CAMBODIA

Case Study 1: Floating Toilets for the Floating Villages in Tonle Sap Lake

Project Owner(s)	▪ The floating communities within the Tonle Sap Lake of Cambodia
Project Partner(s)	▪ Lien Aid ▪ Lien Institute for the Environment (LIFE)
Primary Contacts	▪ Anasuya Sanyal, Lien Aid; admin@lienaid.org

Introduction

This case study is about the floating toilets developed by Lien Aid to help improve the state of sanitation of the people of Cambodia. Lien Aid is a non-government organization which is based in Singapore and its main thrust is to address the water and sanitation crisis in developing countries in Asia.

Background

The project is located in Tonle Sap Lake, Cambodia's great lake. The people in the villages live in houses with floating platforms that are usually moved seasonally. Their outhouses are made out of simple wooden plank just above the open water. With this kind of practice, the villagers' health is at risk because the water that they use for drinking and washing is the very same water that they also contaminate.

There are only 16 percent in rural Cambodia which has proper toilets and data shows that over 11 million Cambodians lack access to improved sanitation. Not to mention that the number one cause of sickness and death among children is diarrhea.

Objectives

The project aims to make a difference in the floating villages by introducing the concept of "floating" toilets which are affordable, locally-made, and therefore sustainable. Simultaneous with building of the floating toilets is providing the villages with a clean and safe drinking water. The organization is also exploring other options on the use of especially adapted septic tanks plus ecological sanitation using the urine diversion-desiccating (UDD) toilet.

Beneficiaries

The project will benefit the floating villages located within the Tonle Sap Lake of Cambodia comprising of about 10,000 people.

Sanitation Technology / System

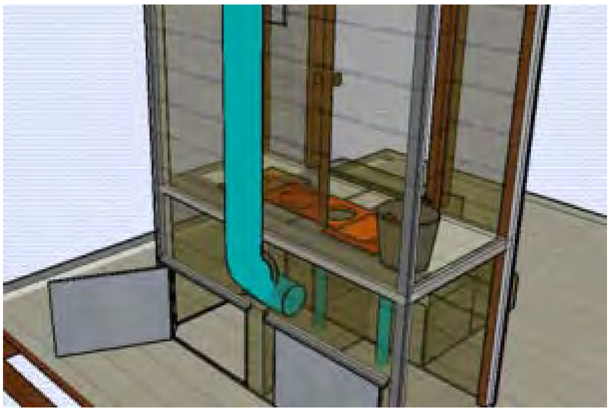
The toilet design is based on the villagers' preferences, thus the consideration on the part of Lien Aid as to determining the size of the toilets, the buckets to be used for storing the excreta, the ecosan pans (2-hole or 3-hole), and other design options.

The cost per toilet is around US$50-200, but also in consideration of other factors such as: 1) whether the family will just upgrade their existing drop-hole toilet to accommodate the UDD technology; 2) whether an entire toilet will be constructed from scratch including its superstructure. Cost consideration is also extended on the size of the toilet, meaning those toilets that can accommodate 2 tanks will obviously cost more [The 2 tanks will be for families who wish to avoid handling semi-decomposed excreta every few months. Once the first vault is full, it can be sealed for a few months until the feces dries up, and the alternate second vault will be used. Toilets with only 1 vault means the family will have to dispose of semi-composted feces at monthly intervals.]. Given this considerations, Lien Aid is looking for ways on how to lower the cost of the toilet construction by using indigenous materials and encouraging local entrepreneurs to manufacture the UDD pans.

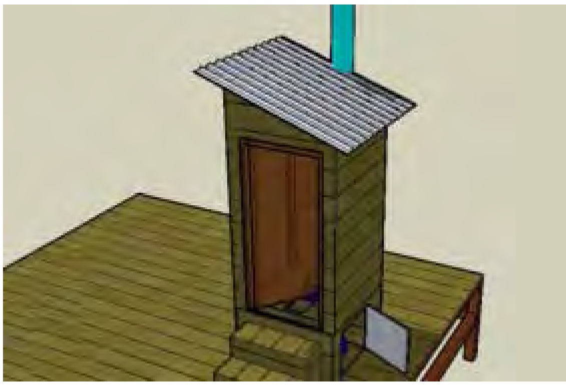
Lien Aid also planned a "land-based composting unit and collection system" to be established in order to manage the semi-composted feces. This is done to complement the concept of the "floating toilets and a long-term plan to promote the use of fully decomposed feces as compost.

Sample Designs for UDD Floating Toilets:

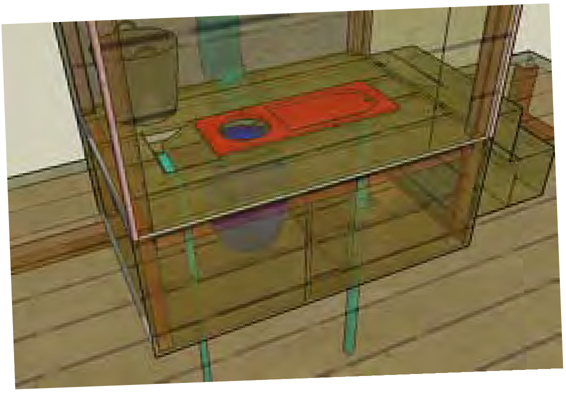

Reversible Pan Front View



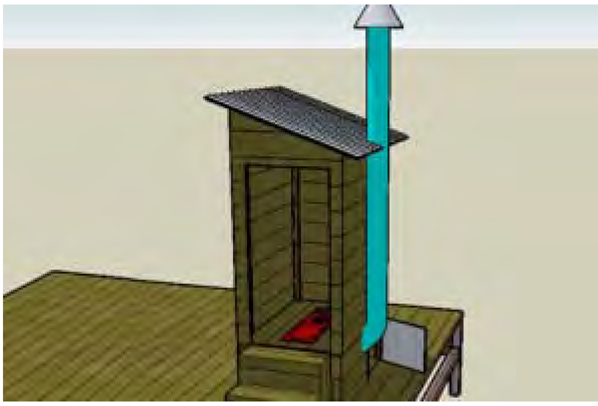
Reversible Pan Semi Transparent Rear View



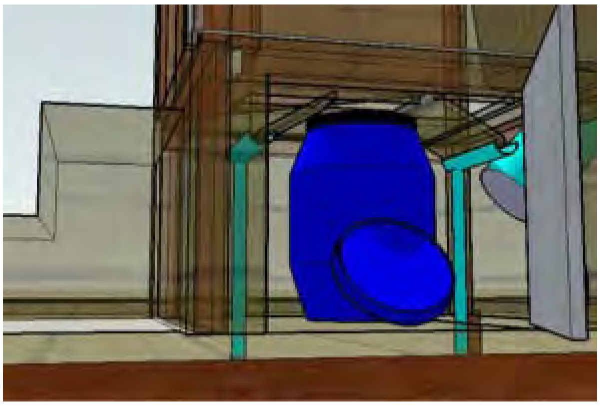
Front View



Semi-Transparent Front View



General View



Semi-Transparent Details View

Partners

Lien Aid is a Singapore-based non-government organization established in 2006 to address the water and sanitation crisis in developing countries around Asia. It is an independent entity established through the Lien Foundation – Nanyang Technological University Environmental Endeavour.

Lien Aid together with Lien Institute for the Environment (LIFE) are responsible for introducing the "floating toilet" concept to the floating communities of Tonle Sap Lake in Cambodia in February 2009, as part of the "River of Life" project.

Support

The Ministry of Rural Development (MRD) supports the River of Life project and works closely together with Lien Aid. Other local authorities are also supportive in terms of developing simple publications on methods of construction, use and maintenance of the "floating toilets".

Impacts and Challenges

One of the project's sustainability efforts is setting up of a community center for water-sanitation related training and advocacy activities. The villages will also be involved, especially the community leaders who will be tapped to form the water-sanitation group.

Another means for sustaining the project is also to get counterparts from the residents like local source of materials in the construction of their own toilets.

Key challenges to the project are the following: 1) modifying existing toilets to incorporate the UDD options; 2) ensuring availability of suitable drying materials for covering feces; and 3) keeping the costs manageable.

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CAMBODIA

Case Study 2: Floating Community Ecological Sanitation Project on the Tonle Sap Lake

Project Owner(s)	▪ Phat Sanday floating communities on the Tonle Sap Lake, Cambodia
Project Partner(s)	▪ Live & Learn Environmental Education Cambodia (L&L) ▪ Engineers Without Borders Australia (EWB) ▪ Ministry of Rural Development (MRD) ▪ Phat Sanday Community ▪ Science and Technology Innovations for the Base of the Pyramid in Southeast Asia (iBoP Asia) ▪ Resource Development Institute Cambodia (RDI) ▪ Royal University Phnom Penh (RUPP) ▪ EEP Mekong
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Introduction

Water and sanitation are some of the most pressing issues facing people in rural Cambodia, and they are even more difficult to access for people that live in floating and flood-affected communities on Cambodia's waterways. Human development in the country is still restrained by pollution and poor health, yet there is a lack of appropriate options for addressing these issues and managing sanitation. The end result is that human excreta is disposed in the environment leading to the contamination of waters, soils and dust, thus adding to the burden of diseases. In an attempt to find an innovative solution to the sanitation issues in Cambodia, the Live & Learn Environmental Education Cambodia (L&L) partnered with Engineers without Borders (EWB) to develop technologies suited for the floating communities of the Tonle Sap Lake, Cambodia.

This case study illustrates floating toilets and floating biodigesters developed as affordable sanitation options for the floating communities.

Background

The project is located on the Tonle Sap Lake, Cambodia's largest lake, with an initial focus in Phat Sanday Commune, Kampong Thom Province for trials and demonstrations. For communities on and around the Tonle Sap Lake and other waterways in Cambodia, there are a number of physical limitations due to the challenging environments of floating villages, flood-affected areas, and marginal riverbank areas. There are no currently affordable sanitation options available for these floating and stilted communities, so they are left with no choice but to urinate and defecate directly into the lake contaminating the waters that are the major source of their daily subsistence, including drinking, washing, bathing, and fishing. As a result, the households are exposed to a range of pathogens and residents in the floating communities suffer from diarrhea and other water-borne diseases.

Objectives

In response to this situation, Live & Learn Environmental Education Cambodia and Engineers Without Borders Australia have been in partnership since 2008 to develop affordable, sustainable and appropriate technology for this problem faced by the floating communities on the Tonle Sap. The focus of the project is to develop innovative technologies and practices for the human waste management for the floating communities and then demonstrate these in a method that provides an incentive for the community to take up improved sanitation by generating social, economic and environmental dividends for the floating communities.

Beneficiaries

The project's initial target is for the surrounding floating communities of Tonle Sap Lake in Cambodia. After assessment and evaluation, the Phat Sunday Commune in the Kampong Thom Province was selected as the first beneficiary of the project. Phat Sanday can be reached by boat from Chhnok Trou and is about 30 minutes across the Tonle Sap. Chnnok Trou is the central port where supplies arrive from and goods are transported to. There are a number of river tributaries of the Tonle Sap, one of them the Stung Sen River where the majority of the villages of the Phat Sunday Commune take haven. The communities are predominantly fishing communities, although during the low water season, the villagers take the opportunity to build their houses and plant crops such as corn.

After demonstrating the technologies, work will focus on scaling up the solutions and implementing them in other communities, as well as disseminating the knowledge to encourage uptake and adaptation by other communities and organizations. The emphasis is on establishing solutions that will be desired by the community and encourage local investment.

Figure 1: An example of a typical floating house in Phat Sanday (photo courtesy of Michael Brown, et.al)

Sanitation Technology / System

The development of the floating toilet design was initiated by Live & Learn Environmental Education and Engineers without Borders Australia (EWB) in consultation with the community. Participation of the community through field surveys and focus groups was central to the design process. The first design and trial floating toilet was tailored as affordable, low cost technology and would become the basis for a broader and holistic approach to sanitation in floating communities in Cambodia. The EWB team conducted a thorough review of existing sanitation options around the world. Upon thorough review, Urine Diversion Desiccation (UDD) was chosen as the most preferred and appropriate solution for the floating communities. This system separates the waste streams using a dedicated toilet-pan, and stores and treats the waste until it is safe to reuse or dispose. An initial trial was undertaken using this approach.

After the initial trial, a UDD floating toilet was then designed and developed using locally available materials from the community. A manufacturing technique was also developed in collaboration with EWB and RDIC in Cambodia. The uptake of the toilet has been controlled and carefully monitored in order to verify the suitability of the system.

In addition to a UDD toilet, the project is also taking the novel approach of developing floating biodigesters. Biodigesters are well established for land-based communities in Cambodia and numerous other locations, however current designs are unsuitable in these water-constrained communities. A number of modifications are required to adapt biodigestion to the floating communities, but the benefits of methane gas for cooking and light, as well as natural fertilizer, are expected to make sanitation a much more appealing option.

A major goal of the project has been to develop the system on the principals of ecological sanitation, creating a closed nutrient cycle by reusing treated waste for agriculture. As such, there is also investigation into how to apply the resources and ways to increase yield, such as ‘floating land’.

Floating Toilet Design

The pan is a custom-made urine-separating squatting pan fabricated by combining cement with other locally available materials. It was thought to be better to produce this locally rather than importing a latrine pan, to empower the community to improve their own design and open local market opportunities for the locally designed latrines.

The pan is needed to separate liquids from feces in order to enable desiccation as the most efficient method for the destruction of pathogens. The community members are currently using water for hand washing and anal cleansing after defecation, so there is an additional requirement for the disposal of wash water.

The pan has 3 holes; one hole is used to divert urine away from the feces hole, a straight hole for feces, and a large pan area and hole for wash-water. The pan is preferably lightweight, and can also be carefully designed making it a strong structure, scratch resistant, lightly colored and shiny. The current available local pan production is limited to the use of cement. The dimension of the pan is 50cm x 70cm.

For a small-scale trial, the material cost for the pan, frame and buckets was US $35, with a labor cost of US$5 per latrine. Upon completion of the prototype floating latrine, the project team undertook an initial trial of 14 prototypes in the target pilot community. The community was given initial information and given proper demonstration lessons on the use of the floating latrines and the importance of total sanitation. The team conducted their IEC campaigns mostly in the primary and secondary schools in Phat Sanday.

Figure 2: A prototype of a floating toilet (photo courtesy of Michael Brown, et.al)

Constraints around the space, weight and process requirements drove the need for reduced weight and volume systems, and a reduced time for storage. The method in the floating toilet design is to separate the faeces from the urine and the wash water. A desiccation process is used in treatment of the faeces using the application of additional wood ash to speed up the drying of faeces and to increase the pH for pathogen destruction. This type of treatment is used in land-based settings and the required minimum time for treatment to kill the faecal pathogens is 6 months.

The project has put a strong emphasis on developing solutions that are affordable, culturally appropriate, and sustainable, which has encouraged the use of local materials and skills. Considering the ease of handling and waste management requirements, the chosen core component of the floating toilet design are 20L buckets that are readily available at low cost. The bucket is situated below the pan, which rests on a simple low frame.

The requirements for this type of treatment are the following:

- 20L bucket for storage of waste (diameter 0.32m, height 0.35m)
- 2 or 3 hole pan for diversion of urine and wash water
- Disposal and/or collection method for urine and wash water
- Storage method for faecal waste for sufficient period of time under desiccating and alkaline conditions
- An appropriate additive to assist the desiccation process (ash).
- An effective means to incorporate the design into existing houses and structures

Super Structure

A superstructure is needed to provide privacy and safety for users and necessary to allow storage of faeces above the water line. This structure will also support the pan and to keep the user safe, providing sufficient room for the pan, anal washing, wash water storage, ash storage and menstrual hygiene management.

