**From Toilets to Rivers**  
*Experiences, New Opportunities, and Innovative Solutions: Volume 2*

This publication showcases a compilation of project briefs culled from case studies of good practices, new approaches, and working models on sanitation and wastewater management from different countries. The project briefs demonstrate solution options from which useful lessons can be derived. Not only do they illustrate how sanitation and wastewater management challenges can be addressed, the project briefs also aim to inspire replication and show opportunities for actions and investments. Given the more complex water resource and health challenges in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, learn from others’ experiences, apply innovative approaches, and tap potential markets.

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Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.
FROM TOILETS TO RIVERS
EXPERIENCES, NEW OPPORTUNITIES AND INNOVATIVE SOLUTIONS
VOLUME 2
## Contents

<table>
<thead>
<tr>
<th>Acknowledgments</th>
<th>vi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>vii</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>viii</td>
</tr>
<tr>
<td>Weights and Measures</td>
<td>x</td>
</tr>
<tr>
<td>Currency Units</td>
<td>x</td>
</tr>
</tbody>
</table>

### Improved Onsite Sanitation: A Business Case

- Decentralized Wastewater Treatment System for a Private Household in Huu Hoa Commune: 3
- Decentralized Wastewater Treatment System for a Prison and Two Hospitals: 5
- Decentralized Wastewater Treatment System for the Bear Rescue Center, Tam Dao National Park: 8
- Decentralized Wastewater Treatment System for Sovann Komar Orphanage: 10
- Decentralized Wastewater Treatment System for a College, Village, and Primary School: 12
- Urine and Brownwater Separation at Deutsche Gessellschaft für Internationale Zusammenarbeit Main Office Building: 15
- Waterless Urinal Sheds in the Inner City: 17
- Urban Urine Diversion and Greywater Treatment System: 19
- Floating Toilets for the Floating Villages in Tonle Sap Lake: 22

### Decentralized Wastewater Treatment Systems for Public Markets and Peri-urban Areas

- City-to-City Cooperation Project for Decentralized Sewerage Treatment Using Eco-tanks: 27
- First Decentralized Wastewater Treatment System: 29
- Decentralized Wastewater Treatment System for a Commune and Primary School: 31
- Decentralized Wastewater Treatment System for the Ha Phong Slaughterhouse: 33
<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decentralized Wastewater Treatment System for the Khac Niem Commune</strong></td>
</tr>
<tr>
<td><strong>Decentralized Wastewater Treatment System for Lai Xa – Kim Chung Commune</strong></td>
</tr>
<tr>
<td><strong>Low-cost Sewerage Systems</strong></td>
</tr>
<tr>
<td><strong>Decentralized Wastewater Management in El-Moufty El-Kobra</strong></td>
</tr>
<tr>
<td><strong>Decentralized Wastewater Treatment System and Desludging Service for Hin Heup Town</strong></td>
</tr>
<tr>
<td><strong>Condominial Water and Sewerage Systems in Brazil</strong></td>
</tr>
<tr>
<td><strong>Estero de Paco Sanitation Project</strong></td>
</tr>
<tr>
<td><strong>Applying Innovative and Multidimensional Approaches</strong></td>
</tr>
<tr>
<td><strong>Distributed Wastewater Infrastructure for Integrated Water Resources Management</strong></td>
</tr>
<tr>
<td><strong>Dockside Green Development</strong></td>
</tr>
<tr>
<td><strong>Ecological Settlement in Allermöhe</strong></td>
</tr>
<tr>
<td><strong>Rethinking Financing Options</strong></td>
</tr>
<tr>
<td><strong>Double Vault Composting Latrine Program in Northern Viet Nam</strong></td>
</tr>
<tr>
<td><strong>Three Delta Towns Water Supply and Sanitation Project</strong></td>
</tr>
<tr>
<td><strong>Sanitation Marketing for Five Provinces in Cambodia</strong></td>
</tr>
<tr>
<td><strong>Latrine-building Project</strong></td>
</tr>
<tr>
<td><strong>Tirupur Water and Wastewater Treatment Project</strong></td>
</tr>
<tr>
<td><strong>Urban Sanitation in Ouagadougou</strong></td>
</tr>
<tr>
<td><strong>Halong City Sanitation Project</strong></td>
</tr>
<tr>
<td><strong>Great Falls Wastewater Treatment Plant</strong></td>
</tr>
<tr>
<td><strong>Creating Synergies for Energy and Nutrient Recovery</strong></td>
</tr>
<tr>
<td><strong>Transforming Wastewater Into Green Energy</strong></td>
</tr>
<tr>
<td><strong>Biogas Digesters for Vietnamese Farmers</strong></td>
</tr>
<tr>
<td><strong>Floating Community Ecological Sanitation Project – Tonle Sap Lake</strong></td>
</tr>
</tbody>
</table>
Wastewater and Septage Treatment and Reuse for Agriculture and Aquaculture 93
Small-scale Sludge Treatment System for Daeum Mien 94
Use of Treated Wastewater in Agriculture 96
Co-composting of Fecal Sludge and Organic Solid Waste 99
Decentralized Wastewater Management at Adarsh College with Biogas Digesters 101
Pour-flush Toilets with Biogas Plant at DSK Training Institute 103
Vinasanres Ecosan Toilets Demonstration in Cam Duc Commune 106
Reuse of Human Urine in Aquaculture 107
Muscat Wastewater Project 109
Qinghe Wastewater Treatment Plant 111

Environmental Sanitation and Good Governance 115
Ankara Sewerage Project 116
Kibera Water and Environmental Sanitation Program 118
Medellin River Sanitation Program 120
Low Income Sanitation Technical Assistance Project 121
Wastewater Reuse in Jordan 122
Fallujah Sewerage System 125
Following the 2nd ADB–DMC and Partners Sanitation Dialogue on May 2011, representatives from the Asian Development Bank (ADB), International Water Association (IWA) and United Nations Secretary General’s Advisory Board on Water and Sanitation (UNSGAB)–Omega Alliance for wastewater revolution–agreed to develop a compendium of case studies of good practices, new approaches and working models on sanitation and wastewater management that could promote the acceptance of innovation and change, create fertile ground for reuse and applying technologies intelligently, demonstrate incentive and financing packages, and inspire investment uptake in wastewater management. The first volume was published in 2014.

For this second volume, Robert Domingo was responsible for the compilation of case studies and project briefs, and prepared the introduction to each section. The project briefs were developed by Maria Corazon Ebarvia and Robert Domingo following the template agreed upon by ADB and IWA. The following helped in finalizing this publication: Anna Lissa Capili for editing; Anna Romelyn Almario and Pia Reyes for additional inputs; and Ginojesu D. Pascua for layout and design.

Contribution of case studies by the following is gratefully acknowledged: Center for Advanced Philippine Studies (CAPS), City of Great Falls Montana, Inter-American Development Bank (IDB), Korea International Cooperation Agency (KOICA), National Council for Public–Private Partnerships, Sustainable Sanitation Alliance (SuSanA), Water Environment Research Foundation, WaterAid Australia and International WaterCentre, World Bank, the World Health Organization (WHO), and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). This publication also benefited from the support and encouragement of Amy Leung, Vijay Padmanabhan, Michiel de Lijster, and Jingmin Huang.
Background

According to the World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), around 2.5 billion people worldwide are without access to improved sanitation as of 20141 — far behind the Millennium Development Goal (MDG) target. Open defecation, inadequate sanitation facilities and discharge of untreated wastewater into water bodies threaten the health of local people as well as affect livelihoods, ecosystems, and water bodies, the latter of which we rely on for drinking, bathing, swimming, and fishing, among others. A paradigm shift is therefore required toward new approaches that include technological innovation, comprehensive package of financing, credit enhancement and delivery mechanisms, and performance-based and business-oriented solutions, and ensuring that investments are appropriate to the communities and industries they serve. More than ever, it is crucial to increase efforts to improve sanitation by 2015 and beyond. We need to identify doable solutions and opportunities, and agree on actions that will make sanitation happen. But neither of these two activities—identifying opportunities and committing to action—can happen without a solid knowledge base to work from.

The project briefs provide a synopsis of case studies from different countries and demonstrate solution options from which useful lessons on sanitation management can be derived. The case studies were selected from existing publications, which can be referred to for more exhaustive discussion. Documentation was done following a template developed by the Asian Development Bank (ADB) and International Water Association (IWA). Each project brief provides an overview of the technology adopted, capital and operating and maintenance costs, financing mechanisms, institutional arrangements, and project outcomes.

While issues of sanitation are often looked at in isolation, they are directly tied to issues of water security, health, food security, environmental sustainability, energy and climate change. The case studies illustrate not only the challenges of sanitation and wastewater management, but also more importantly, the proven results in:

(a) increasing access to sanitation in poor communities through onsite sanitation facilities, low-cost sewerage and decentralized wastewater treatment systems;
(b) improving service delivery through policy reforms, application of appropriate technologies, innovative financing mechanisms and contracts, and public–private partnerships;
(c) ensuring financial viability and sustainability; and
(d) reusing treated wastewater and sludge to augment water supplies for potable and nonpotable uses, produce energy, and contribute to food security and greenhouse gas emission reduction.

This compilation of good practices and working models intends to show that sustainable sanitation is possible, and aims to inspire replication, institutionalization of sanitation both in policy and practice, and scaling up of investments. Given the more complex water resource and health challenges encountered in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, learn from others’ experiences, apply innovative approaches, and tap the potential market.

## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR</td>
<td>anaerobic baffled reactor</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>AF</td>
<td>anaerobic filter</td>
</tr>
<tr>
<td>ASKI</td>
<td>Ankara Water and Sewerage Administration</td>
</tr>
<tr>
<td>BMZ</td>
<td>German Federal Ministry for Economic Cooperation and Development</td>
</tr>
<tr>
<td>BOD</td>
<td>biochemical oxygen demand</td>
</tr>
<tr>
<td>BORDA</td>
<td>Bremen Overseas Research and Development Association</td>
</tr>
<tr>
<td>CAESB</td>
<td>Companhia de Saneamento Ambiental do Distrito Federal</td>
</tr>
<tr>
<td>CAPS</td>
<td>Center for Advanced Philippine Studies</td>
</tr>
<tr>
<td>CBO</td>
<td>community-based organization</td>
</tr>
<tr>
<td>CDA</td>
<td>Community Development Association</td>
</tr>
<tr>
<td>COD</td>
<td>chemical oxygen demand</td>
</tr>
<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>CW</td>
<td>constructed wetland</td>
</tr>
<tr>
<td>DEWATS</td>
<td>decentralized wastewater treatment system</td>
</tr>
<tr>
<td>DVC</td>
<td>double-vault composting</td>
</tr>
<tr>
<td>ecosan</td>
<td>ecological sanitation</td>
</tr>
<tr>
<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit</td>
</tr>
<tr>
<td>GRET</td>
<td>Groupe de Recherches et d’Echanges Technologiques</td>
</tr>
<tr>
<td>GTZ</td>
<td>Deutsche Gesellschaft für Technische Zusammenarbeit</td>
</tr>
<tr>
<td>GWE</td>
<td>Global Water Engineering</td>
</tr>
<tr>
<td>HFCW</td>
<td>horizontal flow constructed wetland</td>
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<tr>
<td>HGF</td>
<td>horizontal gravel filter</td>
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<tr>
<td>IEC</td>
<td>information, education, and communication</td>
</tr>
<tr>
<td>KOICA</td>
<td>Korea International Cooperation Agency</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Lao People’s Democratic Republic</td>
</tr>
<tr>
<td>LIRE</td>
<td>Lao Institute for Renewable Energy</td>
</tr>
<tr>
<td>MBR</td>
<td>membrane bioreactor</td>
</tr>
<tr>
<td>MRD</td>
<td>Ministry of Rural Development</td>
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<tr>
<td>NGO</td>
<td>nongovernment organization</td>
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<tr>
<td>O&amp;M</td>
<td>operation and maintenance</td>
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<tr>
<td>PPP</td>
<td>public-private partnership</td>
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<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
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<tr>
<td>RIAL</td>
<td>Reuse for Industry, Agriculture and Landscaping</td>
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<tr>
<td>SCS</td>
<td>sanitation credit scheme</td>
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<tr>
<td>TWU</td>
<td>town women’s union</td>
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<tr>
<td>UDD</td>
<td>urine diversion desiccation</td>
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<tr>
<td>UF</td>
<td>upflow filter</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Program</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>WES</td>
<td>water and environmental sanitation</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<td>WRIP</td>
<td>Water Reuse Implementation Project</td>
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Weights and Measures

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<thead>
<tr>
<th>Symbol</th>
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</tr>
</thead>
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<tr>
<td>m³</td>
<td>cubic meter(s)</td>
</tr>
<tr>
<td>m³/d</td>
<td>cubic meter(s) per day</td>
</tr>
<tr>
<td>m³/s</td>
<td>cubic meter(s) per second</td>
</tr>
<tr>
<td>GWh</td>
<td>gigawatt-hour</td>
</tr>
<tr>
<td>km</td>
<td>kilometer(s)</td>
</tr>
<tr>
<td>l/d</td>
<td>liter(s) per day</td>
</tr>
<tr>
<td>nm</td>
<td>nanometer</td>
</tr>
<tr>
<td>MLD</td>
<td>million liter(s) per day</td>
</tr>
<tr>
<td>m</td>
<td>meter(s)</td>
</tr>
<tr>
<td>mbar</td>
<td>millibar</td>
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<tr>
<td>mg/l</td>
<td>milligram per liter</td>
</tr>
<tr>
<td>ml</td>
<td>milliliter(s)</td>
</tr>
<tr>
<td>ml/l</td>
<td>milliliter(s) per liter</td>
</tr>
<tr>
<td>mm</td>
<td>millimeter(s)</td>
</tr>
<tr>
<td>Nm³</td>
<td>normal cubic meter</td>
</tr>
<tr>
<td>km²</td>
<td>square kilometer(s)</td>
</tr>
<tr>
<td>m²</td>
<td>square meter(s)</td>
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Currency Units

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</tr>
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<tr>
<td>A$</td>
<td>Australian dollar</td>
</tr>
<tr>
<td>CNY</td>
<td>Chinese yuan</td>
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<tr>
<td>D</td>
<td>Viet Nam dong</td>
</tr>
<tr>
<td>€</td>
<td>euro</td>
</tr>
<tr>
<td>Rs</td>
<td>Indian rupee</td>
</tr>
<tr>
<td>¥</td>
<td>Japanese yen</td>
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I. Improved onsite sanitation: A business case

It is estimated that around 2.5 billion people worldwide lacked access to improved sanitation. Around 1 billion people still practice open defecation, with the situation more pronounced in rural areas, where 90% of open defecation cases occur. Around 1.8 billion people are exposed to health hazards due to fecally-contaminated water sources.²

Access to sanitation is a basic human right just as one’s access to clean, potable water. With exponential growth in population and rapid urbanization around the globe, the problem of universal access to sanitation presents a bigger challenge than ever. Poor sanitation habits and practices, if left unabated, can cause serious health and environmental consequences, with often crippling effects on the country’s economic wellbeing and derail any attempt to achieve growth and development.

The reality is that there is still a long way to go in achieving universal access in sanitation. However, with the influx of various technological innovations and approaches, progress has been made, slowly but surely, on achieving this lofty goal. Various country experiences point out that sanitation interventions need not be technically complex with high cost requirements in order to effectively improve sanitation conditions. In fact, there are a number of systems and approaches currently being employed that, though limited in scope, offer an innovative and cost-effective solutions in improving sanitation conditions both under the rural and urban settings.

Cases from Southeast Asian countries [Viet Nam, Cambodia and Lao People’s Democratic Republic (PDR)] provide a clear demonstration of the versatility of the decentralized wastewater treatment system (DEWATS) in providing a cost-effective and technologically sound sanitation intervention in managing wastewater from various sources. The sources of wastewater ranged from schools, a community, a zoo, an orphanage, and a household. Through DEWATS, the beneficiaries were able to not only successfully comply with existing government regulations on effluent discharge but also enjoy the benefits of reduced exposure to health and environmental risks linked with poor sanitation practices.

The examples from Germany, Austria, and Cambodia, on the other hand, provide a glimpse of applying the ecological sanitation (ecosan) approach in improving sanitation conditions under the urban setting. The cases cited highlight innovative approaches used in urine diversion, containment, and treatment for possible nutrient recovery.

It is worthwhile to note that in the examples cited, active community participation and public awareness are recognized as vital components in ensuring the viability of the sanitation solution implemented.

**Project Briefs:**
- Decentralized Wastewater Treatment System for a Private Household in Huu Hoa Commune: Ha Noi City, Viet Nam
- Decentralized Wastewater Treatment System for a Prison and Two Hospitals: Viet Nam
- Decentralized Wastewater Treatment System for the Bear Rescue Center at Tam Dao: Vinh Phuc Province, Viet Nam
- Decentralized Wastewater Treatment System for the Sovann Komar Orphanage: Cambodia
- Decentralized Wastewater Treatment System for a College, Village and Primary School: Lao People’s Democratic Republic
- Urine and Brownwater Separation at Deutsche Gesellschaft fur Internationale Zusammenarbeit Main Office Building: Eschborn, Germany
- Waterless Urinal Sheds in the Inner City: Hamburg, Germany
- Urban Urine Diversion and Greywater Treatment System: Linz, Austria
- Floating Toilets for the Floating Villages in Tonle Sap Lake: Cambodia
Decentralized Wastewater Treatment System for a Private Household in Huu Hoa Commune
Ha Noi City, Viet Nam

One area chosen for the application of DEWATS is the private household of Mr. Hau, in Huu Hoa Commune, Ha Noi City, Viet Nam. As one of the thousands of households in Viet Nam using only a simple, bottomless septic tank that had never been desludged, the house was not effectively treating its wastewater. Groundwater pollution is being experienced resulting from the leaching of wastewater from the septic tank. While the single house generates only a small environmental and health risk from its pollution, when this issue is compounded across thousands of similar households in Viet Nam (and elsewhere in Asia), this small problem becomes a major issue. In fact, improperly maintained or constructed septic tanks are one of the biggest issues currently facing the urban sanitation situation of Asian cities.

Technology options
- The DEWATS module used by Bremen Overseas Research and Development Association (BORDA)–Viet Nam consists of the following sections, in order of wastewater flow: septic tank, anaerobic baffled reactor (ABR), anaerobic filter (AF), and discharge pipe. The system was designed to treat 2 cubic meters per day ($m^3/d$) of wastewater.
  - The single-chamber septic tank receives all wastewater from the home for initial settling of solids and some primary degradation of organics by anaerobic bacteria in the tank.
  - The ABR, a multichambered tank closed from the air, is then the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.
  - The AF follows the ABR. It consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. This helps
in the removal of dissolved solids, pathogens and remaining chemicals in the wastewater.

- No pumps or chemicals are used at any stage, which lowers operation and maintenance (O&M) costs and maximizes wastewater retention (and thus treatment) time. It is predicted that desludging would be needed only once every 3 years.

Institutional and management arrangements

For this project, the funding agency is the owner of the private house, who is likewise the beneficiary and the executing agency, with BORDA-Viet Nam simply providing design consultation.

Financing arrangements

- The total project cost is estimated to be around D12 million (approximately $600).
- The total cost of the project included the construction costs, BORDA consultation costs, and initial water quality testing costs by BORDA. The homeowner was trained in appropriate O&M and will take this responsibility. The costs of this O&M and the costs of desludging the system every 3 years are currently being covered by the homeowner, with no data yet available on the average monthly cost.

Project outcomes

The project helped reduce health risks and environmental pollution with the DEWATS application to households as well as compliance with environmental regulations and standards set by the government [e.g., biochemical oxygen demand (BOD) < 50 mg/l and chemical oxygen demand (COD) < 80 mg/l] in terms of effluent discharged into public drainage systems.

Contact for more information

Hanoi@borda-sea.org
Decentralized Wastewater Treatment System for a Prison and Two Hospitals
Viet Nam

While water and sanitation are among the most pressing issues facing people living in rural Viet Nam, the habit of using raw feces as fertilizer is of particular concern because of the hazards it brings to the people and the environment (e.g., water and soil contamination and possible disease outbreaks). The United Nations estimated that in 2010, only 18% of rural households, 12% of rural schools, and 37% of commune health stations had hygienic latrines that met the standards of the Ministry of Health. This shows that the country still has a huge amount of work to be done in terms of service coverage expansion.

BORDA-Viet Nam saw the situation as an opportunity to implement a cost-effective and decentralized wastewater treatment solution suited to the needs of the population. Three areas are considered for DEWATS project: Ninh Khanh Prison, Kim Bang District Hospital, and Thanh Hoa Pediatric Facility.

The Ninh Khanh Prison in Ninh Binh Province is a fairly large prison, which relies on a single septic tank for treatment of its wastewater generated by the prisoners and prison staff. However, due to significant increases in the population, the prison’s septic tank, besides being outdated, cannot accommodate as well as effectively treat the additional volume of wastewater inflows. It was therefore discharging untreated wastewater to its surroundings, creating extreme health and environmental risks.

The second area is Kim Bang District Hospital in Ha Nam Province. The problem in the site is that wastewater is being discharged in the nearby field without adequate treatment. Blackwater from toilets was treated only in outdated septic tanks; while all greywater and other wastewater sources simply go through a soak pit before discharge. Such condition created an unsafe situation for the local surroundings, as the inadequately treated wastewater was causing groundwater pollution as well as environmental and health risks that are further aggravated with the presence of higher levels of disease-causing organisms present in hospital wastewater.
The third location, the Thanh Hoa Pediatric Facility in Thanh Hoa Province, is a hospital twice the size of the hospital in Kim Bang District with essentially similar sanitation condition. Again, a huge amount of wastewater flows from the facility created an extremely unsafe situation for the local surroundings.

**Technology options**
- **Ninh Khanh Prison:** volume of wastewater treated is 105 m$^3$/d.
- **Kim Bang District Hospital:** volume of wastewater treated is 125 m$^3$/d.
- **Thanh Hoa Pediatric Facility:** volume of wastewater treated is 300 m$^3$/d.
- The DEWATS module for the three project sites consisted of the following sections, in order of wastewater flow: primary settling unit, ABR, AF, horizontal gravel filter (HGF), polishing pond, and discharge pipe. A grease trap was also used for Kim Bang District Hospital project prior to the DEWATS module.
  - The grease trap preceding DEWATS in the Kim Bang District Hospital project is a simple tank of three chambers, with influent and effluent pipes positioned fairly deep below the anticipated water level.
  - The primary settling unit serves as wastewater retention point and area for control of influent fluctuations.
  - The ABR is then the main treatment area of the DEWATS where solids are settled and anaerobic bacteria facilitates the degradation of harmful organic and chemical components of wastewater.
  - The AF follows the ABR and consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. This helps in the removal of dissolved solids, pathogens and remaining chemicals in wastewater.
  - The HGF [e.g., planted gravel filter and horizontal flow constructed wetland (HFCW)] 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. The plants within the gravel layer oxygenate the wastewater, which help break down the remaining organic pollutants and reduce odor.
  - After the HGF, the effluent proceeds to a polishing pond. The pond allows further aeration and settling time for the effluent. It also serves as an indicator for the effluent’s quality.
Institutional and management arrangements

- **Ninh Khanh Prison**: The executing agencies for the project are the owner of the prison (also the beneficiary and funding agency) and BORDA-Viet Nam.
- **Kim Bang District Hospital**: The executing agency for the project is BORDA-Viet Nam, with the owner of the hospital acting as the beneficiary and funding agency.
- **Thanh Hoa Pediatric Facility**: The executing agencies for the project are the Thanh Hoa Project Management Unit and Thanh Hoa Construction Company. The Thanh Hoa Provincial Government provided funding, while BORDA-Viet Nam acted as the cooperating agency, providing assistance in technical design and advice.

