



Assessing appropriate wastewater treatment options Technology Matrix for Wastewater

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Background

Some quick facts...

- **2.5 billion** people live **without good sanitation**
- **80%** of users of improved sanitation **live in rural areas**
- In Sub-Saharan Africa, treating **diarrhoea consumes 12% of the health budget**
- Conventional systems are neither an ecological nor an economical solution for sanitation problems
- To supply rural areas with adequate sanitation facilities, **sustainable solutions modelled on decentralised systems** are required.



Some quick facts...

- **Rate of return** for sanitation investments estimated to be **more than US\$5 for every US\$1 spent** (WHO 2012, World Bank 2013)
- Evidence shows that the benefits include improvements in:
 - Public health
 - The natural environment
 - Education
 - Economic development
 - Social outcomes
 - Gender equality
 - Poverty alleviation



Wastewater challenges

The main root causes include:

- Poor sewage systems
- Runoff from small scale mining operations
- Urban storm water
- Run off from agricultural activities
- Lack of knowledge on selection of appropriate technology
- Inadequate legal and regulatory framework
- Uncoordinated approach to coastal management
- Variation in institutional arrangements
- Low Stakeholder Involvement in wastewater management



Some of the solutions

- Adopting pertinent and **flexible policy** and **institutional frameworks** for close interaction between various players
- **Updating data** on wastewater management strategies
- **Strengthening** regional and global **networks** (e.g. on marine environment conservation)
- Creation of **platforms** through which appropriate blending of **knowledge systems** and requirements can occur
- Furthering **capacity building, knowledge** and **awareness creation** on matters relating to marine environment degradation as well as its conservation
- Technological developments & innovation (Example - Technology Matrix for Wastewater)

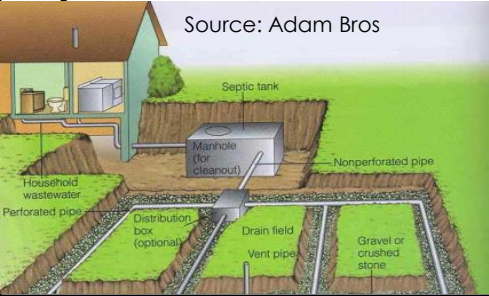
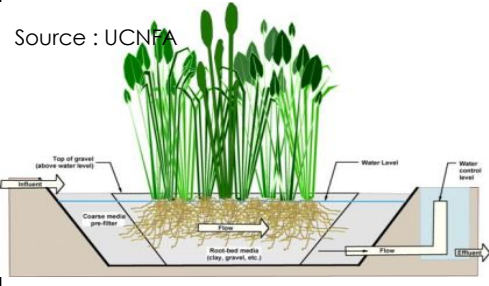
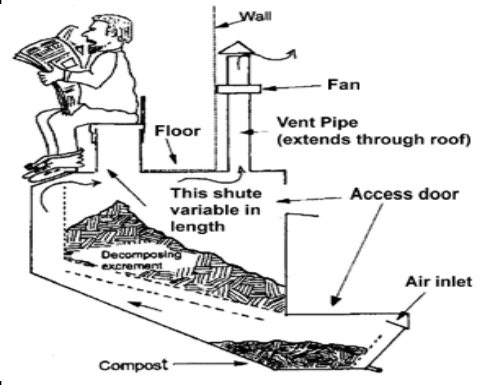
Wastewater treatment technologies


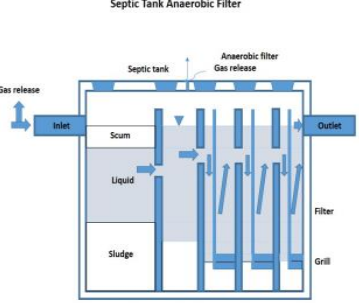

Decentralised Technologies on Wastewater Management

- Septic Tanks
- Constructed Wetlands
- Stabilisation Ponds
- Composting Toilets
- Biodigester
- Anaerobic Filter
- Duckweed Lagoons



