into the climate 2

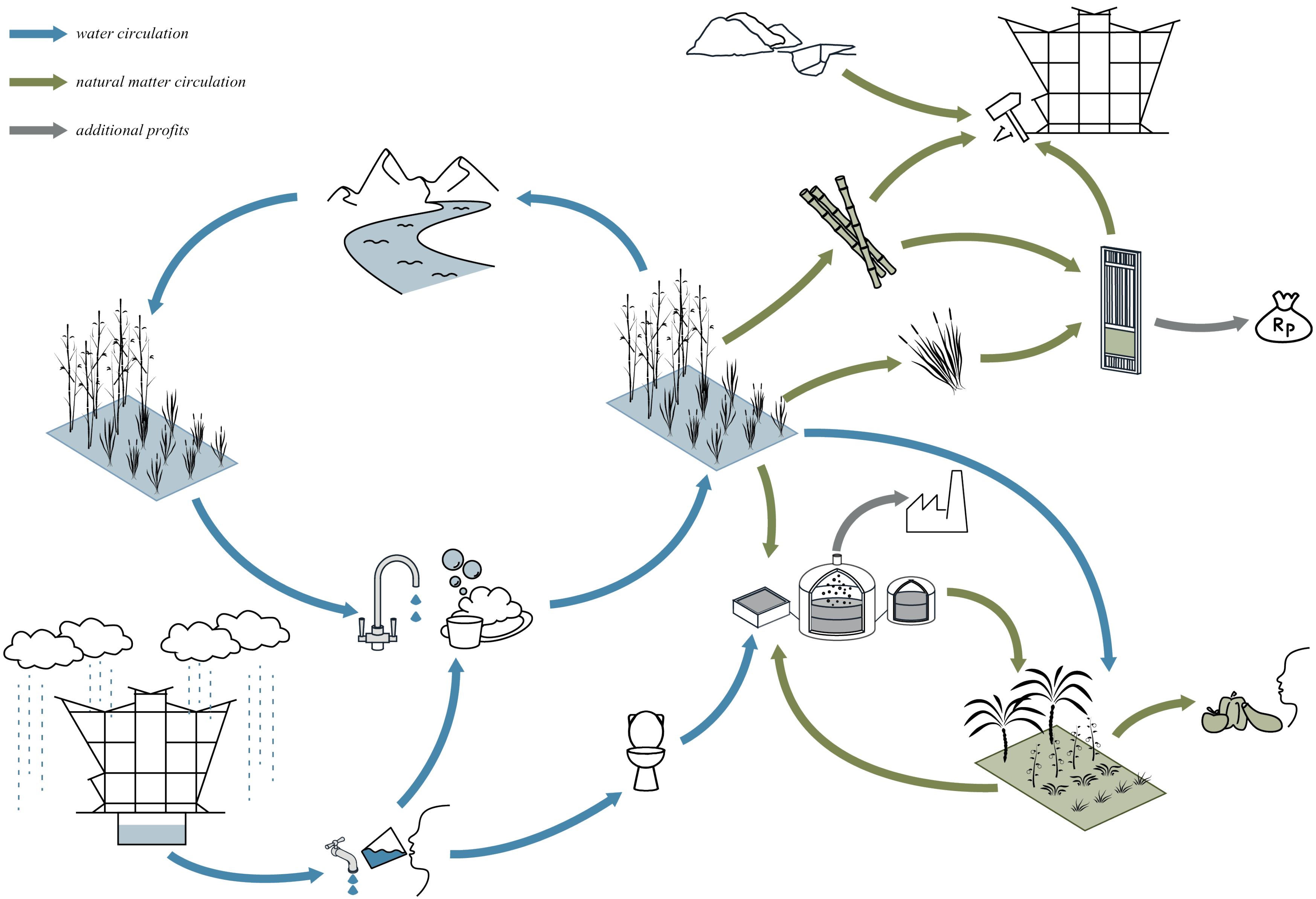
Cigondewah self-sustainable in water and energy

water purification and treatment

constructed wetlands

living in symbiosis with nature

circulation of water and natural matter



water purification

basic data

Land area:
land area of RW 2 = **8.1 ha**

Population:
In RW 2 = 782 families x2 +800 workers
= **1 564 people**

Population density = Number of people/ Land area
= 1 564/ 8.1 ha
= **193 p. / ha**

Future wetland population:
Wetlands -> 1,21ha
Number of people = Land area x Population density
= 1.21 ha x 193 p./ ha
= **234 people**