Financing arrangements

- **Ninh Khanh Prison**: The total project cost is estimated to be around D1.842 billion (approximately $103,000).
- **Kim Bang District Hospital**: The total project cost is estimated to be around D720 million (approximately $45,000).
- **Thanh Hoa Pediatric Facility**: The total project cost is estimated to be around D2.16 billion (approximately $135,000).
- The funding grants were used to cover construction costs, community engagement costs, and initial water quality testing costs. The staff of each facility was trained to undertake O&M. The owners of each facility are currently covering the costs of O&M as well as desludging the system every 2–3 years. The O&M’s average is about D500,000 per month for Ninh Khanh Prison, and D200,000 per month for Kim Bang District Hospital and Thanh Hoa Pediatric Facility projects.

Project outcomes

The project improved the sanitation condition in the areas and compliance with environmental regulations and standards set by the government (e.g., BOD <50 mg/l and COD <80 mg/l) in terms of effluent discharged into public drainage systems. As an example, in Kim Bang District Hospital project site, water quality tests done in 2007 yielded 11 mg/l BOD and 20 mg/l COD levels.

Contact for more information
Hanoi@borda-sea.org or Fladerer@borda.de
Decentralized Wastewater Treatment System for the Bear Rescue Center, Tam Dao National Park
Vinh Phuc Province, Viet Nam

The Bear Rescue Center in Tam Dao National Park, in Vinh Phuc Province, was included in the areas chosen for the application of DEWATS.

The rescue center rehabilitates an average of 50 bears that had been used in zoos, street performances, or other cruel practices. With the bears, including the human staff, producing wastewater, an effective treatment system is needed considering that the rescue center is located inside a national park, which is bound by strict laws regarding the discharge of wastewater.

Technology options
• The DEWATS module used by BORDA-Viet Nam required very clean effluent to comply with national park standards. The system was designed to treat 22 m³/d of wastewater.

• The module consisted of the following sections, in order of wastewater flow:
  0 septic tank (for staff’s wastewater only),
  0 holding tank,
  0 two biogas digesters,
  0 settling unit,
  0 ABR,
  0 AF,
  0 HGF,
  0 WATTs system,
  0 storage tank, and
  0 discharge pipe.

• The septic tank receives all wastewater from the staff toilets and washbasins for initial settling of solids and some primary degradation of organics by bacteria in the tanks.

• The holding tank receives all of the wastewater. It serves as wastewater retention point and an area for control of influent fluctuations.

• The biogas digester is an anaerobic, sealed chamber that serves as a primary settling tank, with relatively fast passage of the liquid effluent through the chamber.

Biogas digesters and ABR under construction.

Completed DEWATS.
and digestion of much of the settled sludge by anaerobic bacteria.

• The next settling unit serves as another wastewater retention point and an area for control of influent fluctuations.

• The ABR is the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.

• The AF follows the ABR and consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. These help in the removal of dissolved solids, pathogens, and remaining chemicals in the wastewater.

• The HGF (e.g., planted gravel filter and 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. The plants within the gravel layer oxygenate the wastewater, which help degrade the remaining organic pollutants and reduce odor.

• After the HGF, effluent is usually considered clean enough and safe for river discharge. But since the project is in a national park, a chlorination tank and subsequent storage tank were also installed.

Institutional and management arrangements

• BORDA-Viet Nam is the executing agency for the project, with funding support extended by Animals Asia Foundation (AAF).

• The main beneficiary for the project is the staff of AAF.

Financing arrangements

• The total project cost is estimated to be around D600 million (approximately $32,000).

• The funding grant was used to cover construction costs, community engagement costs, and initial water quality testing costs. The staff of the rescue center was trained in O&M activities. O&M costs and the costs of desludging the system every 2–3 years are currently being covered by the rescue center through the, with O&M averaging about D1 million per month (about $50 per month).

Project outcomes

The main impacts of the project are the improved sanitation condition in the rescue center and compliance with environmental regulations and standards set by the government in terms of effluent discharged. In terms of effluent quality, water quality testing yielded a BOD of 18.5 mg/l and COD of 29 mg/l. These effluent values surpass national regulation, which set BOD levels at <20 mg/l and COD levels at <50 mg/l for wastewater effluent discharged in national parks.

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Decentralized Wastewater Treatment System for Sovann Komar Orphanage
Cambodia

The Sovann Komar Orphanage in Kandal Province is an institution with an existing mechanized wastewater treatment plant. However, the facility is no longer functioning due to the very high cost of maintenance (estimated cost of replacing a filter was $20,000). Likewise, three of the houses in the orphanage are also not connected to the system. As a result, all of the orphanage’s wastewater is currently being discharged untreated to the Mekong River. Such practice has significantly contributed in causing damage to the downstream activities as well as the ecosystem and river life within the Mekong River.

Technology options

The module of DEWATS used by BORDA-Cambodia consists of the following sections, in order of wastewater flow: primary settling unit, ABR, AF, HGF, and discharge pipe.

- The primary settling unit serves as a wastewater retention point and an area for control of influent fluctuations.
- The ABR is the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.
- The AF follows the ABR and consists of a tank with a submerged layer of material-like crushed gravel or specially formed plastic. These media helps in the removal of dissolved solids, pathogens, and remaining chemicals in the wastewater.
- The HGF 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. The plants within the gravel layer oxygenate the wastewater, which help degrade the remaining organic pollutants and reduce odor.
- After the HGF, effluent is usually considered clean enough and safe for river discharge, or can be held in a separate tank for reuse in watering plants or flushing toilets.

Cross-section of Sovann Komar DEWATS.
Institutional and management arrangements

- BORDA-Cambodia is the main executing agency for the project, with the residents of the Sovann Komar Orphanage as project beneficiaries.
- Sovann Komar Orphanage, OAV and BORDA provided funding support. BORDA-Southeast Asia also extended support.

Financing arrangements

- The total project cost is around $25,000.
- The costs for O&M and the costs of desludging the system every 2–3 years are currently being covered by the orphanage.
- The funding grant was used to cover construction costs, community engagement costs, and initial water quality testing costs.

Project outcomes

The project was able to improve sanitation in the orphanage, reduce the pollution of the Mekong River, and minimize health risks to downstream users as well as environmental risks to the downstream ecosystem and river life. The BOD and COD levels of the effluent are compliant with the Ministry of Environment’s regulations. BOD level is less than 80 mg/l; while COD level is less than 100 mg/l.

Contact for more information

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Decentralized Wastewater Treatment System for a College, Village, and Primary School  
Lao People’s Democratic Republic

Lao PDR is a country surrounded by People’s Republic of China, Viet Nam, Thailand, Cambodia, and Myanmar. In 2005, the country was below average in establishing sanitation access compared to other Southeast Asian countries. Based on the conducted Multiple Indicator Cluster Survey in 2006 (MICS III), Lao PDR reflected 44.8% coverage for those with improved sanitation [or 48% cited by the United Nations Children’s Fund/World Health Organization (UNICEF/WHO) Joint Monitoring Program] as compared to the 67% average for all the Southeast Asian countries.

In the same study, there is at least 52% of the Lao population without access to sanitation. This data translates to over 3 million Laotians living without improved sanitation (without an easily accessible, private and safe place to urinate and defecate). Lao PDR, thus, needs to factor in the effect of population growth in its pursuit to increase sanitation coverage.

With this in mind, BORDA partnered with the Lao Institute for Renewable Energy (LIRE) to complete and successfully implement its pilot DEWATS project in the country. BORDA has successfully completed three more, using the same modular technology.

There were three areas chosen for the project: a village as well as a primary school and temple complex in Vientiane, and a college in Luang Prabang.

- **Units 11, 12, and 13 of Thongkankham Village in Vientiane:** The area is known for (i) 19% of the households do not have private toilet facilities; (ii) poorly constructed and maintained septic tanks, and (iii) household wastewater is discharged to the surrounding ground as the area lacked a proper canal system. This resulted in foul smells and flood risks during the rainy season. Overall, the site had a high risk of groundwater pollution because of these issues.

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• **Khoualuang Primary School and temple complex in Vientiane:** The area is known for (i) an existing canal system that is shallow and clogged causing floods during the rainy season as well as releases foul odor; and (ii) very poor condition of school’s sanitation facilities. The health and groundwater risks to the schoolchildren and surrounding residents were therefore high.

• **Agriculture and Forestry College of Luang Prabang:** All wastewater from the dormitories are discharged directly to a nearby stream leading to the Mekong River. The planned upgrading of the dormitories is ideal to install a DEWATS to address the issue of river pollution.

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**Technology options**

- The basic technologies of the DEWATS used in all three areas are basically identical, with differences only in treatment capacity. The DEWATS module used by BORDA-LIRE consists of sections, in order of wastewater flow: control boxes, grease trap, primary settling unit, ABR, AF, and discharge pipe.

  - Control boxes are valves placed at each connection from a toilet or septic tank to the main drainage line.
  - A grease trap is a simple tank (one or two chambers), with influent and effluent pipes positioned fairly deep below the anticipated water level. Since grease (oil) floats on water, influent grease rises to the surface and is trapped there; while the remaining wastewater exits through the sunken effluent pipe.
  - The primary settling unit serves as wastewater retention point and area for control of influent fluctuations.
  - The ABR is the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.
  - The AF follows the ABR. It consists of a dual-chambered tank with a submerged layer of material that looks like crushed gravel or specially formed plastic (BORDA-LIRE uses crushed mountain rock). The material helps remove dissolved solids, pathogens, and remaining chemicals in the wastewater.

- For the Thongkankham Village project, the system is able to treat 11.2 m³/d of wastewater.
- For the Khoualuang Primary School and Temple project, the system is able to treat 7 m³/d of wastewater.
- For the Agriculture and Forestry College (AFC) project, the system is able to treat 15 m³/d of wastewater.
Institutional and management arrangements

- Thongkankham Village
  - Executing agency: BORDA-LIRE
  - Funding agency: Japan International Cooperation Agency (JICA)
  - Support Agency: Public Works and Transportation Institute
- Khoualuang Primary School
  - Executing agency: BORDA-LIRE
  - Funding agency: JICA
  - Support Agency: Khoualuang Village Office
- AFC
  - Executing agency: BORDA-LIRE
  - Funding agency: Helvetas
  - Support Agency: Agriculture and Forestry College

Financing arrangements

- The cost for each project are:
  - Thongkankham Village: $33,154.
  - Khoualuang Primary School: $36,168.
  - AFC: $25,000.
- For each project, the funding grant covered construction costs, community engagement costs, and initial water quality testing costs.
- A single operator was appointed from the community. The operator is responsible for general O&M of the DEWATS.
- An O&M fee was formulated with the community in order to cover O&M costs, an allowance for the operator, and the costs of desludging the system every 2–3 years.

Project outcomes

The project was able to (i) reduce incidence of groundwater pollution, foul odors and health risks, and (ii) produce effluent in compliance with existing government standards on water quality.

In terms of removal efficiencies of the systems, water quality testing carried out indicated the following based on the levels of BOD and COD:

<table>
<thead>
<tr>
<th>Location</th>
<th>Influent (mg/l)</th>
<th>Effluent (mg/l)</th>
<th>National Standards (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thongkankham Village</td>
<td>BOD 970</td>
<td>28</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>COD 540</td>
<td>80</td>
<td>400</td>
</tr>
<tr>
<td>Khoualuang Primary School</td>
<td>BOD 970</td>
<td>23</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>COD 540</td>
<td>65</td>
<td>130</td>
</tr>
<tr>
<td>Agriculture and Forestry College</td>
<td>BOD 880</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>COD 490</td>
<td>91</td>
<td>350</td>
</tr>
</tbody>
</table>

Contact for more information

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Urine and Brownwater Separation at Deutsche Gessellschaft für Internationale Zusammenarbeit Main Office Building
Eschborn, Germany

The headquarters of the Gesellschaft für Internationale Zusammenarbeit (GIZ) consists of four multistorey buildings located in Eschborn, which is around 10 kilometers (km) northwest of Frankfurt am Main, the financial capital of Germany.

In 2009, it is estimated that around 1,450 people work in the GIZ headquarters. The GIZ main building (House 1) was constructed in 1976. It was completely renovated from 2004 to 2006 because the environmental performance and the technological standards of the building were already creating high O&M costs. The urine diversion system is installed only in the central section of the main building.

Technology options
Sanitary Equipment (Phase 1)
- Urine and brownwater collection consist of the following:
  - 23 waterless urinals;
  - 38 urine-diversion flush toilets for the collection of urine and feces (originally 50 were installed);
  - Waterless urine collection;
  - Brownwater consists of feces, toilet paper, and flush water;
  - Two separate piping systems for undiluted urine and brownwater collection; and
  - Urine storage tanks (each 2.5 m³) in the basement of the building.

- Greywater collection: Daily volume of greywater inflows is estimated to be about 350 liters, coming from kitchenettes and handwashing basins.

Process Technology (Phase 2)
- Urine precipitation: Two treatment options were considered.
  - Treatment by prolonged storage for direct application of urine to fields.
  - Precipitation of phosphorus and nitrogen from urine by adding magnesium oxide. This process produces the crystal magnesium-ammonium-phosphate (MAP) or struvite. The system is airtight.

- Brownwater treatment system: The brownwater treatment system in the
basement of Building 1 consists of two steps:
- Stainless steel tank (cylinder with a storage of 0.4 m³) as hydraulic buffer for the feed to the membrane bioreactor (MBR) tank and pretreatment for solid removal [brownwater filtrate of 200 liters per day (l/d)]. The cylinder is equipped with a stirrer to prevent sedimentation in the conical part of the tank.
- MBR with submerged HUBER ultrafiltration in a synthetic tank. The brownwater is sucked through the membrane with 38 nanometer (nm) nominal size with a vacuum transmembrane pressure of 350 millibar (mbar). Due to the small membrane pore size, all particles, bacteria and the majority of viruses are retained.

• Greywater treatment system: The greywater treatment system includes three steps:
  - Storage tank as hydraulic buffer for the feed to the MBR tank (volume of 480 liters). Equipped with a preceding 3-millimeter sieve for the retention of hairs and other unwanted matter.
  - MBR with submerged HUBER ultrafiltration (3.5 m² membrane surface) in a synthetic tank (volume of 478 liters). The membrane bioreactor works like the MBR of the brownwater treatment system. The flux rate of the membrane is 6 l/d*m²; while the transmembrane pressure was adjusted to 60 mbar. The cleaning efficiency of COD elimination amounts to 96%.
  - The greywater inflow rate also produces permeate rate amounts of 500–600 l/d. The COD is reduced to 95%–97%.

Institutional and management arrangements
- The Maßalsky GmbH is the executing institution for the project, with Pettersson & Ahrens Ingenieur-Planung GmbH, Germany and GIZ ecological sanitation (ecosan) program serving as the planning agencies.
- The agencies that support the project are GIZ GmbH, the Hessen State Ministry for Environment [subsidy for Phase 1 by Investitionsbank Hessen of €43,070 (approximately $32,629)], and the German Federal Ministry of Education and Research (for Phase 2).

Financing arrangement
The total investment cost for the project is about €125,800 (approximately $166,056).

Project outcomes
The project shows the feasibility of urine and brownwater separation in an urban context to visitors from all over the world, and thus helps to disseminate the ecosan concept. It was able to raise the visibility of the ecosan program within GIZ, thereby highlighting the commitment of the organization to the ecosan approach. The waterless urinals save water compared to conventional urinals.

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4 Approximately €1 = $1.32, as of 2011.
Waterless Urinal Sheds in the Inner City
Hamburg, Germany

With an estimated population of 1.7 million and a land area of 755 km², the Free and Hanseatic City of Hamburg is the second biggest city in Germany after Berlin. It is one of Germany’s 16 federal states. Hamburg was also the first city in Germany with a formalized strategic concept for its public toilets.

The continuous increase costs for the O&M of public toilets in Hamburg served as the main driver for introducing improved public toilets in 1996. It has been reported that, aside from insufficiency of equipment, maintenance by private caretakers was only rarely undertaken in an appropriate manner and regular schedule. Only 132 of the 207 existing public toilets were actually open to the public.

Technology options
- All urinals installed in Hamburg’s public toilets (estimated to be around 1,200 units) are waterless urinals (instead of the conventional water flushed urinals that use 4–6 liters per flush).
- Public urinal sheds locally called pisseoirs were installed in 11 locations. The pisseoirs have similar appearance to bus stops.
- In the sheds, urinal troughs made of marble powder are designed with a stainless steel drain and an integrated Keramag flat rubber tube for odor control. The trough is designed in such a way to prevent vandalism.
- Urine storage tanks are also provided for the 11 sheds because: (i) the notion that pure urine from the urinal shed may cause damage (corrosion) to the local sewer pipe; (ii) possible future use of urine for agricultural purposes; and (iii) possible separate treatment of urine for nitrogen removal or struvite production in the future.

Institutional and management arrangements
- The Environmental Protection Office at the Authority for Urban Development and Environment (BSU – Behörde für Stadtentwicklung und Umwelt) is the project owner. As such, it is actively involved in the planning and installation activities. It is responsible for the overall supervision and control as well as in
carrying out regular checks (each public toilet and urinal shed is checked 3–5 times per year). Additionally, BSU is also in charge of any further improvement made on the urinals.

- A private contractor (Decaux) is in-charge of above ground construction as well as the daily maintenance, cleaning, checking, and replacement of broken equipment.
- The district administrations of the Free and Hanseatic City of Hamburg are responsible for emptying the urine tanks (which hold 2.5 m³) through private companies. It is also the districts’ responsibility to check the urinal sheds on a regular basis and to act on issues and problems with the service provided by the private contractor.

Financing arrangements

- Investment costs for the project include:

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsurface installations</td>
<td>25,000–45,000</td>
</tr>
<tr>
<td>(approximately $36,500–$65,700)</td>
<td></td>
</tr>
<tr>
<td>Installations above ground</td>
<td>10,000</td>
</tr>
<tr>
<td>(approximately $14,600)</td>
<td></td>
</tr>
<tr>
<td>Sum (Average)</td>
<td>40,000</td>
</tr>
<tr>
<td>(approximately $58,400)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Subsurface installation includes pipes, pump sump, installation of the tank (cost per tank is €4,000–€5,000 (approximately $5,840–$7,300)), and digging. The item with the highest cost is the waterless urinal trough: €3,000 (approximately $4,380).

- The annual maintenance cost is around €9,500 per public urinal shed (approximately $13,870). The city has a contract with a private company for this service.
- Tenants of public toilets usually have to pay a small amount for rent, depending on their annual turnover to the local district. In eight public toilets found in highly frequented and tourist areas, turnstiles are installed. Single use costs €0.50 (approximately $0.73). This results in an annual income of €350,000 (approximately $511,000).

Project outcomes

The project was able to improve hygienic situation and reduce urine odor; generate water savings; showcase a public toilet solution, which helps save water; develop a sustainable management scheme for the urinal sheds’ O&M; and include an additional alternative to the public toilet concept in the City of Hamburg, which is well accepted and used by different groups in the city center.

Contact for more information

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5 Approximately €1 = $1.46, as of 2010.
Urban Urine Diversion and Greywater Treatment System
Linz, Austria

The project is located in Linz-Pichling, a city with approximately 200,000 inhabitants in the southern part of Linz. Linz-Pichling is known for different types of houses (single houses and flats), small lakes, a creek, and the neighboring Traun-Donau meadows and forest, the biggest joint biotope structure in Upper Austria.\(^6\)

The wastewater treatment system is a pilot ecosan project, which is part of an innovative town-planning venture. The pilot project was developed with the participation of the municipal authorities, 12 housing companies, and the Renewable Energies in Architecture and Design as the main architectural proponent.

Technology options

- The pilot project handles wastewater of around 460 residents through urine separation, compost filters, and constructed wetlands (CWs).

- The ecosan system includes a urine-diversion flush toilet and waterless urinals, separate urine pipe network, urine storage tanks, filtration system, and CWs.

  - The urine-diversion flush toilet model (NoMix toilet) is implemented in the school and residential buildings. The model is made of ceramics with the bowl split into sections for urine and feces. It requires the user to be in a sitting position to activate the urine pipe valve that collects pure urine without flush water. (The user’s weight on the toilet seat triggers the process.)

  - The waterless urinals (popular in many Western European countries) are also made of ceramic, but with a special surface. The special surface prevents urine film from sticking, which causes the odors.

  - The separate urine pipe network leads to the urine storage tanks: six double-wall fiberglass tanks in the housing area and two storage tanks in the basement of the school. With a volume of 1.5 m\(^3\) each in the school

\(^6\) Biotope is a region uniform in environmental conditions and in its populations of animals and plants for which it is the habitat. http://www.merriam-webster.com/dictionary/biotope
and 0.75 m³ each in the residential buildings, the tanks are designed to store urine for 30–60 days. They are then closed to minimize odor and ammonia losses. Pressure equalization happens in the inlet pipes from the houses.

- The first step to treating greywater and brownwater mixture is a filtration system that removes the solids. Two 1-m³ filter units are located in the operation buildings incorporated in the hills of the artificial landscape. The filter units are composed of containers made of stainless steel. The filter units serve as carrier for a filter bag of acid-proof plastic material filled with organic structure substance. Pretreatment of the brownwater and greywater is done in the filter bag through composting under aerobic conditions, and then empties through the structure material.

- The two CWs are those with sub-surface vertical flow, planted with reed. The remaining wastewater has a low nutrient content since urine is separated. As such, the required size of the CW is up to one square meter (m²) per inhabitant. The size is smaller compared to wetlands constructed for domestic wastewater where the standard area is 2.5–3 m² per person.

### Institutional and management arrangements
- LINZ AG is the operating company responsible for maintenance of the ecosan system’s technical equipment.
- OtterWasser GmbH from Lubeck, Germany is the planning institution.