Source : Cameron Webb

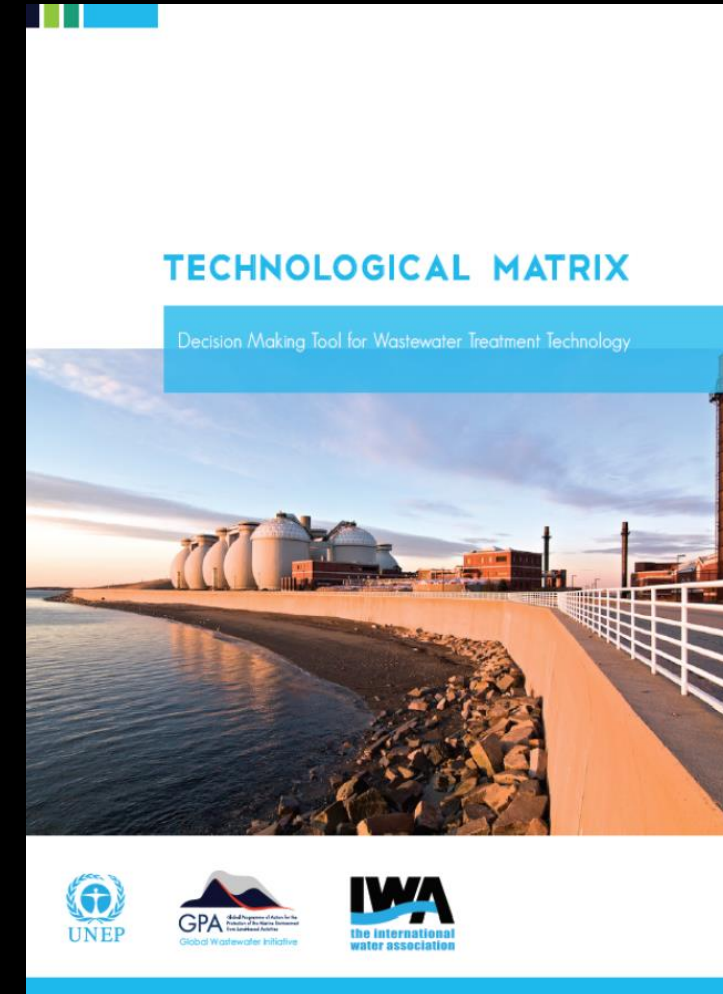
Type	Kind of treatment	Kind of wastewater treated	Advantages	Disadvantages	Nutrients removal
<p>Septic Tank</p> <p>Source: Adam Bros</p> 	<p>sedimentation, flotation and digestion</p>	<p>Domestic wastewater (communities until 100 inhabitants)</p>	<p>Simple, durable, easy maintenance, small area required</p>	<p>Low treatment efficiency, necessity of a secondary treatment, effluent not odorless</p>	<p>COD, BOD, TSS; grease.</p>
<p>Subsurface Flow Constructed Wetlands</p> <p>Source : UCNFA</p> 	<p>biological and physical processes</p>	<p>Domestic and agricultural wastewaters; small communities; tertiary treatment for industries.</p>	<p>Low or no energy requirements; Provide aesthetic, commercial and habitat value.</p>	<p>system clogging; recommended as a secondary treatment, large areas required;</p>	<p>TSS; COD; TN; TP.</p>
<p>Composting Toilets</p> 	<p>unsaturated and aerobic conditions provide biological and physical decomposition</p>	<p>human excreta, toilet paper, carbon additive, food waste</p>	<p>Resulting "humus" used as a resource; conservation of water resources; recycling of nutrients.</p>	<p>If not well sized and maintained can be an environmental problem and a threat for human being, due to its contaminant potential</p>	<p>Volume reduced from 10 to 30%; pathogens.</p>

Type	Kind of treatment	Kind of wastewater treated	Advantages	Disadvantages	Nutrients removal
<p>Biogas Digester</p>  <p>The Bio-Gas Digester:</p>	Sedimentation, flotation and digestion	human excreta, animal and agricultural wastes	Recycling of resource; gas produced is used for cooking and lighting	Expensive to build, difficult to operate. Poor maintenance leads to loss of gas production and blockage of the digester tank with solids.	long period of storage removes pathogens.
<p>Anaerobic Filter</p>  <p>Septic Tank Anaerobic Filter</p>	anaerobic degradation of suspended and dissolved solids	pre-settled domestic and Industrial wastewater of Narrow COD/BOD ratio	simple and fairly durable if well constructed and wastewater has been properly pre-treated, high treatment efficiency, little permanent space required	costly in construction because of special filter material, blockage of filter possible, effluent smells slightly despite high treatment efficiency	BOD, TDS, TSS
<p>Duckweed Based Wastewater Stabilizations Ponds</p> 	sedimentation, anaerobic degradation and sludge stabilization	Domestic and agricultural wastewater;	No clogging risk; High nutrient removal rates	Necessity of large areas; necessity of constant harvesting; unsuitable in very windy regions.	BOD, SS, TN, TP, metals

Technological Matrix for Wastewater

Technological Matrix for Wastewater

- Decision making tool selecting appropriate wastewater systems in urban areas.
- **Developed for non-technical people**; no or little knowledge on wastewater or sanitation
- Assist in decision making to **FIRST consider the entire spectrum** of wastewater solutions based on suitability criteria



Technological Matrix for Wastewater

- Based on Compendium of Sanitation Systems and Technologies (Tilley et al., 2014) by Eawag, IWA and WSSCC (Water Supply and Sanitation Collaborative Council).
- Allows the user to provide both local conditions and priorities to serve as basis for **ranking the different relevant technology systems**
- An efficient and user-friendly **'filtering process'**
 - Multi-criteria analysis that takes environmental, social and economic aspects into account



Why this tool?