The preferred approach is to use and adapt (if needed) existing super structure where it exists. Where no super structure exists, incorporate one onto the corner of the floating home/building, utilizing existing walls.

Minimum dimensions are:

- Floor area - 1m x 1m allowing room for a 3-hole squat pan, and storage of ash and solid waste.
- Roof height needs to allow easy access to step in for all users, approximately, 1.8-2.0m.

Wash water

A ready source of water that includes a 1L ladle (this is commonly found in the market) is necessary for pouring of water to be used for anal washing. A bucket of water outside the cubicle with a rope can be readily filled over from near the house by an adult. This is needed to provide accessible water for all, especially for the children.

Ash/paper delivery

Requirements:

Wood-ash is needed for desiccation in order to increase the pH of the stored feces to speed up the dying process. A bucket is used as a container for the ash with a plastic cup/ladle (about the size of a cup), for use within the cubicle and within reach when standing over the pan.

Faeces Management

The faeces storage bucket fits directly below the pan. The storage should be placed above the water to keep it safe even during storms. The storage should also be able to be sealed for a minimum of 6 months. This faeces storage must be kept away from water to maximize the effectiveness of the treatment. A paint bucket with lid usually 20L is needed. This bucket is also available in the market. Under floor storage can also be considered if the original place for storage is not enough.

Urine Management

The urine is collected from the pan via a small pipe or hose and diverted to a storage container or directly to the water. The pathogen risk from urine is considered to be low and thus disposal to the lake is a safe option, however reuse as fertilizer may be preferable. The container for the urine should be sealable and of a sufficient size so that it can be easily transported and maintained.

Option 1:

The urine is being transported from the pan hole to the storage container using a flexible hose. The average urine storage needed is about 1.2L per person per day with this type of collection. The urine can be stored in 2 alternating plastic cans (20-30L) and should be changed every 5 days or so. The collected stored urine is now ready for reuse. There should be no washing of urine because the water in urine can add to the smell and the risk of bacterial contamination before applying it to plants. An elastic material (such as condom) or other similar material is used by the communities to create a self-sealing pipe in order to prevent the release of urine odors especially in times when no liquid is passing through it.

Option 2:

The urine is directly disposed into the lake via flexible hose. Washing of the urine pan hole is also permitted, being careful not to pour water to the pan hole for feces.

Wash Water Management

This is for the traditional self hand washing after defecation. Wash water only contains low quantities of pathogens, so it can be disposed of into the lake directly. The needed materials can be flexible hose, or jointed pipes, for the wash water to flow directly into lake.

Menstrual Hygiene Management

One fundamental aspect of sanitation for women ages 10 to 50 is the menstrual hygiene management. According to EWB, the results of their surveys and workshops tell them that women in the floating villages almost universally use disposable paper/plastic napkins for menstrual hygiene management. The napkins are either kept in a bag with solid waste and disposed of into the lake later or thrown directly into the lake. The women in the communities really need access to a private disposal option for sanitary napkins. In demonstrating the floating toilet, menstrual hygiene management has been integrated into the management and education around using the system, and biodegradable materials can be disposed of with the faeces and ash, or a bucket or container can be placed within the cubicle.

Children, Elderly and Disability Considerations

The use of the squat pans can be really difficult for the children, the elderly and those with physical disabilities such as leg amputees. While the current floating toilet design is only raised a small amount, this can still be difficult for less-mobile users, so adapted designs are intended to address this. The use of a seat is being considered and could be made customized by the local manufacturer especially for the families with elderly or disabled family members. An additional consideration is the use of a strong galvanized pipe or a properly constructed wooden handrail to be added on either side of the latrine pan to allow users to lower themselves and raise themselves more easily.

Floating Biodigester

Biodigestion technology is successfully used in many circumstances to treat human waste effectively and rapidly, while at the same time producing methane gas and fertilizer. Standard approaches are not suitable for floating communities with little or no access to permanent land, typically small, weak, and mobile structures, and with small quantities of organic waste. So, floating biodigesters are being developed by EWB and Live & Learn, for trials and demonstration within these floating communities. Both continuous and batch biodigesters are under consideration, as well as systems of varying sizes, to assess which options may be most suitable to the community.

Preliminary designs have been developed, and construction, operation, and maintenance aspects are also under investigation. After development, refinement, and assessment of designs, in collaboration with the Phat Sanday community, the preferred options will be prototyped and tested. Operational aspects are likely to be particularly important, potentially requiring skills and training, as well as correct management of feed inputs to ensure successful biodigestion. The strong relationship with the community will be helpful in developing this solution into one that can bring multiple benefits to communities in challenging environments.

Partners

The project is an alliance of the different project partners, the Phat Sanday Community, Live & Learn Environmental Education (L&L), Engineers Without Borders Australia (EWB), Ministry of Rural Development (MRD), Science and Technology Innovations for the Base of the Pyramid in Southeast Asia (IBoP Asia), Resource Development Institute Cambodia (RDI), Energy and Environment Partnership Program (EEP-Mekong) and Royal University Phnom Penh (RUPP).

Engineers Without Borders Australia (EWB) is a non-profit group with operations within Australia and abroad that aims to improve the quality of life of disadvantaged communities through education and the implementation of sustainable engineering projects. EWB Australia was established in 2003 by a group of engineers from Melbourne who were inspired to take action on the developmental front through engineering. The group now has 20 active chapters around Australia. The role of EWB

Australia in the project is more on the technical and design support. The Country Manager for the project was also provided by the project team.

Live & Learn Environmental Education Cambodia (L&L) is a non-profit, non-government organization which promotes greater understanding and action toward human and environmental sustainability through education and dialogue building. L&L provided the Coordinator for the project and handles relationship building and community engagement.

Ministry of Rural Development (MRD) on the other hand has a mandate from the Royal Government of Cambodia for the improvement of the living standards of the people and the alleviation of poverty. The agency played an important role because it opened the access of the project team to the WATSAN forum and draw linkages to other organizations that are working in Cambodia. The MRD also provides grant to projects for the alleviation of poverty in the region.

Phat Sanday Community's role is for the engagement and support of the people in the community and the willingness of the people to participate in the project. Through the participation of people in the community, the project is able to input some local designs and materials to fit into the community's needs.

Science and Technology Innovations for the Base of the Pyramid in Southeast Asia (IBoP Asia) was a previous project grantee. Energy and Environment Partnership Program (EEP-Mekong) are currently supporting the demonstration of appropriate energy for floating communities, including developing floating biodigesters.

Resource Development International Cambodia (RDI) is involved in the prototyping and design development. It offered its expertise in working with the Cambodian environment and the use of its laboratory for testing.

Royal University Phnom Penh (RUPP) also offered its venue for laboratory testing. The organization is also involved in relationship building and capacity development.

Impacts and Challenges

The partnership between Live & Learn and Engineers Without Borders Australia with the support of the MRD was able to exhibit great impact and success especially in the trial of the trial of the floating toilets in Phat Sanday community in Cambodia. The partnership has successfully demonstrated the potential of the floating toilet in challenging environments.

The scale up method to enhance sanitation in the floating and flood affected communities will build upon the Sanitation Marketing methods currently undertaken in Cambodia to suit the circumstance of the flooding and flood affected communities. Live & Learn also has experience planning and executing Sanitation Marketing campaigns in Vietnam and Indonesia, which we will be able to draw upon.

The scale up recommendations will be developed in consultation with communities to ensure a truly sustainable uptake process. The project will also address waste life cycle and reuse, hand washing, menstrual hygiene management to ensure a holistic approach is undertaken to maximize the value of the sanitation solution and to reinforce messages of protecting water quality for the protection of the environment and human health.

The projects future plan will focus on building the supply and demand of floating latrines. The work in progress now is small scale and focused on the prototyping of the designs to ensure a reliable system is developed. With the collaboration of CLTS and Sanitation Marketing, there is a high chance of creating a demand for latrines in the floating communities. If there will be a demand for latrines, then the supply should also be taken into consideration. Working with local suppliers the project aims to improve the quality and the affordability of the system and support the development of local supply chains.

Live and Learn projects to develop a business model using techniques such Community Led Total Sanitation (CLTS) and Sanitation Marketing in order to build supply and demand for floating toilets for floating communities in Cambodia and beyond.

The challenge of this project is to improve the design to make it an attractive option to improve the health and sanitation of communities on Tonle Sap Lake, and other similar communities around the world.

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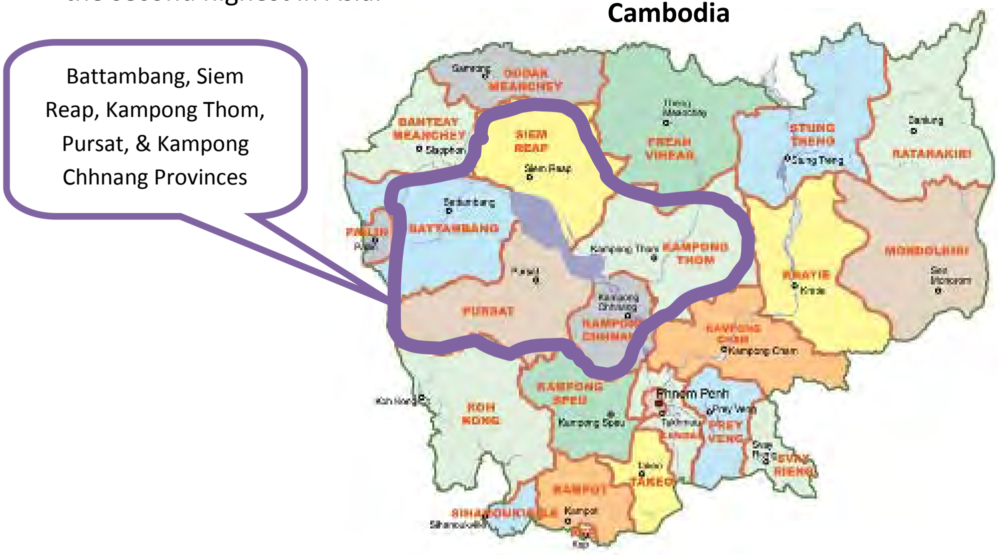
Cambodia
Tonle Sap Rural Water Supply and Sanitation Sector Project
An ADB-funded Latrine-Building Project in Cambodia

Project Owner(s)	▪ Residents of Battambang, Siem Reap, Pursat, Kampong Chhnang, & Kampong Thom Provinces
Project Partner(s)	▪ **Funding Agencies**: Asian Development Bank (ABD); Government of Cambodia – Ministry of Rural Development; Project Beneficiaries ▪ **Executing Agency**: Ministry of Rural Development (MRD) ▪ **Cooperating Agencies**: Many – Central Agencies, Provincial Agencies, International Development Agencies, and the Private Sector
Primary Contacts	▪ Alfredo Perdiguero, Senior Economist, ADB, aperdiguero@adb.org

Introduction and Background

Water and sanitation are one of the most pressing issues facing people in rural Cambodia, especially around the Tonle Sap Lake and river basin. Of particular difficulty for sanitation advocates in Cambodia is the old habit of open defecation, with the result of exposing human excreta to the environment. This leads to water and soil contamination and to widespread disease outbreaks. For the many 'floating communities' of people living on the lake itself, this is an even larger problem, due to their direct contact with the water. The UN estimated that, in 2008, only 23% of rural residents and 82% of urban residents had access to improved sanitation, which means the country still has a long way to go to achieving 'sanitation for all'. Indeed, rural water coverage is the second lowest in Asia, while infant mortality rates – due in part to high levels of waterborne disease – are the second highest in Asia.

Cambodia



Recognizing that large development investments in the country are needed to combat this situation, the Asian Development Bank began a major water supply and sanitation project for the provinces of the Tonle Sap basin, in partnership with the Cambodian government's Ministry of Rural Development. In 2003, the Cambodian government passed a national policy on water supply and sanitation, aimed at increasing water supply coverage to 50% in the rural areas and sanitation coverage to 30%, and that 'every Cambodian' in rural areas will have safe water and sanitation access by 2025. This project is one of its first major steps forward.

Project Purpose and Objectives

This project is aimed at providing rural water supply and sanitation facilities to approximately 1,760 villages in the five provinces of the Tonle Sap basin. It will include capacity building and institution strengthening efforts, as well as community mobilization, sanitation, and hygiene education programs. The purpose of these tasks is to enhance the health of low-income communities in rural areas by improving their hygiene, drinking water, and sanitation facilities. This will, in turn, benefit the environment of the Tonle Sap basin by lessening harmful wastewater inputs to the lake, rivers and groundwater. The specific project objectives are: 1) strengthen the community capability to design, cofinance, build, operate, and manage community-based water supply and sanitation facilities and increase hygiene awareness through information, education, and communication (IEC) campaigns; 2) improve access to safe water through the construction of adequate facilities based on community demand; 3) expand access to sanitation facilities; and 4) improve the capacity of government agencies, particularly at the local level, to plan and facilitate provisions for quality water and sanitation services in target communities. As a result, the project aims to provide an estimated 1.09 million people with safe drinking water and 0.72 million of these same people with improved sanitation facilities.

This project can be considered 'decentralized sanitation' because, even though it is a large, multi-agency project, work 'on the ground' will be accomplished through participating NGOs, who will run IEC and planning activities, as well as install the water supply and sanitation systems.

Partners and Funding Distribution

For this project, the main funding agency was ADB, who supplied an $18.0 million grant to the MRD. The Government of Cambodia will supply an additional $2.06 million, while the beneficiaries themselves, through user fees for O&M and initial construction fees and in-kind assistance, will contribute approximately another $3.94 million. The total project cost for all parties is therefore estimated to be $24.0 million.

The main executing agency for the project is the MRD, which will be guiding beneath it the Project Steering Committee, the Project Management Unit, the Project Implementation Unit, each of the participating provincial District Offices of Rural Development, each of the participating district Commune Councils, and each of the participating commune Village Chiefs and their members. 'Water supply user groups' will then be established in each village that will manage the facilities in the long term, including the collection of capital and O&M fees from villagers.

Some of the cooperating agencies and NGOs may include, depending on their own initiative, UNICEF, Oxfam, IDE International, Plan International, Care, Concern, IRC, GRET, ADRA, UNDP, SIDA, JICA, and AFD, amongst others.

Project Activities

This project is running from Q3 2005 until Q1 2012. The project activities include: project planning and preparatory activities at the central level (2005-2006), prioritizing intervention areas (2006), contracting qualified NGOs (2006), undertaking a community mobilization program (IEC campaigns, water supply and sanitation village plans, formation and training of local villager groups; 2006-2011), capacity building on all government levels (2006-2011), and implementing the water supply and sanitation facilities (preparing their designs and costs, groundwater testing, construction/rehabilitation of water supply and sanitation facilities, transferring of O&M to the villager user groups, and follow-up water quality testing; 2006-2011).

A unique feature of the project's sanitation portion is that, following intensive IEC activities in each village, beneficiaries will be offered a choice of sanitation technology that best suits their needs: dry pit toilet, ventilated improved pit toilet, or pour-flush latrine.

Sanitation Technology / System

This project does not involve the construction of any decentralized wastewater treatment plants, so the technology package consists solely of the latrine choices that will be offered to villagers.