As around 10% of area will be occupied by constructed wetlands, I am assuming that future wetland population will be: **210 people**

water demand

Water demand in the household per capita/ day:
- in urban area: **120 liters**
- in rural area: **80 liters**

(Water Assesment, 2016)

As the area is semi-urban I assume water demand of at least **100 liters/ capita/ day**

Figure 1. Hierarchy of water requirements and its quantity.
Image based on paper of WHO Regional Office for South-East Asia. (n.y.). Minimum Water Quantity Used for Domestic Use. New Delhi: Technical Note No.9

water purification

water demand

As rainwater is significantly less contaminated than water from the river, in first place its appropriation is as a drinking water.

Drinking water:
In tropical countries recomended amount of drinking water per capita is **2,5 liters/ day**

Cooking water:
Depending on if/what people cook - around **3 liters/ capita/ day**

Basic hygiene:
Water used for washing face, brushing teeth, etc. - around **5 liters/ capita/ day**

water demand

Shower:

Average 8 min shower	= 7.5 l/min x 8 min
	= 60.0 liters
Water use for showering/ day	= **60.0 liters/ capita/ day**

Flushing the toilet:

Squat toilet without flush	3 / 12 liters/ flush
Average toilet flush	9 liters/ flush
Low-flow toilet*	6 liters/ flush
Dual-flush toilet*	3 / 6 liters/ flush

*Nevertheless low-flow and dual are more expensive and used in western toilets.

Water use for flushing the toilet/ day = 3 liters/ flush x 4 (average amount of use for urine/ day)
+ 6 liters/ flush x 1 (average amount of use for feces/ day)
= **18 liters/ capita/ day**

water demand

Washing the clothes:

Washing by hand	40 liters/ washing
Washing in washing machine**	150 liters/ washing

**People usually does not possess washing machine

Water use for washing the clothes by hand/ day = 40 liters/ washing/ capita/ 7 days
= **5.7 liters/ capita/ day**

Washing the dishes:

Washing the dishes by hand	7/ 14 liters/ washing
Water use for washing the dishes / day	= 14 liters x 3 times / 4 people
	= **10 liters/ capita/ day**

Cleaning the house:

Average 2 buckets of water/ week	= 10 liters x 2 times
	= 20 liters
Water use for cleaning/ day	= 20 liters/ 7 days / 4 people
	= **0.75 liters/ capita/ day**

water demand

Total water usage in liters/ capita/ day
from the city integral water system:

Drinking water:	2.5
Cooking:	3.0
Basic hygiene:	5.0
Shower:	63.2
Flushing the toilet:	18.0
Washing the clothes:	5.7
Washing the dishes:	10.0
Cleaning the house:	0.8
Total water usage:	108.2

water purification

water demand

Total water usage in liters/ capita/ day
from different water systems:

harvesting rainwater	Drinking water:	2.5
	Cooking:	3.0
	Basic hygiene:	5.0
	Shower:	60.0
	Total water usage:	70.5
purified water from the river by wetlands	Washing the clothes:	5.7
	Washing the dishes:	10.0
	Cleaning the house:	0.8
	Total water usage:	16.5
re-used graywater	Flushing the toilet:	18.0
	Total water usage:	18.0

water purification

harvesting rainwater

Rainfall:

Anual average rainfall: 2 300 mm = **2 300 l/ m^2**

(Taller, 2009)

Quality of rainfall in Greater Bandung:

Acording to Taller (2009) quality of rainwater is good:

- pure
- soft
- almost neutral pH
- free from desinfection products, salts, minerals, contamination

Total rainfall yield from 1 m^2 roof area:

Total Rainfall Yield = Roof area x Annual Rainfall x 0.9 (water losses)