- **Contains factsheets** for each of the technologies mentioned
- **Narrows down the options** hence allows efficient decision making
- **Performs multi-criteria analysis (MCA)** on different sanitation technologies

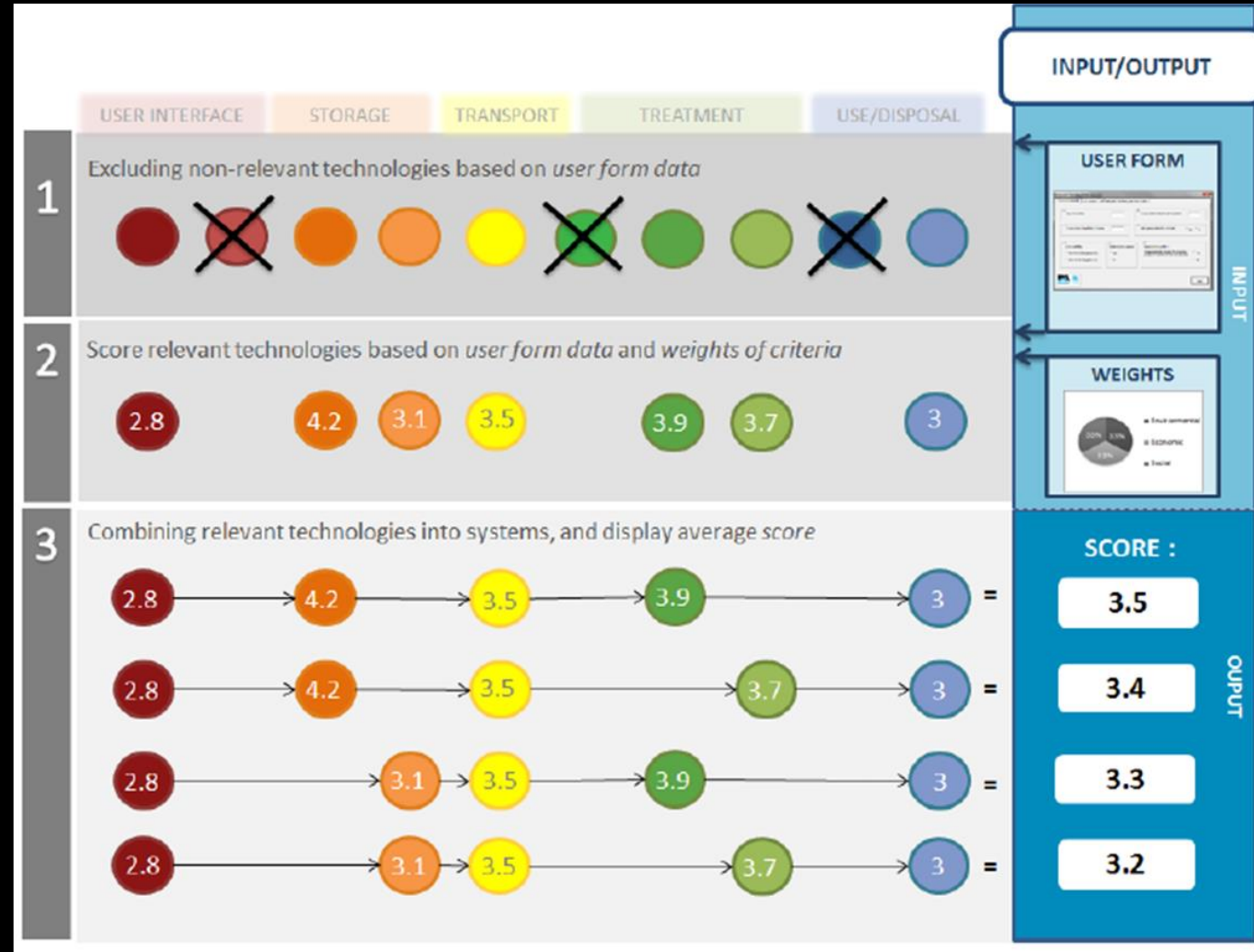
(MCA- Methods to compare all alternative options and to identify the best performing one on the basis of multiple factors)

The screenshot shows a software interface for comparing sanitation systems. It features a table with columns for functional groups (User Interface, Storage, Transport, Treatment, Reuse/Disposal), a main score, and three partial scores (Environmental, Economic, Social). The scores are color-coded from green (5) to red (1). A legend at the bottom indicates that the color-coded column ranges from 5 (green) to 1 (red).