A dry pit toilet is a widely used and cheap form of sanitation. It is made with a latrine superstructure, a squatting/sitting slab that covers part of the hole but leaves area for input of wastes, and a dug pit, into which is deposited all of the excreta, urine, toilet paper, and/or anal wash water used. The dug pits are usually unlined and therefore water pervious, and, when filled, are either emptied or closed and relocated. Pit latrines are considered improved sanitation, though odors, problems with flies, and some groundwater contamination still occur.

A ventilated improved pit toilet (VIP) is essentially identical to a dry pit toilet, except that it includes a vent pipe beside the latrine superstructure that leads up from a second opening in the slab. The vent pipe should be covered with mesh at its top. The addition of this vent pipe reduces odors and flies. The wind passing across the top of the pipe (which should extend above the superstructure) draws out air from the pit through the pipe, rather than out of the input hole, and the light shining into the pipe (assuming the inside of the superstructure area is kept dark) attracts flies to exit the pit up the pipe. However, the mesh covering the top of the pipe prevents the flies from leaving, and they eventually die and fall back into the pit. VIPs are considered improved sanitation, though some groundwater contamination still occurs.

A pour-flush latrine is essentially a flush toilet, except that the water is poured in by the user rather than having an automatically filling cistern. The pour flush latrine can be built similarly to the dry pit toilet and VIP, in that it consists of a superstructure, a dug pit, and a slab covering the pit except for an input hole. In this case though, the input hole is fitted with the toilet bowl (which can be ceramic, concrete, plastic, etc.), which then empties into the pit. The important part about the toilet bowl is that it is water-sealed, using a 'P-trap' style of piping, which prevents odor and flies from the pit. This basic template can take a variety of different construction forms: the toilet can instead be installed over a proper septic tank or leading to a sewerage system, the toilet can be installed inside a house, the bowl can be made for sitting or squatting, and so on. In its basic form though, which is what was used for this project, the pour-flush toilet is considered improved sanitation, though some groundwater contamination still occurs unless the pit is sealed and emptied regularly.

This project hopes to install enough of any of these three types of latrine so as to benefit up to 0.72 million Cambodians.

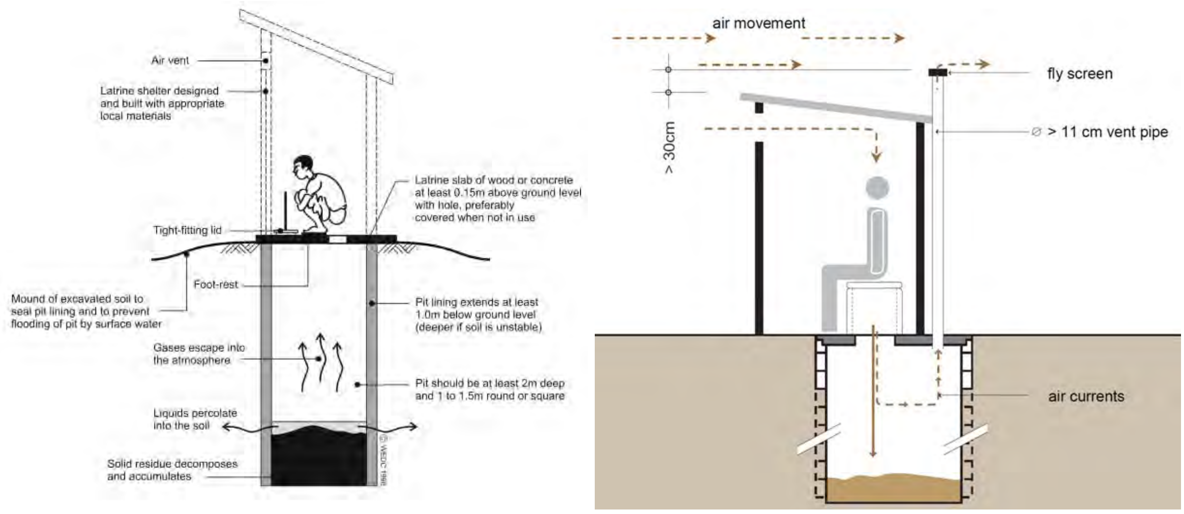


Figure 1. Schematics of a dry pit toilet (left) and a VIP (right)

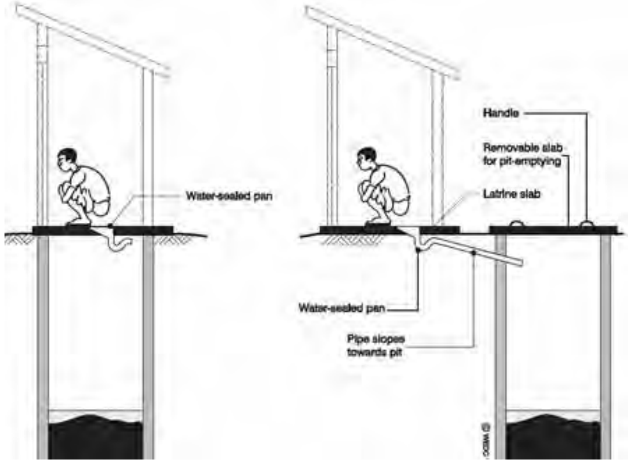


Figure 2. Schematic of a pour-flush latrine, with regular pit (left) or offset pit for emptying (right)

Number, Type, and Location of Beneficiaries

This project aims to directly benefit 1.09 million rural Cambodians in the Tonle Sap basin provinces of Battambang, Siem Reap, Pursat, Kampong Chhnang, & Kampong Thom with safe water supply systems and 0.72 million of those same villagers with improved sanitation systems, thus reducing the health risks to these people of poor existing drinking water and the risks of unmanaged excreta and wastewater. More indirect beneficiaries include the various levels of government staff that will benefit from the IEC and capacity building measures as well as non-recipient villages/villagers in these provinces, who will still benefit from lessened groundwater pollution and reduced health risks.

Impacts and Challenges

This project is still ongoing, so no final analysis of its overall impacts has been yet undertaken. If it delivers on its proposals, then it will, by 2012, have supplied safe water supply and sanitation services to 1.09 and 0.72 million rural Cambodians, respectively, and will also have: empowered these communities to take responsibility for these new systems according to their needs, increased awareness of healthy and hygienic behavior, and improved the various levels of Cambodian governments' capacities to facilitate, regulate, and plan further basic water and sanitation services.

The main challenges foreseen in the early project reporting were: changes to government policy that could deemphasize the project, difficulty in achieving participation and ownership of the local village user groups, and/or an insufficient number of experience and efficient NGOs for carrying out work on the ground. The final project report for this project will give indication if any of these challenges materialized significantly.

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Cambodia
Decentralized Wastewater Treatment Systems for the Sovann Komar Orphanage
A BORDA-Cambodia DEWATS Project in Cambodia

Project Owner(s)	▪ 1) Staff of Sovann Komar Orphanage
Project Partner(s)	▪ 1) **Funding Agency**: Sovann Komar Orphanage, OAV, BORDA; **Executing Agency**: Bremen Overseas Research and Development Agency – Cambodia (BORDA-Cambodia); **Cooperating Agency**: BORDA-Southeast Asia
Primary Contacts	▪ Alex Campbell, BORDA-Cambodia, campbell@borda-sea.org

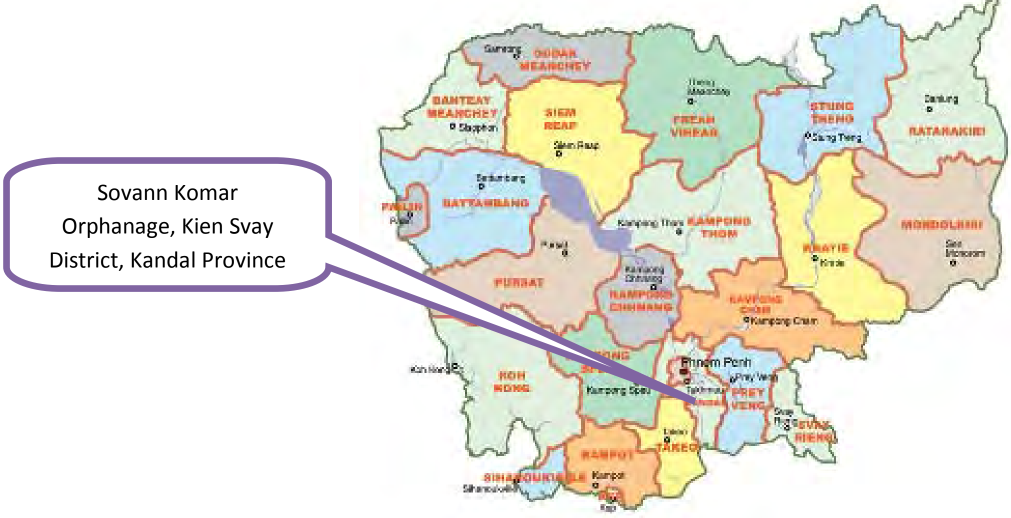
Introduction and Background

The Bremen Overseas Research and Development Agency (BORDA) has a mission to improve the living conditions of disadvantaged communities and to preserve the environment through decentralized sanitation projects. As part of this mission, the Agency has developed modular, decentralized, and cost-effective wastewater treatment service packages that they have termed 'DEWATS' – decentralized wastewater treatment systems, which, with the help of funding agencies, are being installed throughout Asia and Africa.

Water and sanitation are one of the most pressing issues facing people in rural Cambodia. Of particular difficulty for sanitation advocates in Cambodia is the old habit of open defecation, with the result of exposing human excreta to the environment. This leads to water and soil contamination and to widespread disease outbreaks. The UN estimated that, in 2008, only 23% of rural residents and 82% of urban residents had access to improved sanitation, which means the country still has a long way to go to achieving 'sanitation for all'.

With this in mind, BORDA recently established itself in the country, as BORDA-Cambodia. The Agency has completed three projects in Cambodia to date, one of which is outlined here.

Cambodia



The first area chosen for DEWATS was the Sovann Komar Orphanage, in Kandal Province. In this orphanage, a mechanized wastewater treatment plant already existed, but was no longer functioning due to the very high cost of maintenance (the estimated cost of replacing a filter was $20,000USD). As well, three of the orphan houses were not connected to this system anyways. In short, all of the orphanage's wastewater was currently being discharged untreated to the Mekong River due to this unsuitable previous technology. This was helping to cause damage to the downstream activities and life along the Mekong River, which is the focus of several large rehabilitation projects, and was thus not an acceptable discharge.

Project Purpose and Objectives

BORDA's general purpose for the DEWATS projects is to further their goal of "Improved Sanitation for All". Their systems help to fulfill this purpose, which can provide wastewater treatment for domestic or industrial sources and for flows as high as 1000m^3 per day, and are tolerant to flow fluctuations, require low maintenance, and are durable. In addition to this general purpose, each project undertaken by BORDA has its own purpose and objectives, based on the problems being experienced by the project site.

For this project, the purpose was to improve the sanitation situation of the Orphanage by installing a DEWATS for the 120 children and staff that lived and worked there, capable of treating up to 15m^3/day of wastewater flow. This had the objective of reducing pollution into the Mekong River and therefore helping to reduce the health risks to downstream users and the environmental risks to the downstream ecosystem and river life.

Partners and Funding Distribution

For this project, the funding agencies were the Sovann Komar Orphanage itself, OAV, and BORDA, with BORDA-Cambodia being the executing agency and BORDA-Southeast Asia also offering support during the process. The total project cost was $25,000USD.

Project Activities

This project ran from August, 2009, until 9 March, 2010, with construction beginning on 12 October, 2009. The project activities included: consultation with the staff of the orphanage, construction of the DEWATS, connecting the toilets/wash basins of all the orphanage buildings to the DEWATS, and training the staff on operation and maintenance.

Sanitation Technology / System

This module of DEWATS used by BORDA-Cambodia consists of the following sections, in order of wastewater flow: primary settling unit, anaerobic baffled reactor, anaerobic filter, horizontal gravel filter, and discharge pipe.

The primary settling unit serves as a wastewater retention point and an area for control of influent fluctuations (an equalization tank), which allows large sludge, debris, and other floatable/visible wastes to settle or be screened out and also allows a relatively constant flow of wastewater to proceed to the subsequent chambers (rather than having high flows during peak hours and no flow during nighttime). This unit is single-chambered for this project.

The anaerobic baffled reactor (ABR) is then the main treatment area of the DEWATS. As the name implies, this multi-chambered tank is closed from the air and anaerobic. Wastewater flows slowly up (and back down through pipes) through its several identical chambers, each time entering the chamber at its bottom, where it passes through the accumulated sludge. This allows solids to settle out into the sludge and anaerobic bacteria living in the sludge to degrade much of the harmful organic and chemical components of the wastewater. The number of chambers can vary depending on available land area, wastewater strength, and funds – the ABR for this project has 4 chambers, though 5 or 6 are also common.

The anaerobic filter (AF) follows the ABR and consists of a tank with a submerged layer of material like crushed gravel or specially formed plastic. On to this media grows a thick layer of anaerobic bacterial biofilm, which the upflowing influent wastewater then passes through. These biofilms help remove more of the dissolved solids in the wastewater, as well as other pathogens and chemicals still remaining in the wastewater. This unit has 2 chambers for this project.

The horizontal gravel filter (HGF) (synonyms include: planted gravel filter & horizontal constructed wetland) follows the AF and consists of a shallow concrete basin filled with fine gravel, with influent and effluent pipes on opposite ends of the basin. Hardy reed plants, such as Canna, are planted in high density in this gravel layer before the DEWATS becomes operational and are allowed to grow in clean water that is initially flowed through the basin. Once the plants are established, the DEWATS can become operational and introduce the wastewater from the AF into the basin. The plant roots within the gravel help to oxygenate the wastewater, which has been anaerobic to this point and still usually has a noticeable odor, as well as remaining organic compounds. This oxygenation helps to degrade these remaining organic pollutants, which also reduces the odor.

After the HGF, effluent is usually considered clean enough for safe river discharge, or can be held in a separate tank for reuse in watering plants or flushing toilets.

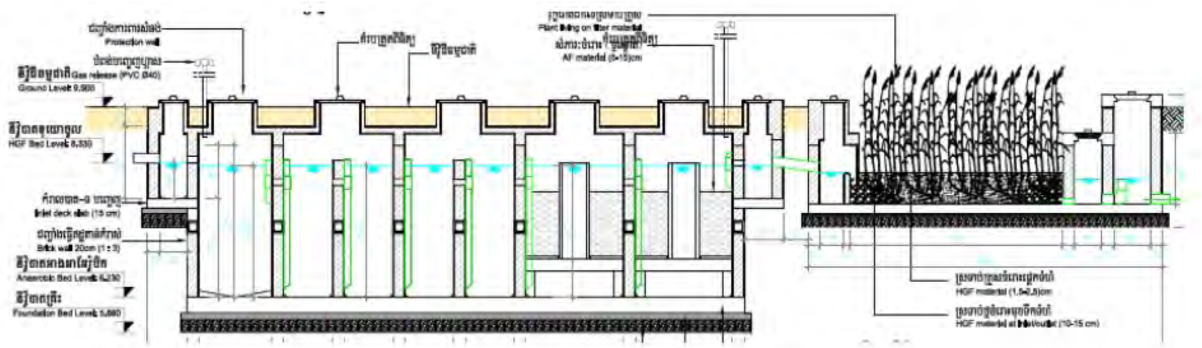


Figure 1. A cross section of the Sovann Komar project's DEWATS, showing the 1 chambered primary settling tank, the 4 chambered ABR, the 2 chambered AF, and the HGF, as well as influent and effluent piping.