= 1m^2 x 2300 l/ (year x m^2) x 0.9

= 2 070 l / year

= 5.67 l / day

water purification

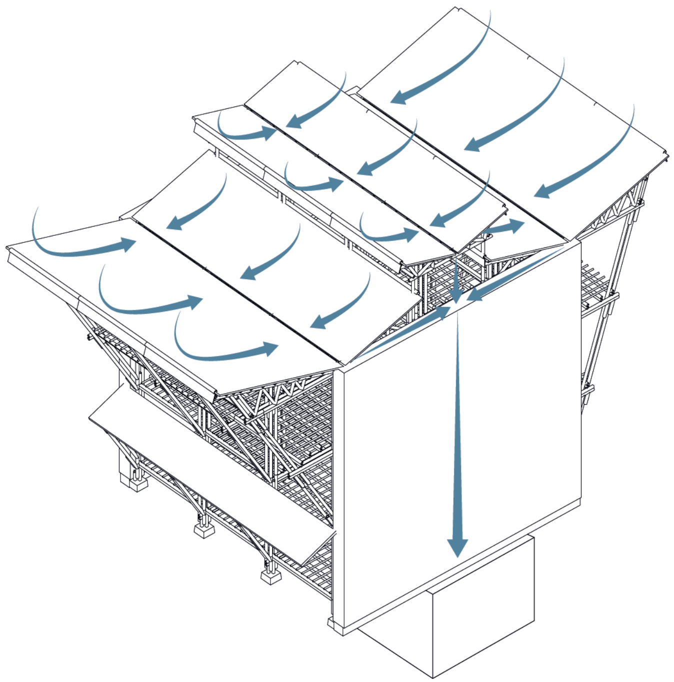
harvesting rainwater

Rainfall yield per capita per day:

The most habitated structure cotains 2 houses of 12 people maximum and is under 1 roof area of 150.75 m^2

Roof area per 1 person = 150.75m^2/ 128 people
= 12.56 m^2

Minimum Rainfall Yield/ capita/ day = Roof area x Annual Rainfall x 0.9 / 365 days
= 12.56 m^2 x 2300 l/ (year x m^2) x 0.9 / 365 days
= **71.24 liters/ capita/ day**



water purification

harvesting rainwater

From minimum rainfall yield/ capita/ day wich is 71.24 liters/ capita/day around 6 liters of water/ capita/ day will be dedicated for drinking and cooking, 5 liters will be used for basic hygiene and aroud 60 liters for the shower.

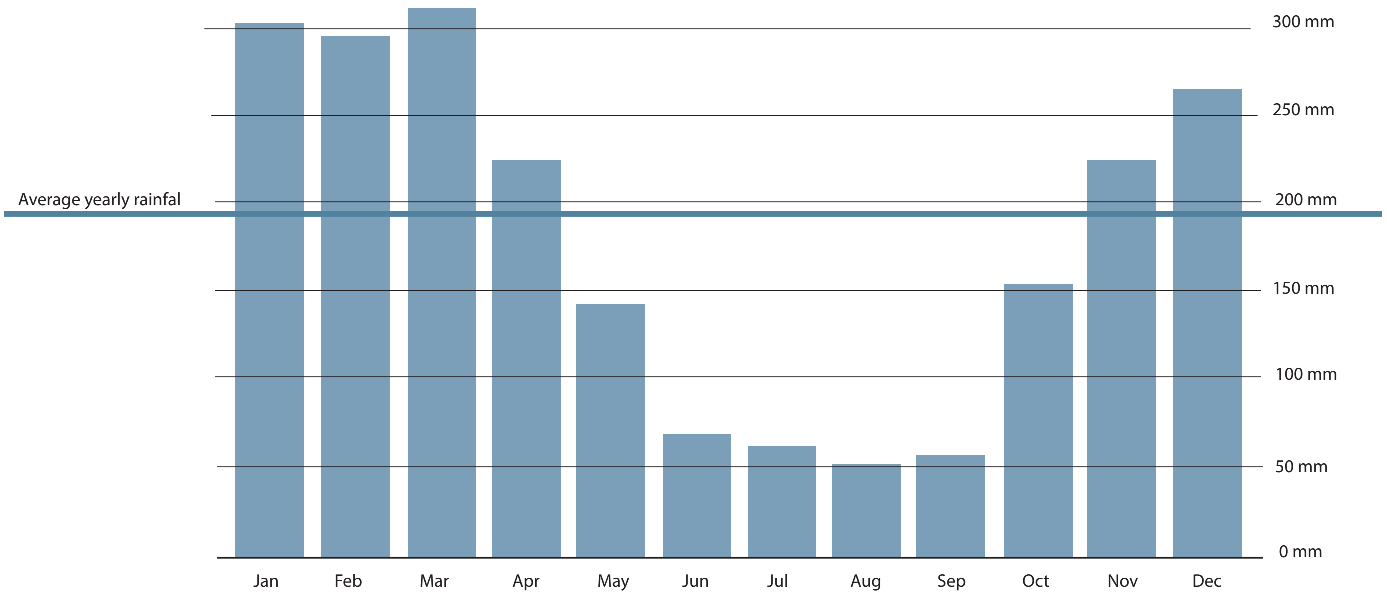
Total rainwater will be beforehand filtered by Nazava filter and ready for drinking. Nazava filter can clean up to 500 litters of water/ hour. The filter is 120 cm high and 20 cm in diamiter.