SANITATION SYSTEMS	FUNCTIONAL GROUPS					SCORE			
	USER INTERFACE	STORAGE	TRANSPORT	TREATMENT	REUSE/DISPOSAL	MAIN SCORE	PARTIAL SCORES		
							Environ.	Economic	Social
1 U.4 Pour Flush	S.9 Septic Tank				D.X2 Disposal	4.1	2.0	4.0	3.3
2 U.4 Pour Flush		C.2 Human p. E&T	T.14 Unpl. Dry.		D.X2 Disposal				
		C.4 Simp. Sewer			D.X2 Disposal	4.0	3.0	3.6	3.5
3 U.5 Cistern Flush					D.X2 Disposal				
4 U.4 Pour Flush	S.12 Biogas Rc.		T.14 Unpl. Dry.		D.X2 Disposal	3.9	3.0	3.4	3.7
5 U.5 Cistern Flush				D.13 Biogas					
6 U.4 Pour Flush		C.4 Simp. Sewer	T.2 Imhoff tank		D.X2 Disposal	3.8	4.4	3.5	3.5
7 U.4 Pour Flush	S.9 Septic Tank		T.14 Unpl. Dry.		D.X2 Disposal	3.8	2.6	3.4	3.6
8 U.4 Pour Flush	S.12 Biogas Rc.				D.X1 Application	3.4	2.0	4.0	3.3
9 U.5 Cistern Flush		C.4 Simp. Sewer	T.3 ABR		D.13 Biogas	2.8	4.4	3.5	3.5
10 U.5 Cistern Flush		C.4 Simp. Sewer	T.14 Unpl. Dry.		D.X1 Application	2.8	3.0	3.6	3.5
11 U.1 Dry toilet	S.4 Double VIP		T.3 ABR		D.X1 Application	2.8	3.0	3.4	3.7
12 U.4 Pour Flush	S.9 Septic Tank		T.2 Imhoff tank		D.X1 Application	2.7	2.6	3.4	3.6
		C.2 Human p. E&T	T.14 Unpl. Dry.		D.X1 Application	0.0	0.0	0.0	0.0
					D.X2 Disposal	0.0	0.0	0.0	0.0

Overview of processes...how does it work?