For this project, this DEWATS was designed to treat $15m^3$/day of wastewater.

Number, Type, and Location of Beneficiaries

For this project, there are approximately 120 orphans and staff who are now covered by the DEWATS. The improvements made in wastewater management, however, extend beyond this orphanage, as downstream users and river life will also benefit from the reduction in pollution to the

Mekong River, in terms of reduction of health risks for users of the river water and less stress on existing marine life.

Impacts and Challenges

This project is now underway and is being operated and maintained successfully by the community members of the orphanage. The funding grant was used to cover construction costs, community engagement costs, and initial water quality testing costs. The staff of the orphanage were trained in appropriate O&M and will take this responsibility. The costs of this O&M and the costs of desludging the system every 2 to 3 years are currently being covered by the orphanage itself, with no data yet available on the average monthly O&M costs for the system.

The water quality testing carried out upon the completion of the project indicates the efficient nature of the DEWATS design. The treated effluent had BOD and COD values (in mg/L) that complied with the Ministry of Environment's regulations for wastewater effluent discharged into public waters and sewers, the standards of which are: COD < 100 and BOD < 80. This compliance should continue given proper O&M and indicates that this project was successful in its objective of treating the wastewater from this orphanage, more so than its previous, 'high technology' treatment plant, which was clearly built without much thought given to the local circumstances, since its O&M costs were much too high for this low-income orphanage to handle. This highlights the importance of BORDA's low cost, low maintenance, localized approach, which can be much more effective for projects like these.

Photos

Figure 2. Sovann Komar orphans and the completed DEWATS

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Cambodia
Decentralized Wastewater Treatment Systems for a Commune and Primary School
BORDA-Cambodia DEWATS Projects in Cambodia

Project Owner(s)	▪ 1) GRET & Residents of Trapeang Sab Commune ▪ 2) Users of the Chroy Chang Va Primary School
Project Partner(s)	▪ 1) **Funding Agency**: GRET & the Commune, District, & Province governments; **Executing Agency**: Bremen Overseas Research and Development Agency – Cambodia (BORDA-Cambodia); **Cooperating Agency**: GRET ▪ 2) **Funding Agency**: MRD, UNICEF, OAV, BORDA; **Executing Agency**: BORDA-Cambodia; **Cooperating Agency**: BORDA-Southeast Asia
Primary Contacts	▪ Alex Campbell, BORDA-Cambodia, campbell@borda-sea.org

Introduction and Background

The Bremen Overseas Research and Development Agency (BORDA) has a mission to improve the living conditions of disadvantaged communities and to preserve the environment through decentralized sanitation projects. As part of this mission, the Agency has developed modular, decentralized, and cost-effective wastewater treatment service packages that they have termed 'DEWATS' – decentralized wastewater treatment systems, which, with the help of funding agencies, are being installed throughout Asia and Africa.

Water and sanitation are one of the most pressing issues facing people in rural Cambodia. Of particular difficulty for sanitation advocates in Cambodia is the old habit of open defecation, with the result of exposing human excreta to the environment. This leads to water and soil contamination and to widespread disease outbreaks. The UN estimated that, in 2008, only 23% of rural residents and 82% of urban residents had access to improved sanitation, which means the country still has a long way to go to achieving 'sanitation for all'.

Cambodia

With this in mind, BORDA recently established itself in the country, as BORDA-Cambodia. The Agency has completed three projects in Cambodia to date, two of which share the same technology package and are outlined here.

The first area chosen for DEWATS was the Trapeang Sab Commune, in Takeo Province. In this commune, the main town was rapidly urbanizing and its traditional sanitation practices were no longer effective. This untreated wastewater being released in increasing volumes in the commune was becoming a hindrance to development because of groundwater pollution and public health issues.

The second area chosen for DEWATS was the Chroy Chang Va Primary School in Phnom Penh. This school was suffering from a very poor septic tank for its wastewater, which was bottomless and cracked, causing groundwater pollution and allowing rainy season flood water to mix in with the wastewater and spread across the school grounds. As well, while the school technically had 13 toilet facilities for its population of over 1000 students, only 3 were in working condition. The health and groundwater risks to the schoolchildren and surrounding residents were therefore very high.

Project Purpose and Objectives

BORDA's general purpose for the DEWATS projects is to further their goal of "Improved Sanitation for All". Their systems help to fulfill this purpose, which can provide wastewater treatment for domestic or industrial sources and for flows as high as 1000m^3 per day, and are tolerant to flow fluctuations, require low maintenance, and are durable. In addition to this general purpose, each project undertaken by BORDA has its own purpose and objectives, based on the problems being experienced by the project site.

For the first project in Trapeang Sab Commune, the purpose was to improve the sanitation situation of the Commune by installing a DEWATS for 250 households and small businesses, capable of treating up to 100m^3/day of wastewater flow. This had the objective of reducing groundwater pollution from the unsafe traditional sanitation practices and reducing associated health risks and foul odors caused by this poor wastewater handling.

For the second project in Chroy Chang Va Primary School, the purpose was to improve the sanitation situation by installing a DEWATS for the school's 13 toilets, as well as by renovating the school's toilets to bring all 13 into full working condition. This had the objectives of reducing groundwater pollution and health risks during floods from the leaking septic tank, as well as promoting better sanitation practices among the schoolchildren through the toilet renovations.

Partners and Funding Distribution

For the first project in Trapeang Sab Commune, the funding agencies were GRET (an NGO) and the Commune/District/Provincial governments themselves, with BORDA-Cambodia being the executing agency and GRET also offering support during the process. The total project cost was $50,200USD.

For the second project in Chroy Chang Va Primary School, the funding agencies were the MRD (Ministry of Rural Development), UNICEF, OAV, and BORDA, with BORDA-Cambodia being the executing agency and BORDA-Southeast Asia offering support during the process. The total project cost was $8,400USD.

Project Activities

The first project in Trapeang Sab Commune began construction on 26 Sept., 2009, and began operations on 18. Feb., 2010. The project activities included: consultation with the Commune Council, construction of the DEWATS, beginning the task of connecting the existing plumbing of the 250 households and small businesses to the DEWATS (ongoing), and training the community on operation and maintenance.

The second project in Chroy Chang Va Primary School ran from June, 2009, until 24 March, 2010, with construction beginning on 5 December 2009. The project activities included: consultation with the teachers and formulation of a school WASH (Water, sanitation, and hygiene) committee, construction of the DEWATS, renovating the 13 school toilets and connecting them to the DEWATS, and training the school community on operation and maintenance.

Sanitation Technology / System

The basic technologies of the DEWATS used in both of these projects are basically identical, with differences only in treatment capacity. This module of DEWATS used by BORDA-Cambodia consists of the following sections, in order of wastewater flow: inlet control chamber, primary settling unit, anaerobic baffled reactor, anaerobic filter, and discharge pipe. The inlet control chamber would consist of control valves for the system, moderating velocity and volume of wastewater entering the system.

The primary settling unit then serves as a wastewater retention point and an area for control of influent fluctuations (an equalization tank), which allows large sludge, debris, and other floatable/visible wastes to settle or be screened out and also allows a relatively constant flow of wastewater to proceed to the subsequent chambers (rather than having high flows during peak hours and no flow during nighttime). This unit is single-chambered in both projects.

The anaerobic baffled reactor (ABR) is then the main treatment area of the DEWATS. As the name implies, this multi-chambered tank is closed from the air and anaerobic. Wastewater flows slowly up (and back down through pipes) through its several identical chambers, each time entering the chamber at its bottom, where it passes through the accumulated sludge. This allows solids to settle out into the sludge and anaerobic bacteria living in the sludge to degrade much of the harmful organic and chemical components of the wastewater. The number of chambers can vary depending on available land area, wastewater strength, and funds – the Trapeang Sab Commune project has a 5 chamber ABR, while the ABR of the Chroy Chang Va Primary School project is only 4 chambers.

The anaerobic filter (AF) follows the ABR and consists of a tank with a submerged layer of material like crushed gravel or specially formed plastic. On to this media grows a thick layer of anaerobic bacterial biofilm, which the upflowing influent wastewater then passes through. These biofilms help remove more of the dissolved solids in the wastewater, as well as other pathogens and chemicals still remaining in the wastewater. The number of chambers can again vary, with the Trapeang Sab's AF having 2 chambers and the Chroy Chang Va's having only 1. After the AF, effluent is usually considered clean enough for safe river discharge, or can be held in a separate tank for reuse in watering plants or flushing toilets.

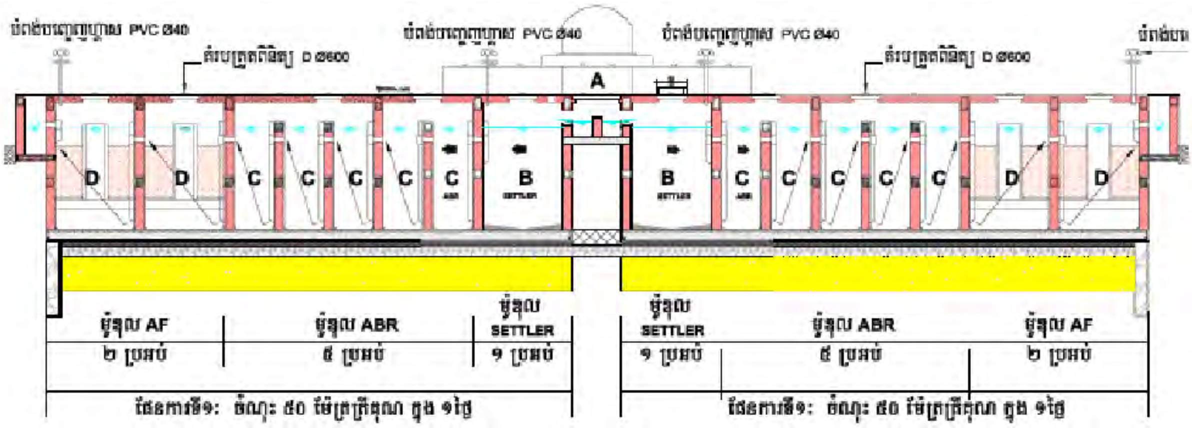

Figure 1. A cross section of the Trapeang Sab Commune project's DEWATS, showing the 1 chambered primary settling tank, the 5 chambered ABR, and the 2 chambered AF, as well as influent and effluent piping. In order to achieve the 100m^3/day wastewater treatment capacity, this module was doubled, with two identical 50m^3/day systems installed side-by-side.

As mentioned previously, the main difference between the two projects was in the size of this DEWATS module installed. For the Trapeang Sab Commune project, the system is able to treat 100m^3/day of wastewater by using 2 identical 50m^3/day systems, as shown in Figure 1. This paired design was implemented as low initial flows were predicted in the first years, with flows increasing as more connections to the system were made by households and businesses. In contrast, for the Chroy Chang Va Primary School project, the system is able to treat only 5m^3/day of wastewater.

Number, Type, and Location of Beneficiaries

For the first project in Trapeang Sab Commune, the DEWATS will eventually be connected to 250 households and small businesses in the Commune, whose residents and users will now receive treatment for their wastewater. The improvements made in wastewater management, however, extend beyond these 250 buildings, and other residents in the Commune area will also benefit from the reduction in groundwater pollution, foul odor, and health risks associated with the status quo.

For the second project in Chroy Chang Va Primary School, there are approximately 1072 students and teachers who are now covered by the DEWATS. As well, since the project included renovation of the school toilets, the community will now be able to enjoy this additional benefit. The residents of the surrounding area will also benefit from the reduction of foul odor, groundwater pollution, and health risks during floods from the previously leaking septic tank.

Impacts and Challenges

Both projects are now underway and being operated and maintained successfully by the community members of each project site. For each project, the funding grant was used to cover construction costs, community engagement costs, and initial water quality testing costs. In the Trapeang Sab Commune project, an operator was contracted by the Commune Council who is responsible for general operations and maintenance of the DEWATS, while, in the Chroy Chang Va project, the school's new WASH committee will take this O&M responsibility. For the Trapeang Sab Commune project, the O&M costs, an allowance for the operator, and the costs of desludging the system every 2 to 3 years are currently being covered by the Commune Council, with no data yet available on the average O&M costs for the system (due to low flows in the first years). For the Chroy Chang Va project, the same expenses are averaging approximately $115USD per month, which is being covered in part by an O&M fee levied on the students of about $0.07USD per month.

The water quality testing carried out upon the completion of each project indicates the efficient nature of the DEWATS design. The treated effluent of the two projects, Trapeang Sab and Chroy Chang Va, had BOD and COD values (in mg/L) that comfortably complied with the Ministry of Environment's regulations for wastewater effluent discharged into public waters and sewers, the standards of which are: COD < 100 and BOD < 80. Trapeang Sab, for example, had effluent with a BOD of 46 and a COD of 94. This compliance should continue given proper O&M and indicates that these projects were successful in their objective of treating the wastewater from these communities to reduce groundwater pollution, foul odors, and health risks.

Photos

Figure 2. Construction underway at the Trapeang Sab Commune project

Figure 3. Before and after of the school toilets and new DEWATS at the Chroy Chang Va Primary School project

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Cambodia
Small-Scale Sludge Treatment System for Daeum Mien – Kandal Province
A GRET Sanitation Project in Cambodia

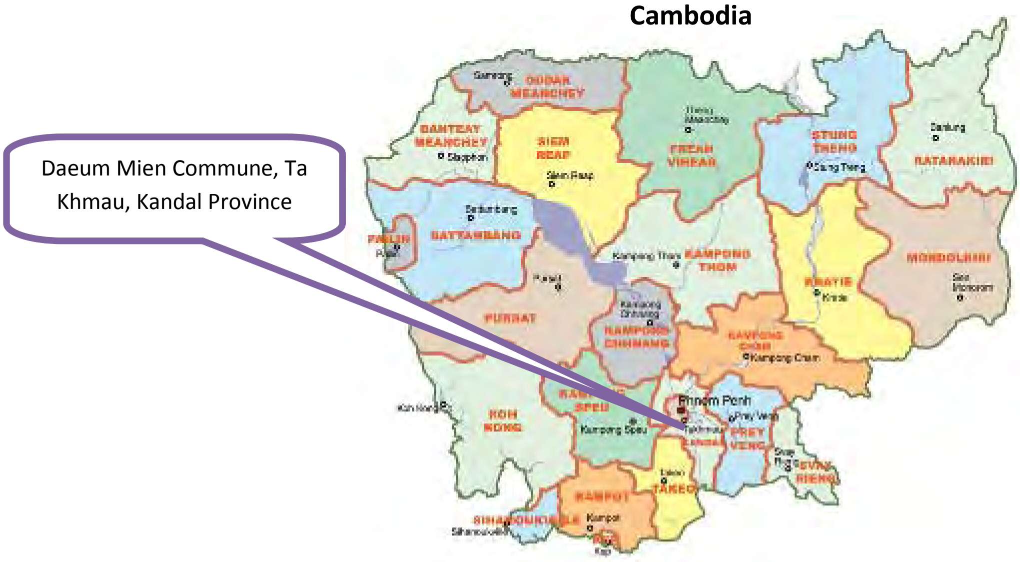
Project Owner(s)	▪ Commune Council of Daeum Mien, Kandal Province
Project Partner(s)	▪ **Funding Agency**: GRET ▪ **Executing Agency**: GRET ▪ **Cooperating Agencies**: Local private desludgers and the Commune Council
Primary Contacts	▪ Benjamin Clouet, GRET, benclouet8@gmail.com

Introduction and Background

The French NGO GRET, established in 1976, has a mission of fair international development, through designing and implementing field projects, providing expertise, conducting research, and running information and exchange networks for development issues, and currently works in 27 countries. As part of this mission, GRET professionals have taken on various water and sanitation projects in developing countries, including, since 1988, in the Kingdom of Cambodia.