### Financing arrangements
- The total costs for the project is about €2.3 million (approximately $3.24 million). The amount includes investment, O&M, and research sponsorship. This was fully covered by LINZ AG, and as incentive, the company was granted tax concessions (8% of the project costs).
- The construction cost was around €1.7 million (approximately $2.38 million). It includes design and project management.
- Research sponsorship (e.g. Hamburg University of Technology, ARC Seibersdorf Research GmbH, and the University of Applied Sciences Upper Austria) costs amounted to €0.5 million (approximately $0.7 million).
- The O&M costs were €100,000 (approximately $141,000) from mid-2006 to mid-2008.
- Residents connected to the ecosan system pay the regular wastewater fees. These include the sewer system and wastewater treatment. The calculation is a combination of the number of toilets and water consumption.

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7 Approximately €1 = $1.41, as of 2009.
Project outcome
The pilot and demonstration project provided a venue for learning and further improvement of sanitation technologies in order to be more responsive to the needs of consumers.

Lessons learned
- There is a need to maximize the NoMix toilet design to make the project fully functional.
- The urine separation flush toilets are difficult to use especially for small children who have to sit far back to defecate.
- Public relations work is crucial to the users' acceptance of innovative sanitation systems and willingness to cooperate.
- Valuable insight to medium-scale application of compost filters can be achieved.
- There is a need to include local authorities from the beginning of the project to prevent future problems.

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Floating Toilets for the Floating Villages in Tonle Sap Lake
Cambodia

The project is located in Tonle Sap Lake, Cambodia’s great lake. Residents in the villages live in houses with floating platforms that are usually moved seasonally. For their sanitation needs, they have built outhouses out of simple wooden planks just above the open water. With this kind of practice, the villagers’ health is at risk because the water they use for drinking and washing is the very same water that they contaminate.

Only 16% of the population of rural Cambodia has a proper toilet. Data shows that over 11 million Cambodians lack access to improved sanitation, and that the primary cause of sickness and death among children is diarrhea.

Technology options
- The project used specially adapted septic tanks plus ecosan system utilizing the urine diversion desiccation (UDD) toilet.
- There were two toilet option designs:
  - Toilets with two tanks for families who wish to avoid handling semidecomposed 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 one vault for those who will have to dispose of semicomposted feces at monthly intervals.

Institutional and management arrangements
- The residents living in floating communities within the Tonle Sap Lake are the project owners
- Lien Aid of Singapore and the Lien Institute for the Environment are project partners. Lien Aid is a nongovernment organization (NGO) established through the Lien Foundation – Nanyang Technological University Environmental Endeavour. Its main thrust is to address the water and sanitation crisis in the
developing countries in Asia. The project partners introduced the floating toilet concept to the floating communities of Tonle Sap Lake in February 2009, as part of the River of Life project.

- The Ministry of Rural Development (MRD) supports the River of Life project and works closely with Lien Aid. Other local authorities also provided support by developing simple publications on construction, use, and maintenance of the floating toilets.

**Financing arrangements**

The cost of the floating toilet is around $50–$200. For the cost, the project partners considered (i) whether the family will just upgrade their existing drop-hole toilet to accommodate the UDD technology; or, (ii) whether an entire toilet will be constructed from scratch including its superstructure. The size of the toilet to be used is also considered.

**Project outcomes**

The main impact of the project is improved community hygiene through the provision of a viable sanitation solution, with the active participation of the community. In order to make the project sustainable, communities are encouraged to form water-sanitation groups responsible for training and advocacy-related activities, as well as get the locals to provide counterpart contributions, i.e., construction materials.

Key challenges that need to be addressed include: (i) modifying existing toilets to incorporate the UDD options; (ii) ensuring availability of suitable drying materials for covering feces; and (iii) keeping the costs manageable.

**Contact for more information**

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**References**

- **Decentralized Wastewater Treatment System for a Private Household in Huu Hoa Commune, Ha Noi City, Viet Nam**  
CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment Systems for a Private Household in Huu Hoa Commune*. A BORDA-Viet Nam DEWATS Project in Viet Nam.  

- **Decentralized Wastewater Treatment System for a Prison and Two Hospitals, Viet Nam**  
CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment Systems for a Prison and Two Hospitals*. Three BORDA-Viet Nam DEWATS Projects in Viet Nam.  

- **Decentralized Wastewater Treatment System for the Bear Rescue Center, Tam Dao National Park, Vinh Phuc Province, Viet Nam**  
CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment Systems for the Bear*
Rescue Center at Tam Dao. A BORDA-Vietnam DEWATS Project in Viet Nam.


- Decentralized Wastewater Treatment System for Sovann Komar Orphanage, Cambodia
  
  CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment System for the Sovann Komar Orphanage.* DEWATS Projects in Cambodia. Bremen Overseas Research and Development Agency (BORDA)-Cambodia.
  

- Decentralized Wastewater Treatment System for a College, Village, and Primary School, Lao People’s Democratic Republic
  
  CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment System for a College, Village, and Primary School.* BORDA-LIRE DEWATS Projects in Laos.
  

- Urine and Brownwater Separation at Deutsche Gessellschaft für

Internationale Zusammenarbeit Main Office Building, Eschborn, Germany


- Waterless Urinal Sheds in the Inner City Hamburg, Germany


- Urban Urine Diversion and Greywater Treatment System, Linz, Austria


- Floating Toilets for the Floating Villages in Tonle Sap Lake, Cambodia

CAPS, KOICA, and UNEP. *Case Study: Floating Toilets for the Floating Villages in Tonle Sap Lake.*

II. Decentralized wastewater treatment systems for public markets and peri-urban areas

The decentralized concept of wastewater management aims to provide a framework for developing “alternative” systems consisting of a variety of approaches for collection, treatment, and dispersal and/or reuse of wastewater. The system is an effective and affordable wastewater treatment solution to improve living environment and reduce health risks associated with poor sanitation.

It goes beyond merely managing individual user systems. Effluent from individual dwellings, industrial or institutional facilities, clusters of homes or businesses, public markets, and entire communities may be routed to further treatment processes in smaller facilities that are closer to the sources. They provide a range of treatment options from simple, passive treatment such as septic tanks with soil dispersal, to more complex and mechanized approaches such as rotating biocontactor, MBR, moving bed biofilm reactor, etc., as well as less complicated systems like the anaerobic baffled reactor. An evaluation of site-specific conditions should be performed to determine the appropriate type of treatment system for each location.

The project briefs presented highlight how decentralized wastewater treatment systems can be sustainable and appropriate options for a vast range of end-users. Decentralized wastewater systems in these sites have been demonstrated to be cost effective, economical, and reliable solutions to improve public health and achieve water quality goals in compliance with existing government environmental regulations. Awareness-raising activities and consultations with stakeholders ensured social acceptability and active participation.

It should be noted, nonetheless, that the decentralized concept would not be the answer to all wastewater management problems. Likewise, centralized systems are not the only appropriate approach. We have to go beyond the “one size fits all” mentality. The many potential benefits of a decentralized system indicate that it is a method which deserves much greater attention, especially in smaller communities, rural areas and the developing urban fringe, where the alternative decentralized strategy makes the best sense.
Project briefs

- City-to-City Cooperation Project for Decentralized Sewerage Treatment Using Eco-tanks: Negombo, Sri Lanka
- First Decentralized Wastewater Treatment System: Vientiane, Lao People’s Democratic Republic
- Decentralized Wastewater Treatment System for a Commune and Primary School: Cambodia
- Decentralized Wastewater Treatment System for the Ha Phong Slaughterhouse: Ha Long City, Viet Nam
- Decentralized Wastewater Treatment System for the Khac Niem Commune: Bac Ninh City, Viet Nam
- Decentralized Wastewater Treatment System for Lai Xa-Kim Chung Commune: Ha Noi Capital District, Viet Nam
City-to-City Cooperation Project for Decentralized Sewerage Treatment Using Eco-tanks
Negombo, Sri Lanka

Negombo, a major city in Sri Lanka, is located on the west coast of the island and at the mouth of the Negombo Lagoon, in the Western province. Negombo is considered the fourth largest city in the country after the capital Colombo, Kandy, and Jaffna. It is the second largest city in the Western province after Colombo. With about 156,000 inhabitants, it is one of the major commercial hubs in Sri Lanka and thrives on its fishing industry, with a host of busy fish markets scattered within the city.

With a growth rate estimated to be at 0.78%, the city’s system in dealing with sanitation revolves around individual and communal septic tanks as well as pit latrines. It is also worthwhile to note that the city has no sewerage network to serve the needs of the population and that a certain percentage of the population is still practicing open defecation.

Technology options
- Capable of handling all kinds of wastewater coming from buildings, toilets, sinks and kitchens, an eco-tank is an innovative small-scale sewerage treatment system composed of a disposal tank that receives and purifies wastewater before discharging it into the environment. The compact, ready-made septic tank works independently and without power supply, using anaerobic bacteria to biochemically transform wastewater into a safe, noncontaminated effluent.
- The system is capable of treating sewage for up to 300 people per day and can also be used to treat organic waste and transform it into compost.
- Eco-tanks are a modification of the johkasou (purification tank) system used in Yokohama, Japan.

EcoTank delivery and installation.
Institutional and management arrangements

- The municipal council of Negombo (and its constituents) is the project owner and beneficiary of the project. The municipal council is responsible for the procurement of contractors for the installation of eco-tanks as well as the conduct of awareness campaigns.

- The project is supported by CITYNET, an international organization committed to helping local governments in improving the sustainability of human settlements; the United Nations Institute for Training and Research; Premier Products of Thailand; and from the Prince Albert II of Monaco Foundation, which provided funding assistance.

- The project has been implemented through a city-to-city cooperation— a highly effective tool in achieving urban development and a flagship modality of CITYNET.

Financing arrangement

- Investment cost for the eco-tanks is estimated to be about $5,000 (for the largest size).

Project outcomes

- The project helped improve living conditions in the area as well as reduced water pollution from domestic wastes and health risks associated with such.
First Decentralized Wastewater Treatment System

Vientiane, Lao People’s Democratic Republic

The Lao PDR is a country surrounded by Cambodia, Myanmar, the People’s Republic of China, Thailand, and Viet Nam. In 2005, the country was below average in establishing sanitation access compared with other Southeast Asian countries. The MICS III in 2006 reflected 44.8% coverage for those with improved sanitation (or 48% cited by the UNICEF/WHO Joint Monitoring Program) as compared to the 67% average for all the Southeast Asian countries.

In the same study, there is at least 52% of the Lao population without access to sanitation. This data translates to over 3 million Laotians living without improved sanitation – without an easily accessible, private, and safe place to urinate and defecate.

With this in mind, BORDA partnered with LIRe in the implementation and successful completion of its first pilot DEWATS in Lao PDR.

Technology options

- DEWATS is a technical approach rather than a technology package.
- DEWATS applications need low maintenance with the most important parts of the system working without technical energy inputs and cannot be switched off intentionally.
- State-of-the-art technology is being offered in DEWATS applications at affordable prices since all of the construction materials are being sourced locally.
- The system has the capacity to treat 10 m$^3$/d of wastewater, which is sufficient to significantly reduce pollution of water and soil by wastewater effluent.

Institutional and management arrangements

- The faculty and staff of the Faculty of Engineering (FoE), National University of Laos (NUoL) in Vientiane Capital are the owners of the project.
- In March 2008, BORDA and LIRe signed an agreement to develop programs in the water supply and renewable energy sectors. In 2009, the two organizations...
focused on promoting the DEWATS for Community-Based Sanitation and Small and Medium Enterprises.

- A completed DEWATS demonstration at the Staff Dormitory Residence in Sokpaluang Campus was done in cooperation with FoE–NuoL, through its ICI Partnership Project with the Finland Futures Research Centre. The activity was done as a community-based sanitation service.

**Financing arrangement**

The Finnish Turku School of Economics through its ICI Project, LIRE, and dormitory residents funded the project.

**Project outcomes**

DEWATS is an effective, efficient, affordable, and proven wastewater treatment solution to address poor sanitation, including hygiene, which is said to cause at least 3 million disease episodes and 6,000 premature deaths annually (one death per 1,000 inhabitants of 6.2 million total population).

**Contact for more information**

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Decentralized Wastewater Treatment System for a Commune and Primary School
Cambodia

Two areas were considered for DEWATS for Commune and Primary School Project in Cambodia:

The Trapeang Sab Commune is located in Takeo Province. In this commune, the main town, although developing rapidly, still observes traditional sanitation practices that are no longer effective. In fact, the untreated wastewater being discharged in increasing volumes in the commune is becoming a hindrance to development because of its contribution to groundwater pollution as well as to the increase in public health risks.

Chroy Chang Va Primary School, on the other hand, is located in Phnom Penh. The sanitation situation within the school premises is faced with difficulties, i.e., groundwater contamination resulting from its bottomless and cracked septic tank threatening to put the school population at risk. Likewise, while the school has 13 toilet facilities for its population of over 1,000 students, only three are in working condition. As such, schoolchildren and surrounding residents’ exposure to health and groundwater risks are very high.

Technology options

- The basic technologies of DEWATS used in both project sites are essentially the same. The only difference is in the 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, ABR, AF, and discharge pipe.
  - The inlet control chamber includes control valves for the system, which moderates velocity and volume of wastewater entering the system.
  - The primary settling unit serves as a wastewater retention point and an area for control of influent fluctuations.
  - The ABR is the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of harmful organic and chemical components of the wastewater.
  - The AF consists of a tank with a submerged layer of material.
In the Trapeang Sab Commune project, an operator was contracted by the Commune Council—the group responsible for general O&M of the DEWATS. The O&M costs, allowance for the operator, as well as the costs of desludging the system every 2–3 years are currently being covered by the Commune Council. There is no data available on the average O&M costs for the system due to low flows in the initial years.

In the Chroy Chang Va project, the school’s new WASH committee will undertake the O&M responsibility. The same expenses are averaging approximately $115 per month, which is being covered in part by an O&M fee levied on the students of about $0.07 per month.

Institutional and management arrangements

- **Trapeang Sab Commune**
  - BORDA-Cambodia is the main executing agency for the project, with Groupe de Recherche et d’Échanges Technologiques’ (GRET), a NGO, providing support.
  - GRET, the commune, district, and provincial governments provide funding support.

- **Chroy Chang Va Primary School**
  - BORDA-Cambodia is the main executing agency for the project, with BORDA-Southeast Asia providing support.
  - MRD, UNICEF, OAV, and BORDA provide funding support.

Financing arrangements

- The total project cost is around $50,200 for the Trapeang Sab Commune, and $8,400 for the Chroy Chang Va Primary School.

Project outcomes

The project was able to improve the sanitation situation in the commune and school vicinity, as well as reduce groundwater pollution, foul odor, and other health risks. Likewise, compliance with environmental regulations and standards set by the government through the Ministry of Environment (e.g., BOD < 80 mg/l and COD < 100 mg/l) in terms of effluent discharged into public waters and sewers is satisfactorily achieved. As an example, in the Trapeang Sab project site, water quality tests done yielded 46 mg/l BOD and 94 mg/l COD levels.

Contact for more information

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Footnotes:

8 WASH stands for water, sanitation, and hygiene.
Decentralized Wastewater Treatment System for the Ha Phong Slaughterhouse
Ha Long City, Viet Nam

Another area chosen for the application of DEWATS is the Ha Phong Slaughterhouse in Ha Long City, Viet Nam. As a fairly large slaughterhouse in the city, the untreated wastewater that it was producing prior to the project was polluting the surrounding area. The health and environmental risks were high as slaughterhouse wastewater is more potent than domestic wastewater. An effective treatment system was therefore needed, especially since Ha Long City sits alongside the world-famous Ha Long Bay tourism area, which is too precious to become polluted.

Technology options

This module of DEWATS used by BORDA-Viet Nam was designed to treat 40 m$^3$/d of wastewater. The system consists of the following sections, in order of wastewater flow: two biogas digesters, settling unit, ABR, AF, HGF, polishing pond, and discharge pipe.

- 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.
- Next is the settling unit that serves as a wastewater retention point and an area for control of influent fluctuations.
- The ABR, a multichambered tank closed from the air, is then the main treatment area of DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.
- The AF follows the ABR and consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. These media helps in the removal of dissolved solids, pathogens, and remaining chemicals in the wastewater.
- The HGF (e.g., planted gravel filter and HFCW) 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. The plants within the gravel layer oxygenate
the wastewater, which help degrade the remaining organic pollutants and reduce odor.

- After the HGF, the effluent proceeds to a polishing pond, which allows the effluent further aeration and settling time, and can also serve as an indicator for the effluent’s quality.

Institutional and management arrangements

The owner of the slaughterhouse is funding the project, with BORDA-Viet Nam and the United States Agency for International Development’s (USAID) Eco-Asia project team as the executing agencies.

Financing arrangements

- The total project cost is estimated to be around D600 million (approximately $32,000).
- The funding grant was used to cover construction costs, community engagement costs, and initial water quality testing costs. The staff of the slaughterhouse was trained in appropriate O&M and will take this responsibility. The costs of the O&M and the costs of desludging the system every 2–3 years are currently being covered by the slaughterhouse owner, with O&M averaging about D200,000 per month (about $10 per month).

Project outcomes

The main impacts of the project are the elimination of groundwater pollution, reduction in health and environmental risks, and compliance with environmental regulations/standards set by the government (e.g., BOD < 50 mg/l and COD < 80 mg/l) in terms of effluent discharged into public drainage systems.

Contact for more information

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Decentralized Wastewater Treatment System for the Khac Niem Commune
Bac Ninh City, Viet Nam

Another area chosen for DEWATS application in Viet Nam is the Khac Niem Commune, in Bac Ninh City. Popular for its rice noodle processing industry, the domestic wastewater from the households of this commune, as well as wastewater from the noodle processing facilities in the commune—which has a high organic load—was being discharged untreated into the local environment. Such practice has created unwanted health and environmental risks from the polluted groundwater and surface waters, aside from the foul odor and the potential for waterborne disease outbreaks. A need for an effective wastewater treatment system was therefore recognized by the national government. The Ministry of Agriculture and Rural Development then enlisted the help of BORDA-VAWR to develop the project in Khac Niem Commune.

Technology options
- The DEWATS module used by BORDA-Viet Nam consists of the following sections, in order of wastewater flow: primary settling unit, ABR, AF, polishing pond, and discharge pipe. The system was designed to treat 400 m³/d of wastewater.
  - The primary settling unit receives all of the wastewater and serves as a wastewater retention point and an area for control of influent fluctuations.
  - The ABR, a multichambered tank closed from the air, is then the main treatment area of the DEWATS, where solids are settled and anaerobic bacteria facilitates the degradation of the harmful organic and chemical components of the wastewater.
  - The AF follows the ABR. It consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. This helps in the removal of dissolved solids, pathogens and remaining chemicals in the wastewater.
• After the AF, the effluent then proceeds to a polishing pond. The pond allows the effluent to aerate (which is still anaerobic at this point and still has a foul odor) and provide further settling time. It also serves as an indicator for the effluent’s quality.

Institutional and management arrangements
• The Ministry of Agriculture and Rural Development provides funding for the project, with VAWR as executing agency. BORDA-Viet Nam is the coordinating agency.
• The Khac Niem Commune People’s Committee supervises O&M.

Financing arrangement
• The total project cost is estimated to be around D6.60 billion (approximately $370,000).
• The costs of O&M and the costs of desludging the system every 2–3 years are currently being covered by the funding agency, with O&M averaging around D500,000 per month (approximately $23 per month).

Project outcomes
The project helped reduce health and environmental risks in the area as well as compliance with environmental regulations and standards set by the government (e.g., BOD < 50 mg/l and COD < 80 mg/l) in terms of effluent discharged into public drainage systems.

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Decentralized Wastewater Treatment System for Lai Xa – Kim Chung Commune
Ha Noi Capital District, Viet Nam

The DEWATS project is located in Lai Xa Hamlet of the Kim Chung Commune—a peri-urban commune of the Ha Noi Capital District, Viet Nam. The hamlet has a population of 4,000 in 855 households and an estimated per capita gross domestic product of $129.

The area is traditionally agricultural but is experiencing rapid industrialization as fields are sold off for the expansion of various industries. This has resulted in poor environmental conditions of the area, with the absence of systems to efficiently manage solid or liquid waste. The few existing public drains are blocked with solid waste, resulting in flooding during rainy days. Garbage is strewn throughout the hamlet, and all stormwater and household wastewater drain directly to nearby marshes, ponds, and fields. This is causing health problems for the workers in the fields, promulgating diseases such as dengue, as well as polluting the natural environment. A cost-effective treatment solution, therefore, is necessary to address these challenges.

Technology options

- The DEWATS module for this project consists of the following sections, in order of wastewater flow: gravity-fed sewers and drainage canals, and five wastewater treatment stations. Each station consists of a primary settling unit, ABR, and AF, with effluent then draining (depending on the specific station) to one of two waste stabilization ponds and vegetated horizontal rock flow filters or directly to an improved irrigation canal.
  - The gravity-fed sewer line consists of piping and open canals installed for each household connected, which will carry its septic tank effluent and greywater to the DEWATS.
  - The primary settling unit serves as wastewater retention point and area to control influent fluctuations.
  - The ABR, a multichambered tank closed from the air, is then the main treatment area of the DEWATS, where
solids are settled and anaerobic bacteria facilitates the degradation of harmful organic and chemical components of wastewater.

- The AF follows the ABR and consists of a tank with a submerged layer of material that looks like crushed gravel or specially formed plastic. This helps in the removal of dissolved solids, pathogens and remaining chemicals in the wastewater.
- The waste stabilization ponds with vegetated horizontal rock flow filters follow next for three of the five wastewater treatment stations. The pond allows the effluent to aerate (which is still anaerobic at this point and has a foul odor) and provides further settling time. It also serves as an indicator for the effluent’s quality.
- Finally, for all five wastewater treatment stations, the effluent then flows out to irrigation canals for use in nearby fields.

- The DEWATS is designed to treat wastewater from approximately 400 households of Lai Xa. Each of the wastewater treatment station is able to treat wastewater from around 80 households.
- The residents of Lai Xa Hamlet – King Chung Commune are the beneficiaries.

Financing arrangements

- Funding contributions to finance the project are broken down as follows: 50% of total project cost shouldered by YWAM-MRDA; and another 50% provided by Lai Xa community and the Kim Chung People’s Committee.
- The committee members and environmental workers group were trained for the O&M of the system. They also supported the construction of domestic septic tanks of the residents. An O&M fee of D6,000 per year (approximately $0.30) is implemented to participating households for the sanitation service.

Project outcomes

The project improved the sanitation condition in the area by reducing health and environmental risks associated with poor solid waste and wastewater management. Access to sanitation facilities increased considerably from 25% to 60%. In terms of operational efficiency of the DEWATS, water quality records show the system’s capability to remove 70%–80% of BOD, COD, and total suspended solids (TSS).