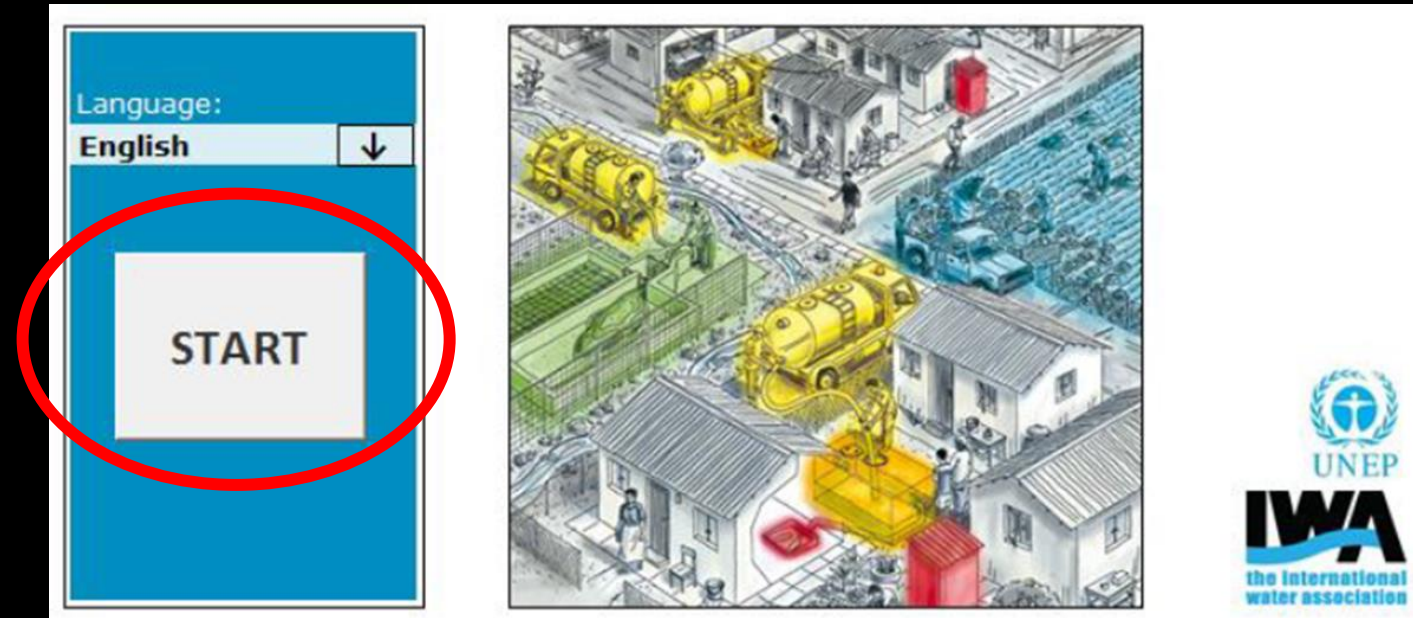
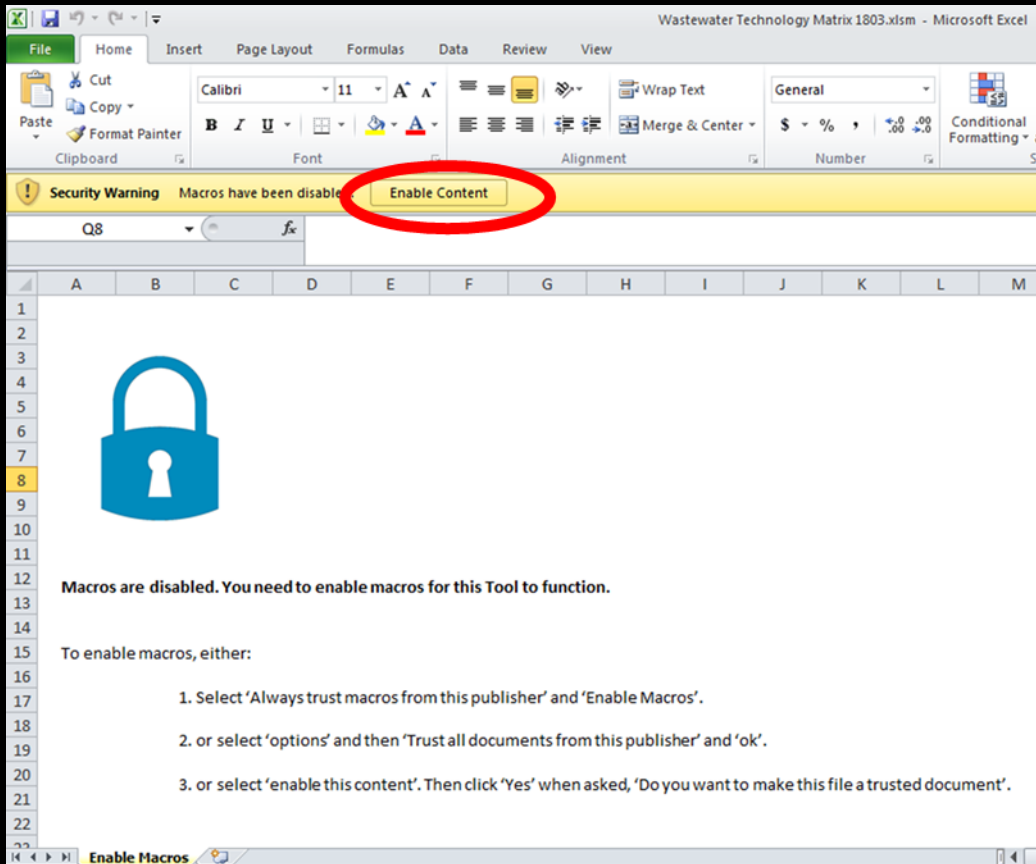
- Input from the user form is used in **Step 1 to exclude certain technologies**, and in **Step 2 to rate them**
- The score of each technology is furthermore based on the weights, which are also provided as input by the user
- **Step 3: combines technologies into systems** and displays their **average score** as output on the results page



Getting started

- Microsoft® Excel-based Tool
- Open ZIP file: Wastewater Technology Matrix
- Open Excel file - enable macros; enable content
- **Click START...you're on your way!**

Opening screen



IMPORTANT! Try to answer as many questions as accurately as possible

1. Space and availability

- Enter basic attributes about location, number households, space availability for treatment, water supply, etc
- Click 'Next'

USERFORM - Wasterwater Technology Matrix

1: Space and availability | 2: End products | 3: Geology and local conditions

1.1 Size of area [km2]:

1.2 Total number of households in the area:



1.3 Average number of people per household:

1.4 Extra space available for treatment: Yes No

1.5 Water supply:
 Piped
 Fetched

1.6 Reliable electricity supply:
 Yes
 No

1.7 Organic matter available :
(Biodegradable plant material for composting process, for example: sawdust, leaves, grass)
 Yes
 No

2. Desirability of end products



- Indicate by **relative desirability** what might the end products of treatment be useful for
- Click 'Next'

USERFORM - Wastewater Technology Matrix

1: Space and availability | 2: End products | 3: Geology and local conditions

How desirable would the following options be as end products? (Choose 1-5 for each. 1=Not at all. 5=Very much.)