Water and sanitation are one of the most pressing issues facing people in rural Cambodia. Of particular difficulty for sanitation advocates in Cambodia is the old habit of open defecation, with the result of exposing human excreta to the environment. This leads to water and soil contamination and to widespread disease outbreaks. The UN estimated that, in 2008, only 23% of rural residents and 82% of urban residents had access to improved sanitation, which means the country still has a long way to go to achieving 'sanitation for all'.

Cambodia



For these residents that do have improved sanitation though, a new problem arises. With the exception of households connected to a sewerage system, the other forms of improved sanitation (pit toilets, pour-flush latrines leading to pits or septic tanks, flush toilets leading to septic tanks) all create sludge – the concentrated solid result of the accumulation and compression of several years of blackwater entering the pit/tank. Failure to regularly remove this accumulated sludge (which is the norm in Cambodia), results in a loss of efficiency of the pit/tank and, therefore, causes further groundwater pollution than would otherwise be the case.

Prior to this project, business for private desludgers was relatively minor, with no sludge treatment plants and correspondingly high prices, given the current standard of living. The 7 private desludging operations established in the city were simply disposing of the highly potent sludge onto farmers' fields, often charging a fee from the farmer for this disposal. This was not a sustainable option, as untreated sludge is dangerous to both human health and the environment due to its high pathogen levels.

Recognizing this issue and opportunity, the French NGO GRET began a small-scale sludge treatment plant project, as part of their larger PACEPAC sanitation programme in Cambodia. Choosing a farmer's field site called Daeum Mien on the rural outskirts of Phnom Penh, the project used an innovative new, small-footprint and low cost design for a sludge treatment plant that would fully process the sludge into useable compost.

Project Purpose and Objectives

This project in Daeum Mien is part of GRET's larger PACEPAC programme in Cambodia. This programme has the objectives of: rural local government capacity building on water and sanitation service infrastructures, improving access to drinking water services and sanitation conditions in targeted rural villages, improving domestic hygiene in the targeted villagers to reduce waterborne illness, and developing appropriate water supply and sanitation technologies for these areas. This specific project had the following goals: 1) improve community sanitation by improving sludge treatment, 2) contribute to sustainable sludge management with both the public and private sectors playing a role, 3) reduce the environmental and health impacts from uncontrolled desludging, 4) promote reusable wastes such as compost from sludge, and 5) design improved latrines / hand pumps to facilitate and reduce the price of hygienic desludging.

In addition to the construction of this pilot sludge treatment plant, GRET would analyze the most economical approaches to desludging, so as to lower the current cost of desludging, as well as attempt to convince the existing desludgers to use the facility (through public private partnerships) and promote greater interest in desludging in the population. Because of Cambodia's weak regulatory system, it was important for the project to engage private desludgers using incentives, rather than threats of enforcement. Through the low cost of the project and the proposed revenues from desludging and sales of compost, GRET would also demonstrate the rapid cost-recovery of an investment in a small-scale treatment plant like this for future constructions elsewhere.

Partners and Funding Distribution

For this project, GRET was the main funding and executing agency. It supplied approximately \$8000USD to build the sludge treatment plant, and an additional \$1200USD for equipment. The initial private desludging company partner wanted to make use of the plant needed simply to invest in their truck and pumping gear. These materials were acquired by the company for about \$5500USD (for a multi-purpose truck, a small holding tank, a motorized sludge pump, soft piping, and an adapted apparatus used to squeeze out remaining sludge from the pipe after pumping, based on a sugarcane juicer). The cost for a prospective desludger like this could be much lower if a motorbike with trailer and manually-operated pump were to be used, but this was not an attractive option for the partners. The cooperating agencies included the local commune council, the farmer on whose land the plant was built, and the existing private desludging companies of Phnom Penh. The local commune council are the plant owners and operators.

Project Activities

The PACEPAC programme of GRET is running from 2006 until 2011, with this sludge treatment plant project being undertaken and completed in Q3 and Q4 2010. The project activities included signing contracts with the farmer whose land the site used and the interested desludger; performing a technical detailed survey; selecting a local construction contractor from solicited bids; carrying out the construction work; and follow-up reporting and community outreach activities on the promotion of desludging.

Sanitation Technology / System

The sludge treatment plant designed for this project is unique. Most small-scale treatment plants, such as those of BORDA, have always traditionally been excavated into the ground on one horizontal level. This plant, however, was constructed above-ground and in two separate floors, which is useful in very rocky areas that are difficult to excavate or in areas with a small available land footprint, due to its multi-storied nature. This small-scale plant was designed to be completely demechanized, requiring no electricity nor water supply, as rainwater would be collected from the roof into a concrete cistern for use around the site. The components of the treatment plant, in order of sludge flow, are as follows: inlet bar screen (2nd floor), solid extraction settler (2nd floor), anaerobic baffled reactor (ABR) (1st floor), aerobic pond (2nd floor), sludge drying beds (SDB) (extends through both floors), and open-air, contained compost heaps (1st floor).

The plant begins on the 2nd floor, with a raised earth ramp for the desludging trucks to drive up and deposit their sludge. The sludge passes first through an open bar screen that will trap any large solid wastes or garbage (for later disposal) that could otherwise clog the system.

The solid extraction settler on the 2nd floor is what the sludge is initially discharged into. This settler, whose base is on the same level as the adjacent SDB, is used in advance of the ABR on the first floor so that a majority of the heavy solid particles will settle here instead of in the ABR, which, being located underneath this unit and the aerobic pond, makes desludging and maintenance a difficult affair that should be kept to a minimum. The effluent in this single-chambered unit then flows by gravity down a raised pipe within the chamber down to the ABR on the first floor. The settled sludge, on the other hand, is periodically discharged directly to the adjacent SDB via a hand-operated valve connecting the base of the tank to the drying bed.

The anaerobic baffled reactor (ABR) is then the main treatment area of the plant. As the name implies, this multi-chambered tank is closed from the air and anaerobic. Wastewater flows slowly up (and back down through pipes) through its several identical chambers, each time entering the chamber at its bottom, where it passes through the accumulated sludge. This allows solids to settle out into the sludge and anaerobic bacteria living in the sludge to degrade much of the harmful organic and chemical components of the wastewater. The number of chambers can vary depending on available land area, wastewater strength, and funds – this project uses a 3 chamber ABR on the first floor. Once into the third chamber, the effluent will then be raised up to aerobic pond on the second floor simply by the rising water level as the tank fills up. Discharge back up to the solid extraction settler will not occur as the first floor water level rises because the connection pipe from this unit to the ABR is higher than the highest achievable water level in the aerobic pond.

Once the effluent rises up into the aerobic pond the second floor, it is exposed again to the air, thus making the unit aerobic. During its estimated 4 day retention time in this pond before discharge to the sludge drying bed, the aerobic nature of the pond will help to remove its odor and kill most pathogens. This is accomplished via the aerobic bacteria that become established in the pond, which digest remaining organic material and destroy most disease-causing pathogens. As well, approximately 20-30% of the ammonia present within the effluent upon its entry to the aerobic pond will be dissipated into the air during its holding time. After this, the effluent normally flows via a raised pipe to one of the two adjacent SDBs (which bed it flows to is controlled by hand-operated valves), though the aerobic pond also contains two similar valves at its base. One of these allows discharge of the whole tank to the adjacent SDB, while the other would discharge the tank contents directly to the adjacent river. These options are only used for maintenace purposes, in order to gain access to the ABR (for desludging/maintenance) located underneath via the three manholes that are built into the base of the aerobic tank.

The normal path of the effluent to the SDB is via the raised pipe, which then runs along the length of the drying bed on a descending slope. The pipe is actually a trough at this point, in that its upper half has been removed, with a jagged pattern then cut into the side of the remaining pipe to allow the effluent to discharge evenly across the length of the bed. Once one bed is full, the pipe valves are alternated to direct the effluent into the adjacent, empty bed. A roof is constructed over the SDBs using translucent material, so as to allow sunshine to dry the sludge but prevent rain from remoistening it. The SDBs are constructed with a sand layer on top, a gravel/rock layer underneath, and a perforated collection pipe running along the bottom, with waterproof, sloped liners guiding all drained liquid to these two pipes, which then discharge to the nearby river. In order to avoid removing parts of the sand layer every time the sludge is shovelled out to the adjacent compost heaps, a plastic ‘geoweb’ (see image below) was inserted into the sand layer, which would prevent a shovel from scraping at the sand. At a capacity of $7.5m^3$ each, an 8-day rotation between the two SDBs is expected, meaning 8 days for the drying of the sludge before it is shovelled down to the adjacent compost heaps containment areas on the first floor.

Six compost bins were constructed beside the SDBs, to allow those shovelling out the sludge to simply toss it down into the bins while standing in the SDB. The sludge will be heaped up in one of the bins, layering it with corn straw, rice straw, or coconut waste, and then mixing the pile regularly. Once full, another pile will start in another bin, while the first one continues degradation and curing. The operator doing this will be trained in the proper principles of composting and will allow the finished heaps to age before removal for sale as a compost product.

During the design of this plant, other novel ideas were proposed for its design. These included a hand-drawn lift system to raise accumulated sludge out from the first floor, a wind-powered air pump to provide further aeration to the aerobic pond, and the collection of biogas generated within the ABR. While dropped, these could be applicable in future models if the circumstances are right.

For this project, this plant was designed to treat approximately $2m^3$/day of sludge.

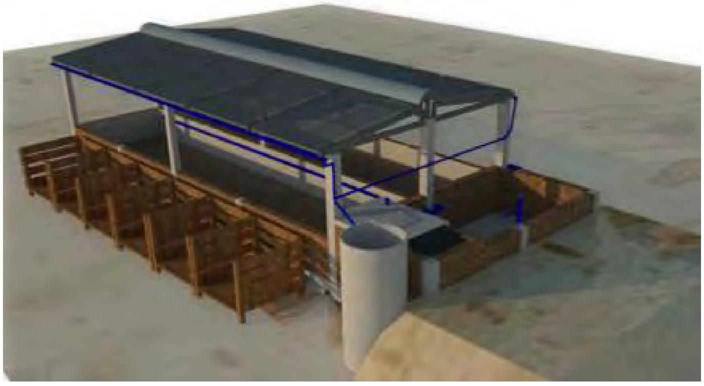


Figure 1. An overall schematic of the treatment plant site, showing the compost bins, roofed SDBs, rainwater collection, sludge inlet screen, aerobic pond, and raised earth hill for discharge

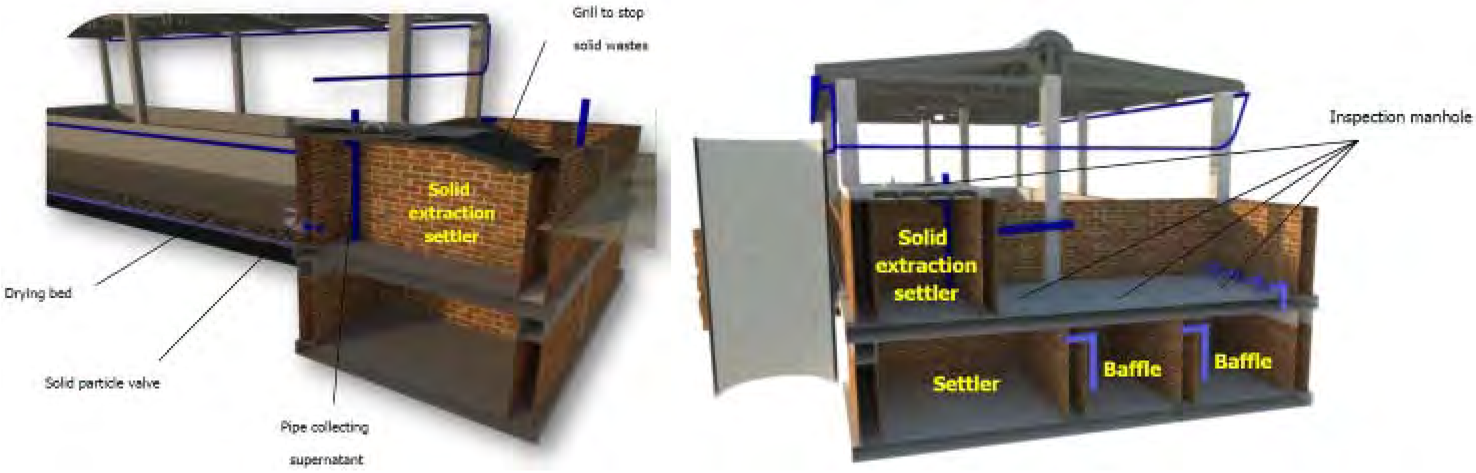


Figure 2. Cross-sections of the two-story treatment plant. On the left, the solid extraction settler, its raised effluent pipe, its sludge discharge valve, its inlet screen, and the first chamber of the ABR underneath, as well as the adjacent SDB, are visible. On the right, the rainwater collection tank, solid extraction settler, 3-chamber ABR, aerobic pond, and the 3 inspection manholes are visible.

