Therefore if the value of urine as fertiliser can be explained to farmers, EcoSan toilets and the use of urine as organic fertiliser could be a popular option for many farmers in the country.
- The system that has been established for the promotion of biogas in Nepal presents a good model for institutionalisation of EcoSan promotion in Nepal.
- National and international interest on sanitation in general, and EcoSan in particular, is increasing. This presents opportunities for resource mobilisation and projects related to EcoSan.
- The demand for organic food such as vegetables, tea and honey, both in the national and international market, is growing. Therefore the demand for organic fertiliser will probably increase in the future.

Threats

The main threats that may hamper further growth of EcoSan toilets in Nepal are as follows:

- With the growing popularity of the Community Led Total Sanitation (CLTS) approach, which discourages the use of subsidy for toilets, there is a growing trend for promoting toilets without providing subsidies. Although CLTS itself is a very innovative and effective tool,

removing subsidy for all types of toilets would lead to more people installing low-cost toilets such as pit latrines. As EcoSan is slightly more expensive than other technologies in terms of initial investment and EcoSan toilets include waste processing as well as other benefits, some subsidy for EcoSan, particularly for poor families, is justifiable and should be continued. The amount of subsidy can be reduced and uniform as in the case of biogas, but not having any subsidy will mean that less people will choose EcoSan toilets.

- Political disturbance and instability in the country has an adverse effect on all development efforts, including promotion of EcoSan toilets.
- Wide scale promotion of chemical fertilisers will reduce people's interest in EcoSan and organic fertiliser
- Construction of sewer systems will encourage people to simply connect their toilets to the sewer lines instead of adopting innovative solutions such as EcoSan.

7.2 The way ahead

Overall, the introduction and promotion of EcoSan toilets in Nepal has been successful and the positive response of users, as well other key stakeholders, clearly indicates that there is a need to further promote this innovative technology. The SWOT analysis has indicated that the existing EcoSan toilets and the system to promote them, have plenty of strengths as well as opportunities. In this context, the road ahead for EcoSan should be designed to build on the strengths and to take advantage of the opportunities, while overcoming the few weaknesses and avoiding the threats. Listed below are key recommendations for scaling up the application of EcoSan toilets in Nepal.

1. **Institutionalise a system for promoting EcoSan** – For this, DWSS should take the lead in bringing together key stakeholders/EcoSan promoters to design a system to standardise designs based on local needs, develop a uniform financing system and ensure quality control. The model used for promoting biogas in Nepal can be used as an example of such a system. Just as in the case of biogas, a central EcoSan fund can also be set up to provide some financial support, along with technical advice, to anyone who wishes to set up EcoSan toilets.

2. **Use agricultural sector to further promote EcoSan** – So far only people working in the water and sanitation sector have been promoting EcoSan and this is only seen as a tool for sanitation. Nepal has a large network of agricultural extension workers who could also be used for promoting EcoSan. For this, initially, institutions such as the Nepal Agricultural Research Council (NARC) and the Central Horticulture Centre should be

mobilised to conduct research on the application of urine so they can endorse this practice and provide guidelines on the use of urine to farmers. This should be followed by extensive training to extension workers and also demonstration of urine application in several different locations. Lobbying should also be done to gain policy support and budgetary allocations from the Ministry of Agriculture.

3. **Demonstrate EcoSan in different areas outside the Kathmandu valley** – So far most EcoSan toilets have been built only in the Kathmandu valley. There is a need for demonstration projects outside the valley, especially in communities where there is likely to be a great demand for EcoSan toilets. These include communities where availability of water and fertiliser is a problem and where the use of human excreta is not a social taboo.

4. **Include EcoSan promotion in existing projects and programmes** – Several sanitation projects, such as the Small Town Water Supply and Sanitation Project and the Urban and Environment Improvement Project as well as agricultural related projects are being implemented in the country and many more are in the planning stages. Promotion of EcoSan should be included in these projects. Furthermore, institutions such as the Rural Water and Sanitation Fund Board should also include EcoSan promotion in its programmes.

5. **Promote urine utilisation** – This study has clearly indicated that many of the EcoSan toilet users are not effectively utilising the urine. Therefore, a good urine collection system, with 100 litre plastic tanks, and proper training on urine utilisation, should be mandatory for all EcoSan toilets.

6. **Demonstrate the concept of a urine bank** – Many people are not able to fully utilise the urine they produce because the demand for fertiliser is seasonal and storage of urine is difficult. Therefore, the possibility of a urine bank that collects urine from different EcoSan users or from places where urine is produced in large quantities, and then stores it properly and distributes it when there is a demand for it, should be explored. Slowly, the possibility of trading urine commercially should also be explored as it is done in some European countries. The possibility of urine crystallisation for easy storage and use should also be explored together with international research agencies.

7. **Reduce the cost of EcoSan** – Although several efforts have been made to reduce the cost of EcoSan toilets, there is still a need to introduce EcoSan toilet

models that cost less. Wet EcoSan and Indoor EcoSan are positive steps in this direction.

8. **Promote organic fertiliser** – The promotion of organic fertiliser will not only improve soil quality but also promote EcoSan and the use of urine. EcoSan should be promoted among organic farmers and people interested in organic farming as a source of organic fertiliser.

9. **Build local capacity** – A wide range of people such as technicians involved sanitation promotion, masons, agricultural extension workers, community development workers and policy makers should be trained on various aspects of EcoSan and its use.