	1	2	3	4	5
2.1 Application / Irrigation / Fertiliser	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
2.2 Disposal / Discharge / Soil infiltration	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
2.3 Biogas / Electricity	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Geology and local conditions

- Specify the **local conditions, vehicular accessibility and underlying geological/soil attributes**
- Click 'Finish'

USERFORM - Wasterwater Technology Matrix

1: Space and availability | 2: End products | 3: Geology and local conditions

3.1 Is the area prone to floods?

Yes
 No
 Unknown

3.2 Vehicular (septic truck or similar) access to households



Easy
 Difficult/ Limited
 Unknown

3.3 Groundwater table is (at its highest)

...deeper than 2 meters
 ...shallower than 2 meters
 Unknown

3.4 Soil type

Clay Silt Sand Gravel (Mostly) bedrock Unknown

Back Finish

Weighting of criteria

- Each of the three criteria (Environmental, Economic and Social) is multiplied with a weight in the MCA
- These **weights can be adjusted** by answering the three questions in this user form
- **NOTE:** these answers will be important for the accuracy of results; **take care that the correct weighting is applied**
- Click 'Ok' to get the result

WEIGHTING OF CRITERIA - Wastewater Technology Matrix

C.1
Environmental aspects are ... times as important as Economic aspects
(0.2= much less important, 1= equally important, 5= much more important)

0.2 0.4 0.6 0.8 1 2 3 4 5

C.2
Environmental aspects are ... times as important as Social aspects
(0.2= much less important, 1= equally important, 5= much more important)

0.2 0.4 0.6 0.8 1 2 3 4 5

C.3
Economic aspects are ... times as important as Social aspects
(0.2= much less important, 1= equally important, 5= much more important)

0.2 0.4 0.6 0.8 1 2 3 4 5

Ok

Results

- Data is sorted in **descending order of score**, according to the MCA Matrix calculations
- **Main score** and **partial score**
 - Partial score: unweighted score for each of the criteria
- **Suitable options** in green
- **Unsuited (excluded) options** in red; assigned score of '0'

	USER INTERFACE	STORAGE	TRANSPORT	TREATMENT	REUSE/DISPOS.	SCORE	Environ.	Economic	Social
1	U.4 Pour Flush	S.9 Septic Tank	C.2 Human p. E&T	T.14 Unpl. Dry.	D.X2 Disposal	3.7	2.0	4.0	3.3
2	U.4 Pour Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.6	3.5
3	U.5 Cistern Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.4	3.6
4	U.5 Cistern Flush		C.4 Simp. Sewer	T.2 Imhoff tank	D.X1 Application	3.5	1.9	3.4	3.6
5	U.4 Pour Flush	S.9 Septic Tank	C.2 Human p. E&T	T.14 Unpl. Dry.	D.X2 Disposal	3.5	2.0	4.0	3.3
6	U.4 Pour Flush		C.4 Simp. Sewer	T.3 ABR	D.X2 Disposal	3.3	2.3	3.6	3.5
7	U.4 Pour Flush	S.12 Biogas Rc.			D.13 Biogas	3.3	3.9	3.5	3.5
8	U.5 Cistern Flush		C.4 Simp. Sewer	T.3 ABR	D.X2 Disposal	3.3	2.3	3.4	3.6
9	U.5 Cistern Flush		C.4 Simp. Sewer	T.2 Imhoff tank	D.X2 Disposal	3.2	1.9	3.4	3.6
10	U.4 Pour Flush	S.12 Biogas Rc.			D.13 Biogas	3.0	3.9	3.5	3.5

11	U.4 Pour Flush	S.9 Septic Tank	C.4 Simp. Sewer	T.3 ABR	D.X2 Disposal	0.0	0.0	0.0	0.0
12	U.4 Pour Flush	S.9 Septic Tank	C.4 Simp. Sewer	T.3 ABR	D.X1 Application	0.0	0.0	0.0	0.0
13	U.1 Dry toilet	S.4 Double VIP	C.2 Human p. E&T		D.X1 Application	0.0	0.0	0.0	0.0
14	U.1 Dry toilet	S.4 Double VIP	C.2 Human p. E&T		D.X2 Disposal	0.0	0.0	0.0	0.0
15	U.4 Pour Flush	S.9 Septic Tank	C.4 Simp. Sewer	T.2 Imhoff tank	D.X2 Disposal	0.0	0.0	0.0	0.0
16	U.4 Pour Flush	S.9 Septic Tank	C.4 Simp. Sewer	T.2 Imhoff tank	D.X1 Application	0.0	0.0	0.0	0.0
17	U.4 Pour Flush	S.9 Septic Tank	C.3 Motorized E&T	T.14 Unpl. Dry.	D.X2 Disposal	0.0	0.0	0.0	0.0
18	U.4 Pour Flush	S.9 Septic Tank	C.3 Motorized E&T	T.14 Unpl. Dry.	D.X1 Application	0.0	0.0	0.0	0.0

Results

- **Row** = 1 sanitation system/sanitation chain of combination of technologies
- **Column** = 5 technology steps or functional groups



RESULTS:

	USER INTERFACE	STORAGE	TRANSPORT	TREATMENT	REUSE/DISPOSAL	SCORE	Environ. Economic Social		
1	U.4 Pour Flush	S.9 Septic Tank	C.2 Human p. E&T	T.14 Unpl. Dry.	D.X2 Disposal	3.7	2.0	4.0	3.3
			C.4 Simp. Sewer	T.3 ABR	D.X1 Application				
2	U.4 Pour Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.6	3.5
				T.14 Unpl. Dry.	D.X1 Application				
3	U.5 Cistern Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.4	3.6
				T.14 Unpl. Dry.	D.X1 Application				
			C.4 Simp. Sewer	T.2 Imhoff tank	D.X1 Application				

Water phase Sludge phase

Information links to technology options

Click to access additional documentation

RESULTS:

	USER INTERFACE	STORAGE	TRANSPORT	TREATMENT	REUSE/DISPOSAL	SCORE	Environ. Econmic Social		
1	U.4 Pour Flush	S.9 Septic Tank	C.2 Human p... F&T	T.14 Unpl. Dry.	D.X2 Disposal	3.7	2.0	4.0	3.3
2	U.4 Pour Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.6	3.5
3	U.5 Cistern Flush		C.4 Simp. Sewer	T.3 ABR	D.X1 Application	3.6	2.3	3.4	3.6

U.1 Dry Toilet

Applicable to: Systems 1, 2

Inputs: Faeces Urine
 Anal Cleansing Water Dry Cleansing Material

Outputs: Faeces (+ Anal Cleansing Water)
 Dry Cleansing Material

option 1

option 2

A dry toilet is a toilet that operates without flushwater. The dry toilet may be a raised pedestal on which the user can sit, or a squat pan over which the user squats. In both cases, faeces (both urine and faeces) fall through a drop hole.

In this compendium, a dry toilet refers specifically to the device over which the user sits or squats. In other literature, a dry toilet may refer to a variety of technologies, or combinations of technologies (especially pits).

Design Considerations: The dry toilet is usually placed over a pit; if two pits are used, the pedestal or slab should be designed in such a way that it can be lifted and moved from one pit to another. The slab or pedestal base should be well sized to the pit so that it is both safe for the user and prevents stormwater from infiltrating the pit (which may cause it to overflow). The hole can be closed with a lid to prevent unwanted intrusion from insects or rodents. Pedestals and squatting slabs can be made locally with concrete (providing that sand and cement are available). Fibreglass, porcelain and stainless steel versions may also be available. Wooden or metal

models can be used to produce several units quickly and efficiently.

Appropriateness: Dry toilets are easy for almost everyone to use though special consideration may need to be made for elderly or disabled users who may have difficulty. When dry toilets are made locally, they can be specially designed to meet the needs of the target users (e.g., smaller ones for children). Because there is no need to separate urine and faeces, they are often the simplest and physically most comfortable options.

Health Aspects/Acceptance: Squatting is a natural position for many people and so a well-kept squatting slab may be the most acceptable option. Since dry toilets do not have a water seal, odours may be a problem depending on the Collection and Storage/Treatment technology connected to them.

Operation & Maintenance: The sitting or standing surface should be kept clean and dry to prevent pathogen/disease transmission and to limit odours. There are no mechanical parts; therefore, the dry toilet should not need repairs except in the event that it cracks.

C.4 Simplified Sewer

Applicable to: Systems 1, 2

Application Level: Household Neighbourhood City

Management Level: Household Shared Public

Inputs/Outputs: Blackwater Brownwater Greywater Effluent

A simplified sewer describes a sewerage network that is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than Conventional Sewers (C.6). The simplified sewer allows for a more flexible design at lower costs.

Conceptually, simplified sewerage is the same as Conventional Gravity Sewerage, but without unnecessarily conservative design standards and with design features that are better adapted to the local situation. The pipes are usually laid within the property boundaries, through either the back or front yards, rather than beneath

self-cleansing velocity, the design of simplified sewers is based on a minimum tractive tension of 1 N/m² (1 Pa) at peak flow. The minimum peak flow should be 1.5 L/s and a minimum sewer diameter of 100 mm is required. A gradient of 0.5% is usually sufficient. For example, a 100 mm sewer laid at a gradient of 1 m in 200 m will serve around 2,800 users with a wastewater flow of 60 L/person/day. PVC pipes are recommended to use. The depth at which they should be laid depends mainly on the amount of traffic. Below sidewalks, covers of 40 to 65 cm are typical. The simplified design can also be applied to sewer

T.3 Anaerobic Baffled Reactor (ABR)

Applicable to: Systems 1, 6-9

Application Level: Household Neighbourhood City

Management Level: Household Shared Public

Inputs: Effluent Blackwater Brownwater Greywater

Outputs: Effluent Sludge

An anaerobic baffled reactor (ABR) is an improved Septic Tank (S.9) with a series of baffles under which the wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment.

time (HRT) between 48 to 72 hours, upflow velocity of the wastewater below 0.6 m/h and the number of upflow chambers (3 to 6). The connection between the chambers can be designed either with vertical pipes or baffles. Accessibility to all chambers (through access ports) is necessary for maintenance. Usually, the biogas