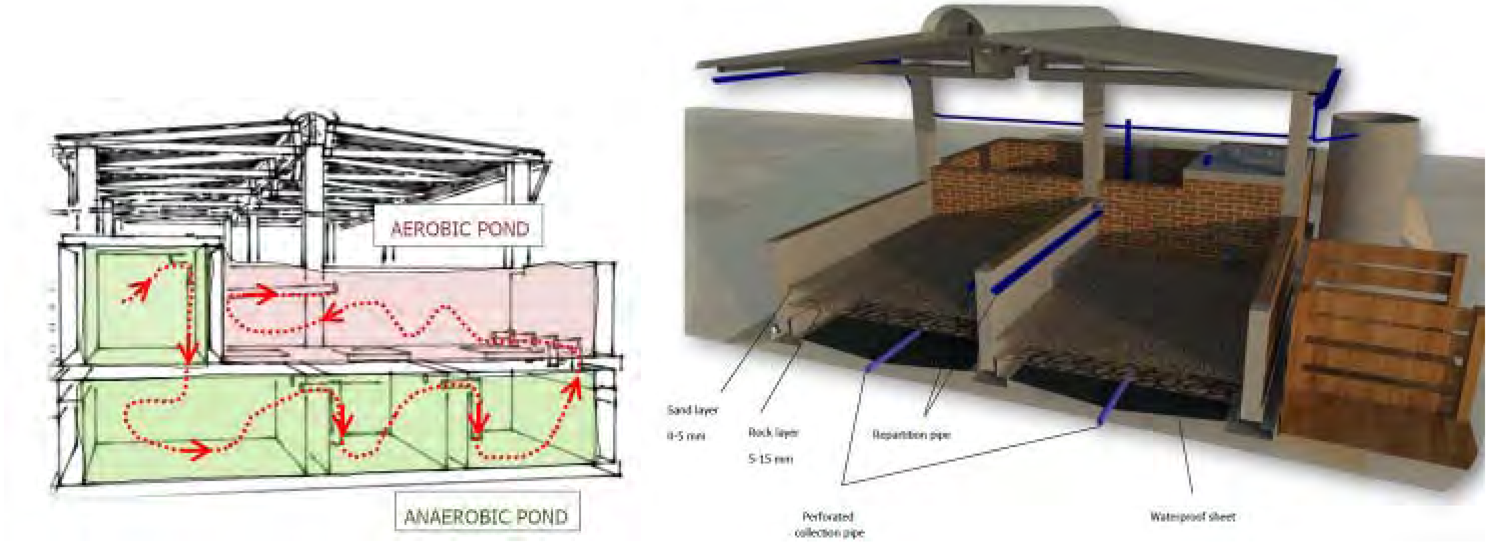


Figure 3. On the left, a view of the water flow through the treatment plant. On the right, a view of the SDBs, including the 'repartition pipes' (the troughs allowing effluent to spill evenly along the bed length), the sand and gravel layers, the waterproof, sloping liners, and the perforated collection pipes for discharge

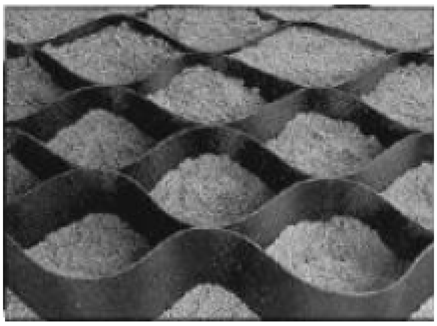


Figure 4. The 'geo-web' placed into the sand layer to prevent sand loss during sludge removal

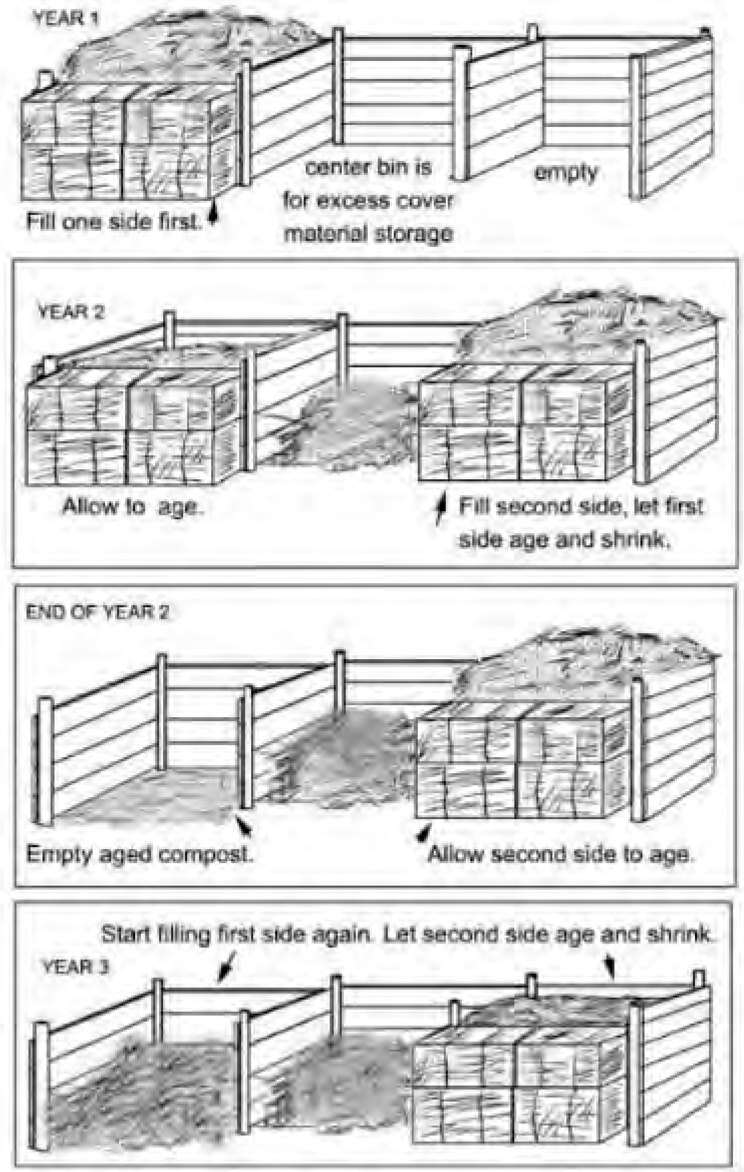


Figure 5. A schematic of the proposed bin usage for composting

Number, Type, and Location of Beneficiaries

This plant will be able to treat approximately 2m^3 per day of domestic sludge. Within a 3km distance of this treatment plant in all directions (the distance cited by local desludgers as about the maximum distance they would be willing to travel to deliver sludge to a plant) lie approximately 12,000 households. Surveys by GRET on these households suggest only about 25% of them have ever desludged their pit latrine. Taking this number and assuming one desludging every 3 years means that, just to accommodate the desludging needs of the existing 25% would equate to 1000 households per year to desludge, not to mention any more households who become convinced by IEC activities to begin requesting desludging. If a latrine pit contains at least $1m^3$ of sludge, then this figure is too high for this plant to accommodate – only about 600 households could have their sludge treated at this plant.

Besides these households, who would benefit from a lower cost desludging, other beneficiaries include the desludgers who will utilize this plant, as they will see higher profits, as well as the citizens and natural life in the Daeum Mien Commune area, who will benefit from reductions in the groundwater pollution caused by accumulated, untreated pit sludge.

Impacts and Challenges

Construction of this plant is now complete and desludging is beginning to get underway by a local desludger. As a prerequisite to using the plant, desludgers will sign a contract with the commune, who will own the plant, that stipulates they will charge a fixed price to households of $15 per desludging, rather than the $30 being charged by larger desludgers. Thus far, the desludgers have been very interested in the project and are concerned about their perception in the community, so want to use this plant to show their good behavior. The return on investment to be gained by these small-scale desludgers is great. They could, for example, earn up to $6000 per year by desludging the maximum 600 households, which would recover the initial investment of $5500, with profit being made starting in year 2. Given this strong financial incentive – and the likelihood that, if IEC campaigns promoting desludging are undertaken, more people will request desludging – then it is likely that many more desludging operations may start up.

This will result in a need for more low cost, low maintenance treatment plants like this and their associated PPP schemes, which can be built and underway in a matter of months. It should be noted though that designing a plant like this was not without its issues, since its small-scale, non-mechanized nature meant all sludge had to flow by gravity through the different levels, and also that maintenance on the lower levels was more difficult. As mentioned previously, the design went through many stages, with some ideas becoming unfeasible. Provided that this plant's O&M goes smoothly though, it is hoped that more plants of this nature can be constructed to cope with the rising demand for low cost desludging, at which point efficiency improvements and other ideas for modifications to the design can be made specific to each project's circumstances.

There is money to be had in the compost as well. At the moment, there are basically no bio-fertilizer products like this on the market in Cambodia. So, while farmers are currently not used to buying such a product and may be resistant, with some basic IEC, pilot studies on the compost's effectiveness, and appropriate pricing – which are all planned activities by GRET – this market could take off as a cheaper alternative to fertilizer. Conventional fertilizer currently sells for around $30 per 50kg on the market. Even if priced at only $5 per 50kg for this new compost, if it sells, the commune could make substantial profits on it (several hundred USD per year at least), even accounting for labor costs needed in making the compost. These funds could be used for O&M costs and could also be saved for investment in another treatment plant or other project by the commune.

As to the quality and safety of the sludge after treatment, provided that the plant operates as planned, that no industrial (heavy metal-rich) sludge is added, and that the compost piles are properly mixed and monitoring, the sludge will emerge as safe compost, basically free of pathogens.

Meanwhile, the remaining effluent liquid discharging out from the SDB collection pipes is also relatively safe for discharge to the river. The treatment plant processes will reduce its BOD and COD by at least 70%, while the aerobic pond will reduce the majority of its foul odor and up to 95% of its remaining pathogens.

While the overall success of this project remains to be seen, it has the elements needed for success, and its innovative design and work on decreasing the price of desludging should help to increase interest in desludging among the villagers, thereby decreasing groundwater pollution and the health problems it can cause.

Photos

Figure 6. Photos of the plant under construction

Figure 7. Photo of the SDBs and their inlet troughs, also showing the two drainage valves from the solid extraction settler and the aerobic pond

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Cambodia
Sanitation Marketing for Five Cambodia Provinces
A Joint IDE, Lien Aid, & WTO Project in Cambodia

Project Owner(s)	▪ Any Cambodian resident who purchases a latrine through the program
Project Partner(s)	▪ **Funding Agencies**: USAID-Cambodia, USAID-Regional Development Mission-Asia, & Water and Sanitation Program of the World Bank, ▪ **Executing Agencies**: International Development Enterprises (IDE)-Cambodia, Lien Aid, World Toilet Organization (WTO) ▪ **Cooperating Agencies**: GRET Cambodia, Cambodian Ministry of Rural Development, WaterSHED Asia, Provincial Governments and Commune Councils of Kampong Speu, Kampong Cham, Takeo, Kandal, and Svay Rieng Provinces.
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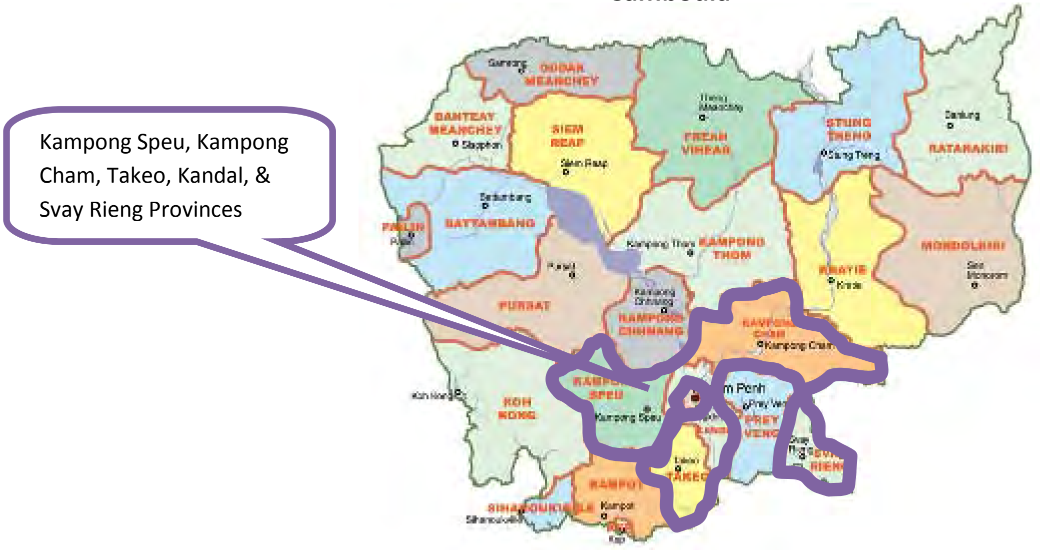
Introduction and Background

Latrine-building projects have been a popular form of development assistance for decades. These types of projects act as "hardware subsidies", where the desired sanitation technology is installed by the Government or large NGO relatively free of charge to the recipients, often lacking any form of outreach or community engagement, with the belief that, "if you build it, they will come". But do these types of programs actually work? Abundant evidence exists for hardware subsidy projects that fail in the long-term, due to no personal motivation or 'ownership' of the recipients for the facility. Too often, follow-up studies to these types of projects find the latrine having fallen into disuse, due perhaps to lack of understanding of proper maintenance procedures or lack of desire by the recipients to use it.

Recognizing this, development agencies are coming to the realization that alternative approaches to promoting proper sanitation are needed. These include the Community-Led Total Sanitation (CLTS) movement, which focuses on educating people –especially communities practicing open defecation – about the real risks their unsanitary practices pose to them and essentially 'shaming' them about it enough to inspire in them the motivation to go out and build or purchase their own improved sanitation facility. Most recently, a group of development NGOs in Cambodia decided to implement a different, market-focused, approach, which they have termed 'sanitation marketing'. The idea of the approach is to bring together three elements deemed crucial to sparking a demand for improved sanitation products in low-income people who would otherwise have little interest in them: 1) appropriate designs for low-cost latrines, 2) the provision of business training to interested local sanitation entrepreneurs, and 3) the effective marketing in the community of sanitation as a desirable purchase priority. With low-cost latrine designs that meet the needs, wants, and desires of the consumer, with properly trained and equipped local businesses to sell this design and make money, and with a populace motivated by effective marketing to value a latrine as an important purchase, a sanitation program can expand and spread like wildfire with very little NGO intervention and no hardware subsidies. Soon more businesses are starting up, seeing the profit to be had, and are offering new designs and new marketing slogans to attract even more customers, which, in turn, attract even more customers as residents grow envious of their neighbor's attractive new latrine.

Cambodia



Determined to demonstrate the effectiveness of this idea on the ground, USAID and the Water and Sanitation Program of the World Bank (WSP) funded International Development Enterprises (IDE), Lien Aid, and the World Toilet Organization (WTO) – three large development NGOs – to collaborate and develop this sanitation marketing program in rural Cambodian provinces, by working to bring together the "design", the "training", and the "marketing".

Project Purpose and Objectives

This project has three main components: 1) developing an innovative, low-cost new latrine design, 2) undertaking a demand-generation campaign for improved sanitation, and, simultaneously, 3) undertaking a supply-chain strengthening program for local masons and entrepreneurs. The purpose of these tasks is to foster sustainability and affordability in the sanitation marketplace in a way that inspires large numbers of Cambodians who currently do not use improved sanitation to invest in it for their households. The specific objectives are to: 1) motivate and sustain changes in sanitation, water, and hygiene behaviors, 2) create consumer demand by addressing barriers to consumption and increasing knowledge of water and sanitation products and services, and 3) improve supply by increasing access to safe, sustainable, and affordable water and sanitation products and services. As the project is currently ongoing, the current interim goal for Lien Aid & WTO is to reach 11,000 latrine sales through up to 50 private sector suppliers in 2011, in the Provinces of Kampong Speu, Kampong Cham, and Takeo. The first goal of IDE was to have 10,000 latrines sold in Kandal and Svay Rieng Provinces before April 2011, which was surpassed already in January 2011.

Partners and Funding Distribution

The main funding agencies for the project are USAID-Cambodia, through its Micro, Medium, and Small Enterprise (MSME) Project, and USAID's Regional Development Mission – Asia, through its WaterSHED Asia Partnership, as well as the Water and Sanitation Program of the World Bank. The executing agencies are the NGOs IDE, Lien Aid, and WTO, who were the main groups designing the latrine and carrying out the IEC on marketing and supply-chain. Additional support is being provided by the Cambodian Ministry of Rural Development, the NGO GRET (who assisted in the latrine design), the WaterSHED Asia partnership, and the provincial governments and commune councils of the 5 provinces targeted to date (Kandal, Svay Rieng, Takeo, Kampong Speu, Kampong Cham).

Project Activities

This project is still ongoing, having begun in approximately March, 2009. The project activities to date have included: 1) developing an attractive, low-cost latrine design to sell for $35USD, dubbed the "Easy Latrine" (which began prior to the project in 2007 by IDE), 2) early surveys on identifying and developing market-based mechanisms for sanitation and identifying potential private sector pioneers of the low-cost latrine, 3) training these pioneers in latrine production and sales in pilot areas, 4) trialing a savings-group mechanism in a pilot village to see if loans were necessary to spark demand, 5) when demand for latrines rapidly outstripped supply (showing loans as unnecessary), a rapid expansion of the program, identifying more producers and sales agents to expand the latrine sales and marketing, 6) working with the Ministry of Rural Development to create a package of social marketing tools and methodologies with images and messages that resonate with rural households regarding sanitation and hygiene, and then 7) continuing to expand the private sector suppliers and sales agents (and corresponding latrine sales) in more districts and provinces, beginning in earnest in October 2009, and, during this time, 8) developing new 'mid-range' superstructure models for the latrine, for retailing at $40 – 50USD, as well as, most recently, developing an entirely new latrine model that includes a shower, dubbed the "Easy Shower", for future trialing.