Institutional and management arrangements

- The Kim Chung Commune People’s Committee and Youth with a Mission – Mercy, Relief and Development Asia (YWAM-MRDA) are the funding as well as executing agencies for the project.

Contact for more information

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References


- Decentralized Wastewater Treatment System for the Khac Niem Commune, Bac Ninh City, Viet Nam. CAPS, KOICA, and UNEP. Case Study: Decentralized Wastewater Treatment Systems for the Khac Niem Commune. A
VAWR/BORDA-Viet Nam
DEWATS Project in Viet Nam.

- Decentralized Wastewater Treatment System for Lai Xa-Kim Chung Commune, Ha Noi Capital District, Viet Nam
  CAPS, KOICA, and UNEP. *Case Study: Decentralized Wastewater Treatment Systems for Lai Xa – King Chung Commune. A Youth with a Mission – Mercy, Relief, and Development Asia Project in Viet Nam.*

Low-cost sewerage systems are alternative and cost-effective sanitation interventions for the collection and transport of wastewater to treatment facilities. These systems afford the users the convenience associated with conventional sewerage systems without the need for putting up huge capital investments. These systems can be classified under two categories: settled sewerage and simplified sewerage. The former refers to systems or configurations where wastewater from sources (households) is discharged into single compartment septic tanks and/or solids interceptor tanks. The purpose of these tanks is to screen and trap solids to facilitate the discharge of low solid concentration effluent into small-bore gravity sewer pipes. Aside from shallower pipe trench depths, these systems utilize simple inspection boxes as opposed to large manholes, as well as ensure that flows can be achieved using much less energy in cases where gravity flow is not possible. Simplified sewerage, on the other hand, closely resembles that of conventional sewerage systems.

Employing shallow and smaller diameter pipes, these systems do not utilize septic tanks nor do they convey presettled sewage. Other variants of these systems are known as backyard or condominial sewerage systems.

Low-cost sewerage systems have been used in slum and peri-urban areas in Brazil, Pakistan, Peru, South Africa, Sri Lanka, etc. The project briefs cited provide good examples in successfully managing wastewater at a decentralized level through the implementation of these systems.

**Project briefs**
- Decentralized Wastewater Management in El-Moufty El-Kobra: Kafr El-Sheikh, Egypt
- Decentralized Wastewater Treatment System and Desludging Service for Hin Heup Town: Lao People’s Democratic Republic
- Condominial Water and Sewerage Systems in Brazil: Brasilia, Brazil
- Estero de Paco Sanitation Project: Manila, Philippines
Decentralized Wastewater Management in El-Moufty El-Kobra
Kafr El-Sheikh, Egypt

The village of El-Moufty El-Kobra in Kafr El-Sheikh is located in the northern part of the Nile Delta, close to the Mediterranean Sea. The project village has around 2,750 inhabitants, in which approximately 90% are farmers.

The Nile Delta represents a substantial portion of the total cultivated area in Egypt. Irrigation for agricultural production is heavily dependent on a dense network of irrigation and drainage canals diverting water from the Nile to the Nile Delta, as the area experiences low annual average rainfall.

In the Nile Delta, while access to drinking water supply is high (around 99% for urban areas and 96% for rural areas), the sewerage coverage is very low and the hygienic conditions are of a very low standard. It is estimated that while in the urban areas 86% are connected to a sewerage system, only around 34% are covered in the rural areas. Open trenches are sometimes used for drainage and sewage is directly discharged into the nearest drain without the benefit of treatment. This situation has increased the exposure of the residents to health risks associated with the use of drainage water for irrigation purposes, as well as groundwater contamination.

Technology option
- A small-bore sewer system and a treatment plant have been installed because of its design and operational simplicity.
  - **Interceptor tanks**: An interceptor tank was installed between the connected houses and the sewerage line, which leads to the treatment and disposal network. In the interceptor tanks, solids like grit and grease are collected to avoid blockage in the sewerage line. Part of the anaerobic digestion has already taken place in these tanks. The interceptor tanks have to be cleaned out every 6 months.


Conveyance: The liquids are transported through the small-bore sewers to a collective pumping station that is connected to the treatment plant. The pumping station consists of two alternately operating submersible high-pressure pumps with a standby generator.

Wastewater treatment: The treatment plant consists of 2x3 stabilization ponds. The first stabilization pond is for anaerobic processes (not hermetically sealed); the second for facultative; and the third for maturation. The first two ponds reduce and stabilize BOD, while the maturation pond reduces pathogens.

Sludge treatment: The solids collected in the interceptor tanks and the sludge of the anaerobic pond are deposited in four drying beds.

**Institutional and management arrangements**

- The Kafr El-Sheikh Water and Sewerage Company (KWSC) is the implementing agency for the project. The KWSC is responsible for water and wastewater service provision in the governorate as well as the conduct of regular inspections and tendering procedures. A reporting and monitoring system was established within the project.
- A Community Development Association (CDA) was created to represent the community and to assure a legal framework for the collection of fees for wastewater services. It is also responsible for the selection and employment of the contractor for O&M. The CDA Board meets weekly or at least once a month to discuss project affairs. Women are encouraged to participate.
- GIZ, through Rodeco Consulting GmbH, provided planning support.
- The German Federal Ministry for Economic Collaboration and Development (BMZ) extended funding support via GIZ.

**Financing arrangements**

- The investment cost is estimated to be about €300,000, (approximately $394,736) 10% of which was shouldered by the community, while the costs for planning, design, and construction were handled by GIZ.
- For O&M of the system, around €0.6 (approximately $0.79) per household per month is collected by CDA. Monthly fees of €1 (approximately $1.32) are also collected by the CDA from each household for revenues. The O&M costs include staff, transport, maintenance, repairs, and solid waste collection. In addition, costs for upcoming expenditures are included. The fees are collected every 6 months.
- If full cost recovery of the system had been required, the households would have to pay around €3 (approximately $3.95) per month.
- The monthly fee for the services is according to willingness to pay.

9 Approximately €0.76 = $1, as of 2011.
**Project outcomes**

- There is improved community hygiene and environment through a decentralized and cost-effective wastewater treatment system based on a community approach.
- Increased awareness on health and environmental issues made the community work harder to keep the environment clean.
- An institution was established (CDA) where people can communicate their demands. The village and its system, which is unique in Egypt, served as a model in the governorate to upscale the concept of a simple decentralized wastewater treatment plant.
- Performance of wastewater treatment using the stabilization pond systems indicates the following:

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BOD₅ = Five-day biochemical oxygen demand; COD = chemical oxygen demand; mg/l = milligram per liter; ml = milliliter.

**Lessons learned**

- A demand-driven approach and agreement are necessary to achieve cooperation.
- Ownership, responsibility, and accountability among the beneficiaries were established.
- There was involvement of all relevant stakeholders.
- There was sharing of financial responsibility from the beginning of the project.

**Contact for more information**

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Decentralized Wastewater Treatment System and Desludging Service for Hin Heup Town
Lao People’s Democratic Republic

Hin Heup, a district capital with moderate economic profile, is located only 2 hours from the capital of Vientiane. The site was chosen by GRET, a French NGO. Hin Heup was selected for the project because of its topography, which is appropriate for the construction of a gravity sewer system, and with its villagers’ willingness to pay for simple sanitation services.

While 99% of the town’s households already utilize pour-flush latrines, simple soak pits were preferred rather than sealed septic tanks. Out of these households, only 24% have engaged desludging services for their pits when full, with the rest either opting to build a new one or have yet to fill their pit. Additionally, only 10% of households have any form of grey water collection. Hence, the town has a relatively high risk of surface (Nam Lik River) and groundwater contamination, which would likely threaten the environment as well as the sources of drinking water for the town’s population. Given this scenario, the DEWATS and desludging service project was developed for Hin Heup Town.

Technology options
- GRET based their WWTP system on experiences in Brazil and Pakistan with simplified sewers (documented by Duncan Mara), as well as on a simplified version of the BORDA DEWATS model.
- The household collection piping consists of a simple polyvinyl chloride (PVC) pipe that is connected to the main greywater-producing areas of the households and the toilets (thus, bypassing the soak pits and ceasing their pollution inputs to the surrounding groundwater). These pipes merge at the collection box that is installed for each household before the pipe proceeds to the main sewer line, which then flows to the WWTP. This sewer works by gravity, without pumps. This means that all piping has to flow downhill to the WWTP.
• The primary settling unit allows large sludge, debris, and other floatable and/or visible wastes to settle or be screened out. It also allows for even distribution of the flows of wastewater to proceed to the subsequent chambers through an opening throughout the tank’s width.

• The ABR, a multichambered tank closed from the air, is the main treatment area of the WWTP. Wastewater flows slowly up through its several identical chambers (and back down through the pipes), each time entering the chamber at its bottom, where it passes through the accumulated sludge. Solids are settled and anaerobic bacteria facilitate the degradation of harmful organic and chemical components of the wastewater.

• Two sludge drying beds, each 16 m² in area, serve to dry – and therefore partially treat and reduce in volume – the sludge that will be regularly removed from the ABR, as well as all of the septage collected from the desludging operations by the local water supply operator.

• The WWTP is designed to handle up to 30 m³/d of wastewater flow, which is the estimated flow in 15 years from the current 60 households and four small businesses (taking into account 2% population growth, a unit water consumption assumed at 100 liters per capita per day in 2015, and other technical factors).

Institutional and management arrangements
• GRET is the primary executing agency of the project, together with the “Mini Reseaux d’Eau Potable” – the “Small Scale Water Supply Networks” (MIREP) program owner, and the Department of Housing and Urban Planning of the Ministry of Public Works and Transport (MPWT).

• GRET is also the funding agency for the project, with funds for the overall MIREP program supported by grants from the French organizations Syndicat des Eaux d’Ile-de-France, the French Ministry of Foreign Affairs, Agence Francaise de Developpement, and to a lesser extent, the Municipality of Paris and UN-Habitat.

• The local water supply operator, selected by public authorities to be operator of the wastewater management service, provided some minor additional funding toward the project (i.e., vehicle).

• The Water Supply Regulatory Office of the MPWT and the provincial administration office and its relevant departments also supplied cooperative assistance and project approvals.

Financing arrangements
• The total project cost is approximately $61,000, broken down as follows: GRET – $54,000; water operator – $5,000; and $2,000 from user connection fees.

• The local wastewater operator will operate and maintain the facility and perform desludging services for at least the 10-year duration of the initial management contract. It is estimated that O&M will cost around $40 per month for labor and $40 per month for
maintenance. The WWTP itself will require very low maintenance, essentially with only the desludging of the ABR every 2–3 years.

- The funding grant covered design and monitoring costs; construction of the WWTP; procurement of equipment for the desludging service (the private operator shall bring in its own vehicle, small truck or local tractor); and other consultation and engagement costs.
- To ensure the project’s sustainability, a connection fee and a user fee were formulated, in consultation with the locals, to cover the O&M costs as well as part of the project cost. Each household connected to the sewer system is being charged a fee of approximately $30, followed by a fixed monthly user fee of about $1.30. For those households receiving desludging services, they will be charged a fee of $20 for every service.

**Project outcomes**

The project helps reduce the incidence of pollution of water bodies and the associated health and environmental issues that go with it. It aims to benefit 360 households either through the provision of sewer connections and/or desludging services.

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Condominial Water and Sewerage Systems in Brazil
Brasilia, Brazil

The city of Brasilia, the nation’s capital, is situated in the central plateau of Brazil. Over the years, it has experienced rapid population growth, from 140,000 in 1960 to about 2.1 million inhabitants in 2005.

Sewerage infrastructure is inadequate throughout the country, with majority of the residents adopting septic tanks in managing wastewater. This has proven to be ineffective as the discharge of untreated sewage in Lake Paranoa has eventually led to signs of contamination and eutrophication.

Combined with the lack of sanitation in peri-urban areas as well as the growing environmental concerns resulting from the contamination of Lake Paranoa, the Brasilia Water and Sewerage Company (CAESB) decided to take action to address the problem.

Technology options

- CAESB looked for cheaper alternatives because of the massive investment needed to construct sewer networks in the city. It decided to pursue the condominial approach both in the peri-urban and affluent areas in the city.

- For the public network, the following criteria was observed and used:
  - The approach utilizes pipes ranging from a minimum of 100 mm in diameter to 250 mm.
  - Pipe depth ranged from a minimum of 0.5 meters up to 1.20 meters.
  - Traditional high cost manholes are replaced with simple inspection chambers and installed every 24 meters.

- For the condominial branches, the following criteria was applied:
  - Minimum pipe diameter of 100 mm.
  - Minimum slope of 0.005 meters per meter.
  - Pipe material: PVC.
  - Interconnections with main network through inspection boxes or chambers.
  - Minimum depths: 0.60 meters (outside the plot) and 0.30 meters (inside the plot).
Institutional and management arrangements

- CAESB is the executing agency for the project, with the help of local authorities. It is responsible for the design, construction, operation and management of the system. Additionally, CAESB is also responsible for awareness building and engaging community participation.
- CAESB employed the services of firms in conducting social intermediation activities.

Financing arrangements

- The total cost of the public network amounted to $1.7 million, with the condominial branches estimated at $2.8 million.
- The condominial branches accounted for 60% of the total expansion cost and were covered by the beneficiary communities through connection fees ($47-$256).
- For the public network, the unit cost per one meter of network is estimated to be $19.

Project outcomes

- From 1993 to 2001, a total of 188,000 condominial sewerage connections were installed benefitting around 680,000 residents.
- Savings were generated in sewerage charge as percentage of water bill (conventional: 100%; condominial: 60%).
Estero de Paco Sanitation Project
Manila, Philippines

Estero de Paco is one of the estimated 50 tributaries of the Pasig River system in Manila. It is connected to the left bank of the Pasig River, approximately 4 km upstream of the river mouth.

Rapid urban development, dense population, and improper waste management practices of the community have contributed heavily to the degradation of its surrounding environment. This situation has prevailed despite several initiatives carried out focused on environmental rehabilitation.

Among the classification of users present in the catchment area, domestic users have been validated to be the foremost source of pollution. Domestic use is estimated to contribute about 81% of the total pollution loading received by Estero de Paco.

In cognizance of the urgency to improve water quality in the Pasig River System and its tributaries, a pilot project for Estero de Paco was conceptualized. Prepared under a small-scale technical assistance program by ADB, the project aims to conduct pilot activities on wastewater management in the site, with the end view of replicating the same model in other areas in the metropolis.

Technology options
- Wastewater technological options applied can be classified into two categories:
  - Collection and transport of wastewater
    - Domestic black and grey water are collected and transported using a condominial sewerage system. PVC pipes, with diameter of 150 mm, along with several manholes were utilized to transport wastewater into a sump pit.
  - Wastewater treatment
    - Treatment of wastewater was carried using an ABR and CW. The ABR was constructed about 70 meters away from the sump pit and is fitted with gate valves to regulate effluent discharge toward the CW.
- The design capacity of the wastewater treatment system is around 30 m³/d of wastewater.
- Around 6 m$^3$/d of wastewater, representing about 20% of the total effluent flow, is diverted to the CW for further treatment.
- Wastewater from the sump pit is pumped into the ABR-CW system using two 0.5- horsepower submersible pumps. The pumps are powered using two 490-watt batteries (charged with solar panels) to minimize electricity costs.

Institutional and management arrangements
- The Pasig River Rehabilitation Commission is the executing agency of the project. It is responsible for: (i) coordinating with the Kapit-Bisig Para sa Ilog Pasig, its main implementing partner; (ii) ensure regular communication and consultation with local government and barangay officials, key national government and private sector entities, and community-based organizations (CBO); and (iii) conduct water quality monitoring and data verification.
- The recipient barangay is expected to be responsible for the operation and upkeep of the wastewater treatment system in partnership with the CBOs.
- The Kilusang Pang-Kapitbahay at Pang-Kabuhayan, Incorporated is responsible for collecting user fees from households for O&M activities.
- Grupo Inclam is the private consulting firm engaged by ADB to provide technical assistance during project implementation and commissioning stages.

Financing arrangements
- ADB financed the pilot project.
- The estimated total project cost is around $78,000, covering only the capital cost requirements.
- Annual O&M cost requirement is estimated to be around $750. Considering that there are about 58 households directly benefitting from the wastewater treatment system, each household is expected to contribute around $13 annually.

Project outcome
- The project benefitted a total of 58 households in the site.
- Based on a 3-month period water sampling activity, BOD removal rate is estimated to be around 87%, with TSS, oil, and grease levels of the resulting effluent well within the regulatory limits set for Class C water quality.
References

• Decentralized Wastewater Management in El-Moufty El-Kobra, Kafr El-Sheikh, Egypt

• Decentralized Wastewater Treatment System and Desludging Service for Hin Heup Town, Lao People’s Democratic Republic (PDR)
  CAPS, KOICA, and UNEP. Case Study: Decentralized Wastewater Treatment System & Desludging Service for Hin Heup Town – A GRET MIREP Pilot Project in Laos.

• Condominial Water and Sewerage Systems in Brazil, Brasilia, Brazil
  Melo, J.C. 2005. The Experience of Condominial Water and Sewerage Systems in Brazil: Case Studies from Brasilia, Salvador and Parauapebas. The World Bank, Bank-Netherlands Water Partnership (BNWP), and


• Estero de Paco Sanitation Project, Manila, Philippines
Sanitation challenges, both existing and emerging ones, vary in intensity and complexity. Governments and local administrators are bound to come up with sanitation solutions suitable to the prevailing environment and/or setting they are in. Factors such as climate change, changes in the regulatory regime, population growth, and rate of urbanization all need to be taken into consideration before a particular intervention is considered for implementation.

The emergence of various technological innovations and approaches over the years has provided governments the flexibility to implement a whole range of interventions, both structural and nonstructural measures, to deal with varying sanitation challenges. Additionally, those who implement are gradually opening up to the idea that while dealing with sanitation is urgent, finding the appropriate intervention to achieve the economic, societal, and environmental objectives identified from a broader and holistic perspective is equally important. Governments realize the need to shift from the traditional piecemeal approach of implementing sanitation interventions with exclusive sectoral outcomes to one that promotes a more integrated and holistic approach as well as sustainable in the long-term.

The three case studies feature innovations in technologies, design, financing, contract management and structure, and ways in dealing with the sanitation needs of communities. Such innovations are necessary in today’s world to meet the challenge of having universal sanitation coverage, scaling up much-needed wastewater treatment, and promoting environmental conservation and sustainable development.

The case of Piperton, Tennessee highlights the city officials’ decision to veer away from pursuing the conventional sewerage system in dealing with its wastewater problem. Instead, the city opted for the decentralized approach in wastewater management, placing emphasis on adopting technologies which are modular and scalable (flexible enough to expand capacity due to population increase), minimum operation and maintenance costs, and capability to provide treated wastewater safe for reuse in irrigation.

IV. Applying innovative and multidimensional approaches
The Dockside Green Development in Canada placed emphasis on providing an integrated approach in developing the community. City planners and developers focused on employing technologies that would enable the community to treat both wastewater and stormwater, and reclaim these for landscape irrigation, toilet flushing, and maintenance of an onsite stream. With this approach, the city’s dependence on its source of potable water supply is significantly reduced. A biomass plant was also constructed to manage wastewater treatment residuals such as sludge and biosolids, and then converting them as feedstock. Likewise, the city actively promoted the development of brownfields utilizing innovative and sustainable approaches.

The example from Germany, on the other hand, focused on the implementation of the ecosan approach in dealing with the sanitation needs of the community under an urban setting. The case highlighted the implementation of a sustainable sanitation system with minimal footprint in terms of water and energy usage.

Project briefs
- Distributed Wastewater Infrastructure for Integrated Water Resources Management: Piperton, Tennessee, United States of America
- Dockside Green Development: Victoria, British Columbia, Canada
- Ecological Settlement in Allermohe: Hamburg, Germany
Distributed Wastewater Infrastructure for Integrated Water Resources Management
Piperton, Tennessee, United States of America

As in many other cities around the globe, Piperton City in the State of Tennessee is poised for rapid growth and with it, population growth. Estimates point out that by 2024, the population of the city is expected to reach 200,000.

To deal with the challenge of treating the increase in wastewater flows, city administrators initially thought of linking up with the centralized sewer system of adjacent areas. However, these areas were reluctant to allocate additional capacity to accommodate wastewater flows coming from Piperton.

On the other hand, city officials are also aware that building their own sewage treatment plant is capital-intensive, where the main consideration would be managing operational costs.

Given such predicament, they eventually decided to pursue a decentralized wastewater treatment solution, which has the flexibility to be expanded in anticipation of population growth.

**Technology options**
- The wastewater technical solution to be implemented needs to take into account the following considerations:
  - The system needs to be modular and scalable.
  - It can accommodate wastewater flows ranging from 2,000 to 400,000 liters per day.
  - Minimal operator attention.
  - Very low life cycle and O&M costs.
  - It can treat wastewater for reuse for drip irrigation.
- The option implemented is the AquaPoint’s Bioclere™ technology given its track record for successful installations, ease in installation, and low capital and O&M requirements.
- Efficiency parameters of the technology are shown below:

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<th>Pollutant</th>
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<th>Effluent (mg/l)</th>
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<td>Total Kejldahl Nitrogen (TKN)</td>
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</tr>
<tr>
<td>Total Nitrate (NO₃⁻)</td>
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<td>&lt;20</td>
</tr>
<tr>
<td>Fecal coliform</td>
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<td>&lt;23</td>
</tr>
</tbody>
</table>
Institutional and management arrangement

The Sewer Committee of Piperton City is the executing agency of the project.

Financing arrangements

- Capital and installation cost is estimated to be around $5,000 per dwelling.
- O&M labor is estimated to be around 1 hour per week.
- Electrical consumption per household in a month ranges from $1.85 to $2.96.

Project outcomes

- As of March 2008, installed Biocler™ systems were able to benefit around 750 households, with wastewater flows varying from 80,000 liters per day to 320,000 liters per day.
- Total distribution network is capable of handling 1,120 liters per day.

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Dockside Green Development
Victoria, British Columbia, Canada

Dockside Green is a sprawling community estimated to be about 120,000 m², situated on the inner harbor in Victoria, British Columbia, Canada. The property is composed of residential, commercial, and light industrial structures.

With an estimated volume of 120 MLD of untreated wastewater discharged into the Strait of Juan de Fuca, the developers of Dockside Green recognized the potential hazards to health and environment brought about by such situation. This prompted the developers to treat it as an opportunity to actively find ways to mitigate the problem. This was done by treating and reclaiming 100% of the generated wastewater and stormwater onsite.

City planners, despite the property having sewer networks, encouraged the development of brownfields utilizing sustainable and innovative approaches toward achieving Canada Green Building Council’s Leadership in Energy and Environmental Design (LEED™) certification.

