Brief to support citywide FSM assessment methodology for FSM Toolbox

Notes for Discussion

Prepared by:

Consortium for DEWATS Dissemination Society

Consortium for DEWATS Dissemination Society
Survey No. 205, Ground Floor
Opp. Beedi Workers Colony, Kommaghatta Rd.
Bandemath, Kengeri Satellite Town
Bangalore 560 060
INDIA
T/F: +91 80 28486700
+91 80 28482144
E: bangalore@cddindia.org
www.cddindia.org

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Consortium for DEWATS Dissemination Society
Survey No. 205, Ground Floor
Opp. Beedi Workers Colony, Kommaghatta Rd.
Bandemath, Kengeri Satellite Town
Bangalore 560 060
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+91 80 28482144
E: bangalore@cddindia.org
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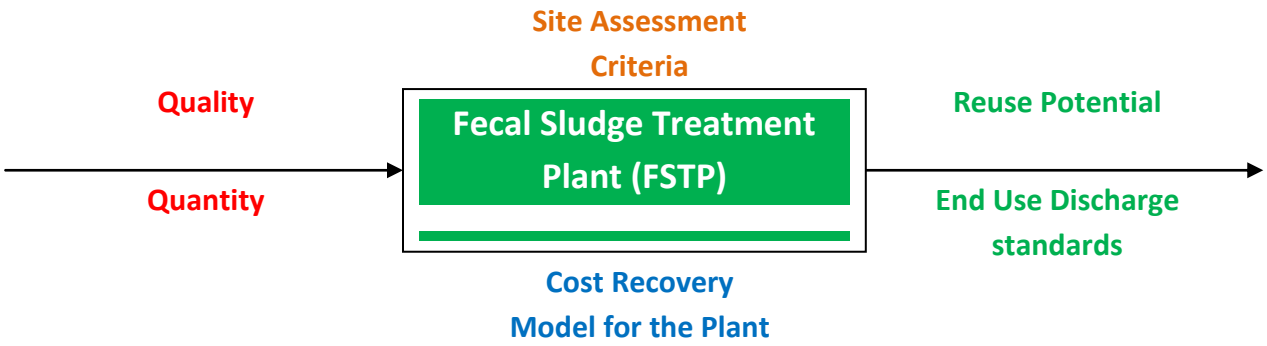
Framework for developing a Treatment Concept



The above framework is a minimalist schematic to act as a decision support framework for deciding on FSTP technology assessment.

Each attribute mentioned here (i.e. Quantity, Quality, Reuse Potential, End Use Discharge standards, Site Assessment Criteria, Cost Recovery Model for the Plant) have been explained in a fair amount of detail within this brief report.

Prior to understanding these attributes in detail, it is necessary to understand the two major premises that drive the selection of technology of an FSTP:

1. Technology is determined by the kind of reuse and its potential for the treated products of wastewater and fecal sludge (FS).
2. The other factor determining technology selection is the level of discharge standards the treated wastewater/fecal sludge should meet.

Apart from the above, nuanced decisions also need to select modules for each stage of fecals sludge/wastewater treatment, i.e., for:

- Solid-liquid separation,
- Stabilization,
- Dewatering/drying and
- Pathogen reduction.

For the same, refer figure 1 to get a sense of the technology modules that can be used for each of these stages of treatment.

The criteria (Tilley, Ulrich, Luthi, Reymond, & Zurbrugg, 2014) for deciding the favorability of a technology option in a specific context depends on various determinants:

1. To address treatment objectives (CAWST and Eawag-Sandec, 2016) of
    - Pathogen Inactivation
    - Dewatering

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   - Stabilization/Nutrient Management
2. To meet performance objectives
   - TS>20-30 %
   - Hygienic quality of solids
   - Quality of liquid effluent
3. Simplicity & Reliability of the technology option
   - Minimal O+M requirements
   - Basic Skills required for operation and supervision
   - Possibility of failure
4. Costs
   - Minimal Land requirement
   - Minimal Investment costs
   - Minimal Operation and maintenance cost

