Technology and Management situation of decentralized domestic wastewater in Vietnam

TRAN Thi Hien Hoa, Dr.,
NGUYEN Viet Anh, Assoc. Prof. Dr.,

Institute of Environmental Science and Engineering (IESE),
National University of Civil Engineering (NUCE)
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• 4. Opportunities and Challenges in decentralized wastewater management
• 5. Recommendations and Conclusions
1. INTRODUCTION

- October 2013: 766 cities and towns, with 30% of total population
- Nov, 1st 2013: 90 million people.
- Fast urbanization process
### Process of urbanization in Vietnam over last 25 years and forecast to 2020

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of urbans</td>
<td>480</td>
<td>500</td>
<td>550</td>
<td>649</td>
<td>689</td>
<td>750</td>
<td>-</td>
<td>760</td>
<td>1000</td>
</tr>
<tr>
<td>Urban population (million)</td>
<td>11.87</td>
<td>13.77</td>
<td>14.94</td>
<td>19.47</td>
<td>22.6</td>
<td>25.4</td>
<td>30.4</td>
<td>29.5</td>
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<tr>
<td>Rate of urban population of the total population</td>
<td>19.3</td>
<td>20.0</td>
<td>20.75</td>
<td>24.18</td>
<td>26.7</td>
<td>29.6</td>
<td>33.0</td>
<td>34</td>
<td>45.0</td>
</tr>
</tbody>
</table>

(Source: Tran Hieu Nhue et.al., 2011)
Urbanization process in Vietnam over last 25 years and forecast to 2020

- Number of urban
- Urban population (million)
- Rate of urban pop. of the total pop. (%)
2. Situation of sanitation in Vietnam

- Combined sewerage system
- 32 cities have executed sewerage and sanitation projects funded by ODA
- Access to toilets: > 90%
- 40 - 70% population have access to sanitation service (sewerage and drainage network)
- Majority of existing sanitation works in urban areas is septic tank: 80%
- Only > 10% of urban wastewater is treated
- 18 WWTPs only treat app. 345,000 m³/d of total 3,080,000 m³/d domestic WW generated
- Diversified technologies
- Difficulties in operation and maintenance (cost recovery, skills, etc)
<table>
<thead>
<tr>
<th>No</th>
<th>Plants</th>
<th>City</th>
<th>Start up Year</th>
<th>Capacity, m3/d</th>
<th>Sewer type</th>
<th>Treatment process/technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>Design</td>
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<tr>
<td>4</td>
<td>Yen So</td>
<td></td>
<td>2012</td>
<td>200,000</td>
<td>120,000</td>
<td>CSS</td>
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<tr>
<td>5</td>
<td>Binh Hung</td>
<td></td>
<td>2009</td>
<td>141,000</td>
<td>141,000</td>
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<td>Binh Hung Hoa</td>
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<tr>
<td>7</td>
<td>Canh Doi (Phu My Hung)</td>
<td></td>
<td>2007</td>
<td>10,000</td>
<td>10,000</td>
<td>SSS</td>
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<td>15,000</td>
<td>SSS</td>
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<tr>
<td>No</td>
<td>Plants</td>
<td>City</td>
<td>Start Year</td>
<td>Capacity, m³/d</td>
<td>Sewer type</td>
<td>Treatment process/technology</td>
</tr>
<tr>
<td>----</td>
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<tr>
<td>9</td>
<td>Son Tra</td>
<td>Da Nang</td>
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<td>10</td>
<td>Hoa Cuong</td>
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<tr>
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<td>Phu Loc</td>
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<td>2006</td>
<td>36,430</td>
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<td>Ngu Hanh Son</td>
<td></td>
<td>2006</td>
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<td>CSS</td>
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<td>13</td>
<td>Bai Chay</td>
<td>Quang Ninh</td>
<td>2007</td>
<td>3,500</td>
<td>CSS</td>
<td>SBR</td>
</tr>
<tr>
<td>14</td>
<td>Ha Khanh</td>
<td></td>
<td>2009</td>
<td>7,000</td>
<td>CSS</td>
<td>SBR</td>
</tr>
<tr>
<td>15</td>
<td>Da lat</td>
<td>Da Lat</td>
<td>2006</td>
<td>7,400</td>
<td>SSS</td>
<td>Imhoff tank + Trick. Filt.</td>
</tr>
<tr>
<td>16</td>
<td>Buon Ma Thuot</td>
<td>BMT</td>
<td>2006</td>
<td>8,125</td>
<td>SSS</td>
<td>Stab. Ponds (AP,FP,MP)</td>
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<tr>
<td>17</td>
<td>Bac Giang</td>
<td>Bac Giang</td>
<td>2010</td>
<td>10,000</td>
<td>CSS</td>
<td>OD</td>
</tr>
<tr>
<td>18</td>
<td>Phan rang</td>
<td>Ninh Thuận</td>
<td>2011</td>
<td>5,000</td>
<td>CSS</td>
<td>Facultative. Ponds + Mat. Ponds</td>
</tr>
</tbody>
</table>
## Sanitation status in Vietnam