Technology options
- The treatment technology adopted is the zenon MBR plant, coupled with ultraviolet disinfection.
- At the onset, the plant is expected to process around 140 m³/d of treated water, steadily increasing to its full potential of 380 m³/d.
- Treated wastewater and stormwater is reused for landscape irrigation, toilet flushing, and onsite stream to further reduce the community’s dependence on its potable water supply.
- A biomass plant will be constructed where wastewater treatment residuals such as biosolids and sludge will be dewatered and gasified onsite to produce feedstock for the plant.
- A press will also be provided onsite specifically to remove water from the sludge to produce bricks as well as significantly reduce the accumulated sludge volume.

Institutional and management arrangements
- The developer is responsible for owning, managing, and funding the entire project. This would include billing collections and handling of customer complaints.
- The developer is bound to ensure compliance with performance requirements, as stipulated in the permit conditions.
- Spaces will be leased to both residential and commercial tenants, which include water and sewer services.
- The regional government and provincial Ministry of Environment are responsible for monitoring and regulating the operation of the proposed wastewater treatment plant.
- The Ministry of Health is responsible for issuing approval to reuse reclaimed water in both residential and commercial establishments.
Financing arrangements

- The estimated operating cost for a two-bedroom unit is around $215 per year inclusive of the replacement costs, with the value decreasing for smaller units.
- Compared with a typical Victoria household, tenants are expected to save around 33% from water and sewer charges due to the use of water efficient appliances, waived sewage bill from the city and waived water bill for irrigation and/or toilet flushing due to the use of reclaimed water.

Project outcomes

The tenants within the Dockside Green development stand to enjoy lower property tax and water utility bills due to the tax policy reform implemented by the Capital Regional District. Savings of up to 33% from water and sewer charges were also expected. Additionally, water stress on the city’s limited potable water supply is alleviated through the promotion of reclaimed water use. Environmental and health risks in the area have been greatly reduced.

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Ecological Settlement in Allermöhe
Hamburg, Germany

The ecological settlement is part of the new district Neu-Allermöhe, where 3,800 residential units were built between 1982 and 1994. Situated 15 km southeast of Hamburg City Center, it is a very green area with relatively low buildings (all less than four storeys). The eco-settlement in Neu-Allermöhe-Ost (New-Allermöhe-East), on the other hand, is made up of 36 single-family houses with approximately 140 inhabitants.

All inhabitants are owners of their houses. The area of Allermöhe has a network of small canals and characterized as having a high groundwater table.

Technology options
- Composting toilet systems - Each household has a composting toilet system, which consists of one or two toilet pedestals as well as a composting container in the basement to handle the treatment of the human excreta (feces and urine), toilet paper and garden and organic kitchen waste.
- CW system - The greywater (wastewater from kitchens and bathrooms) from all houses in the ecological settlement are directed to a CW located in the southern end of the settlement.
- Rainwater harvesting - Nine of the 36 households collect rainwater from their roofs in four underground cisterns with a capacity of 5–16m³.

Institutional and management arrangements
- The Ökologisches Leben Allermöhe e.V. is the executing agency for the project, with Berger Biotechnik GmbH (composting toilet systems) and AWA-Ingenieure (CW) implementing the planning activities.
- The city government of Hamburg, the German Federal Ministry of Transport, Building and Housing, and the Hamburg Environmental Authorities provided support for the construction, operation, and scientific monitoring of the composting toilet systems and CW.
Financing arrangements\textsuperscript{10}

Composting toilet system
- Initial investment costs: During the construction period, the price of a complete Terra Nova system (standard) with two toilets is approximately €3,700 (approximately $5,217). This includes quantity discount for all houses constructed in 1986–1992. Special requests raised the price from €4,000 (approximately $5,640) to €4,500 (approximately $6,345). The costs for delivery and installation were estimated to be around €500 (approximately $705). In 2009, the cost for an improved Terra Nova system, delivery and installation is approximately €6,500 (approximately $9,165).
- O&M costs: When necessary, moving parts such as the ventilation fan have to be replaced after some years of use—at the earliest after 5 to 20 years with annual periodic cleaning (Price of one fan: €190).

Constructed wetland
- Initial investment costs: The total cost for the CW is €95,000 (approximately $133,950) (treating greywater from 140 people). Nowadays, such a facility is less expensive because of more economical designs.
- O&M costs: External quality checks and sampling costs are about €500 (approximately $705) per year.
- Additionally, the sludge removal from the Imhoff tank costs €250 (approximately $352.50) each time. Pumps and moving parts have to be renewed from time to time.
- The projected generated savings from the ecosettlement project is about €18,000 per year (approximately $25,380 per year) [equal to €130 per person per year (approximately $183.30)] based on reduced water consumption, zero wastewater fees and relatively low O&M costs.

Project outcomes
The project was able to improve the sanitation condition within the settlement, and generate cost savings resulting from a sustainable sanitation system (smaller footprint in terms of water and energy use).

The effluent quality of the CW indicated resulting levels of 4.5 mg/l BOD and 16 mg/l COD. The levels surpass the legal limits set for discharge to surface water levels of 20 mg/l BOD and 80 mg/l COD.

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\textsuperscript{10} Approximately €1 = $1.41, as of 2009
References

- Distributed Wastewater Infrastructure for Integrated Water Resources Management, Piperton, Tennessee, United States of America

- Dockside Green Development, Victoria, British Columbia, Canada

- Ecological Settlement in Allermöhe, Hamburg, Germany
Expanding sanitation access and coverage is a daunting task for governments worldwide. Governments are hard-pressed to keep up with the provision of sufficient infrastructure for their constituents amidst the ever-changing demands of the public and rapid pace of population growth and urbanization.

Generally, sanitation expenditure is low compared with that of water supply. This situation persists despite global estimates pointing to a significantly larger population without access to improved sanitation facilities compared with those without access to improved drinking water sources (375 million vs. 143 million).\(^\text{11}\)

Funding for sanitation, or more specifically the insufficiency of it, has always been the perennial hurdle of governments. Nonetheless, such situation is understandable. Budgeting limited public funds to cover a wide and diverse range of public infrastructure and services is complicated. Sectors have to ‘compete’ with each other to secure the necessary financing. And most of the time, governments channel funding to sectors based on their priority programs and thrusts.

Unfortunately, the sanitation sector, for the longest time, has not been given the recognition it deserves as among the priority development agenda of most governments. As a result, the problem of expanding sanitation access and coverage to include the marginalized sectors of society continue to persist, exposing the public to health and environmental risks.

In recognition of the problem involving scarcity of funds to advance the sanitation agenda, several innovative financing mechanisms and instruments have been explored and developed over the years to bridge the gap between funding requirement vis-a-vis infrastructure and services needed. These modalities, although differing in scope and complexities, offer a common solution in creating the fiscal space needed, relieve the financial pressure on government coffers, and enable implementing agencies to pursue and finance sanitation interventions to benefit the public as a whole.

The project briefs presented provide a diverse lot of innovative financing mechanisms designed to enable the implementation of

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sanitation infrastructure and facilitate wider access to the same. In the case of India, the modality chosen involved the government partnering with the private sector for the construction of the wastewater treatment facility for Tirupur and expansion of sanitation services in the area. Public-private partnership (PPP) is also the chosen strategy of the City of Great Falls in improving the operation and delivery of sanitation services. On the other hand, the cases from Viet Nam, Cambodia, and Burkina Faso highlight the relevance of microfinance and well-placed subsidies and grants in bringing sanitation services to benefit the poor households. These financing mechanisms were instrumental in providing the financing window and credit facility for households to avail of sanitation interventions. In turn, these mechanisms were able to improve the households’ current sanitation conditions by empowering them in choosing the best available intervention most suitable to their needs.

Project briefs
- Double Vault Composting Latrine Program in Northern Viet Nam: Viet Nam
- Three Delta Towns Water Supply and Sanitation Project: Bac Lieu, Ha Tien, and Sa Dec Urban Wards and Communes, Viet Nam
- Sanitation Marketing for Five Provinces in Cambodia: Cambodia
- Latrine-building Project: Cambodia
- Tirupur Water and Wastewater Treatment Project: Tamil Nadu, India
- Urban Sanitation in Ouagadougou: Burkina Faso
- Halong City Sanitation Project: Viet Nam
- Great Falls Wastewater Treatment Plant: City of Great Falls, Montana, United States of America
Double Vault Composting Latrine Program in Northern Viet Nam
Vie"n Nam

Vie"n Nam is one of the countries in Southeast Asia faced with serious problems on sanitation. It is estimated that in rural Vie"n Nam, 25% of households had no latrine, while 19% had unhygienic latrines. This is based on studies conducted by the World Bank through their Water and Sanitation Program (WSP).

To address the growing need for proper sanitation, the government included in its development plans the construction of 2.6 million hygienic latrines [e.g., double-vault composting (DVC) latrine, septic tank latrine, pour-flush water-sealed latrine, and ventilated pit latrine] by 2010.

Despite the septic tank latrine’s ranked as the most preferred option, the DVC has since been advocated as an appropriate sanitation facility throughout rural Vie"n Nam. Introduced in the 1950s, the DVCs were quite popular among the Vietnamese and Chinese farmers because of the value and convenience they can get from the fertilizer byproduct generated.

Technology options
- Given the high value cost of a typical DVC latrine, PLAN Vie"n Nam thought of creating a more cost-effective design. Thus, the ‘granito’, a locally manufactured and affordable DVC pan, was introduced. The granite—a premolded pan made out of cement with a polished surface—was collaboratively developed by PLAN Vie"n Nam and Ha Nam’s Center for Rural Water Supply and Sanitation (CERWASSS2).
- Granito is known for its convenience and durability because it is easy to clean and the occurrence of urine seepage into the concrete is minimized thereby causing lesser odors.

Institutional and management arrangements
- PLAN Vie"n Nam, in partnership with CERWASSS2, is responsible for the innovation of the DVC.

Typical granite pan.

Granito pan with covered defecation holes.
The project owners are households in the three communes (Chinh Ly, Don Xa, and Yen Thanh) in northern Viet Nam.

Financing arrangements

- The introduction of the DVC latrine was openly accepted by a large number of households in Viet Nam.
- PLAN Viet Nam subsidized D700,000 (approximately $32.16) due to the high rates of participation. This amount was given to every participating household. It would then be assumed that the household will shoulder the rest of the amount from the total cost of constructing a typical DVC latrine ranging from D1.1 million to D1.5 million (approximately $68.92).
- The invention of granito has helped the households save on their latrines since the cost of one granito is only D70,000 (approximately $3.22) as compared to the old premolded double pans that cost D165,000 (approximately $7.58).

Project outcome

The project improved the sanitation condition in the communes by introducing a cost-efficient and ecologically sound technology to the households in Viet Nam.

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Three Delta Towns Water Supply and Sanitation Project
Bac Lieu, Ha Tien, and Sa Dec Urban Wards and Communes, Viet Nam

The Three Delta Towns (3DT) Project was located in three sites: Bac Lieu, Ha Tien, and Sa Dec in Viet Nam. For each of the three project sites, the percentage of population without any toilet facilities are: Ha Tien – 53% (population of 40,000); Bac Lieu – 33% (population of 135,000); and Sa Dec – 27% (population of 95,000).

The most common means of excreta disposal is open defecation in rice fields or canals, and use of pit latrines and fishpond toilets. Fishpond toilets are most commonly used in Sa Dec. These sanitation practices are unsanitary, particularly during the wet season, as well as pose a significant risk to the health of the populace and the environment.

Technology options
Initial investigations and local consultations concluded that reducing use of unsanitary pit latrines and fishpond toilets can be achieved by promoting the construction of simple two-compartment septic tanks with discharge to soak-aways and local drainage systems.

Institutional and management arrangements
- The 3DT project team was responsible for developing the sanitation credit schemes (SCS) and ensuring its sustainability in each of the three towns identified.
- The town women’s union (TWU) is responsible for taking full management control of the SCS as well as ownership of the seed fund.
- The town people’s committee (TPC) and other stakeholders provide support in ensuring that SCS parameters identified are suitable for borrowers, lenders, and local administrators.
- Gutteridge Haskins & Davey, acting as co-manager of the project, provided consultancy services.

Financing arrangements
- External funding for the project came from AusAID, the Australian government’s foreign aid program. Total expenditure on the project by the Australian government upon completion in 2008 is around A$50 million (approximately $44.5 million). The government of Viet Nam contributed an additional A$28 million (approximately $24.92 million).
- The 3DT project team developed SCS in each of the three towns as one of the four strategies for improving sanitation.
programs within the community development component of the project. The main objective was to establish a sustainable revolving sanitation credit fund at the TWU level in order to meet the credit needs of poor households to build septic tank systems.

- The project staff worked with each TPC and TWU to establish the SCS parameters that are suitable for borrowers and lenders, as well as acceptable to local administrators. Management arrangements and responsibilities of the project partners were defined, including the provision of training for the TWUs.
- Initially, each TWU received A$38,000 (approximately $33,820) as seed fund for loan capital. This was later increased to A$53,000 (approximately $47,170) in both Ha Tien and Sa Dec. Additional funds were likewise provided for training and awareness materials relating to septic tanks and improved sanitation. The management of the SCS as well as the seed fund was transferred to the TWUs in 2005.
- Loans to households were fixed at D1.5 million (about A$190 in 2002) with a repayment term of 15 months. The loan amount was estimated to be sufficient to cover the cost of putting up a septic system.
- Borrowers are required to pay in fixed monthly repayments, subject to an interest rate of 1% per month. Around 50% of the interest amount is returned to the credit fund to form part of the loan capital, with the other 50% utilized to pay for salaries and overhead costs.

Project outcome
The project improved sanitation condition (expansion of septic tank coverage and increase in sanitary toilets in each household benefitting around 22,500 people) in the three towns identified through community empowerment and the implementation of an innovative credit scheme.
Sanitation Marketing for Five Provinces in Cambodia
Cambodia

Latrine-building projects are recognized as a popular form of development assistance for decades, where the same serve as “hardware subsidies”. The desired sanitation technology is installed either by the government or a large NGO, relatively free of charge to the recipients. However, abundant evidence exists for unsustainable hardware subsidy projects whose failure is attributed to the lack of personal motivation or ‘ownership’ of the recipients for the facility.

Recognizing the reason for the projects’ failure, development agencies realize that alternative approaches to promoting proper sanitation are needed. These include the Community-Led Total Sanitation movement, which focuses on educating people—especially communities practicing open defecation—about the real risks associated with unsanitary practices and essentially ‘shaming’ them, enough to motivate them to acquire an improved sanitation facility.

A group of development NGOs in Cambodia recently 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 in generating a demand for improved sanitation products in low-income people who would otherwise have little interest in them:

- Appropriate designs for low-cost latrines;
- Provision of business training to interested local sanitation entrepreneurs; and
- Effective marketing in the community, which highlights sanitation as a desirable purchase priority.

Technology options

- The price of the “Easy Latrine”—$35—makes it a very attractive choice to users.
- The latrine consists of a concrete slab with porcelain pour-flush squatting pan, an underlying concrete chamber to collect the wastewater from the pan, and PVC drain pipe to channel it down into the pit.
- The pit consists of three concrete rings topped with a bottomless, concrete lid that is buried at an offset to the latrine to a
depth of about 1.5 m. With additional funding, 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 drainpipe is rotated to the other empty pit. Then, once the second pit is full, the contents of the first pit should have, by then, composted enough to allow its excavation and reuse as a soil additive for farming activities.

Institutional and management arrangements
- The executing agencies are the International Development Enterprises (IDE), Lien Aid, and World Toilet Organization (WTO). They design the latrine and carry out the information, education, and communication campaign (IEC) in the marketing and supply-chain.
- The main funding agencies for the project are USAID-Cambodia, through its Micro, Medium and Small Enterprise 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 Ministry of Rural Development, GRET—the NGO who assisted in the latrine design, the WaterSHED Asia Partnership, and the provincial governments and commune councils of the five provinces targeted for the project (Kandal, Svay Rieng, Takeo, Kampong Speu, and Kampong Cham) provided additional support.

Financing arrangements
- The “Easy Latrine” is estimated to cost around $35 each.
- Initial investment needed from prospective entrepreneurs include a vehicle worth $2,000 for making deliveries; $440 worth of concrete molds; and, $650 worth of raw materials for manufacturing the latrines (power tools and ash/cement/sand for concrete).
- The remarkably low-cost nature of the latrine design allows profit to be made quickly, which serves as a powerful incentive for potential business partners.

Project outcomes
- The project improved sanitation resulting from the thousands of latrines already sold by local start-up businesses and sales agents, who were trained in supply-chain management and marketing by the NGOs of this project. Over 100,000 Cambodians have benefitted from improved sanitation due to the project. For example, in Kampong Speu Province, the 5,000 latrines sold translated to increased sanitation coverage from 24% to about 42%. In Svay Rieng and Kandal Provinces, 11,195 latrines have already been sold, which accounted for the 15% increase in latrine coverage as well as the 800% increase in sanitation business profits.

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Latrine-building Project
Cambodia

Among the most pressing issues confronting Cambodians from the rural areas are water and sanitation, including those around the Tonle Sap Lake and river basin. The practice of open defecation 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.

In 2008, the United Nations estimated that only 23% of rural residents and 82% of urban residents had access to improved sanitation. Rural water coverage is the second lowest in Asia, while infant mortality rates—due in part to high levels of waterborne diseases—are the second highest in Asia. This meant that Cambodia still has a long way to go in achieving sanitation for all.

Technology options

- The project presented a range of technology options consisting of various latrine designs for the villagers to choose from.
- A dry pit toilet, a popular and cheap form of sanitation, is made up of the latrine superstructure; a squatting or sitting slab that covers part of the hole but leaves space for input of wastes; and a dug pit into which all of the excreta, urine, toilet paper, and/or anal wash water used are deposited.
- A ventilated improved pit (VIP) toilet, while essentially identical to a dry pit toilet in design, includes a vent pipe beside the latrine superstructure that leads up to a second opening in the slab to further reduce odors and flies.
- A pour-flush latrine is a flush toilet except that the water is poured in by the user rather than having an automatic-filling cistern. It is built similar to that of the dry pit toilet and VIP, consisting of a superstructure, a dug pit, and a slab covering the pit except for an input hole.

Schematic diagram of dry pit toilet (left) and VIP (right).

Schematic diagram of pour-flush latrine with regular pit (left) and offset pit for emptying.
Institutional and management arrangements
- The residents of Battambang, Siem Reap, Pursat, Kampong Chhnang, and Kampong Thom Provinces are the project’s beneficiaries.
- The MRD is the main executing agency for the project and is in charge with providing guidance to a whole range of project units at various levels of implementation.
- ADB, the Government of Cambodia-MRD, and project beneficiaries contributed to the project’s fund.

Financing arrangements
The total project cost is around $24 million, broken down as follows:
- ADB: $18 million grant to the MRD;
- Government of Cambodia: $2.06 million; and
- Project beneficiaries: $3.94 million through user fees for O&M, initial construction fees, and in-kind assistance.

Project outcomes
The project is able to:
- Empower the communities to take responsibility for these new systems according to their needs;
- Increase awareness in healthy and hygienic behavior;
- Improve capacities of stakeholders in facilitating, regulating, and planning further basic water and sanitation services; and
- Provide sanitation services to an estimated 720,000 Cambodians living in the rural areas by 2012.

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Tirupur Water and Wastewater Treatment Project
Tamil Nadu, India

Tirupur is located in the state of Tamil Nadu and is considered India's largest producer of cotton knitwear. The region, considered as one of the most economically dynamic in Southern India, accounts for over 75% of the entire country's knitwear exports, with over 2,500 textile businesses established earning around $1 billion.

While water is essential to the textile industry in Tirupur, the area has been extensively using groundwater and tankers to satisfy its needs in light of the city's lack of water supply. However, over the years, the operation of the industry is threatened with the heavy groundwater pollution brought about by the use of chemical dyes.

By 1990, groundwater had become progressively more saline and contaminated, and the need to address the situation had become of pressing regional importance.

Technology options
- The project involved the construction of two new treatment works, ultimately providing the area with a daily supply of 185 million liters of potable water and the capacity to treat 30 million liters of domestic sewage.
- Sanitation provision within the scheme includes 100 of the city’s designated slum areas. The water treatment plant was built using a conventional design, utilizing a rapid gravity filter with a lamella clarifier with a capacity of 185 MLD.
- The wastewater facility takes domestic sewage only and uses an activated sludge system to achieve secondary treatment standards. The plant discharges into the Noyyal River. Initially built with a capacity of 15 MLD, its design allows for eventual expansion to double its capacity when sewer provision is extended to the remaining 15 of the town’s 52 wards.

Institutional and management arrangements
- The New Tirupur Area Development Corporation Limited was created to manage the process of international competitive tendering. The company acted as a special purpose vehicle to access commercial funding and implement the project.
- The Hindustan Construction Company was the contractor for engineering, procurement, and construction (EPC) 1. They are responsible for building the water intake, transmission pipeline from the river to Tirupur, and the master-balancing reservoir.
- The Mahindra & Mahindra/Larsen & Toubro joint venture company (JVC) was responsible for the EPC 2 contract. They built the main feeder pipelines and distribution networks, overhead and ground level storage tanks, and the sewerage network in the Tirupur town area.
The Mahindra Water Utilities – a Mahindra/United Utilities JVC, provided O&M.

Other partner institutions in the project included the municipality of Tirupur, Tirupur Exporters Association, Infrastructure Leasing and Financial Services (IL&FS), the Tamil Nadu Corporation for Industrial Infrastructure Development, and the Indo-US Financial Institutions Reform and Expansion.

USAID and the World Bank have also committed to provide long-term aid.

Financing arrangements

The Tirupur project funding is a mixture of debt and equity—an approach, which involved a number of sources including public money, various commercial interests, financial institutions, and international funding agencies.

Assistance came from the IL&FS and from USAID, with loan guarantees for over 30 years amounting to $25 million.

The total project cost is around $220 million.

Project outcomes

The project was able to improve living standards for an approximate 800,000 residents, including 80,000 slum inhabitants in Tirupur town and its surrounding areas. More than 600 textile firms were relieved of tanker dependency for water supply; while 185 MLD of potable water were provided for domestic use. Additionally, low cost sanitation was provided for slum areas.
Urban Sanitation in Ouagadougou
Burkina Faso

In 1991, of the estimated 700,000 residents of Ouagadougou, only 40% have access to the city’s water supply network. In terms of the sanitation situation, majority of the households (around 70%) utilize traditional latrines, with 13% using septic tanks. Although the commercial establishments in the town are connected to a conventional sewage system, which is responsible for transporting sewage to designated treatments stations, these facilities are, however, not functioning.

The situation prompted the Office National de l’Eau et de l’Assainissement (ONEA) to implement an improvement program designed specifically to increase coverage and access to improved onsite sanitation facilities.