Sanitation Technology / System

As a $35USD latrine, the "Easy Latrine" does not consist of anything special from a technological perspective, other than its price. The model has already won numerous design competitions and gained heavy media attention, most notably being its 2010 winning of the International Design Excellence Award, organized by the Industrial Designers Society of America. As quoted by one of the jurors, the Easy Latrine is "not beautiful, but a beautiful example of 'design thinking' employed to harness local knowledge and expertise to solve the problem in an economically sustainable way".

The latrine itself consists of a concrete slab with porcelain pour-flush squatting pan, an underlying concrete chamber to collect the wastewater from the pan and a PVC drain pipe to channel it down into the pit. The pit consists of three concrete rings (a commonly used product in Cambodia) topped with a concrete lid (but is bottomless) that is buried at an offset to the latrine to a depth of about 1.5m. With a little bit more cash, a second twin pit can be installed to create a 'fossa alterna'-style system, whereby when the first pit is full, it is topped with soil and the PVC drain pipe is rotated to the other, empty pit. Then, once the second pit is full, the first pit should have composted enough to allow its excavation and reuse, with the composted feces able to be used as a soil additive in farming. In addition to this basic model, villagers can choose to build their own superstructure out of local materials or can purchase a fibre cement board or corrugated zinc model for $40-50USD, as a 'mid-range' option.

As for the prospective entrepreneurs, they are encouraged to join the program from the slogan, "invest $3090 to earn $4200 in just 4 months". The initial investment needed includes a $2000 vehicle for making deliveries, $440 worth of concrete molds, and $650 worth of raw materials for making the latrines (power tools & ash/cement/sand for concrete). The projected $4200 is generated from the sale of 25 of the $35 latrines per week for the first two months, then 50 per week for the following two months (with a second investment of $440 in an additional set of molds). The remarkably low-cost nature of the latrine design therefore allows profit to be made quite quickly, which serves as a powerful incentive for potential business partners.

Figure 1. The Easy Latrine, showing the squatting pan, slab, collection box, PVC pipe, and offset pit of 3 concrete rings and a lid, to be sold for only $35.

Number, Type, and Location of Beneficiaries

This project turns “beneficiaries” into “buyers”. Since there are no hardware subsidies, every household who decides to purchase a latrine is no more of a ‘beneficiary’ than they are beneficiaries of purchasing any other product, which is empowering for the owners and ensures they will take better care of their latrine than if it was just given to them free of charge. In terms of the number of latrines sold, and therefore the number of Cambodians who now have access to improved sanitation, IDE has sold 11,195 latrines as of March 1, 2011 in Kandal and Svay Rieng Provinces, while Lien Aid / WTO had sold 4,990 latrines in Kampong Speu Province as of January 2010, and are now expanding to Kampong Cham and Takeo Provinces in the hope of reaching 11,000 latrine sales in 2011. In fact, Easy Latrine sales have been recorded in 1060 villages already, which includes areas both inside and outside the targeted program provinces. Since the average household size in Cambodia is 5 people, this means that over 100,000 new Cambodians may already be benefitting from improved sanitation. As well, the entrepreneurs who became engaged in creating these latrines have created for themselves successful livelihoods, with their owners already becoming some of the wealthiest people in the villages.

Impacts and Challenges

This project is still ongoing, but its impacts are, without a doubt, already spreading like wildfire through Cambodia and beyond. As mentioned earlier, the innovative latrine design and this project have resulted in scores of media stories from news organizations as prominent as the BBC, and with good reason. Over 100,000 Cambodians are already benefitting from improved sanitation who did not before, thanks to the thousands of latrines already sold by hard-working local start-up businesses and sales agents, who were trained in supply-chain management and marketing by the NGOs of this project. This is also providing great support to the sanitation Millennium Development Goal for Cambodia, which is aimed at having access to improved sanitation, by 2015, to 30% of rural Cambodian homes. As an example of the power of this program, Lien Aid’s initial project communes in Kampong Speu Province – where nearly 5000 latrines were sold by Jan. 2010 – has already increased sanitation coverage from a previous average of 24% to a current average of 42%, greatly exceeding the MDG target already. The same exceeding of expectations is visible in IDE’s work in Svay Rieng and Kandal Provinces, where their target of selling 10,000 latrines by April, 2011, was already surpassed in January, 2011, with 11,195 having been sold as of March 1, 2011. IDE's work has already resulted in a 15% increase in latrine coverage and an 800% increase in sanitation business profits, with 69 Easy Latrine enterprises established in these provinces already. 16 of these were created in training partnership with the NGOs, 8 of them were subsequently created as 'copy-cats' (learning from these existing enterprises), and the 39 others self-formed later on (a 'ripple effect'), without any assistance from the NGOs. These enterprises are all being creative with their original products in various different ways, often hiring ambitious salespeople and working to gain every advantage over their opponents, in the same capitalist spirit already applying to products like cell phones and soft drinks.

This increase in latrines is benefitting both human health and the environment. The most common previous practice of open defecation in nearby fields is a very dangerous activity, as the collective feces from all of the villagers undertaking this action pollute both the surface and ground waters and pose major risks of waterborne illness to farmers who work in these fields. With the use of Easy Latrines instead, while not all groundwater pollution is eliminated (since the concrete pit is bottomless and allows percolation of wastewater to the groundwater), it is minimized to a great degree and retained to the immediate areas around the latrine, rather than being spread over a wide area in the fields. This should result in fewer waterborne illnesses in the residents and make their communities cleaner places to live.

Overall, this project has already shown that 'hardware subsidies' are not necessary for successful promotion of improved sanitation in Cambodia. Indeed, with nothing more than marketing, a successful design, and training of interested entrepreneurs, the market for latrines among low-income villagers has taken off, with the purchase of a latrine gaining greater value and priority. It is often noted as a curiosity by travelers to developing countries that people may own a cell phone or TV but live in otherwise very basic conditions. This is because of the effective marketing given to these items that convince even the very poor to value them highly. This program is now demonstrating that the same can be done for latrines and shows no signs of stopping.

Photos

Figure 2. An excerpt from a Latrine Building Manual created by IDE for the businesses (left) and one of the businesses constructing a concrete ring for the pit using their pre-purchased mold (right)

Figure 3. A marketing / sales session of the Easy Latrine to local villagers (left) and a proud new owner of an Easy Latrine (right), with a self-constructed superstructure

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Cambodia
Biogas Digesters for Cambodians
A Multi-Partner National Biodigester Program in Cambodia

Project Owner(s)	▪ Farmers who purchase biodigesters from the program
Project Partner(s)	▪ **Funding Agencies**: Dutch Ministry of Foreign Affairs: Asia Biogas Program; GIZ- German International Cooperation; FMO- Netherlands Development Finance Company ▪ **Executing Agencies**: Cambodian Ministry of Agriculture, Forestry, & Fishery (MAFF); Cambodian Department of Animal Production and Health (DAPH); SNV- Netherlands Development Organization; ▪ **Cooperating Agencies**: Humanist Institute for Development Cooperation (HIVOS); PRASAC Microfinance Institution; AMRET Microfinance Institution; ACLEDA Bank; Cambodian Center for Study and Development in Agriculture (CEDAC); Preah Kossomak Polytechnic Institute; Development Technology Workshop Cambodia; Cambodia-India Entrepreneurship Development Center (CIEDC); Groupe Energies Renouvelables Environnement et Solidarite (GERES) (Consultant); Cambodia Institute of Development Study (CIDS) (Consultant); iLi Consulting Engineers Mekong (Consultant); Local governments of the following provinces: Siem Reap, Battambang, Pursat, Kampong Thom, Kampong Cham, Kampong Chhnang, Kampong Speu, Svay Rieng, Prey Veng, Kandal, Takeo, Kampot, Kep, & Sihanoukville
Primary Contacts	▪ Program Website: www.nbp.org.kh; Program Email: admin@nbp.org.kh

Introduction and Background

Water and sanitation are one of the most pressing issues facing people in rural Cambodia. Of particular difficulty for sanitation advocates in Cambodia is the old habit of open defecation, with the result of exposing human excreta to the environment. This leads to water and soil contamination and to widespread disease outbreaks. The UN estimated that, in 2008, only 23% of rural residents and 82% of urban residents had access to improved sanitation, which means the country still has a long way to go to achieving 'sanitation for all'.

For the many rural Cambodians who work in agriculture – many of whom have no access to electricity, use collected fuelwood for cooking, and rely on expensive fertilizers or risky raw animal manure to fertilize their fields – all of these disparate challenges can be addressed in a single solution: the biogas digester. The biogas digester is a simple, but powerful, sanitation technology option that can simultaneously: process human & animal feces into safe and free fertilizer; reduce groundwater contamination by processing feces instead of having it be discharged untreated; create biogas for use in cooking and household lighting, thus reducing need for fuelwood and allowing more night-time activities; empower women and families by reducing their time spent on fuelwood gathering and cooking; reduce indoor air pollution by reducing the need for fuelwood burning; and help eliminate the need for fossil fuel-based cooking gas and the CO_2 emissions created during fermentation of openly-discharged sewage, thereby helping to reduce the threat of climate change and potentially creating carbon offset credits for sale to industrialized countries.

Recognizing the power of this technology and its usefulness to rural Cambodians, the Cambodian Ministry of Agriculture, Forestry, & Fishery (MAFF) joined with the Netherlands, through the Dutch Ministry of Foreign Affairs' Asia Biogas Program and their development agency, SNV, and Germany, through their development agency, GIZ, to create a National Biodigester Program for Cambodia, so as to disseminate biodigester technology – using marketing techniques and grant/loan assistance – to farmers in the neediest of the Cambodian provinces.

Cambodia

Provinces of Focus: Siem Reap, Battambang, Kampong Thom, Pursat, Kampong Chhnang, Kampong Cham, Svay Rieng, Prey Veng, Kandal, Takeo, Kampong Speu, Kampot, Kep, & Sihanoukville

Project Purpose and Objectives

This project had the purpose of establishing a permanent domestic biodigester sector on a commercial, market-oriented basis for the dissemination of biodigesters as an indigenous, sustainable energy source in selected provinces in Cambodia. By 2012, the program's specific objectives are: 1) to increase the number of family-sized, quality biodigesters to 22,000 units in the selected provinces; 2) to ensure the continued operation of all biodigesters installed under the biodigester program; 3) to maximize the benefits of the operated biodigesters, in particular, the optimum use of digester effluent; 4) to develop technical and promotional capacity of the stakeholders within the program for further wide-scale deployment of biodigester technology in Cambodia; and 5) to strengthen and facilitate the establishment of institutions for the continued and sustained development of the biodigester sector.

Partners and Funding Distribution

For this project, the main funding agency is the Dutch Ministry of Foreign Affairs, through their Asia Biogas Program, with additional funding coming from the German development agency GIZ, with funding going towards program establishment and maintenance, IEC activities, and a flat rate subsidy on the cost of the biodigesters for farmers. The Netherlands Development Finance Company (FMO) is also providing loans to two local cooperating microfinance institutions, PRASAC and AMRET, to provide loans to farmers (up to the total cost of the biodigester plant, a max. of $1000USD, at an interest rate of only 1.2% per month and for a duration of 4 months or 24 months) for the purchase of their biodigester facilities. The main executing agencies are the MAFF – as the program owner and host – SNV – as the main technical assistance and planning agency – and the Cambodian Department of Animal Production and Health (DAPH) – as the coordinating agency for the project. The project has several cooperating agencies, including: 1) the Humanist Institute for Development Cooperation (HIVOS), which is purchasing the carbon offsets generated by the project; 2) the ACELDA Bank, which is channeling funds from the program to individual farmers for a post-construction, flat rate subsidy of $150USD off the cost of all biodigesters purchased through the program; 3) the Cambodian Center for Study and Development in Agriculture (CEDAC), which is acting as the Provincial Biodigester Program Office (PBPO) in Kampot, Prey Veng, Kandal, and Kampong Thom provinces; 4) the Preah Kossomak Polytechnic Institute, which is training technicians and masons on biodigester construction; 5) Development Technology Workshop Cambodia (DTW), which is developing appropriate biodigester accessories (e.g. stoves, drains, lights) for the program; 5) the Cambodia-India Entrepreneurship Development Center (CIEDC), which is assisting in capacity building for entrepreneurs who wish to start a new biodigester company as part of the program; and 6) the local governments of the selected program provinces of Siem Reap, Battambang, Pursat, Kampong Thom, Kampong Cham, Kampong Chhnang, Kampong Speu, Svay Rieng, Prey Veng, Kandal, Takeo, Kampot, Kep, & Sihanoukville, who helped to establish their Provincial Biodigester Program Offices (PBPO) (except in the 4 provinces mentioned above in #3), which liaise directly with the biodigester sales companies, the microfinance institutions, and the interested farmers. In addition, three different consultants are used from time to time by the program: Groupe Energies Renouvelables Environnement et Solidarite (GERES), for rural energy-related studies; Cambodia Institute of Development Study (CIDS), for socio-economic studies; and iLi Consulting Engineers Mekong, for technical engineering issues.

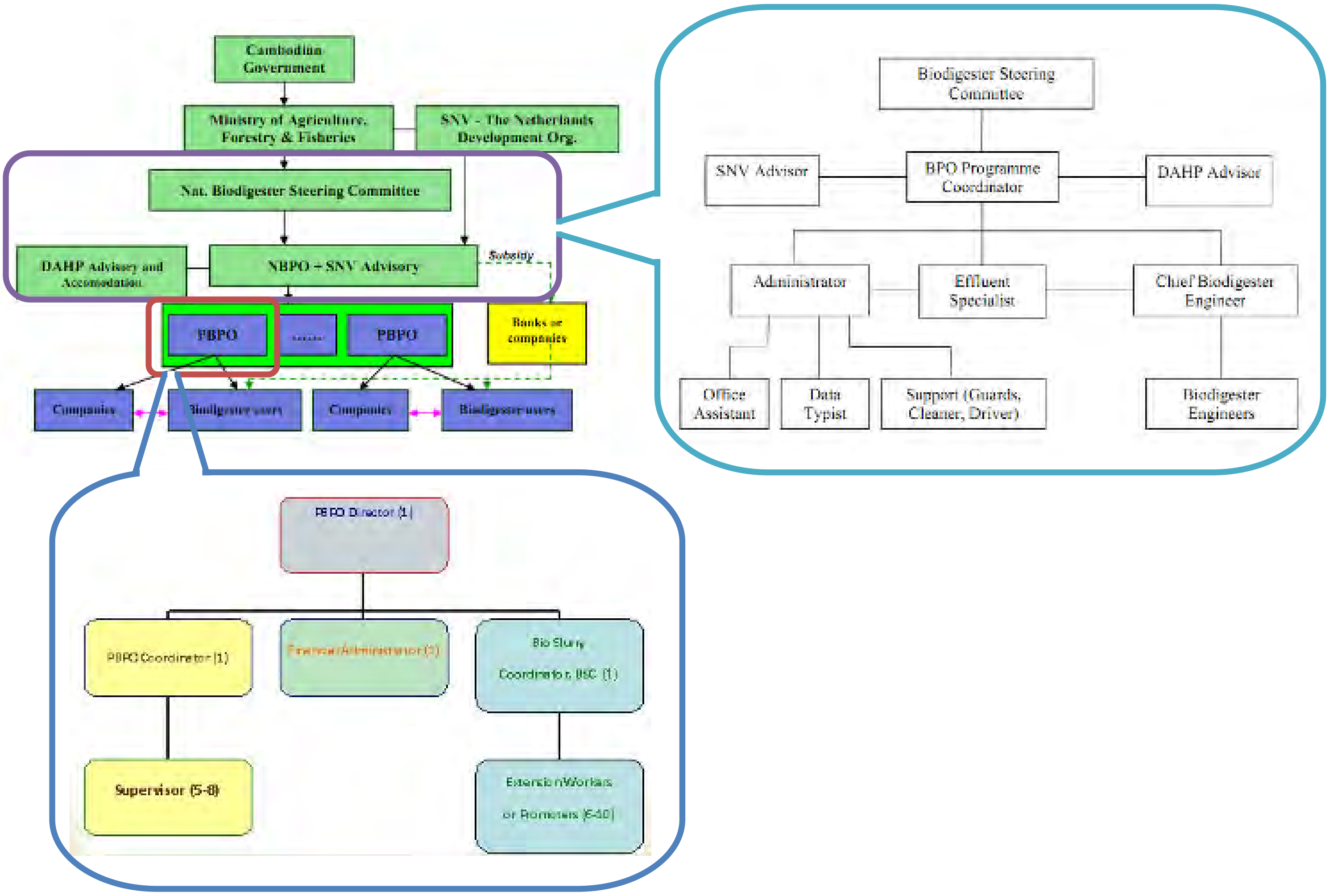


Figure 1. Organizational charts of the various levels of the program's management, showing the overall scheme, as well as the scheme for the NBPO and PBPOs.