The water will be heated up for each building in the electric water heater mounted in the service wall. Its size is 150 cm high and 50 cm diamiter. The heater can store 230 liters of water.

water purification

harvesting rainwater

The size of the water storage tank under the house:



Based on: Average temperatures and precipitation. https://en.climate-data.org/location/607890/

Surplus of the water during rainy season = (Jan+Feb+Mar+Apr+Nov+Dec rainfall) - 6 x average yearly rainfall
= (306+298+310+205+221+260) - 6x 192
= 1600 - 1152
= **448 l /m²**

Amount of rainfall needed to be stored/m² = the surplus amount of water + average rainfall for one month
= 448 + 192
= **640 l /m²**

water purification

harvesting rainwater

The size of the water storage tank under the house:

Amount of water needed to be stored from the biggest roof top

= 640 l /m^2 x 147.65 m^2

= 94 500 liters

= **94.50 m^3**

The theoretical size of the tank under the building

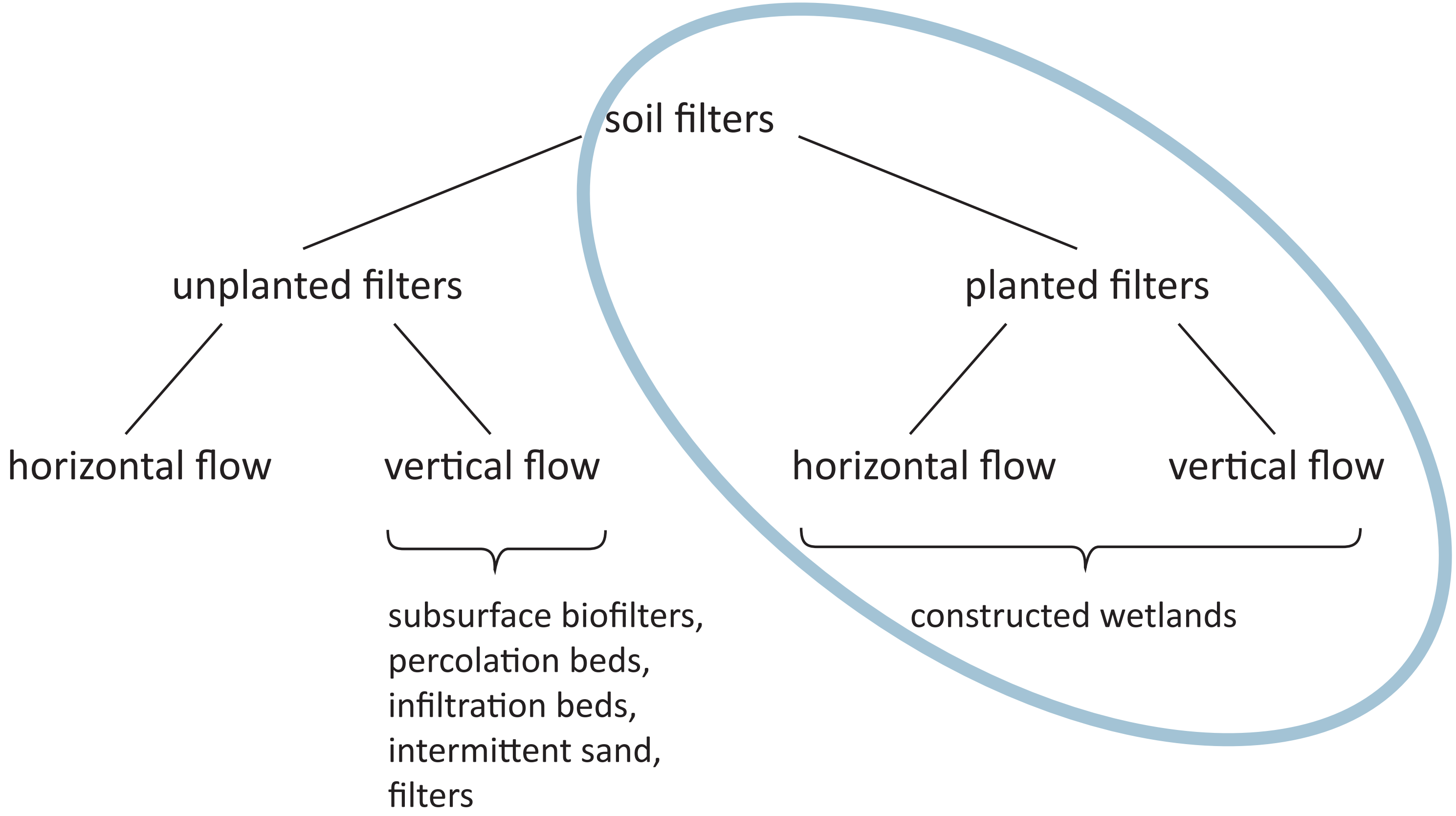
= 94.50 m^3

= **9m x 3m x 3.5m**

The water before entering the tank needs to be filtrated and get through the sceptic tank.