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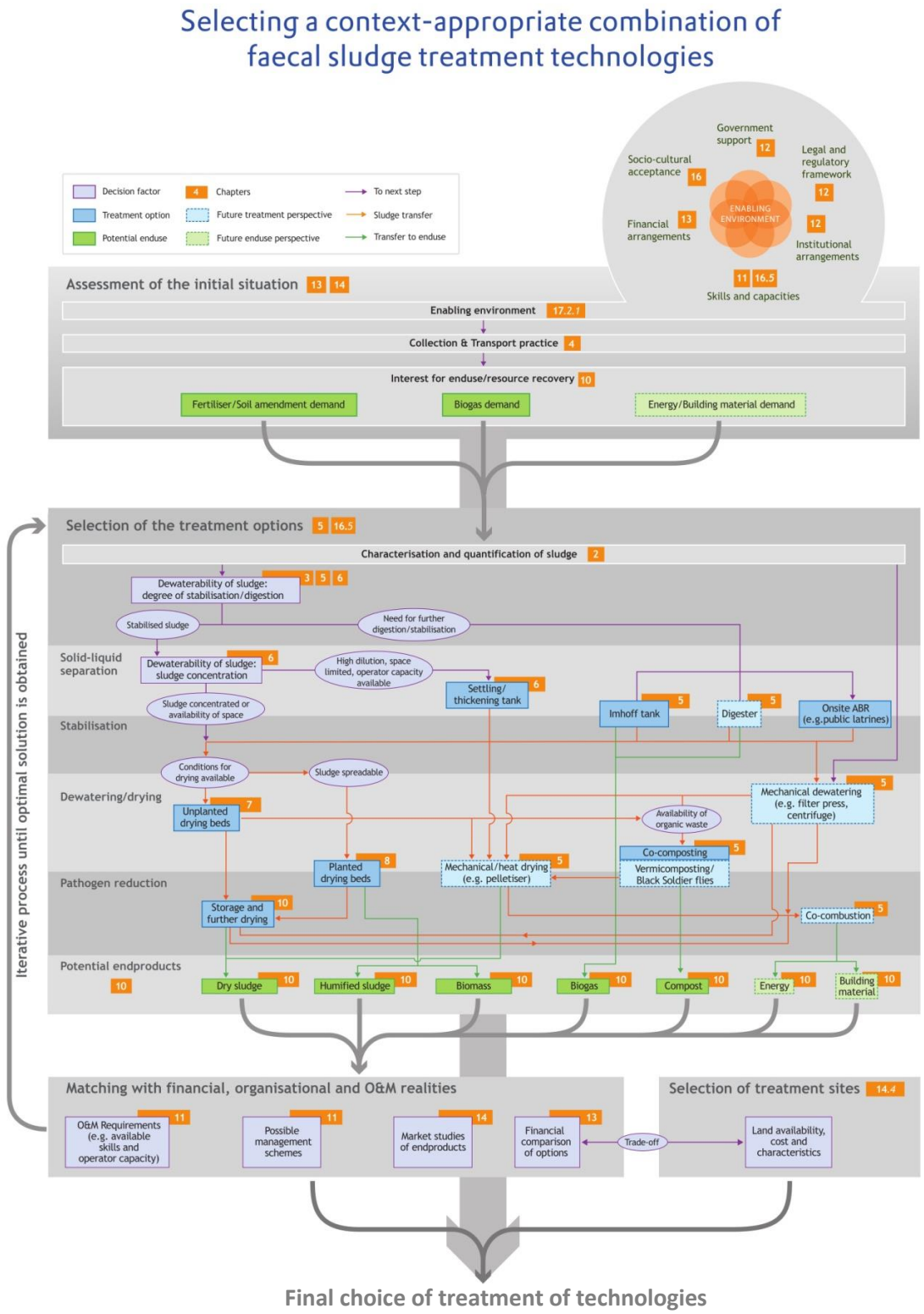

Figure 1: Selecting a context appropriate combination of faecal sludge treatment technologies (Strande, Ronteltap, & Brdjanovic, 2014)

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Approach for estimating Quantity

1. **Population Method:** FS generation can be quantified based on the total population in the service area and total sludge production per person in LPCD. The following rules of thumb – as suggested by the CPHEEO (Central Public Health Environmental Engineering Organization) can be adopted to calculate the overall FS generated:
   - 0.00021 m^3 per person day (Septic Tank)
   - 67 liters per person per annum (For Pits)