<table>
<thead>
<tr>
<th>Areas</th>
<th>Percent, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No toilet</td>
</tr>
<tr>
<td>Rural areas</td>
<td>13.50</td>
</tr>
<tr>
<td>Urban areas</td>
<td>3.78</td>
</tr>
<tr>
<td>Average</td>
<td>11.20</td>
</tr>
</tbody>
</table>
## Sanitation status in Vietnam

<table>
<thead>
<tr>
<th>Grade of city</th>
<th>Ratio using septic tank</th>
<th>Ratio using pit latrines or double vault latrines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large cities (special and grade 1, 2)</td>
<td>50-80%</td>
<td>10-20%</td>
</tr>
<tr>
<td>Small city (grade 3-5)</td>
<td>20-50%</td>
<td>30-50%</td>
</tr>
</tbody>
</table>

- Improvement of sanitation systems for urban, peri-urban and rural areas in Vietnam is very challenging and becoming more and more crucial in this fast-developing country.
Conventional wastewater management

✓ Not affordable
✓ Big investment. Leakage.
✓ Difficult reuse
✓ Limited participation
✓ ...

Decentralized w/w management

✓ More affordable
✓ Less investment and O&M costs
✓ On-site reuse
✓ Encouraging participation
✓ Low-cost technologies
✓ Step-wise approach…
Government policies

– Over the last two decades: about USD 2 bio. for water and sanitation infrastructure improvement.
– More and more stakeholders have started to recognize importance of DEWATS.
– This term is now mentioned more and more as a solution.
– Great efforts are to be acknowledged:
  • projects and activities of DESA group, IESE,
  • projects of GTZ and KfW, other donors,
  • BORDA, etc.
– DESA concept and technologies have been brought into teaching curricula at some Universities.
Government policies (cont.)

- Effluent Standard for not connected to the sewers, and small flows: TCVN 6772:2000 has been developed, later replaced by the National Code QCVN 14:2008/BTNMT.
- Some technical guidelines are being compiled.
- Some thousands of DEWATS systems have been installed for office buildings, public toilets, hotels, factories, hospitals, new communities, trade villages, …
Vietnamese National Code for wastewater effluent quality QCVN 14:2008/BTNMT

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Column A(^{(a)})</th>
<th>Column B(^{(b)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>5 - 9</td>
<td>5 – 9</td>
</tr>
<tr>
<td>2</td>
<td>BOD(_5) (20°C), mg/l</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>TSS, mg/l</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>NH(_4)-N, mg/l</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>NO(_3)^-, mg/l</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>PO(_4^{3-}), mg/l</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Total Coliforms, MPN/100 ml</td>
<td>3,000</td>
<td>5,000</td>
</tr>
</tbody>
</table>

\(^{(a)}\) - Maximum allowable values for wastewater discharged to water bodies serving domestic water supply purpose.

\(^{(b)}\) - Maximum allowable values for wastewater discharged to water bodies serving another purposes (irrigation, water transport, etc.).
3. Technical and Management aspects of decentralized sanitation

3.1. On-site sanitation
• On-site dry sanitation
  – UD eco-san toilet Reuse of urine and compost
  – VIP
• On-site wet sanitation
  – PF toilet + infiltration pit/trench
  – PF toilet + Anaerobic treatment: Biogas digester/Septic tank/Improved septic tank
  – Anaerobic treatment + subsurface filtration (Infiltration trenches, sand filter, constructed wetlands)
Technological options (cont.)