water purification and treatment

classification of soil filters



Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

constructed wetlands

advantages and disadvantages

Prerequisites for constructed wetland:
- wastewater **not too toxic** for bacteria and plants
- sufficient amount of **light** for plant photosynthesis
- adequate quantities of **nurients** to support growth
- treatment **time** long enough
- **organic loading not too high**

Use of constructed wetlands:
- graywater treatment
- faecal sludge treatment
- post-treatment after anarobic treatment of black water

Advantages:
- site location flexible (comparing to natural wetlands)
- simple operation and maintenance
- can be integratedinto landscape

Disadvantages/ challanges:
- mosquitoes (in free water surface flow typology)
- space requirement
- variable performance possible

Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

plants

There are 3 types of plant species :
- floating plants
- submerged plants
- emergent plants

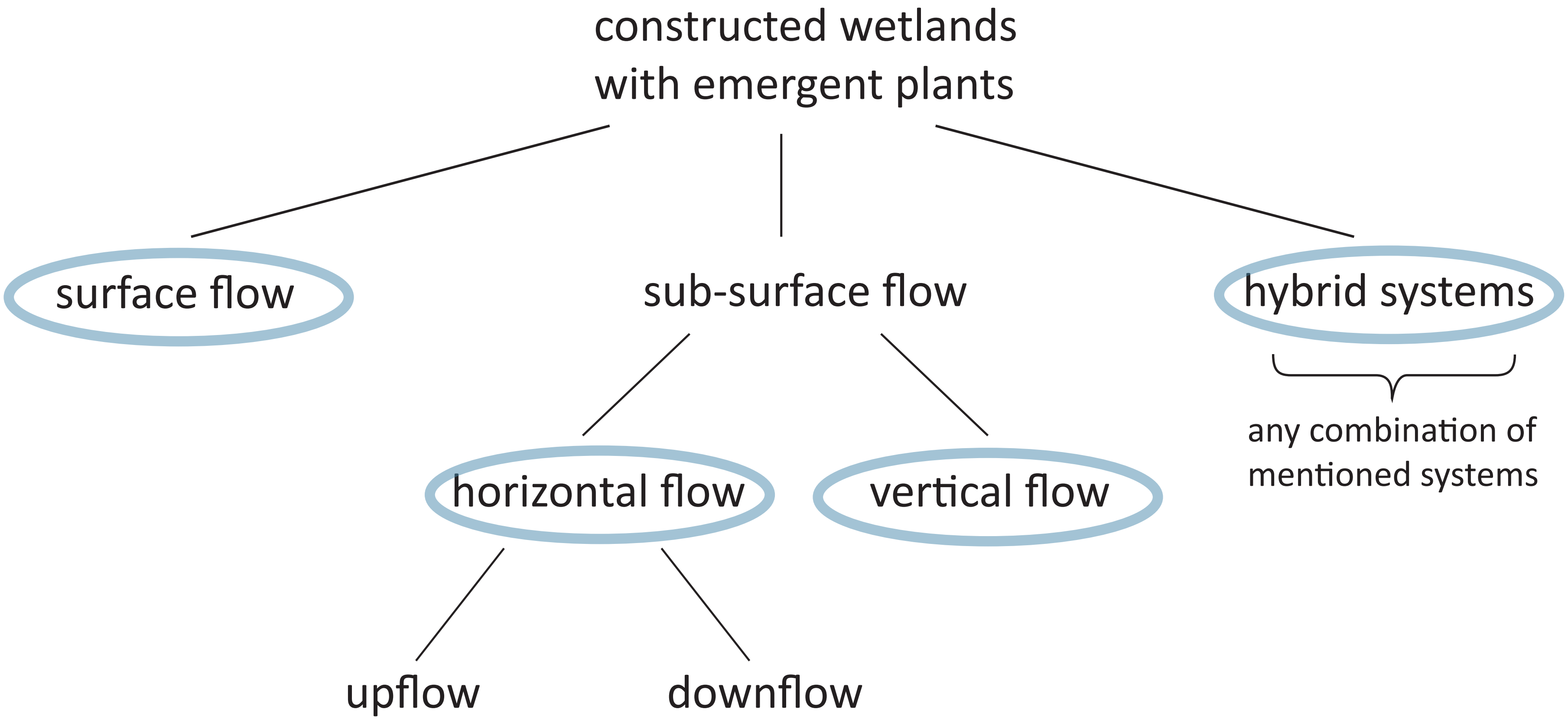
Most often the **emergent plants** areused for constructed wetlands: reeds, rushes, sedges.