Re-evaluation

- Note the weighting calculated
- Have the option to re-evaluate the criteria weightings

The screenshot displays a software interface for re-evaluation. On the left, a blue sidebar contains two buttons: "Change Userform Data" and "Export Results To New Workbook". The main content area is divided into three sections. The top section shows a pie chart with three segments: Environmental (38%), Economic (35%), and Social (26%). A legend to the right of the chart identifies the segments with colored squares: dark blue for Environmental, medium blue for Economic, and light blue for Social. The middle section is a table with two columns: "Criteria" and "Weight". The table lists Environmental (38%), Economic (35%), and Social (26%). The bottom section is a blue bar containing a "Change Weights" button.

Criteria	Weight
Environmental	38%
Economic	35%
Social	26%

Detail of the MCA

- For each criterion there are numerous indicators
- Each indicator is rated 1-5 based on a literature review and expert's consultation - cannot be changed by the user
- If the pre-screening eliminates a technology a red 'X' and a text explanation will be displayed in the 'Exclusion Field'
- The colour of each cell indicates its value from high to low (green to red).

Criteria	Indicator	User interface						Criteria score weighted, product of weight of criteria & criteria score. Bottom row (bold) is their sum				
		U.1 Dry toilet	U.2 Urine-Diverting Dry Toilet (UDDT)	U.3 Urinal	U.4 Four Flush	U.5 Cistern Flush	U.6 Urine-Diverting Flush Toilet (UDFT)	S.1 Urine Storage Tank/Containers	S.2 Single pit	S.3 Single VIP	S.4 Double VIP	S.5 For Altern
TOTAL:		3.6			3.6	3.4					3.6	
All data is rated from 1-5. For explanations and references for choice of rates, please go to advanced settings	U.1	0.0			0.0	0.0					1.3	
	U.2	1.7			1.2	0.8					1.3	
	U.3	0.7			1.2	1.4					0.9	
	U.4	0.0			0.0	0.0					0.0	
Advanced		1.37			2.37	2.23					3.60	
Excluded as option because:												
Environmental												4.0
Effluent Nitrogen quality (low-high 1-5)												5
Effluent Phosphorus quality (low-high 1-5)												5
Effluent Pathogen quality (low-high 1-5)												5
Effluent suspended solids quality (low-high 1-5)												5
Effluent BOD quality (low-high 1-5)												5
Volume reduction (low-high 1-5)												5
Energy requirements												5
CO2 emissions												5
Biogas produced												5
Economic		5.0			3.5	2.5						4.0
Capital Cost (high-low 1-5)		5			3	2						4
OpM Cost (high-low 1-5)		5			3	2						4
Income potential (low-high 1-5)		5			3	2						4
Social		2.2			3.0	4.2						2.8
Impact of operation (low-high 1-5)		2			3	4						2
Use of construction (low-high 1-5)		2			3	4						2
System robustness (low-high 1-5)		2			3	4						2
Cultural appropriateness		2			3	4						2
Health		2			3	4						2

Criteria

Indicator

Criteria score, average of all indicators within this criteria

Indicator score, 1-5 for each indicator, based on literature review.

Exclusion field, red "X" and explanation here if technology is excluded

○ = Colour coded cell, from 5 (green) to 1 (red)

Contribution to...



SUSTAINABLE DEVELOPMENT

GOALS

Core SDG targets

- Target 6.2 - access to adequate and equitable sanitation and hygiene
- Target 6.3 – good ambient water quality
- Target 6B - participation of local communities in improving water and sanitation management
- Target 14.1 – reduced nutrient pollution in the marine environment



Resources and contact information

Contact at United Nations Environment Programme

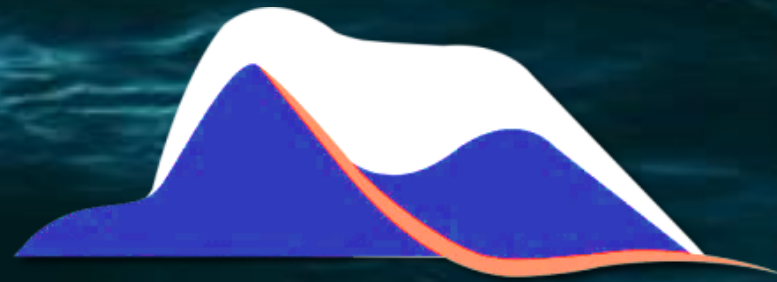
- Birguy Lamizana, birguy.lamizana@un.org; UN Environment

**For more information
visit us at**

<https://www.unenvironment.org/explore-topics/oceans-seas/what-we-do/addressing-land-based-pollution>



**United Nations
Environment Programme**



GPA

**Global Programme of Action for the
Protection of the Marine Environment
from Land-based Activities**