   Considering the incumbent STs and Pits, the ones to be installed and the new units to be built for the future, the generation rate should be multiplied to arrive to the sludge generated in the town/city. The indicators looked at are:
      - Avg. number of persons per household
      - Population
      - Number of septic tanks
      - Number of pits
      - Households without containment units
      - Household without toilets
      - Floating population – person days
   - **Advantages**
      - Quick and documented estimation of FS
      - Easy buy in on numbers
      - No cost estimation
   - **Disadvantages**
      - Is a theoretical approach
      - Only considers the sludge accumulation and not entire emptying volume
      - Does not consider different varieties of OSS and site conditions
2. **Collection Method:** Here, the average containment unit size is used to ascertain the total sludge generated in the town. For this, data is collected regarding containment units from across household and non residential surveys (institutions, public and community toilets). Under this method, the data on containment type, volume, desludging frequency and type of desludging and access is collected. The process can cost anywhere between Rs. 2,00,000 to Rs. 3,00,000 for data collection and requires 25 – 30 person days. The indicators looked at are:
      - Desludging frequency
      - Number of (surveyed) households
      - Average volume in m^3
      - Volume desludged per annum
   - **Advantages**
      - Estimations based on contexts
      - Surveys brings a lot more information for FSM – Access, method of desludging, desludging incentives, etc.

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INDIA

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- **Disadvantages**
  - Future estimation based on current patterns
  - Data collection to be robust and requires skill
  - Expensive and time consuming
  - Cannot incorporate impacts of FSM

Transportation method: In the Indian context, this is the most reliable and practical method to ascertain the sludge quantity. Herein, the attempt is to measure the sludge getting disposed as opposed to the sludge getting generated in the town. This is done by:

- Survey of desludging operators
- Snowballing of respondents
- Determine – Volume of sludge hauled in a day (cross check with trips per month)
- Insights on disposal practice, faecal sludge characteristics, type of containment units and access areas

The indicators looked at are:

  - No of trucks undertaking trips
  - No of trips undertaken by the trucks
  - Quantity of sludge conveyed by these trucks
- **Advantages**
  - Realistic assessment of sludge volumes
  - Parallel insights and low cost
- **Disadvantages**
  - Can't measure impact of FSM in future or of new trucks
  - Difficult in bigger cities to determine number of operators
  - Difficulty in getting correct information

Approach adopted: is generally by means of triangualting between the sludge quantity numbers caluclated through all three methods.

Approach for measuring Quality parameters

The following parameters have to be traditionally studied to understand the level of pollution in the wastewater to determine the level of treatment required:

  - pH
  - Conductivity
  - Turbidity
  - COD
  - BOD at 27^{o}c

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- Total suspended solids
- Nitrate
- Nitrite
- Ammonical Nitrogen
- Phosphates (as PO4)

For determining the desired sludge quality post treatment, the following indicators need to be measured and studied:

- Moisture (% by weight)
- Particle size(in mm)
- Bulk Density (g/cm^3)
- Total organic carbon (% by weight)
- Total Nitrogen as N (% by weight)
- Total Phosphates as P_2O_5 (% by weight)
- Total Potash as K_2O (% by weight)
- C:N Ratio
- Arsenic as As_2O_3 (mg/kg)
- Cadmium as Cd (mg/kg)
- Chromium as C (mg/kg)
- Copper as Cu (mg/kg)
- Mercury as Hg (mg/kg)
- Nickel as Ni (mg/kg)
- Lead as Pb (mg/kg)
- Zinc as Zn (mg/kg)
- Iron as Fe (in %)
- Manganese as Mn (mg/kg)
- Calcium as Ca (in %)
- Magnesium as Mg (in %)
- Sulphur as S (% by weight)
- Nitrate Nitrogen as N (% by weight)
- Faecal Coliform (per g)
- Escherichia coli (per g)

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Site Assessment Criteria

Site identifying criteria[1] for FSTP facility (or for co-treatment facilities):

1. Immediate habitation: preferably a 200 m margin
2. Water bodies: preferably a 200 m margin
3. Wetland: No land fill permitted
4. Flood prone areas: No landfill permitted
5. Airport: 20 km buffer margin
6. Heritage site: 10 km buffer margin
7. Groundwater table: 3 m

In addition to the above, the following general criteria for land are also assessed:

- The distance between the centre area of each ward and the selected land for FSTP (this will help us determine the vacuum truck operational cost)
- Areas with limited access of vacuum trucks on Municipality map
- Budget available (if any) with the Municipality for setting up of FSTP
- Political commitment of the Municipality to demonstrate an FSTP
- Site selected for FSTP and SWM on Municipality map (GPS location from your phone)
- Existing infrastructure for collection and conveyance

[1] The site selection criterion for the FSTP facility is prepared based on experiences of CDD Society from other projects on fecal sludge management. This criteria is defined by agencies such as the World Bank and Asian Development Bank to administer environmental clearance for selection of FSTP sites

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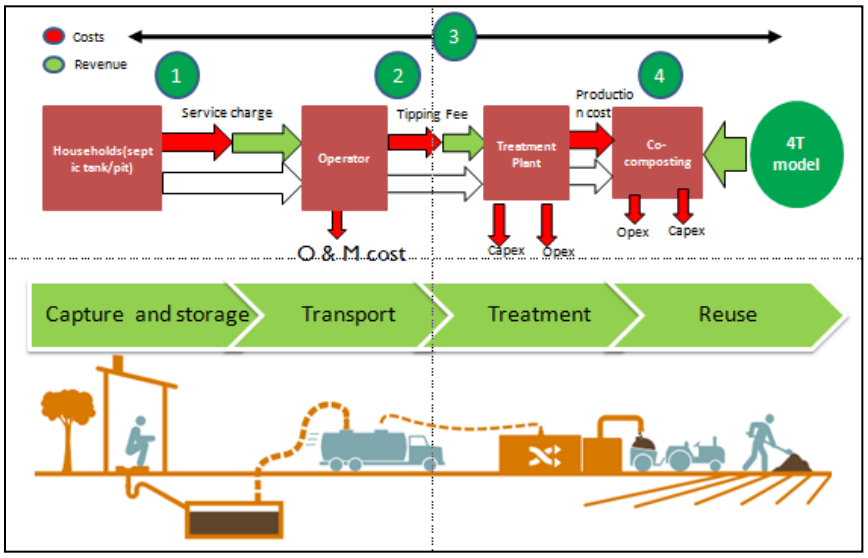
Cost Recovery Model for the Plant



Note: The illustration in the left image shows the schematic of costs and revenues exchanged across an FSM value chain. This potential revenue model (proposed by CDD Society) is referred to as a 4T model, wherein finances are generated by all the following means:

- Trade
- Tariffs
- Transfers
- Taxes

Figure 2: Cost revenue schematic for a fecal sludge management system

1. Taxes: Citizens pay taxes such that the cost for rendering the desludging service is met. This could be via levying a special tax at household level/make additions to existing property tax etc. Alternatively, citizens could also pay a fee to operators in which case, care must be taken on not double taxing the citizen.
2. Tariffs: Tariffs are when fees are charged for using the treatment plant. This could be in the form of tipping fees for operators and even fees for external visitors.
3. Transfers: This is when special state/central government subsidies or funds are availed for putting an FSM system in place.
4. Trade: Trade happens during sale of treated wastewater/sludge to potential customers. For example, the sale of dry sludge as manure, and the use of wastewater for irrigation. FSTP by products

The following financial models illustrate the various ways in which institutions can own the operations and financial exchanges can be conducted. For more details, refer the FSM Book by IWA (Strande, Ronteltap, & Brdjanovic, 2014).

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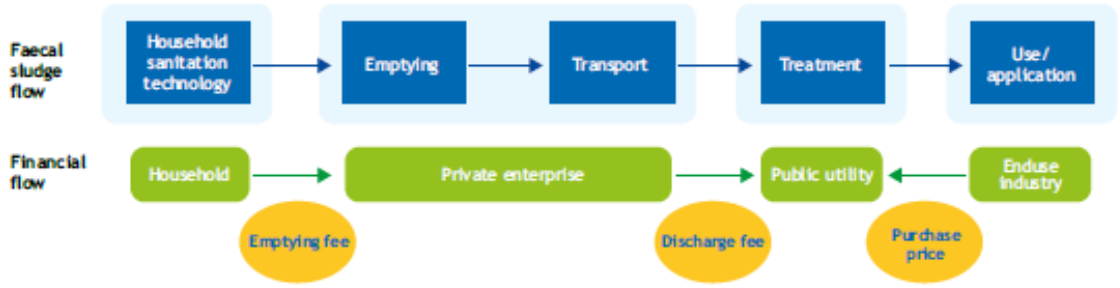