Plants should have **high biomass production,** an **extensive root system** and should be able to **withstand shock loads** and **short dry periods**.

Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

water purification and treatment

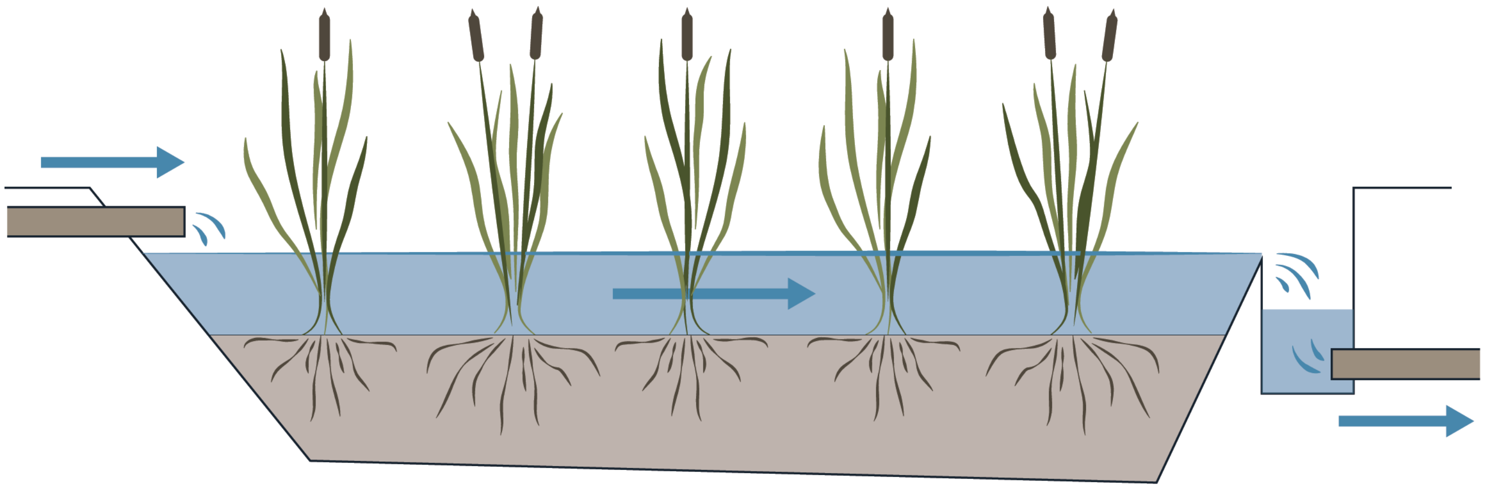
typologies



Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

type 1: free water surface flow

section

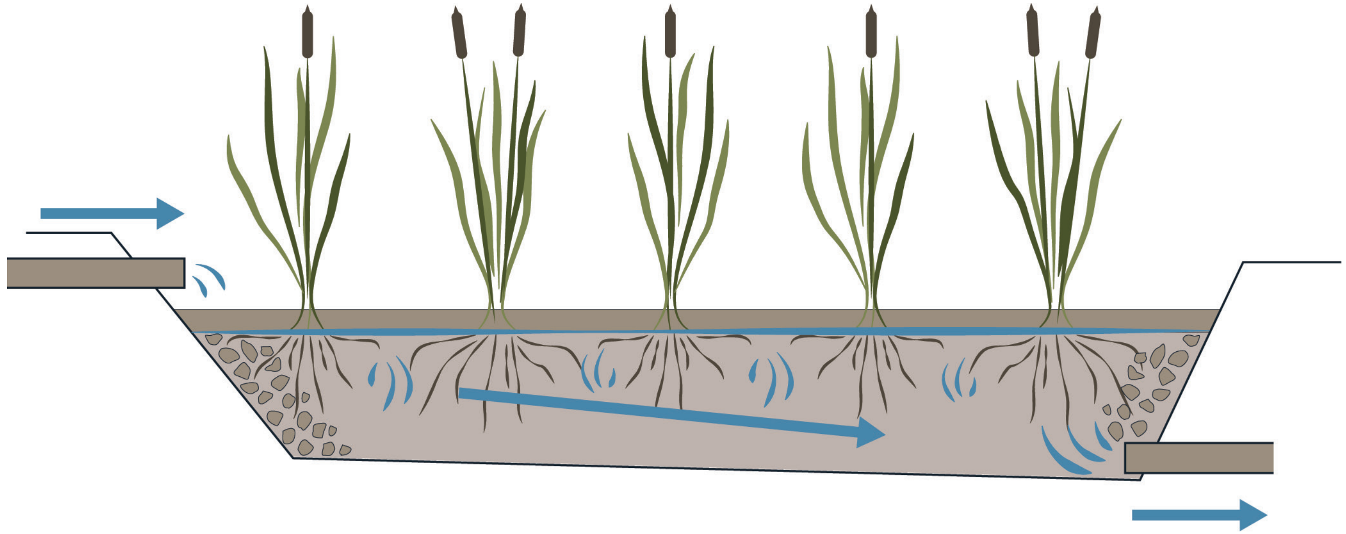


- water flows on the top od the soil
- water depth <50 cm deep
- bed made from soil, sand or gravel
- slope 1%
- watertight membrane at the bottom