• **Off-site (decentralized/centralized) sanitation**
  – (Anaerobic treatment) + natural wastewater treatment: WSP, CW
  – Conventional treatment processes
  – Combination: Conventional + natural processes
  – Package treatment systems: Anaerobic + Aerobic processes

• **Collection alternatives**
  • Conventional combined collection system with CSO
  • Conventional separate collection system
  • Septic tank + settled sewerage
  • Simplified sewerage

• **Reuse of wastewater and sludge** in irrigation, aquaculture
Hygienic latrine

- Collecting and isolating of human and livestock waste from environment (soil, water, air, insects, …).
- Killing pathogens in the faeces.
- Clean, convenient for users including elder

Enabling for reuse of nutrients from faeces and urine for plantation, soil conditioning
VIP latrines

- Not flush water
- Insects prevention
- Low-cost, easy to build
- When pit is full: close the pit for composting and move toilet to another site
Nutrients in Urine and Faeces

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Urine Percentage</th>
<th>Faeces Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>P</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>K</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>S</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Ca</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>Mg</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Fe</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>
Dry ecosan toilet

- No flushing water.
  Separating faeces and urine
- To add lime or ash
- Diluting urine for irrigation
- 6 – 12 months compost for disinfection before fertilizer
- Low-cost
Pour flush toilet

Siphon for odor control
Pour flush toilet + septic tank
### 3.2. On-site treatment options

Pollutants loading rate and concentration in domestic w/w from household or cluster households

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Loading rate, g/cap.d</th>
<th>Concentration*, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>115-117</td>
<td>680-1.000</td>
</tr>
<tr>
<td>VS</td>
<td>65-85</td>
<td>380-500</td>
</tr>
<tr>
<td>SS</td>
<td>35-50</td>
<td>200-290</td>
</tr>
<tr>
<td>VSS</td>
<td>25-40</td>
<td>150-240</td>
</tr>
<tr>
<td>BOD&lt;sub&gt;5&lt;/sub&gt;</td>
<td>35-50</td>
<td>200-290</td>
</tr>
<tr>
<td>COD</td>
<td>115-125</td>
<td>680-730</td>
</tr>
<tr>
<td>T-N</td>
<td>6-17</td>
<td>35-100</td>
</tr>
<tr>
<td>NH&lt;sub&gt;4&lt;/sub&gt;sup+&lt;sub&gt;-N&lt;/sub&gt;</td>
<td>1-3</td>
<td>6-18</td>
</tr>
<tr>
<td>T-P</td>
<td>3-5</td>
<td>18-29</td>
</tr>
<tr>
<td>PO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;3-&lt;/sup&gt;P</td>
<td>1-4</td>
<td>6-24</td>
</tr>
</tbody>
</table>
Pollutant concentrations of Effluent w/w from septic tank

- BOD5 : 120-140 mg/l
- TS: 50-100 mg/l
- NH$_4^+$-N: 20-50 mg/l
- NO$_3^-$-N: <1 mg/l
- T-N : 25-80 mg/l
- T-P : 10-20 mg/l
Septic tank

Cover

Influent

Effluent

Infiltration well
ST treatment efficiency improvement
Baffled septic tank with anaerobic filter BASTAF
(*IESE – SANDEC, 1998 - 2007*)

ST < BAST < STAF < BASTAF (HRT = 48 h)

50 – 60%  70 – 80%  80 – 85%  80 – 90%  (COD, COD_f, TSS)

- ST – Septic tank
- BAST – baffled septic tank
- STAF – septic tank with anaerobic filter
- BASTAF – baffled septic tank with anaerobic filter.
PRE-FABRICATED WASTE WATER TREATMENT SYSTEMS
AFSB® and BASTAFAT®
### 3.3. Decentralized w/w treatment technologies

<table>
<thead>
<tr>
<th>Location</th>
<th>Technologies applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitals, hotels, apartments, office buildings in the urban centers (a)</td>
<td>Activated sludge process, MBR Tricking filter, RBC Submerged aerated filter A²O Jokashou and other packaged pre-fabricated plants</td>
</tr>
<tr>
<td>Pig farms (a)</td>
<td>Biogas digester</td>
</tr>
<tr>
<td>Vietnam Friendship Village in Xuan Phuong commune, Tu Liem district, Hanoi (2008) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF + HF CW</td>
</tr>
<tr>
<td>Low-income residential area in Vinh Yen town, Vinh Phuc province (2007) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF</td>
</tr>
</tbody>
</table>