Technology options
The sanitation improvement program built sanitary structures such as VIP latrines, soak pits and the rehabilitation of existing sanitary structures. Program activities also included the design and production of key sanitary components such as latrine covers and ventilation pipes. The pipes are to be undertaken during the project implementation.

Institutional and management arrangements
- ONEA supervised the improvement program.
- Scaling up started in 1995 (extension to 30 areas), and at present 25% of the population has access to improved onsite sanitation facilities.
- Increased role of private artisan workshops – involving the construction and rehabilitation of sanitary structures and production of sanitary components (e.g., latrine covers and ventilation pipes).
- NGOs and other organizations played an important role in preparing the market—paying multiple visits before the start of installation and rehabilitation works. In parallel, sections of the public were regularly informed about the program through TV and radio spots.

Financing arrangements
- ONEA arranged for subsidies (18%–30%) which took the form of building materials (e.g., platforms, ventilation pipes, etc).
- Funds for subsidies could be collected through a 4% sanitation levy on water bills.

Project outcomes
- Installation of more than 28,000 onsite sanitation systems.
- Artisans started to organize themselves to improve coordination and to have better access to microcredit.
- Poor people preferred cheaper options and showed a strong preference for solutions based on the soak pit. Demand for the soak pit was stimulated by low costs, better promotion, and higher subsidies.
- Competition between artisans, NGOs, and consultants led to improvements in the quality of work and reduction in costs.
Halong City Sanitation Project  
Viet Nam

Situated in the northeastern part of Viet Nam, Halong City forms part of the Three Cities Sanitation Project. Conceived in the mid 1990s, the initiative was aimed at improving public health of around 1.5 million residents living in Da Nang, Hai Phong, and Quang Ninh provinces.

Specifically, the project targeted the reduction of incidences of water-borne diseases and mitigates environmental problems as well as the effects of flooding through the provision of necessary infrastructure and improved wastewater management.

This initiative is of particular importance as the site borders Halong Bay, which is considered by the United Nations Educational, Scientific and Cultural Organization as a World Heritage Site.

Technology options
- The project involved the installation of a sequencing batch reactor (SBR) and conveyance structures and other appurtenances made up of the following:
  - 31 km of open and closed drainage channels;
  - 10 km of sewer pipes;
  - Construction of three sanitary landfills;
  - Construction of two septic sludge treatment plants;
  - 3.5 km of pressure sewage pipelines;
  - Construction of eight underground pump stations; and
  - 27 vehicles for the collection of solid waste and septic sludge.

Institutional and management arrangements
- The project management unit for Quang Ninh Province is the implementing agency for the project.
- A private consulting firm (COWI) handles the engineering design, project management, and capacity building of the two urban environment companies currently operating the wastewater facility.
- The construction contract for the SBR system was likewise awarded to the private sector (joint venture between Biwater Man Lee and Constrexim Holdings).
- Funding assistance is extended by the following institutions: (i) the World Bank; (ii) governments of Australia, Denmark and Finland; and (iii) International Development Association (IDA).

Financing arrangements
- Total project cost is estimated at $34.5 million (inclusive of works undertaken in Cam Pha Town).
- Grants were also made available to benefit around 11,000 households particularly in constructing septic tanks. Funding of these grants is sourced from a revolving fund.

13 Amount is estimated based on 2009 price levels.
Project outcomes

The project is envisioned to benefit around more than 300,000 residents of the city. Additionally, the project is expected to provide the following outcomes:

- Improved environment;
- Reduction in health risks;
- Reduction in the incidences of flooding;
- Growth in tourism and increased investments (increase in both tourist arrivals and revenues by a margin of 113% from the period 2002 to 2006);
- Reduction of BOD levels (from 80 mg/l in 1999 to 8 mg/l in 2008);
- Increased volume of solid waste collected and transferred in disposal sites (from 25,000 tons per year in 1999 to 120,500 tons per year in 2008) and
- Increased value in urban properties.

Contact for more information

World Bank
Great Falls Wastewater Treatment Plant
City of Great Falls, Montana, United States of America

The City of Great Falls is located in the State of Montana. To manage its wastewater, the city officials constructed a wastewater treatment plant with a capacity of around 79.5 MLD in 1960, with upgrades made in the mid 1970s.

The wastewater treatment plant is capable of servicing a population of about 63,000 residents, covering a 27-km radius. The system has over 20,000 service connections and a sewer network of more than 377 km of sewer lines and an estimated 3,300 manholes.

In order to better serve its constituents, the city engaged the services of a private company to improve the operation and management of its wastewater treatment plant. By entering into a PPP, city officials envisioned achieving better and more efficient delivery of services, significant cost savings, and plant upgrades.

Technology options
- In 1977, the City of Great Falls entered into a PPP arrangement with Veolia Water to manage its new wastewater treatment facility.
- The contract involved operating and maintaining the 79.5 MLD treatment plant, including the 31 lift stations. The plant is a secondary activated sludge treatment facility designed to treat domestic sewage.
- A prototype was created utilizing the chlorine-ring system for improved disinfection.

Institutional and management arrangements
- The City of Great Falls is the executing agency of the project.
- Veolia Water acted as the private proponent. It is responsible for:
  - Operating and maintaining the city’s wastewater treatment plant for an agreed period (e.g., 30 years);
  - Designing, building, and operating small capital improvements in the wastewater treatment facility;
  - Conduct of training and capacity building activities for the plant employees; and
  - Installation of new instrumentation and control systems in the plant.

Financing arrangements
- Small capital plant improvements and upgrades are at the expense of the private operator.
- Sustainability of operations is ensured through the imposition of tariffs.

Project outcomes
Under the PPP agreement, the following benefits were realized:
• Superior process control and maintenance protocols translated to significant reduction in O&M costs as well as profitable operations.
• Treatment plant employees benefitted from the training and capacity building shouldered by Veolia Water.
• Health and wellbeing of the residents of the city are ensured.
• Reduction in environmental risks in the Missouri River ecosystem.

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References

- Double Vault Composting Latrine Program in Northern Viet Nam
  CAPS, KOICA, and UNEP. Case Study: Double Vault Composting Latrine Program in Northern Viet Nam.

- Three Delta Towns Water Supply and Sanitation Project, Bac Lieu, Ha Tien, and Sa Dec Urban Wards and Communes, Viet Nam

- Sanitation Marketing for Five Provinces in Cambodia
  CAPS, KOICA, and UNEP. Case Study: Sanitation Marketing for Five Cambodia Provinces – A Joint IDE, Lien Aid, and WTO Project in Cambodia.

- Latrine-building Project Cambodia

- Tirupur Water and Wastewater Treatment Project, Tamil Nadu, India

- Urban Sanitation in Ouagadougou, Burkina Faso
• Halong City Sanitation Project, Viet Nam
  water-technology.net. Halong City
  www.water-technology.net/
  projects/halongcitysanitation/
  (accessed 21 September 2011).

  World Bank. 2009. The Three Cities
  Sanitation Project. Implementation
  Completion and Results Report:
  bit.ly/1XzuXJB (accessed 19 June
  2014).

• Great Falls Wastewater Treatment Plant
  City of Great Falls, Montana, United
  States of America
  National Council for Public-Private
  Partnerships. Great Falls
  Wastewater Treatment Plant.
  http://www.ncppp.org/resources/
  case-studies/operation-and-
  management-maintenance-
  contracts/great-falls-wastewater-
  treatment-plant/ (accessed 28
  September 2011).

  City of Great Falls Montana.
  Wastewater Treatment Plant
  net/sites/default/files/
  fileattachments/wastewater_
  treatment_plant_process_3.pdf
  (accessed 28 September 2011).
VI. Creating synergies for energy and nutrient recovery

In an era where the focus of governments is the attainment of economic growth through sustainable development, the optimal use of earth’s resources such as water and energy has noticeably gained traction. Stakeholders are more cognizant of the fact that the drive for economic growth and development puts tremendous stress on these scarce resources and that harnessing the same needs to be done in a more sustainable manner.

A better understanding of the linkage and interdependence of these resources has led to interventions designed to capitalize on such synergy of resources. In the case of wastewater management, the rapid advancement in technologies over the years has been instrumental in spawning a wide range of innovations – from the simple to the more complex ones – for stakeholders to choose from. Aside from primarily treating and improving water quality of effluent discharged to water bodies, these interventions helped harness wastewater by-products for productive use. Most notable examples of valuable by-products include methane from biogas (for cooking, power generation, transportation fuel, and carbon credits), and sludge, which can be converted to soil conditioners and fertilizers to increase agricultural productivity.

The case from Thailand provides a very good example of sustainable wastewater management done by the private sector. Aside from addressing the problem of deteriorating water quality within the industrial plant complex, the technology adopted by the owners allowed them to produce electricity for sale to the provincial power grid, generate substantial fuel savings from the use of biogas to power boilers and heating, and generate carbon credits.

The examples from Viet Nam and Cambodia, on the other hand, highlight that sustainable sanitation systems need not utilize technically complex technologies in order to work successfully. Through the use of biogas digesters, the communities are presented with affordable interventions to adequately address their sanitation concerns as well as provide them with an alternative source of energy (biogas for cooking and lighting purposes) and fertilizer.

Project briefs
- Transforming Wastewater Into Green Energy: Nakhorn Ratchasima, Thailand
- Biogas Digesters for Vietnamese Farmers: Viet Nam
- Floating Community Ecological Sanitation Project - Tonle Sap Lake: Cambodia
Transforming Wastewater Into Green Energy
Nakhorn Ratchasima, Thailand

The project site is located 20 km east of Nakhorn Ratchasima, which is about 250 km away from Bangkok. Nakhorn Ratchasima is one of the five biggest cities in Thailand, where most of the tapioca starch plants in the country are located.

A partnership between Global Water Engineering (GWE) and Chokyuenyong Industrial was established to reduce by more than 95% the effluent COD pollution levels at its cassava production plant. Coupled with this objective, gas will be extracted from the wastewater collected to power the company's boilers and generate electricity for its own use as well as sell back to the provincial grid.

Processing 1,200 tons of cassava roots a day, Chokyuenyong Industrial uses GWE anaerobic technology with a capacity of 3,200 m³ effluent a day. The installation provides wastewater cleanliness while generating green power and carbon credit profits.

Technology options
• Chokyuenyong Industrial’s process involves an equalization basin (total volume 1600 m³) with submerged agitators, degasifying basin with agitator (24 m³) in-line pH adjustment, NaOH storage tank (25 m³) Upflow Anaerobic Sludge Blanket methane reactor (active volume 4800 m³) and biogas flare (standby for use if required). The technology is aboveground for simplicity and ease of maintenance.
• With the use of GWE’s state-of-the-art anaerobic treatment, the plant’s carbon footprint is significantly reduced through the prevention of methane gas from escaping into the atmosphere.
• Prior to entering a GWE methane reactor (where bacteria in a closed reactor digest the wastewater’s organic content), the wastewater is subjected to several pretreatment steps. This helps optimize degradation of the compounds and converting the same into valuable biogas and cleaned effluent.
• To further improve results achieved at the plant, GWE’s innovative treatment system for solid organic residues is utilized to enable conversion of solid wastes (residual pulp from the roots, after starch extraction) into biogas as well.
• The Rapid Transformation of Organic Residues technology is a powerful liquid-state anaerobic digestion process consisting of enhanced pretreatment followed by multistep biological fermentation to optimize conversion of almost any organic residue or energy crop into biogas, valuable electricity or heat.
Institutional and management arrangements

GWE, represented by local agent Retech Energy, supplied and built the facilities attached into the existing factory. The work was carried out on behalf of the client and factory owner, Chokyuenyong Industrial.

Financing arrangements

Chokyuenyong Industrial covered the total investment cost. Sustainability of the project is hinged on the clean development mechanism revenues generated from the sale of carbon credits as well as savings generated from fuel and electricity costs.

Project outcomes

- Reduction of the COD pollution level of influent wastewater from 22,500 milliliters per liter (ml/l) (14,525 mg/l BOD, BOD$_{O_2}$) to less than 1,125 mg/l, resulting in substantially cleaner discharges to treatment ponds, and ultimately, the environment.
- Production of up to 2.7 megawatts of electricity a year for sale to a provincial power grid, the Provincial Electricity Authority (PEA). PEA serves some areas far from major generating sources and welcomes fresh input of green power generated locally.
- Savings equivalent to 21,000 liters a day of fuel oil by producing up to 34,000 normal cubic meter (Nm$^3$) of biogas, which is utilized to power the boilers and heating equipment used extensively in cassava drying and processing. This is also used to generate electricity for the large amounts of rotating equipment operated during processing.
- Generation of carbon credits under the United Nations’ Framework Convention on Climate Change, through which it earns valuable internationally tradable certified emission reduction certificates, representing the right to emit a ton of carbon dioxide or carbon dioxide equivalent.
Biogas Digesters for Vietnamese Farmers

Viet Nam

Majority of the Vietnamese who live in the rural areas are into agriculture. They have no access to electricity, use collected firewood for cooking, and rely on either expensive commercial fertilizers or risky raw animal manure to fertilize their fields. With these range of challenges confronting them, the biogas digester presents a cost-effective solution to address said problems.

The biogas digester is a simple, yet powerful, sanitation technology option that is capable of:

(i) processing human and animal feces into safe and free fertilizer; (ii) reducing cases of groundwater contamination by processing feces instead of having it discharged untreated; (iii) creating biogas for use in cooking and household lighting; (iv) empowering women and families by reducing their time spent on fuelwood gathering and cooking; (v) reducing indoor air pollution brought about by fuelwood burning; and (vi) eliminating carbon dioxide (CO₂) 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.

Technology options

• Serving as the primary settling tank, the biogas reactor is an anaerobic, sealed chamber, which facilitates the relatively fast passage of liquid effluent through the chamber and digestion of much of the settled sludge by anaerobic bacteria.

• It functions like a septic tank, except that its sealed nature allows all of the biogas to be captured and used.¹⁴

• The biogas reactors built for this project are of the ‘fixed dome’ type with two varieties being promoted, the KT. 1 model and KT. 2 model. Both models have (i) an inlet mixing chamber, where animal manure can be mixed with water to allow its flow into the unit; (ii) a main chamber, where the anaerobic fermentation and

¹⁴ Biogas is a mixture of methane and CO₂ that is released from anaerobic digestion.
biogas production takes place; and (iii) a raised outlet area (and maintenance manhole), where liquid effluent and sludge is gradually discharged through the pressure exerted on the liquid by the accumulating biogas.

- The generated gas, which is dependent on the size of the biogas reactor, can be used either for small scale applications such as operating a gas stove or light, or for large scale applications such as powering the scalding vats of a slaughterhouse.

Institutional and management arrangements

- There are two executing agencies for the biogas digester project:
  - The Department of Livestock Production of the Ministry of Agriculture and Rural Development as program owner and coordinating agency; and
  - Stichting Nederlandse Vrijwilligers (SNV) Viet Nam as the main technical assistance and planning agency.

- The two agencies are consolidated into a national Biogas Project Division. It then provides project direction and guidance to the Provincial Biogas Project Divisions (PBPD). The PBPDs are established in each participating province and are staffed by the provincial departments for agriculture and rural development and their Agricultural Extension Centers.

- The PBPDs carry out the ‘on-the-ground’ work, which includes:
  - Training masons to sell and construct biodigesters;
  - Conducting local IEC campaign activities;
  - Channeling the program’s financial subsidy to purchasers upon successful purchase and construction of a biogas digester unit; and
  - Liaising generally with the rural consumers.

- Cooperating agencies, on the other hand, are composed of:
  - ETC Foundation (a Dutch NGO responsible for promotion and marketing support);
  - Local governments of the selected program provinces (58 provinces);
  - Trained mason groups (as private sector companies who are selling, constructing, and maintaining the biodigesters on the local level); and
  - Viet Nam Postal Service (for subsidy disbursement).

- The Netherlands Directorate General for International Cooperation (DGIS) provides funding support through their Asia Biogas Program, with contributions coming from the national and provincial governments.

Financing arrangements\(^{15}\)

- The total investment in this program is approximately €44.8 million (approximately $52 million), with €6 million (approximately $7 million) coming from the official development assistance grant of the Netherlands DGIS and €1 million (approximately $1.16 million) from

\(^{15}\) Approximately €1 = $1.16, D1,000 = $0.05, as of January 2015.
the technical assistance extended by SNV. Around €4 million (approximately $4.64 million) are sourced from the selected provincial governments, with the remaining balance coming mostly from the sales of the biodigesters.

- Funds are geared toward program establishment and maintenance, IEC activities, and the provision of a flat rate subsidy of D1 million (approximately $50) on the cost of the biodigesters for farmers who purchased and had one constructed through the program.
- The total costs of varying sizes of biodigester offered by the program average between D2.5 million–D3.5 million (approximately $125–$175).

**Project outcomes**

Overall, the project is expected to:

- Improve the overall sanitation in Viet Nam;
- Improve the lives of the farming families by utilizing an existing resource (manure of their animals) to provide them free biogas for cooking and lighting;
- Improve the agricultural productivity of the farmers through their ‘closing the loop’ use of the output bioslurry; and
- Improve the governing and marketing institutions by using this multipartnership program to bring together and utilize the talents of the different government organizations and NGOs operating in the country.

Specifically, the project was able to provide the following outcomes:

- Over 103,000 biodigesters sold have benefitted around 500,000 Vietnamese.
- About 55% of the units sold (as of 2006) represent users making use of bioslurry produced by the digesters thereby reducing dependence on costly synthetic fertilizers to increase agricultural productivity.
- About 48% of the units sold in 2011 have personal toilets attached to the biogas digester units, which is instrumental in exceeding the connection rate target of 45% in 2012.
- As of 2009, the program has contributed to the reduction of CO₂ emissions by around 167,000 tonnes annually.

**Contact for more information**

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Floating Community Ecological Sanitation Project – Tonle Sap Lake

Cambodia

Among the most pressing issues confronting Cambodians from the rural areas are water and sanitation. Access to such facilities is particularly difficult for those 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. Despite such situation, appropriate options have yet to be established to address these challenges as well as manage sanitation.

With no affordable sanitation options available for the floating and stilted communities, majority of the populace are left with no choice but to urinate and defecate directly into the lake, thereby significantly contributing to its contamination. As a result, the households are exposed to a range of pathogens and residents in the floating communities suffer from diarrhea and other waterborne diseases considering that the lake water is a major source of their daily subsistence (for drinking, washing, bathing, and fishing).

Technology options

- UDD toilets were chosen as the most preferred and appropriate solution for the floating communities. The system is capable of separating waste streams using a dedicated toilet-pan, and then stores and treats the waste until it is safe to reuse or dispose.
- Use of biodigesters was also considered with specific modifications made to make biodigestion adaptive to the floating communities and ensure that benefits derived from methane gas (e.g., fuel for cooking and light) and byproducts such as natural fertilizer are maximized.

Institutional and management arrangements

- The Phat Sanday floating communities on Tonle Sap Lake are the project owners.
- Engineers Without Borders Australia provided technical and design support. Engineers Without Borders Australia is a nonprofit 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.
- Live & Learn Environmental Education Cambodia (L&L) provided coordination.
and handled relationship building and community engagement for the project. L&L is a nonprofit, NGO, which promotes greater understanding and action toward human and environmental sustainability through education and dialogue building.

- The MRD played an important role in providing access to the project team to the Water and Sanitation forum. MRD also provided linkages to other organizations that are based in Cambodia.
- Phat Sanday Community’s main role is to engage the people in the community to be involved and participate in the project.
- Science and Technology Innovations for the Base of the Pyramid in Southeast Asia and the Energy and Environment Partnership Program—Mekong are currently supporting the demonstration of appropriate energy for floating communities, including developing floating biodigesters.
- Resource Development International (RDI) Cambodia is involved in the prototyping and design development. RDI Cambodia provided the government with expertise and use of its laboratory for testing.
- Royal University Phnom Penh (RUPP) also offered its facility for laboratory testing. RUPP is also involved in relationship building and capacity development.

**Financing arrangement**

The cost per toilet pan, frame and bucket, including installation, is estimated to be about $40.

**Project outcomes**

The project was able to improve community hygiene by providing a viable sanitation solution wherein there is active participation by the community. By developing innovative technologies and practices, and then pilot-testing these for human waste management, the project provided an incentive for the community to improve sanitation by generating social, economic, and environmental dividends for the floating communities.

**Contact for more information**

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References

  

- Biogas Digesters for Vietnamese Farmers, Viet Nam. CAPS, KOICA, and UNEP. Case Study: Biogas Digesters for Vietnamese – A Multi-Partner National Biodigester Program in Viet Nam.
  

- Floating Community Ecological Sanitation Project – Tonle Sap Lake, Cambodia. CAPS, KOICA, and UNEP. Case Study: Floating Community Ecological Sanitation Project on the Tonle Sap Lake.
  
VII. Wastewater and septage treatment and reuse for agriculture and aquaculture

With the increasing scarcity of freshwater resources, but ever growing demand for more efficient food production for the expanding populations, much wider recognition is being given to wastewater as an important resource. In arid and semi-arid climates, and in areas without irrigation systems, wastewater can be an indispensable source of water and nutrients for agriculture. In rural and peri-urban areas of most developing countries, use of sewage and wastewater for irrigation is a common practice because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers. Wastewater treatment and reuse also protects groundwater from both contamination and depletion.

Concern for human health and the environment are the most important constraints in the reuse of wastewater. Applying suitable irrigation techniques and wastewater and sludge treatment technologies, selecting crops that are less likely to transmit pathogens to consumers, and using protective measures to reduce exposure can minimize risks.

Another aspect worth looking into is the use of wastewater to improve aquaculture activities. Specifically, studies have shown promise on the use of urine mixed with animal manure in increasing phytoplankton production in the grazing food chain of farmed fish.

The project briefs selected illustrate the opportunities for wastewater and septage management particularly on the aspect of reusing wastewater and its byproducts (e.g., sludge) to enhance agricultural and aquaculture productivity, without damaging the environment.

Project briefs
- Small-scale Sludge Treatment System for Dauem Mien: Kandal Province, Cambodia
- Use of Treated Wastewater in Agriculture: Jordan Valley, Jordan
- Co-composting of Fecal Sludge and Organic Solid Waste: Kumasi, Ghana
- Decentralized Wastewater Management at Adarsh College with Biogas Digesters: Badlapur, Maharashtra, India
- Pour-flush Toilets with Biogas Plant at DSK Training Institute: Gujarat, India
- Vinasanres Ecosan Toilets Demonstration in Cam Duc Commune: Cam Ranh District, Viet Nam
- Reuse of Human Urine in Aquaculture: Kalyani, West Bengal, India
- Muscat Wastewater Project: Governate of Muscat, Oman
- Qinghe Wastewater Treatment Plant: Beijing, People’s Republic of China
Small-scale Sludge Treatment System for Daeum Mien
Kandal Province, Cambodia

With the exception of households connected to a sewerage system, other forms of improved sanitation (e.g., pit toilets, pour-flush latrines leading to pits or septic tanks, and flush toilets leading to septic tanks) create sludge. Failure to regularly remove this accumulated sludge results in inefficiency of the pit or tank to function optimally as well as enhances the risk of exposure to groundwater pollution.