Figure 3: Model 1 - A Discrete FSM Model

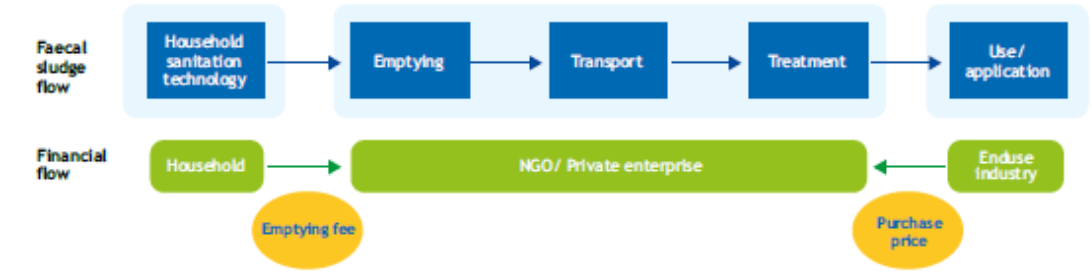

Figure 4: Model 2 - Integrated collection, transport and treatment by private agency model

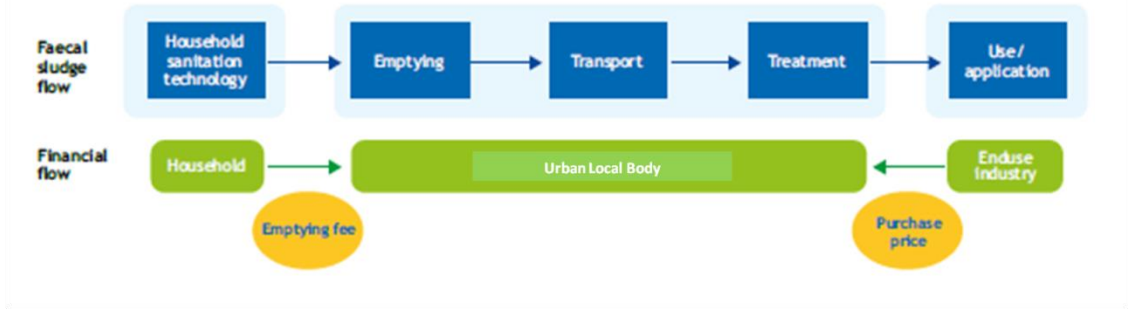

Figure 5: Model 3 - Integrated collection, transport and treatment by ULB model

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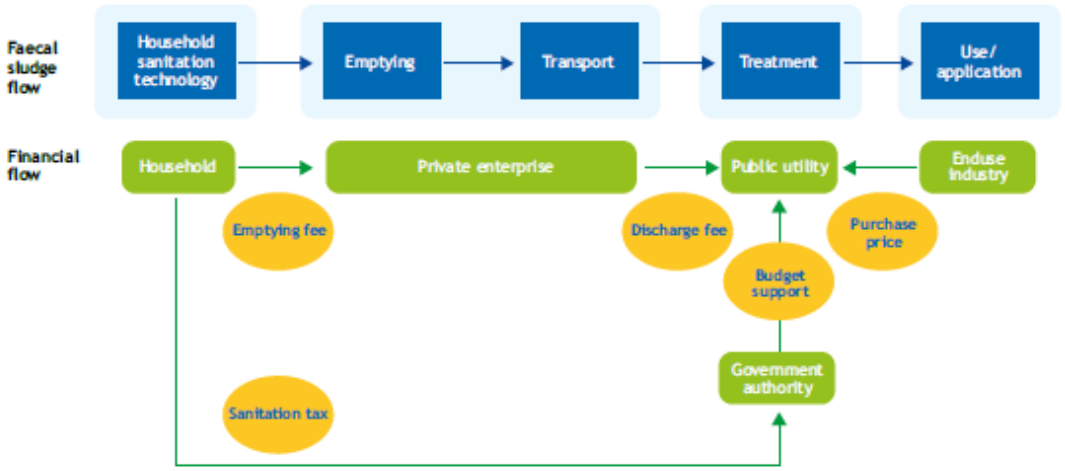