- A²O – anaerobic – anoxic – oxic treatment process.
- ABR – anaerobic baffled reactor.
- BASTAF – baffled septic tank with anaerobic filter.
- CSO – combined sewerage with overflow chambers.
- HF CW – horizontal flow constructed wetland

(a) – implemented by different service providers.
(b) – by DESA team, IESE.
(c) – by BORDA Vietnam
<table>
<thead>
<tr>
<th>Location</th>
<th>Technologies applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xuan Mai concrete factory residential quarter, Chuong My district, Hanoi (2007) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF</td>
</tr>
<tr>
<td>Lai Xa village, Kim Chung commune, Hoai Duc district, Hanoi (2006 – 2007) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF + HF CW</td>
</tr>
<tr>
<td>Ta Thanh Oai and Huu Hoa communes, Thanh Tri district, Hanoi (2005) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF</td>
</tr>
<tr>
<td>Tam Da village, Tien Son district, Bac Ninh province (2002) (b)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF</td>
</tr>
</tbody>
</table>

- A²O – anaerobic – anoxic – oxic treatment process.
- ABR – anaerobic baffled reactor.
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### Decentralized w/w treatment technologies

<table>
<thead>
<tr>
<th>Location</th>
<th>Technologies applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater collection and treatment system for Cho Ra town, Bac Kan province&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>Separate low-cost sewerage, BASTAF + HF CW</td>
</tr>
<tr>
<td>Wastewater collection and treatment system for Cho Moi town, Bac Kan province&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>Separate low-cost sewerage, BASTAF + HF CW</td>
</tr>
<tr>
<td>Wastewater collection and treatment system for Nuoc Hai town, Cao Bang province&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>Separate low-cost sewerage, BASTAF + HF CW</td>
</tr>
<tr>
<td>Kim Bang district hospital, Ha Nam province&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td>ABR + HF CW</td>
</tr>
<tr>
<td>Location</td>
<td>Technologies applied</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Thanh Hoa Children hospital, Thanh Hoa province (c)</td>
<td>ABR + HF CW</td>
</tr>
<tr>
<td>Bear care center in Tam Dao Natural park, Vinh Phuc province (c)</td>
<td>ABR + HF CW</td>
</tr>
<tr>
<td>Cluster in Kieu Ky Commune, Gia Lam district, Hanoi city (c)</td>
<td>Combined sewerage and drainage with CSOs, ABR + HF CW</td>
</tr>
<tr>
<td>Cluster in Lim town, Bac Ninh province (a)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF + Facultative pond</td>
</tr>
<tr>
<td>Cluster in flood evacuation cluster, An Giang province (a)</td>
<td>Combined sewerage and drainage with CSOs, BASTAF + Facultative pond</td>
</tr>
</tbody>
</table>
**Type of sewerage and drainage system?**
**Coverage? HH connection?**
**Wastewater fee collection?**
DWWM in peri-urban areas

Lai Xa village, Hoai Duc, Hanoi

Kieu Ky, Hanoi, Gia Lam

VFV, Xuan Phuong, Hanoi

- Type of sewerage and drainage system?
- Coverage? HH connection?
- Investment?
- Wastewater fee collection?
## Features of built systems (BASTAF + CW)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baffled septic tank</th>
<th>Constructed wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment performance</td>
<td>Removal efficiency: COD = 72–90%; BOD = 72–83%; SS = 78–94%; TP = 33%; TKN = 47%</td>
<td>Removal efficiency: COD = 80–90%; BOD = 75–85%; SS = 80–95%; TN = 40–60% Effluent quality: BOD &lt; 30 mg/L</td>
</tr>
<tr>
<td>Unit configurations</td>
<td>1 sedimentation chamber (50% of total volume) and 2–3 up-flow chambers; HRT = 48 hours (0.2 – 0.3 m³ per person) Critical up-flow velocity = 0.5–0.7 m/h</td>
<td>Series of vertical-flow units, horizontal-flow units, free-water surface units; 2 vertical-flow units Sizing: 14.5 m²/m³/day or 0.35 PE/m² HRT = 4 days Pre-treatment is required</td>
</tr>
<tr>
<td>Construction costs</td>
<td>150–200 USD/m³ of wastewater</td>
<td>(land price not included)</td>
</tr>
<tr>
<td>Operation and maintenance</td>
<td>Desludging frequency: 2–3 years Reactor start-up period: 90 days Critical hydraulic peak-flow factor = 4</td>
<td>Regular harvesting of wetland plants Removal of oil and grease on the CW surface Cleansing of CW unit surface</td>
</tr>
</tbody>
</table>