Given the current standard of living in the province, business for private desludgers is relatively small, with no sludge treatment plants available and correspondingly high rates for desludging service. Hence, the seven private desludging operators in the city simply dispose highly potent sludge onto farmers’ fields for a fee.

Recognizing such situation, the French NGO, GRET, began a small-scale sludge treatment plant project as part of their larger sanitation program in Cambodia. The chosen project site is Daeum Mien, which is located on the rural outskirts of Phnom Penh. The project involved the installation and construction of an innovative, small-footprint, and low-cost sludge treatment plant intended to fully process the sludge into useable compost.

Technology options

- The sludge treatment plant designed for this project was constructed aboveground and in two separate floors.
- This design is suitable for very rocky areas where excavation works are difficult to perform, or in areas with little land available.
- The small-scale plant was designed to be completely de-mechanized (i.e., no electricity requirement and utilizes rainwater collected in a concrete cistern for use around the site). The components of the treatment plant are (in order of sludge flow): inlet bar screen (second floor), solid extraction settler (second floor), ABR (first floor), aerobic pond.

Sludge drying beds and their inlets.

Schematic diagram of the treatment plant site.
(second floor), sludge drying beds (SDB) (extend through both floors), and open-air, contained compost heaps (first floor).

- The plant was designed to treat approximately 2 m³/d of sludge.

Institutional and management arrangements
- GRET is the main funding and executing agency for the project.
- Cooperating agencies include the local commune council, the farmer on whose land the plant was built, and the existing private desludging companies of Phnom Penh.
- Members of the local commune council consist of the plant owners and operators.

Financing arrangements
- The total project cost is estimated to be around $8,000 for the sludge treatment plant and $1,200 for purchase of equipment.
- Private desludging company partners that want to make use of the plant need only to invest in their truck and pumping gear.
- As a prerequisite to using the plant, local desludgers will sign a contract with the commune that stipulates a fixed rate of $15 per desludging will be charged to households, instead of the $30 being charged by much larger desludge service operators.
- Composts generated from the plant can also be sold at a much cheaper rate than conventional fertilizers to earn additional revenues.

Project outcomes
- The project was able to:
  - Improve community sanitation by use of innovative and cost-effective sludge treatment technology, in partnership with the private sector.
  - Reduce in the environmental and health impacts from uncontrolled desludging.
  - Promote reusable wastes such as compost from sludge.
  - Generate substantial profits from small-scale desludging activities as well as sale of composts.
- Effluent coming from the SDB collection pipes is relatively safe for discharge to the water body due to the reduction of BOD and COD by at least 70% brought about by the treatment plant processes; while the aerobic pond reduces odor and removes 95% of remaining pathogens.

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Use of Treated Wastewater in Agriculture
Jordan Valley, Jordan

The project area is situated in the middle and southern portions of the Jordan Valley, extending over a length of about 50 km between Kreimeh and the Dead Sea.

The Jordan Valley is characterized by low annual rainfalls (an average of less than 300 mm at Deir Alla and 100 mm at South Shuneh). However, the mild winter season between November and April allows an off-season production of vegetables under irrigation.

It is estimated that irrigated agriculture in the area consumes about 42% of the available freshwater resources, which directly competes with the drinking water needs of the populace. As such, the safe use of marginal water resources for irrigation, such as brackish and reclaimed water, is a highly desirable option in view of the shortage of the resource.

Technology options
- There are 22 wastewater treatment plants operating in Jordan, treating approximately 250 MLD of wastewater. Majority of the treatment plants have small capacities, except for the plant As-Samra, which handles more than 80% of the said volume. To further improve the effluent quality generated, the As-Samra Treatment Plant was rehabilitated and upgraded in August 2008.
- The new plant, while receiving only 50% of its design flow rate, utilizes the activated sludge process with nutrient removal and chlorine for disinfection. It is capable of serving 2 million people in the two cities—Amman and Zarqa (the two most populated cities of Jordan), and has a capacity to treat 276 MLD.
- Treated effluent is diluted with surface and precipitation water by the passage through the wadies and is extensively used for irrigation purposes. Water flows by gravity from the wastewater treatment plant via the King Talal Reservoir to the agricultural fields.
Institutional and management arrangements

- The Jordan Valley Authority is the executing agency for the project.
- Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH provided planning support; while the BMZ handled the funding requirements for the program via GTZ.
- The Jordan Food and Drug Administration frequently test crops produced on reclaimed water for biological contamination and heavy metals.
- The Ministry of Environment supervises the enforcement of the environmental law that prohibits illegal dumping of industrial waste before it receives treatment.

Financing arrangements

- The hydraulic infrastructure in the Jordan Valley was constructed, operated and maintained by the Jordan Valley Authority, supported by international donors. There are no investments in physical infrastructure by the project.
- The project is an integral part of the GTZ Water Program with the budget for just the reuse activities (being one component of the program) is not known separately. The budget for the water program in the first phase (2006–2009) was €9 million (approximately $13.14 million), with another €4.5 million (approximately $6.57 million) allotted for the second phase (2009–2011).

Project outcomes

- The artificial mineral fertilizer use in the middle and southern part of the Jordan Valley is reduced, lowering the soil salinization pace.
- It is estimated that farmers would save up to 60% of their fertilization cost, which is equivalent to €564 per hectare (approximately $823.33), and can be translated into income improvements of 30%.
- At the national level, more than 80% of fertilizers used in Jordan are imported; thus, any savings in fertilizers translates to a reduction in foreign currency payments to the exporting countries. Savings generated from use of nutrients in treated wastewater are estimated to be about €3.8 million per year (approximately $5.5 million).
- With the farmers’ appreciation of the added value of reclaimed water and the acceptance of its reuse, water use conflicts on freshwater sources are dwindling. This reduces the pressure on barely sufficient drinking water resources.
- Aside from the fact that reuse of treated wastewater in agriculture is a productive approach, the project has several positive impacts on the environment. Reduced salinity, energy consumption, and CO₂-emissions are among the indirect benefits.
- Nutrients in treated wastewater lead to a 5,839-ton per year reduction in the consumption of fertilizers. This amount is equivalent to saving 86 gigawatt-hour

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16 Approximately €1 = $1.46, as of 2009.
(GWh) annually (about 1% of the current Jordanian electricity consumption).

- Another important aspect of reduction in fertilizer use is the reduction of greenhouse gases generated during fertilizer production. CO$_2$ emission for producing a kilogram of fertilizer was estimated to be 1.7 kg. Based on this value, reduction in fertilizer use in Jordan Valley would lead to a reduction of 11,000 tons of CO$_2$ emissions.

**Contact for more information**

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Co-composting of Fecal Sludge and Organic Solid Waste
Kumasi, Ghana

Kumasi is the second largest city in Ghana, West Africa. With approximately 1 million inhabitants, the city is considered as an industrial center for timber, food processing, and soap manufacturing. Its residents are also actively engaged in woodwork, vehicle repair, footwear production, furniture manufacture, and metal fabrication.

Around 38% of Kumasi residents use public toilets. About 400 of these facilities are equipped with either flush toilets with a holding tank, or Kumasi ventilated improved pit (KVIP) latrines. The KVIP latrines are built with two pits per latrine (used alternatively) or one pit per latrine. An estimated 26% of the population use household water closets linked to septic tanks and seepage pits. Only 8% of the population is connected to a sewerage system; and the remaining 28% have no toilet facilities at all.

The city produces around 860 tons of solid waste and 500 m³ of fecal sludge collected daily from onsite sanitation systems. Approximately 70% of the produced solid waste is biodegradable (organic), which can be co-composted together with fecal sludge, and then utilized as a fertilizer and soil conditioner. Given the substantial volume of organic solid waste and fecal sludge collected and to further explore the potential of the same for reuse and/or beneficial purposes, a pilot plant was established to focus on the concept of co-composting.

Technology options
The basic technology chosen for this project consists of two main process steps: fecal sludge drying on unplanted drying beds; and open windrow system for co-composting of dried fecal sludge and organic solid waste.

Institutional and management arrangements
• The following agencies implemented the project:
  o International Water Management Institute (IWMI), Executive Institution, Accra, Ghana;

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17 Fecal sludge is created from human excreta and water. Onsite sanitation systems used in Kumasi include septic tanks, pit latrines, and uns sewered public toilets.
Department of Water and Sanitation in Developing Countries (SANDEC) of the Swiss Federal Institute for Aquatic Science and Technology, Dübendorf, Switzerland; Kwame Nkrumah University of Science and Technology, Accra, Ghana; and Waste Management Department, Kumasi Metropolitan Assembly, Kumasi, Ghana.

- Funding support is extended by:
  - Ministry of Foreign Affairs, France;
  - National Centre of Competence in Research (NCCR) North-South, Switzerland; and
  - Kehrichtverbrennungsanlage Zürcher Oberland (KEZO), Switzerland (Waste Disposal Services Zurich Oberland).

Financing arrangements

- Total investment costs is around €16,500 (approximately $24,090). The Ministry of Foreign Affairs, France provided funding.
- NCCR North-South and KEZO funded operation costs (PhD students, video documentary, and initial O&M costs).
- Operation of the co-composting plant is labor intensive. Solid waste sorting is the most costly activity contributing to approximately 30% of the total O&M costs.
- It was estimated that the amount of compost produced from the pilot plant would be approximately 37 tons/year. A subsequent study valued the compost produced at the plant to be approximately €3.5 per 50-kg bag (approximately $5.11).

Project outcomes

- Demonstrated the merits of co-composting to policy makers, engineers, farmers, city planners, and waste managers.
- The pilot project was replicated in Senegal and Mali, funded by SANDEC.
- It helped increase awareness and high acceptance among farmers on the use of excreta-based compost for agricultural activities.

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18 Approximately €1 = $1.46, as of 2009.
Decentralized Wastewater Management at Adarsh College with Biogas Digesters
Badlapur, Maharashtra, India

Adarsh Vidya Mandir School is located in Badlapur town, in Maharashtra’s Thane district, about 68 km from Mumbai, about 34 km from Thane and 10 km from Ulhasnagar.

The school has a population of around 2,600 students. The college building is located at the southern fringe of the school premises and is used as the Senior College in the morning and Junior College in the afternoon. There are approximately 1,400 students attending the Senior College per day; while the Junior College has approximately 1,200 attending daily.

The primary objective of the project is to meet the sanitation needs of the students as well as the people attending special programs (e.g., wedding ceremonies at the school premises). The project, more importantly, is developed to protect the environment and raise awareness amongst the students on the importance of water and sanitation in promoting health and hygiene.

Technology options
- A sanitation block with two enclosures—one for female and another for male users, has been constructed next to the school building.
- In addition to a sufficient number of washbasins, each enclosure is equipped with four bucket-flush squatting-type toilets and a western-style cistern-flush pedestal. The pedestal is provided for the physically challenged.
- Blackwater and greywater from the washbasins are discharged to a biogas settler where solids are retained and subjected to anaerobic decomposition.
- The biogas settler effluent is drained by gravity flow to an ABR and upflow filter (UF) for further anaerobic treatment.
- Post treatment of the UF effluent happens in a small-scale HFCW. The final stage of the treatment consists of a pond that doubles as storage tank.
- Waterless urinals with membrane stench traps are provided for the source-separate collection of urine, which is then drained into a collection tank outside the toilet block. The tank is provided with a fail-safe overflow emptying to the anaerobic treatment plant.
• It is proposed that treated water and urine are to be utilized in a kitchen garden, which has yet to be established. On the other hand, drying beds will be constructed for dewatering the sludge from the biogas settler, ABR, and UF.

Institutional and management arrangement
• The Kulgaon Badlapur Municipal Council is the executing agency for the project.
• Ecosan Services Foundation is responsible for the technical planning and project implementation.
• Paradigm Environmental Strategies provided the design of the treatment system.
• Seecon GmbH, a Swiss consulting firm, provided consultancy services.
• Resource managers are hired for the O&M of the toilet blocks and reuse of recyclates. Students are also actively engaged to support the resource managers in their daily activities.

Financing arrangement
• The total estimated project cost is around Rs450,000 (approximately $9,900).
• About Rs360,000 (approximately $7,920) of the total project cost was used to construct the biogas settler, ABR, and UF. Rs50,000 (approximately $1,100) covered the construction of the wetland and Rs40,000 (approximately $880) for the pond.

Project outcomes
The long-term impacts of the project include:
• Improved sanitation;
• Enhanced agricultural productivity (use of urine and dried sludge for agricultural purposes);
• Provision of an alternative source of fuel (substitution of liquefied petroleum gas by biogas); and
• Safe reuse of the treated water for irrigation purposes.

19 Approximately Rs1 = $0.022, as of 2010.
Pour-flush Toilets with Biogas Plant at DSK Training Institute
Gujarat, India

The vocational training institute, Dalit Shakti Kendra, was built in 1999 on an area of 32,000 square meters in Nani Devti village near Sanand, about 30 kms southwest of Ahmedabad City in the state of Gujarat, west of India.

Domestic wastewater from the kitchen building and the workshop building (i.e., blackwater from toilets and greywater from the kitchen and bathrooms) was handled through its collection and infiltration into the ground using a soak pit located close to the hostel building. A second soak pit close to the administrative building was installed to collect wastewater from the community training center.

However, in order to effectively address the sanitation demands of the training institute, a new sanitation facility needs to be established. This was further confirmed by factors such as:

(i) Accumulation of sludge at the bottom and walls of the soak pits due to poor maintenance;
(ii) Flooding of sewers and soak pits;
(iii) Presence of a near-to-surface aquiclude\(^\text{20}\) which prevents the rapid infiltration of rainwater during monsoon season; and
(iv) Need to meet the requirements resulting from the institute’s expansion.

Technology options

Water supply

- The entire campus utilizes groundwater sourced from a depth of approximately 200 m.
- The water is pumped into a surface storage tank before it is pushed into an overhead storage tank.
- Water used for cooking and drinking needs to be treated in a reverse osmosis plant because of its high salinity.
- The brine, (approximately 3,000 l/d) resulting from the production of

\(^{20}\) Solid, impermeable area overlying an aquifer.
approximately 1,000 liters of drinking water per day, is collected on the roof of the kitchen building, and then used to flush the toilets.

- Water spent for nonpotable purposes such as showering is not pretreated but used directly.

**Pour flush toilets and biogas plant**

- A sanitation complex consisting of 22 toilet cabins (equally divided for females and males) are arranged in a circular shape around a biogas plant located in the center. The complex was established for the residents staying in the campus.
- The toilet cabins are equipped with pour-flush squatting pans made of ceramics (so-called “rural” or “pour-flush” pans). These toilet cabins reduce water consumption and keep the blackwater relatively concentrated.21
- The biogas plant was constructed to treat the blackwater and to recover energy in the form of biogas. The biogas plant has a “floating drum” cover, which simultaneously stores and provides the produced gas at a constant pressure. The slurry is transported to the sludge drying beds.

**Urinal center**

- The institute provided two independent enclosures—for female and male users.
- There were four tanks used to collect urine. When the tanks are full, urine is then pumped to the storage and hygienization tanks to make it available by gravity while being transported to the fields with jerry cans or container carts.

**UDDTs for night-time use**

- Students from the Massachusetts Institute of Technology built three single vaulted UDDTs in 2007. The UDDTs – two near the hostel and one behind the Community Training Centre, serve as “emergency toilets” during the night.

**Greywater from dishwashing and kitchen area**

- A new stall for dishwashing was built, which was designed to direct the effluent through a vertical flow organic filter made of rice husks toward a storage tank.
- There were two new shower blocks comprising of 40 shower facilities, washbasins, and laundry facilities that have been constructed to serve people staying at the campus – one behind the hostel building and the other one next to the community training center.
- Greywater collected from the showers and laundry area at the hostel is discharged to elevated greywater gardens for infiltration. Surplus water that did not infiltrate is then collected in a tank and subsequently reused for irrigation purposes particularly during dry periods.

**Sludge drying beds**

- The slurry generated from the biogas plant is transported to a drying bed, composted, and then stored for reuse as soil conditioner.

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21 Blackwater is a mixture of urine, feces, anal cleansing water, and flushing water.
Organic solid waste management

- Kitchen waste is disposed in a landfill; while grass clippings are used to cover the sludge drying beds. These materials can also serve as inputs to the biogas plant.

Institutional and management arrangements

- The Navsarjan Trust, an Indian NGO, is the executing agency for the project.
- Agencies responsible for the technical planning and project implementation are Seecon GmbH (a Swiss consulting firm) and GTZ GmbH, sustainable sanitation – ecosan program.
- Support agencies include the Swiss Agency for Development and Cooperation and the BMZ via GTZ.
- Trained institute staff is responsible for the O&M of the system.

Financing arrangement

Detailed information on costs is currently unavailable.

Project outcomes

- Improved environmental conditions (e.g., reduced odor and groundwater contamination).
- Enhanced agricultural productivity (use of urine and dried sludge for agricultural purposes and reuse of treated water for irrigation).

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Vinasanres Ecosan Toilets Demonstration in Cam Duc Commune
Cam Ranh District, Viet Nam

The Cam Duc commune is comprised of 9,440 residents and 1,831 households. Vulnerability to groundwater pollution is a big problem for the residents. Open wells are the commune’s main source of water supply (52% of the households own a well that is 5–15 m deep). Rainwater harvesting is likewise practiced. However, due to the unhygienic practices by the residents, feces contaminate most of the commune’s water sources. About a third of the households have a “hygienic” toilet (i.e., pour-flush, septic tank or double vault in good condition), while two-thirds have a simple, shallow pit toilet. The rest (approximately 5%) have no toilet facilities at all.

Technology options
- The project offered six different models of Vinasanres toilet that were initially tested in order to determine the storage time needed to make the dried feces safe for reuse as fertilizer in agriculture.
- All of the toilets are urine-diverting types; and all of them use ash to cover freshly deposited fecal matter.

Institutional and management arrangements
- The project has been carried out in cooperation with the Ministry of Health and the Nha Trang Pasteur Institute, with support from the Swedish International Development Cooperation Agency (Sida) through the Sanres program in October 2000.
- Sanres an international research and development program funded by Sida.

Financing arrangement
The cost of a basic Vinasanres toilet is around D1.03 million (approximately $47.40).

Project outcomes
The project was able to improve public health and environmental protection as well as enhance productivity and savings through the use of dried feces and urine for farming activities.

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Reuse of Human Urine in Aquaculture
Kalyani, West Bengal, India

Kalyani is located in the state of West Bengal. It is a well-planned modern town with a centralized sewer system. While fish farming is considered a common source of income in the rural areas, residents of Kalyani also engage in paddy farming, horticulture, and vegetable farming. The local Agricultural University is active in providing technical support for the introduction of innovative farming techniques, with experiments carried out at the International Centre for Ecological Engineering, University of Kalyani.

With the support of the University of Kalyani, the fertilizer potential of commonly used animal manure, which is easily available to farmers at a cheap price, has been evaluated for aquaculture. Encouraged by a published paper on the experimental use of urine for the mass production of zooplankton, the project was extended through financial assistance from Deutsche GTZ. The project, which now includes carp production, is expected to achieve results that would be of high interest among fish farmers interested in a viable substitute for chemical fertilizers to increase fish production.

Technology options
• The study used groundwater stored in 4,500-liter holding tanks. Fish growth in such farm ponds is dependent on the input of macro and micronutrients in the form of either chemical fertilizers or manure. Optimum levels of major nutrients (e.g., phosphate, nitrogen, and carbon) and water quality parameters (e.g., pH, dissolved oxygen, alkalinity, etc.) play a vital role in fish production. It is believed that human urine, which contains all the essential nutrients for phytoplankton production, can be a major player at the base of the grazing food chain for farmed fish.
• Fresh human urine was collected from the urinals used by the male students while fresh cattle dung was procured from a local source. Human urine and other combinations of fertilizers were applied in the tanks every week.
• In all the tests, advanced fry of fish with diverse feeding habits (e.g., catla, rohu, mrigal, bata, tilapia, and freshwater prawn) were stocked together under polyculture. The stocking density was 22 per tank (equivalent to 48,000 per hectare). The urine served as basal manure that upon degradation triggers and sustains phytoplankton production in the grazing food chain of fishes.
The experiment was performed in outdoor tanks using three replications. There were three tanks used for each treatment to observe the effects of fresh and stored urine.

**Institutional and management arrangements**
- The International Centre for Ecological Engineering, University of Kalyani is the executing agency for the project.
- The BMZ extended funding support via GTZ.

**Financing arrangements**
- A very basic cost-benefit analysis was developed based on per tank unit. The costs include fish, labor, and manure and/or urine. The profits were calculated based on the market price of harvested fish from each tank.
- The pilot study showed that the highest profit was earned under isonitrogenous condition, amounting to €0.5 (approximately $0.66) per tank after a total growth period of 4 months. When this figure is calculated on hectare basis, the profit is around €1,200 (approximately $1,584) per hectare for 4 months culture. The second highest profit was achieved by isophosphorus condition (€0.4 per tank = approximately $0.53). There was no difference, however, on net profit between aerated (€0.4 per tank) and urine-fed (€0.4 per tank) treatments.
- If only the input cost of fertilizer is considered, the net profit was 27% higher for the cattle dung treatment (€0.6 per tank = approximately $0.79) than the best net profit found among the urine-fed treatments (€0.4 per tank).

**Project outcomes**
- The project has considerable impact on resource use, economics, and technical operation. However, there is no adequate data to validate the quality of fish raised on a urine-fed system particularly on its impact on health and hygiene.
- By extending this practice to local farmers, it may be possible to raise the income levels of rural people and generate employment opportunities through self-help groups. It may also help in establishing linkages with stakeholders for opening an outlet to sell urine for growing feeds (e.g., zooplankton, algae, etc.) for live food production.

**Lessons learned**
- Addressing social issues relative to the acceptance of human urine as fertilizer is very important. The social structure should be motivated to accept fish grown in urine-fed ponds.
- It is necessary to create an environmental awareness program.
- Further research is required to investigate any pathogenic microbial hazards to human beings and the health impact on fish due to antibiotics, pharmaceutical drugs and other hormonal residues that may be present in human urine.

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22 Approximately €1 = $1.32, as of 2010.
23 Fish feed is calculated based on the following factors: caloric density (isocaloric), protein level (isonitrogenous), and phosphorus level (isophosphorus). http://bit.ly/1HW5yCK
Muscat Wastewater Project
Governate of Muscat, Oman

Muscat is the capital of the Sultanate of Oman. It is where the country’s government is located aside from being considered the center of economic activities and tourism.