Project Activities

This project began in May 2005 and is still ongoing and in its second phase, having been renewed in 2009 to last at least until 2012. The project activities, in general, fall into one of the following six components: 1) trainings and workshops, for capacity building of stakeholders, including government staff, masons, and farmers through technical / user / managerial trainings, through 'training of trainers' and subsequent training activities; 2) promotion and marketing, to create awareness and raise interest in farmers to purchase a biodigester through the production and use of various IEC (information, education, communication) materials; 3) quality management, to ensure long-term program success by implementing and following quality control processes for supervisors of construction and offering regular technical assistance to farmers should problems arise with an installation; 4) bio-slurry management and promotion, to promote the use of biodigester effluent as a fertilizer among purchasing farmers, by establishing demonstration farms using the product and showcasing them via exchange visits, and instructing on the proper storage, treatment, and application of the bio-slurry; 5) research and development, to continually adapt or improve the biodigester technology being promulgated by the program and improving standardizations, performance, and construction techniques; and 6) institutional support, to create market supply for biodigesters by developing private sectors partners responsible for marketing, constructing, and servicing biodigesters, through selection of potential entrepreneurs who agree to sign on to the sales conditions of the program, and subsequent trainings and coaching. The majority of the 'on-the-ground' work is being done by the PBPOs and local government or NGO groups, which include the promotion and marketing activities, investigation for potential users, registration and assistance to purchasers, quality control, local trainings, and database management and reporting. The NBPO and NBP Steering Committee are responsible for more of the general IEC activities and marketing, the research and development, the financing activities, and overall reporting on and management of the program. The private sector businesses hold main responsibility for the actual construction of the biodigesters, and hold supporting responsibility for sales and technical support.

Sanitation Technology / System

The biogas reactor is an anaerobic, sealed chamber that serves as a primary settling tank, with relatively fast passage of the liquid effluent through the chamber and digestion of much of the settled sludge by anaerobic bacteria. In this way it is much like a septic tank, except that its sealed nature allows all of the 'biogas' – a mixture of methane and carbon dioxide that is released from anaerobic digestion – to be captured and used. Since most of the organic matter is converted to biogas, sludge production is relatively low. The settled sludge usually remains in the unit for several years and, when removed, is relatively pathogen-free, requiring only some post-composting to ensure sterility. As well, biogas units are climate-friendly, since the generated biogas is offsetting the need for additional gas at the project site.

The biogas reactors built for this project are of the 'fixed dome' type, named the "Farmer's Friend Biodigester" with an inlet mixing chamber, where animal manure can be mixed with water to allow its flow into the unit, the main chamber, where the anaerobic fermentation and biogas production takes place, and the raised outlet area (and maintenance manhole), where the liquid effluent and sludge is gradually discharged through the pressure exerted on the liquid by the accumulating biogas. This outlet can be connected to further treatment processes, such as an anaerobic baffled reactor/anaerobic filter unit, though for this program, effluent sludge, termed "bio-slurry" here, is simply being collected and disposed of or – the preferred option – used as fertilizer in the agricultural practices of the farmers.

It makes sense for farmers to reuse the bio-slurry on their fields. It is odorless and does not attract insects; it in fact repels termites when applied on fields, whereas raw manure attracts them, which can subsequently damage plants. Bio-slurry also helps reduce weed growth by about 50%, whereas raw manure on fields can increase weed growth from the sprouting of the undigested weed seeds in the feces. As well, the overall levels of the fertilizing nutrients Nitrogen, Phosphorus, and Potassium are all present at higher levels than in raw manure and the nitrogen is in a form that is easier for plants to absorb than the form it is in when it is a component of raw manure. Reuse of the slurry also 'closes the loop' on the cycle, so that no product of the process is wasted, as in Figure 2. Most importantly, it is free and can both help reduce the need for costly synthetic fertilizers and reduce the sanitation and health risks generated from working with raw manure.

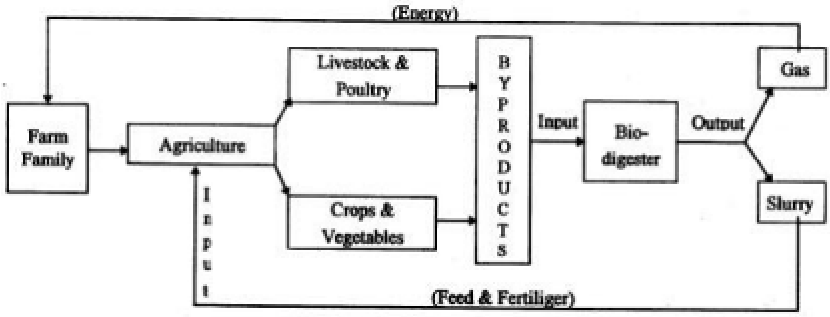


Figure 2. The relationship between a biodigester and agriculture for a farming family

Depending on the size of the biogas reactor, this generated gas can be used either for small scale applications like operating a gas stove or light, or larger scale applications like powering the scalding vats of a slaughterhouse. The sizes of biodigesters offered to the farmers through this program, their daily requirements of dung and mixing water input (for optimal biogas generation), and the resulting length of time that the optimal volume of daily generated biogas is able to power a stove or lamp are all illustrated in Table 1, as is the volume of initial input dung needed before biogas production will reach its optimal level.

Table 1. Biodigester Characteristics in the NBP

Biodigester size	Initial Feeding (cattle dung or pig manure)	Daily dung feeding (kg)	Water to mix with dung (litre)	Use of Biogas Stove (hour)	Use of Biogas Lamp (hour)
4	1500	20-40	20-40	3.5 to 4	8-10
6	2300	40-60	40-60	5.5 to 6	12-15
8	3000	60-80	60-80	7.5 to 8	16-20
10	3800	80-100	80-100	9.5 to 10	21-25
15	6000	100-150	100-150	10 to 15	25-32

The biodigester can be appropriately sized by calculating the number of animals the farming family owns, and, if they also connect their personal toilet to the unit (which is encouraged for sanitation purposes), the number of family members using the toilet. For example, the average cow generates 10-15kg of manure per day, while water buffalos generate 15-20kg/day, pigs generate 2-4kg/day, chickens generate 0.02-0.03kg/day, and humans generate 0.18-0.34kg/day. The 6m^3 plant is proving the most popular to date.

The total costs of these different sizes of biodigester to the program, as well as the $150USD subsidy provided by the program to each individual farmer upon completion of construction and the subsequent costs to the farmer, are displayed in Table 2.

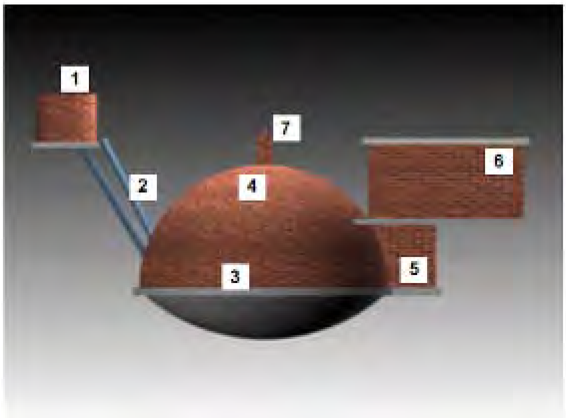
Table 2. Cost of Biodigesters in the NBP

Biodigester size (m3)	Total cost (US$)	subsidy from NBP (US$)	Farmer cost (US$)
4	400	150	250
6	500	150	350
8	550	150	400
10	650	150	500
15	900	150	750

While these costs sound high for poor rural Cambodian farmers, the economics of using free biogas instead of fuelwood/charcoal/LPG/kerosene help to provide a fast payback period, as shown in Table 3 for a $4m^3$ unit, which therefore provides a strong incentive to buy, even without considering the loans that are also available through the microfinance institutions.

Table 3. Payback Period of the $4m^3$ Biodigester at a Cost of $400USD, Per Prior Fuel Source

Type of Fuel Sources	Quantity saved	Cost per unit	Total cost saved per day	Total cost saved per year	Payback period without subsidy	Payback period with subsidy (US$ 150)
Firewood	6 kgs	US$ 0.07	US$ 0.42	US$ 153	2.6 years	1.6 years
Charcoal	2 kgs	US$ 0.2	US$ 0.42	US$ 153	2.6 years	1.6 years
Kerosene	0.7 litre	US$ 0.65	US$ 0.46	US$ 166	2.4 years	1.5 years
LPG	0.5 kg	US$ 1.00	US$ 0.50	US$ 183	2.2 years	1.3 years



1. *Mixing Tank*
2. *Inlet Pipe*
3. *Digester*
4. *Gas Holder*
5. *Manhole*
6. *Outlet Tank*
7. *Main Gas Pipe*

Figure 3. The standard model of the Farmer's Friend Biodigester designed and being implemented by the program, including a mixing tank (for mixing the dung with water), an inlet pipe (or pipes, if the toilet is also connected), the digester and gas generation area, the outlet area, and the gas pipe.

Figure 4. A nearly completed biodigester, showing the mixing tank (rear), digester (middle), and outlet (front)

Number, Type, and Location of Beneficiaries

This project turns 'beneficiaries' into 'buyers'. Since there is only a partial hardware subsidy on the product, every farmer who decides to purchase one of these biodigesters is using their own funds, which empowers them and ensures they will take better care of their system than if it was just given to them free of charge. In terms of the number of units sold, and therefore the number of Cambodians who now are better managing the wastes of their animals – and, to date, in about 10% of cases, themselves as well, through the connection of their personal toilet to the unit – the program has sold, as of May 30, 2011, 12,014 units across the aforementioned provinces as follows: Battambang – 49 units; Siem Reap – 126 units; Kampong Thom – 83 units; Pursat – 127 units; Kampong Chhnang – 605 units; Kampong Speu – 1279 units; Kampong Cham – 1858 units; Kandal – 751 units; Prey Veng – 882 units; Svay Rieng – 1824 units; Takeo – 2441 units; Kampot – 1888 units; Kep – 79 units; and Sihanoukville – 22 units.

Since the average Cambodian family size is 5 persons, this means that approximately 60,000 Cambodians are already benefitting from these biodigesters. As mentioned, since approximately 10% of these biodigesters have the toilet attached as well, this means that about 6000 Cambodians are also benefitting from improved personal sanitation and reduced risk of groundwater contamination or illness. As well, the program has employed over 450 people and 21 private biodigester sales and installation companies have already been established, which are providing these Cambodians with stable and prosperous livelihoods.

Impacts and Challenges

While this program is still underway, its results to date have nevertheless been substantial. As mentioned, 12,014 biodigester units (with the most commonly sold size being the 6m^3 version) have already been sold, benefitting over 60,000 Cambodians. While this value is still approximately 10,000 units away from the fast-approaching 2012 goal of 22,000 units sold, sales are continually growing as more new businesses are trained, with 21 companies already established and more being trained, which should allow monthly sales volumes to continue growing.

Even if the sales fall short of the goal, having sold 12,000+ biogas digesters and established a comprehensive management framework for their sales and maintenance, including businesses, banks, microfinance loan institutions, marketing and promotions campaigns, business trainers, technical designers, researchers, and the various levels of managing administration is an impressive feat that ensures the long-term sustainability of the demand for and supply of biogas digesters in Cambodia, as well as their long-term operation and proper maintenance. Indeed, an important result to date is that, from local monitoring, 95% of all biogas digesters sold are still operational, which shows both the effectiveness of the quality control measures implemented for construction and also on the availability of the local PBPOs and businesses to address any maintenance issues that may arise. As well, to date, 75% of the units sold are making use of the bio-slurry produced by the digester for fertilizing the owner's agriculture, which is improving the lives of these farmers by reducing their need for costly synthetic fertilizers and eliminating the health, groundwater, termite, and weed risks to the farmer that were previously brought about by using raw manure as a direct fertilizer.

One issue of the project to date is that only 10% of the units sold thus far also had a personal toilet of the purchasing family connected to them. This means that, while all the units are improving local sanitation by at least treating the feces of the farm animals, only about 1,200 of them to date are also giving effective treatment to the otherwise risky human feces produced by these farming families. The remaining families are likely still practicing open defecation or are making use of a basic pit latrine that helps create groundwater pollution. This could be perhaps because this program did not provide a toilet as part of the installation, either as an additional cost or as a subsidy or loan-worthy accessory, since many of these purchasing families likely do not have toilets. This program could have benefitted from being more closely integrated with the various latrine marketing / building programs currently underway by other NGOs in Cambodia, so that joint latrine-biodigester models could have been offered for sale.

Nevertheless, every biogas digester sold by this program is helping to improve overall sanitation in Cambodia, improve the lives of the farming families by utilizing an existing resource (manure of their animals) to give them free biogas for cooking and lighting, improve the agriculture generated by these farmers through their 'closing the loop' use of the output bio-slurry, and improve the governing and marketing institutions of the country by using this multi-partnership program to bring together and utilize the talents of the different government, private sector, and NGO groups operating in the country. With additional revenue now being generated from the sale of verified carbon offsets from these biogas digesters, the program is also helping to prevent climate change and make money for the program at the same time. It is hoped that this program will continue in earnest beyond 2012 and make Cambodia a model for biodigester marketing and sales.

Photos

Figure 5. A site visit by SNV and program staff to a biodigester installation (left), a technical training session for program masons and construction workers (right)

Figure 6. The locally-produced biogas stove (left) and biogas lamp (right), made by DTW

Figure 7. A farming family kitchen making use of the biogas stove (left), a farmer applying the bio-slurry output from the biodigester to his crops (right)

References

National Biodigester Program. (2011). http://www.nbp.org.kh. [Accessed 8 June 2011]