(Morel et al, 2007)
3.4. Sludge management
Sludge treatment
SLUDGE TREATMENT & DISPOSAL

Raw sludge

Stabilization by chemicals and disinfection

Anaerobic composting

Aerobic composting

Biogas

Dewatering

Fertilizer

Drying

Burning

For agriculture

Landfill

Input
4. Opportunities and Challenges in decentralized wastewater management

Financing mechanisms for sanitation projects

- Work order for O&M: paid by city’s budget. Part of it: collected w/w fees
- Urban w/w fee: 10% surcharge to water bill. Hai Phong city: 15%. Other cities are preparing to increase.
- For not connected households: environmental fee (10%). (Decree No. 67/2003 to be revised)
- Industrial w/w charges: Decree No. 67/2003, followed by Decree No. 04/2007 (kg of COD, BOD, SS, heavy metals discharged)
Major challenges in sanitation projects

- Lack of knowledge of decentralised options
- Quality of design and construction, associated with
  - consultants’ competency,
  - administrative appraisal procedures,
- Low rate of household connection,
- Capacity building component during project implementation is poor,
- Financial sustainability,
- Problems in O&M, M&E
- Shortage of qualified work force and skills for O&M.
- Out-sourcing services are often not available or not affordable in the area.
- Others.
• **Technical aspects**
  – There are still very few decentralized technical options developed and applied.
  – **Systematic review** has not been conducted:
    • DEWATS system performance, public acceptance, etc.
    • Balancing of investment, and O&M costs, including required space, manpower, energy and chemicals.
  – After AD (mostly under-ground), polishing step (large space) is required.
    • Alternative options: Packaged system BASTAFAT, Jokashou, etc.
• **Technical aspects** (cont.)
  
  – Collection of wastewater: little national and international experience in combined drains + septic tanks.
  
  – Design guidelines are still lacking.
  
  – Most of urban sanitation projects: neglect tertiary network.
  
  – Most of rural sanitation projects: focus on on-site sanitation facilities.
  
  – Environmental sanitation and infrastructure planning of the community is lacking.
  
  – Environmental industry is still very weak. Lack of firms’ capacity for R&D, marketing strategy, etc.
  
  – Import of hi-tech products with “heavy armed” marketing campaigns are contributing to weaken this young industry.
• Financial aspects
  – Wastewater fees is still very low in urban areas, and zero in rural areas (Decree 88...)
  – Private sector is till not interested in this business.
    • No recovery for O&M and system upgrading
    • Lack of financial sustainability after construction works.

• Social aspects
  – Traditional acceptance of untreated wastewater disposal by most of people.
  – Wastewater reuse attitudes of the public and policy makers hinder the adoption of wastewater treatment and safe reuse systems.
  – The main challenge is to create informed demand for improved sanitation.
5. Conclusions and Recommendations

- Sanitation improvement should start from household
- Ecosan concept
- Technical aspects
- Wastewater management regulations
- Sustainable sanitation model
Sanitation has to be started from the household!

- In-door sanitation
  - Cluster sanitation
    - Centralized sanitation facilities
      - Discharge/Reuse
• **Technical aspects**
  
  – Combination of different options
  
  – Cost-benefit analysis of different sanitation options should be developed.
  
  – We need information of unit costs of different sanitation options, in different local contexts
Other issues to be considered

• **Sludge management** (centralized or decentralized. Resource recovery options).

• A special **National policy on DWWM** is needed in order to fill the gap of sanitation coverage besides Centralized WWM.

• Together with: Codes, Standards, Technical Guidelines, **local w/w management regulations**. Enabling Environmental Industry’s development.

• **For sustainability:**
  – Household connection regulation.
  – O&M activities
  – Organization structure, management and financial models.

• **DWWM in special environments:** flooding, rocky soil, low density, etc.
• Sustainable Sanitation Model
Thank you very much for your kind attentions!