With rapid population growth—estimates point out that the 630,000 residents based on the 2003 census is expected to exceed 1 million by 2025—the government recognized the urgency to adequately address the expected sharp increase in demand in wastewater services. This led to the establishment of the Oman Wastewater Services Company (OWSC) to address this challenge.

Technology options
• Expanding the design capacity of the Darsait Wastewater Treatment Plant by 7,500 m³/d.
• Construction of a 25-km trunk line and drainage basin in Muscat.
• Provision of a vacuum sewage collection systems and network covering an area of more than 500 km².

Bausher and the Al-Ansab Plant
• The project involved the installation of a treatment facility at Al-Ansab in the Bausher region with an initial capacity of 53,000 m³/d, which could be later expanded to 80,000 m³/d.
• The MBR technology will be adopted. Envisioned to be the largest of its kind globally, the facility would comprise of a series of submerged units housing a total of 124,000 flat sheet membrane cartridges.
• SCADA and distributed control systems will be utilized in monitoring remote stations and day-to-day operations.
• The sewer network is estimated to be around 300 km in length, with 18,000 service connections installed and pump and lift stations installed strategically.

A’Seeb Wastewater Treatment Plant
• The proposed facility will have a capacity of 80,000 m³/d. It will be implemented in three phases.
• The plant will utilize the SBR process technology and UF membrane system.
• Other infrastructure to be constructed includes pump stations, storage facilities, and an integrated control automation system.
Institutional and management arrangements

• The OWSC is the executing agency of the project. Originally a state company established in 2002, it was eventually privatized in 2010. It is responsible for developing the master plan for Muscat as well as for the overall supervision of the project.
• Veolia served as the operations and performance management contractor.
• Engineering design, construction supervision, architectural works, equipment supply and installation were contracted out to several private companies and consultants.

Financing arrangement

The estimated total project cost is around $1 billion.

Project outcomes

• Around 330 km of sewer pipeline and 70 km of irrigation pipelines have been installed benefitting around 18,000 households.
• Decreased dependence on potable water as reclaimed water is utilized for irrigation purposes.
• It is envisioned that service coverage will reach 90% by 2017, benefitting around 46,000 households.
Qinghe Wastewater Treatment Plant
Beijing, People’s Republic of China

The project was conceived as part of the government’s massive program of infrastructure development in anticipation of the 2008 hosting of the Beijing Olympic Games. It was also the government’s response to address the water shortage experienced in the city due to rapid urbanization and economic growth as well as reduce water pollution in the Qinghe River.

Technology options
- The treatment plant, with a footprint of about 30.1 hectares, is capable of serving around 814,000 residents.
- The plant has an MBR with a capacity of 80,000 m$^3$/d.
- The plant utilizes microfiltration and reverse osmosis technology as well as performs sludge processing.
- ZeeWeed membranes treat secondary effluent from the plant.
- Without having a primary clarifier, wastewater is subjected into two series: inverse anaerobic-anoxic-oxic (A$^2$/O) and A$^2$/O.
- The plant was upgraded through the installation of the Roto-Sieve drum screens, which expanded the MBR capacity to 240,000 m$^3$/d.
- The plant’s disposal capacity is estimated to be around 400,000 m$^3$/d.

Institutional and management arrangements
- The Government of the People’s Republic of China is the executing agency of the project.
- Various suppliers and contractors were engaged particularly in supplying the membranes and drum screens used.

Financing arrangements
The estimated total project cost is around Y717 million (approximately $115 million), Y83 million (approximately $13 million) of which was financed through a loan extended by the Government of Sweden.

Project outcomes
- The project was able to benefit around 814,000 residents.
- Treated water from the plant was utilized for agricultural and industrial use as well as for urban landscaping. Households likewise utilized the reclaimed water for flushing toilets.
- The project improved water quality of the Qinghe River.

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25 Approximately Y6.21 = $1, as of 2015.
References

- Small-scale Sludge Treatment System for Daeum Mien, Kandal Province, Cambodia
  CAPS, KOICA, and UNEP. *Case Study: Small-Scale Sludge Treatment System for Daeum Mien–Kandal Province – A GRET Sanitation Project in Cambodia.*

- Use of Treated Wastewater in Agriculture, Jordan Valley, Jordan

- Co-composting of Fecal Sludge and Organic Solid Waste, Kumasi, Ghana

- Decentralized Wastewater Management at Adarsh College with Biogas Digesters, Badlapur, Maharashtra, India

- Pour-flush Toilets with Biogas Plant at DSK Training Institute, Gujarat, India

- Vinasanres Ecosan Toilets Demonstration in Cam Duc Commune, Cam Ranh District, Viet Nam
  CAPS, KOICA, and UNEP. *Case Study: Vinasanres Ecosan Toilets Demonstration in Cam Duc Commune, Cam Ranh District.*
• Reuse of Human Urine in Aquaculture, Kalyani, West Bengal, India

• Muscat Wastewater Project, Governate of Muscat, Oman

• Qinghe Wastewater Treatment Plant, Beijing, People’s Republic of China
VIII. Environmental sanitation and good governance

The United Nations Economic and Social Commission for Asia and the Pacific defines governance as the process of decision-making and the process by which decisions are implemented (or not implemented). Good governance embodies the framework where institutions and processes are bound together seamlessly for the attainment of a common goal. It provides an environment where: i) pertinent legal and regulatory instruments are put in place and enforced; ii) institutions are identified with clear delineation of responsibilities; iii) processes are structured to promote accountability and transparency; and iv) stakeholders are actively engaged, with linkages among them strengthened.

Good governance thrives on three complementary and mutually reinforcing dimensions:

- **Effectiveness**: pertains to identifying clearly defined sustainable water policy goals and targets in all levels of government and the methods to implement such goals and attain targets;
- **Efficiency**: pertains to maximizing the benefits derived from sustainable water management at the least cost possible; and
- **Trust and engagement**: pertains to building linkages and engagement of stakeholders through democratic legitimacy and fairness.

Needless to say, good governance affects the way basic services are delivered in any particular country or locality. Sanitation, particularly the developmental and promotional aspects of which, is dependent on good governance to ensure that societal, environmental and economic gains derived from proper sanitation are enjoyed by the public as a whole.

The project briefs selected, though derived from different country experiences, illustrate how good governance plays a crucial factor in implementing sanitation programs and projects. The examples are bound by the prominence of a governance framework and participatory approach in ensuring the successful implementation of sanitation interventions in their respective areas.

**Project briefs**

- Ankara Sewerage Project: Turkey
- Kibera Water and Environmental Sanitation Program: Kibera, Nairobi, Kenya
- Medellin River Sanitation Program: Medellin, Colombia
- Low Income Sanitation Technical Assistance Project: Brazil
- Wastewater Reuse in Jordan: Jordan
- Fallujah Sewerage System: Fallujah, Iraq

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Ankara Sewerage Project
Turkey

With the aim of reducing the incidence of deaths attributed to water-borne diseases and sewage-based pollution and to meet the increasing demand on urban water and wastewater facilities, the Turkish government embarked on establishing water and sewerage authorities in 1981. Through these entities, it is envisioned that local sector systems would be developed and operated on a sustainable manner.

This business model was launched in many metropolitan areas such as Istanbul and Izmir and formed as a basis for requesting funding assistance for a sewerage project in Ankara.

Although a vast water distribution network is extensively serving residents of Ankara, only a limited percentage of the population is covered with sewerage systems. Most of the domestic sewage are left untreated and eventually discharged into the Ankara River, posing serious environmental and health concerns among the residents.

Technology options
- The project involved the construction of a sewerage network composed of collector sewers and interceptors and a sewage treatment plant. These activities are complemented by institutional improvements and the mapping out of the Ankara Water and Sewerage Administration's (ASKI) service area.
- The entire project will improve sewerage coverage in the area as well as reduce the incidence of flooding in heavily affected parts of the city.

Institutional and management arrangements
- The executing agency of the project is ASKI. The agency is responsible for procurement of contractors to undertake the detailed engineering and civil works component of the project, establish the Project Coordination Unit, and implement tariffs and undertake billing and collection, among others.
- Operation of the wastewater treatment plant was carried out by BEL-KA, which is an incorporated municipal-owned company.
• Funding assistance is extended by the following institutions: (i) the World Bank through the International Bank for Reconstruction and Development (IBRD); (ii) European Investment Bank (EIB); (iii) Kreditanstalt fur Wiederaufbau (KfW); and (iv) internal cash generated by ASKI.

Financing arrangements

• Total project cost is estimated to be $597.2 million. Project financing is broken down as follows:
  o World Bank: $100.9 million;
  o EIB: $50.4 million;
  o KfW: $160 million; and
  o ASKI internal cash generation: $285.9 million.

Project outcomes

• Construction of around 2,058 km of sewer lines.
• Reconstruction of 2,700 manholes and installation of 40,350 new ones.
• Construction of a wastewater treatment plant with a capacity of 7.5 cubic meter per second (m³/s), capable of servicing 3.9 million inhabitants and producing effluent levels with 30 mg/l of BOD and suspended solids;
• About 4,228 digital maps of the service have been produced.
• Environmental and health risks in the area have been greatly reduced.

Contact for more information

World Bank

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28 Estimated at 1999 price levels.
Kibera Water and Environmental Sanitation Program
Kibera, Nairobi, Kenya

The project site is the peri-urban area of Kibera, which is located around 7 km southwest of Nairobi City center. It has approximately around 500,000 inhabitants and covers a land area of around 235 hectares.

A slum area, Kibera has scarce basic social amenities, with inadequate water supply and sanitation facilities. The potable water supply is deemed unsafe for human consumption. This has resulted in the prevalence of various water and sanitation-related diseases particularly among the children. Solid waste disposal also presents a big problem in the area, contributing heavily to the unhealthy environmental condition in the community.

Technology options
- The program aims to:
  - Provide safe water and environmental sanitation (WES) for three schools in Makina, Stara, and Kisumu Ndogo;
  - Facilitate WES activities in the villages of Makina and Kisumu Ndogo;
  - Engage community groups in environmental management;
  - Implement water quality treatment using solar water disinfection (SODIS)\(^{29}\); and
  - Promote hygiene to stakeholders.
- Specific activities identified in the implementation of the program include:
  - Construction of water and sanitation facilities (e.g., water tanks and ventilated improved pit latrines);
  - Engaging the community through the participatory approach in creating awareness and support in pursuing WES activities;
  - Conduct household training and capacity development activities;

\(^{29}\) SODIS is a water treatment method developed by EAWAG/SANDEC, which involves putting water in transparent pet bottles and placing the same under the sun for at least 6 hours. Ultraviolet radiation and heat from the sun would facilitate the inactivation of pathogens in the water thereby improving its quality.
Promotion of SODIS; and
Conduct of hygiene training (e.g., handwashing) in schools.

Institutional and management arrangements

- The Kenya Water for Health Organization (KWAHO) is the executing agency of the program. A national NGO founded in 1976, KWAHO is active in facilitating the provision of safe water and environmental sanitation in rural areas and urban centers in Kenya.
- CBOs were engaged in the O&M of water supply and sanitation facilities within the communities. They are also responsible implementing the solid waste management system developed under the program.
- Residents participated in the construction of water and sanitation facilities as well as in hygiene promotion and training. They are also responsible for keeping records of all activities carried out during the implementation period.

Financing arrangement

Residents of target communities contributed at least 10% of the total project cost.

Project outcomes

- Benefitted more than 1,500 students in Kibera as well as 19,500 households.
- Improved access to safe water and sanitation.
- Increased knowledge about health and hygiene.
- Improved abilities of CBOs in operating and managing WES activities.

Contact for more information

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Medellin River Sanitation Program

Medellin, Columbia

Located in the northwestern region of Colombia, Medellin is situated in the state of Antioquia and consists of two areas: Metropolitan Area of Medellin (MAM) and the city of Medellin itself.

As a result of rapid population growth and urbanization, the unabated discharge of a large volume of untreated wastewater into the Medellin River became a serious concern. A combination of municipal and industrial wastewater coupled with upstream agricultural activities produce a toxic runoff discharged directly into the river system, threatening the residents of the city with serious environmental and health risks.

Technology options

• The program involved the construction of the San Fernando Wastewater Treatment Plant near the southern end of the Aburra valley where around 10 municipalities comprise the MAM.
• The program proposed to construct a second treatment plant in the Bello district, which is situated at the northern end of the Aburra valley.
• With these facilities and the installation of conveyance structures, it is expected that the city will be able to treat 95% of the wastewater discharged into the Medellin River.

Institutional and management arrangements

• The Empresas Publicas de Medellin (EPM) is the executing agency of the program. EPM is a municipal public utility company that provides potable water, sewer, power, combustible gas distribution, telephone, and garbage disposal services to around 3 million people.
• The Inter-American Development Bank (IDB) provided funding assistance.

Financing arrangements

• The program is proposed to be financed through a loan secured from IDB, broken down as follows:
  • Construction of the San Fernando Wastewater Treatment Plant: $130 million; and
  • Construction of the Bello district wastewater treatment facility: $450 million.
• IDB loan terms include 25-year financing, 6-year grace period, and interest rate based on the London Interbank Offered Rate.

Project outcomes

• Rehabilitation of the river system.
• The quality of life of local communities in the areas has improved.
• Environmental and health risks in the form of waterborne diseases have been reduced.
• Treatment of around 95% of wastewater being discharged into the Medellin River.
• With the cleanup of the river system, municipalities of Bello, Medellin, Copacabana, Girardota, and Barbosa are incentivized to plan and construct riverside parks to attract both residential and commercial developments.
• Riverside real estate values have increased.

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30 Estimated at 2009 price levels.
Low Income Sanitation Technical Assistance Project
Brazil

The challenges facing the water supply and sanitation (WSS) sector in Brazil can be categorized into three areas: (i) weak institutional and regulatory framework; (ii) lack of incentives to extend the service to the poor; and (iii) ineffective water pollution control policies. These factors are seen as major contributors to the less than ideal service coverage particularly for the urban poor.

It is estimated that over 19 million urban poor residents are without access to safe water supply. For the sanitation sector, the situation is much worse, with an estimated 34 million residents without access to adequate sanitation facilities and services.

To address these issues, the government of Brazil has initiated a program called the Programa de Saneamento para Populações em Areas de Baixa Renda (PROSANEAR) in 1995. The program utilized the subsidized credit from the federal employee indemnity fund to jumpstart investments in water supply and sanitation sector services targeting peri-urban areas. The fund source was subsequently replaced with the Program for the Acceleration of Economic Growth’s Saneamento Integrado subsidized lending and grant program.

Technology option
The project was developed to achieve an integrated and demand-driven WSS service delivery involving various participating local government agencies under the framework of the PROSANEAR national low-income sanitation program.

Institutional and management arrangements
- The Government of Brazil through the National Secretariat for Environmental Water Supply and Sanitation is the executing agency of the project.
- Implementing agencies are comprised of various entities from cities and beneficiary municipalities.

Financing arrangements
The total cost of the project is estimated to be $49.3 million. IBRD extended loan financing amounting to $30.3 million; while Brazil’s Federal Government, States and Municipalities contributed $19 million in the form of nonfinancial counterpart.

Project outcomes
From 1999 to 2008, development objectives of the project were measured with the following indicators:

- Number of participating local government agencies adopting and implementing a participatory approach in WSS delivery and undertaking integrated urban planning as part of WSS delivery increased from 0 to 30.
- Number of participating local government agencies establishing a multidisciplinary team in implementing low-income WSS projects increased from 0 to 30.
- Level of awareness and satisfaction among municipal officials, community groups, federal, and state officials regarding the PROSANEAR approach was measured to be at 95% (approval and satisfaction rating).
- A substantial achievement was gained in the beneficiary investment costs of less than $100 for water and $120 for sewerage for the loan supported investment programs.

31 Estimated at 2008 price levels.
Wastewater Reuse in Jordan

Jordan

Situated in Southwest Asia, Jordan covers a territory of about 90,000 km², receiving an annual rainfall of less than 50 mm. The land is mainly an arid landscape, with meager vegetation supported by very limited fresh water resources.

Rapid population growth, inefficient water management, limited wastewater treatment plants and inappropriate pricing mechanisms all contribute to the problem of scarcity of water resources.

The ever increasing demand for water to sustain economic activities has forced the government to look into alternative water sources such as the reuse of treated wastewater, particularly for irrigation purposes.

To integrate the use of reclaimed water resources in national water planning activities, the government, with support from USAID, has aggressively implemented various programs demonstrating the reliability, viability, social acceptability, and environmental sustainability of wastewater reuse. Prominent examples of such programs include the Water Reuse Implementation Project (WRIP) and the Reuse for Industry, Agriculture and Landscaping (RIAL) Project.

Institutional and management arrangements

- The government of Jordan is the executing agency of the project.
- USAID extended funding assistance.
- The Water Reuse and Environment Unit (WREU) was established specifically to develop a master plan, monitor, and manage wastewater reuse projects and activities throughout Jordan.
- The National Water Reuse Coordination Committee (NWRCC) was established to bring together relevant stakeholders, both public and private, to discuss and resolve various issues concerning wastewater reclamation and reuse on a regular basis.

Technology options

- WRIP involved the implementation of three wastewater reuse pilot sites: Aqaba, Wadi Mousa, and Irbid (located at the Jordan University of Science and Technology).
- Using the accomplishments from implementing WRIP, the RIAL project focused on four components: (i) agricultural; (ii) landscape; (iii) industrial reclaimed water reuse; and (iv) institutional capacity building.
  
  Particularly, the project involved further development of the pilot sites earlier identified under the WRIP through wastewater reuse for agriculture and landscaping activities, the introduction and promotion of an Environmental Management System (EMS) framework approach, and intensive partnership building and public participation activities.

Financing arrangement

The total grant assistance extended for the two projects are:

- WRIP – $ 3.5 million; and
- RIAL – $ 7.1 million.
Project outcomes

The project made an impact on three areas: (i) environmental and socioeconomic gains; (ii) institutionalization and capacity building; and (iii) demonstration sites.

Environmental and socioeconomic gains

- Reduction of groundwater exploitation and conformity with safe yields;
- Promotion of desertification control and reduction of soil erosion rate;
- Biodiversity protection;
- Reduction in unemployment and poverty;
- Increase in farmers net income (from $530 to $2,300 for the period 2005-2010);
- Increased productivity of irrigated lands, with less dependence on supplemental irrigation;
- Development of human resources; and
- Enhanced public awareness on the value of environmental protection, health, and safety.

Institutionalization and capacity building

- Establishment of the WREU within the Ministry of Water and Irrigation, Water Authority of Jordan;
- Establishment of the NWRCC;
- Support extended to the Aqaba Special Economic Zone Authority (ASEZA) to establish the Water Resources Management Directorate; and
- Establishment of the Water Reuse Information Office in Aqaba.

Demonstration sites

- Wadi Mousa
  - Safe and effective use of reclaimed water in irrigating high value crops; and
  - Established revolving fund using the funds collected from the sale of crops.
- Jordan University of Science and Technology
  - Promotion of drip system of irrigation utilizing color-coded pipes and a new spraying system which generates larger water drops; and
  - Establishment of the Needy Student Fund wherein the proceeds from the sale of vetch and barley will go.
- ASEZA
  - Provision of technical assistance and on-the-job training in crop selection, water irrigation scheduling, and irrigation network design; and
  - Provision of a business model for replication to other urban areas.
- Greater Amman
  - In conjunction with the municipality of Greater Amman, a program was implemented to promote the safe and effective use of reclaimed water in urban landscaping.
Contact for more information
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Fallujah Sewerage System
Fallujah, Iraq

An estimated 6% of the entire population of Iraq (about 27.5 million) is being served by wastewater treatment plants. The city of Fallujah, located 69 km west of Baghdad, is heavily reliant on individual septic tanks. The absence of regular maintenance activities on the tanks contributed to the problem of raw sewage being discharged directly into streets and storm drains, which then ultimately finds its way into the river system. This presents a severe problem of contamination of the Euphrates River.

The sewerage system project was proposed to rectify the adverse environmental and health risks associated with a contaminated water source as well as to provide jobs to Iraqis residing in areas of high unemployment.

Technology options
- The project proposed a sewerage system that involves installation of around 30,000 meters of sewer lines in the southwest portion of the city. Future expansion is targeted to cover the entire city.
- The proposed wastewater treatment plant has a capacity of 40,000 m$^3$/d capable of serving a population of 140,000. It also has sufficient capacity to accommodate a projected 50% increase in population growth.
- Two large capacity pump stations will be constructed capable of handling 150,000 m$^3$/d of wastewater. These facilities would pump wastewater from five collection points to a trunk collection network.
- The proposed wastewater treatment plant would employ the conventional approach to treatment: screening, biological processing, settlement, and chlorination prior to effluent being discharged into the Euphrates River.

Institutional and management arrangements
- The Government of Iraq, through its Ministry of Public Works, sponsored the project.
- The United States Corp of Engineers manages and oversees the project.
- The city and national officials are responsible for operation and management of the sewerage system.

Financing arrangement\(^{32}\)
The estimated total project cost is around $100 million.

Project outcomes
- The project is expected to provide around 700 jobs to Iraqis.
- The project is expected to benefit around 140,000 residents of the city.
- Environmental and health risks in the area have been greatly reduced.

\(^{32}\) Estimated at 2006 price levels.
References

• Ankara Sewerage Project, Turkey

• Kibera Water and Environmental Sanitation Program, Kibera, Nairobi, Kenya

• Medellin River Sanitation Program, Medellin, Colombia

• Low Income Sanitation Technical Assistance Project, Brazil

• Wastewater Reuse in Jordan, Jordan
  Hayajneh, O. and Majali, J. *Water Reuse in ASEZA.*
UNEP. *Water and Wastewater Reuse; An Environmentally Sound Approach for Sustainable Urban Water Management.*

Wastewater Management Services in Water Stressed Countries: Guiding Principles and Options for Sustainable Development. The 2nd Asian Conference of Water and Wastewater Management, 8–9 May 2001, Tehran, Islamic Republic of Iran.

- **Fallujah Sewerage Systems, Fallujah, Iraq**
  
From Toilets to Rivers
*Experiences, New Opportunities, and Innovative Solutions: Volume 2*

This publication showcases a compilation of project briefs culled from case studies of good practices, new approaches, and working models on sanitation and wastewater management from different countries. The project briefs demonstrate solution options from which useful lessons can be derived. Not only do they illustrate how sanitation and wastewater management challenges can be addressed, the project briefs also aim to inspire replication and show opportunities for actions and investments. Given the more complex water resource and health challenges in many parts of the world, it is time to engage in a rational analysis of all possible management strategies, learn from others’ experiences, apply innovative approaches, and tap potential markets.

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