10. **Raise awareness on EcoSan** – As many people are still not aware of EcoSan, its benefits and its application, campaigns to raise the awareness of general public, local leaders, politicians and policy makers is essential for further promoting EcoSan. The awareness campaigns should use tools of mass communication as well as interpersonal communication. This will also require appropriate communication materials such as leaflets, brochures as well as audio/video materials.

11. **Conduct research and monitoring** – As EcoSan is still a relatively new concept in Nepal, there is still need for research in areas such as urine application and optimisation of design. Furthermore, the existing EcoSan toilets should be regularly monitored to assess their performance.

12. **Build effective networks for learning and coordination** – A network of EcoSan promoters and users in Nepal should be formed to learn from each other's experiences and also develop linkages with research and promotion related activities being done in other countries. Interconnection between the network of EcoSan users, promoters and organic farmers can extract potentialities on urine marketing. That will be a common forum for users, promoters and farmers.

Roof Top Eco-San: A New light house

"My friends are coming to see my new toilet", exclaimed 9-year old Ashim Maharjan. He has been using the exo-san toilet since two months. Though he used to feel a bit uncomfortable using the new system of toiletry initially, he felt at home with it now. "My mom told me how to use it and every now and then she reminds me that I should use different holes for urination and defecation." giggled Ashim. With a twinkle in his eyes he added. "When I squatted on the pan for the first time I faced the wrong direction and urinated in the bigger hole, Ha, Ha. " He did not elaborate on the jeopardy that might have occurred on the other direction. When asked, "Do you wash your hands properly after anal cleaning?" he nervously answered 'No'. Even though he knows that hands should be washed carefully, he has been indifferent. When told about the consequences and ridiculed about how he has been eating his own faeces, he promised to wash his hand properly.

Ashim is from a farmer community and lives with his father, mother and three sisters in Thecho. The family has been using a dark corner under the ground floor ladder for night time and emergency use. At other times they practiced pen defecation. Ashim often overheard his sisters rueing about the difficulties associated with open defecation like exposure and safety. "Now, Thank God," Ashim thought, "we don't have to go anywhere and get humiliated."

When Lumanti suggested that they construct an eco-san toilet in their house hold the family was initially very sceptical because they did not have any spare land in their premises. Ashim's father expressed his frustration thus, "Oh! How I wish I had a piece of backyard space so I could save on buying fertilizers by generating our own fertilizer though this eco-san" When told about a house-owner in Tokha who constructed an eco-san inside the house, he expressed the desire to see it. An exchange visit to Tokha was arranged to include other members of the community. Impressed by the well functioning toilets there, Ashim's father hit upon the idea of constructing his eco-san on the terrace of his house. The idea was good for the faeces too, because they got enough sunlight for decomposition and turn into safe and valuable organic manure.

Ashim is proud to own a roof top modern toilet system and he often talks about it in school with his friends he once shared his pride with his teacher wondering what kind of response he would get but was pleasantly surprised when she congratulated him.

References

DWSS, 2005: Promotion of Ecological Sanitation (ECOSAN) in Parsa District, Department of Water and Sanitation (DWSS), World Health Organisation (WHO) in association with Community Development Forum (CODEF), Kathmandu.

Holden, R. Terreblanche, R. Muller, M, 2004: 'Factors which have influenced the acceptance of Ecosan in South Africa and development of a marketing strategy' in Werner et al. 2004: Proceedings of the 2nd International Symposium on Ecological Sanitation in Lubeck, Germany, GTZ, Eschborn, Germany. Available at http://www.gtz.de/de/dokumente/en-ecosan-symposium-luebeck-session-b-2004.pdf

Manandhar, A., 2004: 'Investigation of the fate of indicator microorganisms in source separated human faeces and of the impact of urine application on potato crops in Khokana', MSc. Thesis, UNESCO-IHE, Delft.

Ranjit, R. & Heijnen, M, 2006: 'Developing opportunities: safe water and sanitation for all', World Health Organisation, Kathmandu.

Rockström, J, Axberg, G.N., Falkermark, M., Lannerstad, M., Rosemarin, A., Caldwell, I., Arvidson, A., Norström, M., 2005: 'Sustainable pathways to attain the Millennium Development Goals: Assessing the key role of water, energy and sanitation', Stockholm Environment Institute with contributions from Stockholm International Water Institute (SIWI), Stockholm.

Thapa, G.B., 2004: 'Knowledge, attitude, practice and performance of ecological sanitation toilets', MSc thesis, Institute of Engineering, Tribhuwan University, Kathmandu.

WaterAid

WaterAid's mission is to overcome poverty by enabling the world's poorest people to gain access to safe water, sanitation and hygiene education.

For more information, please contact:
WaterAid in Nepal
Kupondole, Lalitpur, Nepal
GPO Box: 20214, Kathmandu, Nepal
Telephone: + 977 1 5552764 / 5552765 / 5011625
Fax: + 977 1 5547420
Email: wateraid@wateraidnepal.org.np

www.wateraid.org/nepal

INTERNATIONAL YEAR OF SANITATION 2008

www.iys2008.org.np

END WATER POVERTY
SANITATION & WATER FOR ALL

www.endwaterpoverty.org.np

With thanks to:

ENPHO
Creating Eco Societies

Environment and Public Health Organisation
110/25 Adarsa Marga-1,
Thapagaon, New Baneshwor
GPO Box: 4102, Kathmandu, Nepal
Telephone: + 977 1 4468641, 4493188
Fax: + 977 1 4491376
Email: enpho@mail.com.np
www.enpho.org