Figure 6: Model 3 - Discharge Fee and Sanitation Tax Model

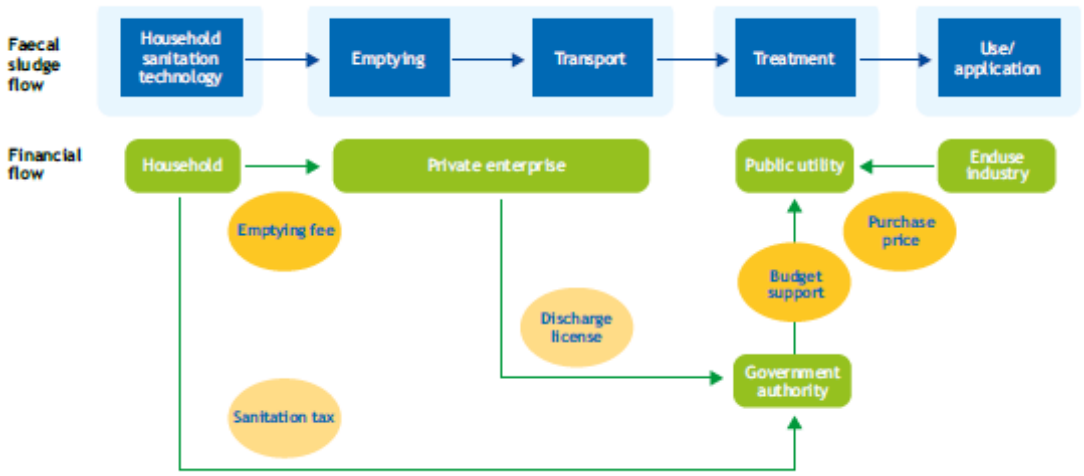

Figure 7: Model 4 - Discharge License Model

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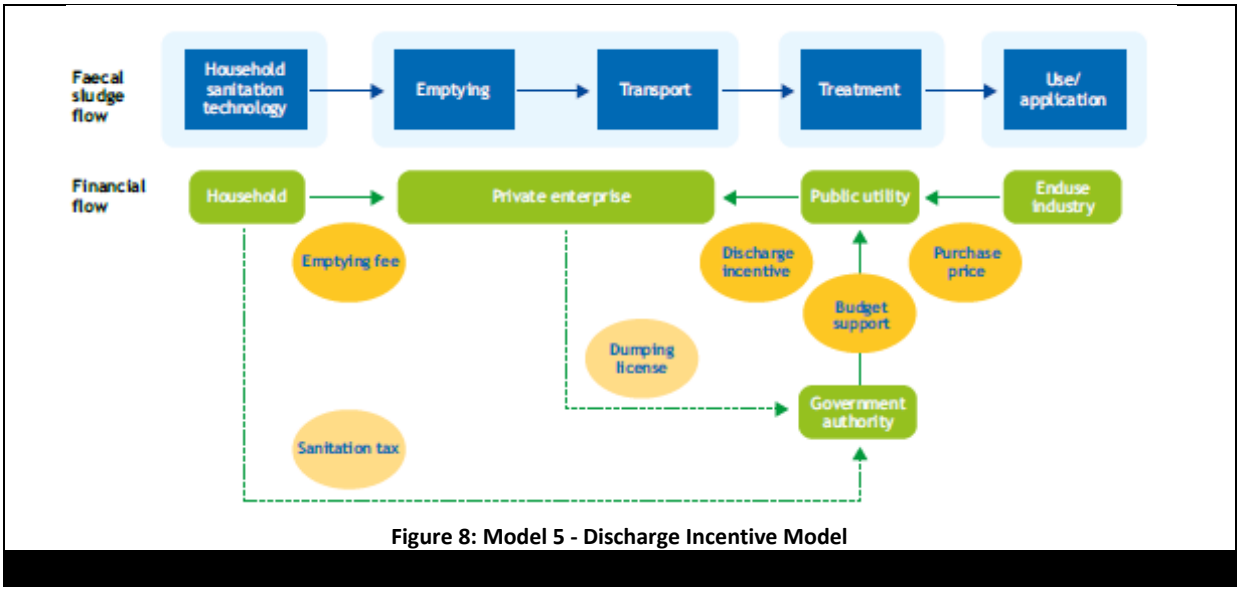

Figure 8: Model 5 - Discharge Incentive Model

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