- problem with mosquitos
- land intensive system

Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

type 2: horizontal sub-surface flow

section

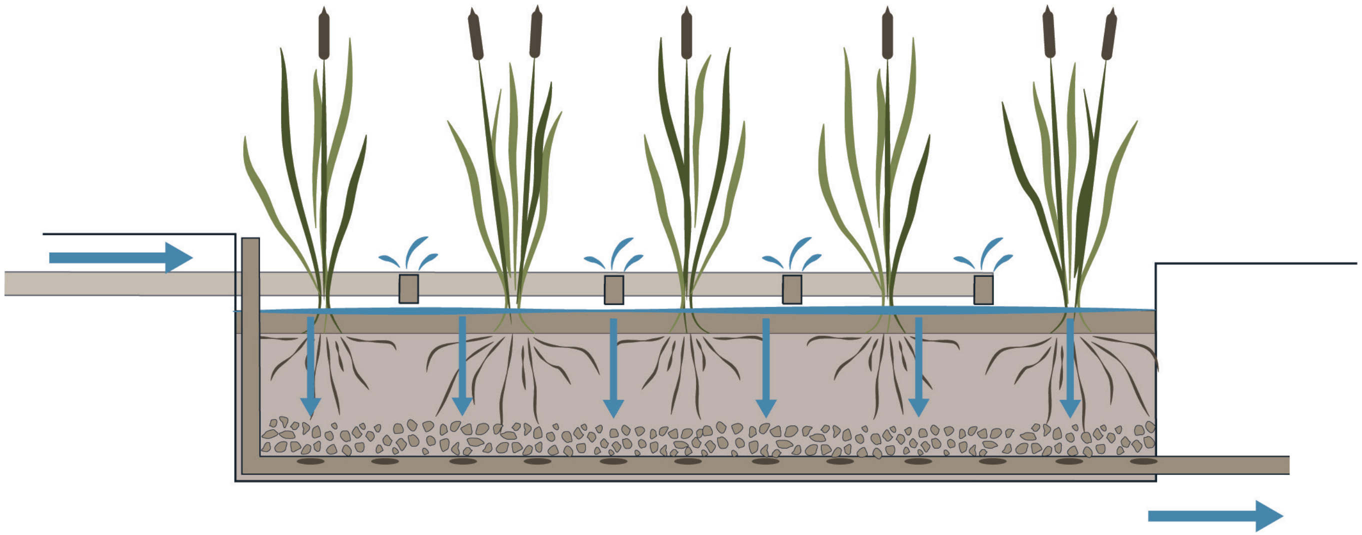


- water flows inside a layer of sand, gravel or soil (60 - 80 cm)
- bed made from soil, sand and gravel
- slope 1%
- watertight membrane at the bottom
- require pre-treatment through sceptic tank to avoid clogging
- inlet and outlet zone filled with small rocks
- bed field with fine gravel
- mutliply inlet pipes on entire width to ensure water was redistributed equally

Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

type 3: vertical sub-surface flow

section

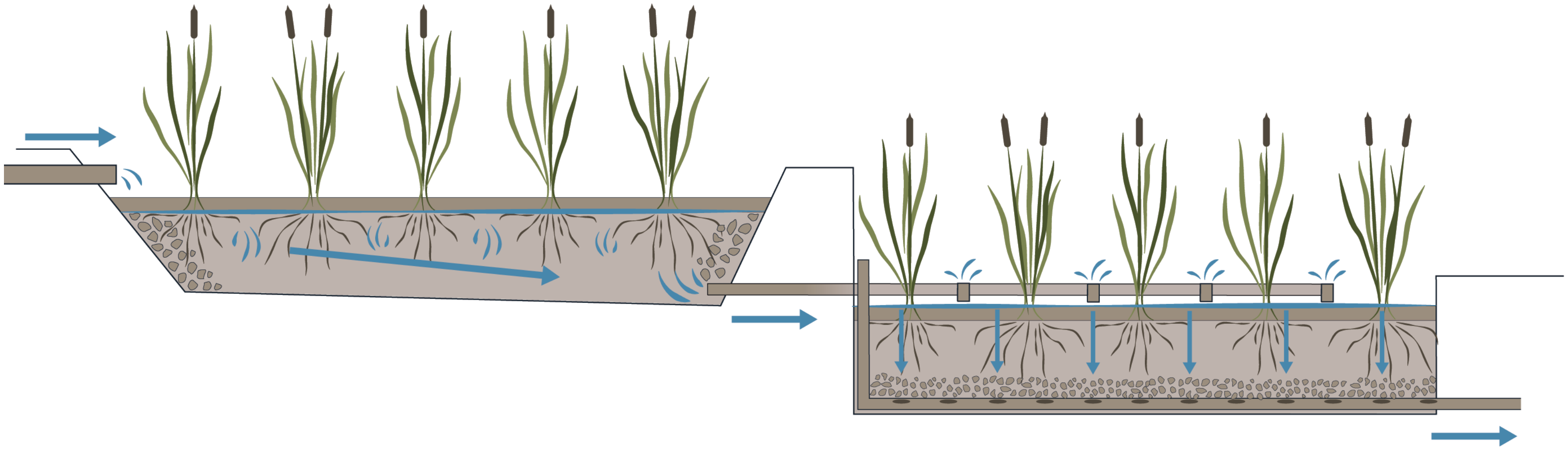


- water is pumped on the surface
- water is drained dowm through the filter layer
- bed created from coarse sand and fine gravel
- watertight membrane at the bottom
- require pre-treatment through sceptic tank to avoid clogging
- mutliply inlet pipes on entire width to ensure water was redistributed equally
- amount of used land minimal

Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

type 4: hybrid system - horizontal and vertical sub-surface flow

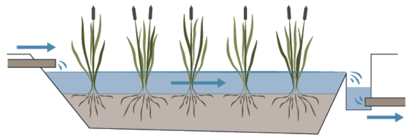
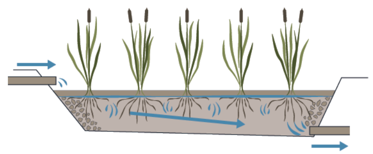
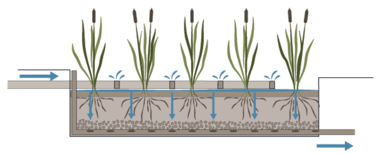
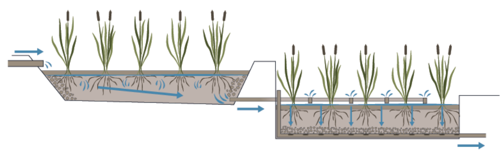
section



- two step constructed wetland
- most efficent - different methods of water treatment remove different elements
- most nitrogen is removed
- the flow can have closed - recycling circle improving denitrification in horizontal system

Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

area requirements

Type of constructed wetlands	Example	Design area required (m^2 / PE)
Type 1: Free water surface flow		4 - 8
Type 2: Horizontal sub-surface flow		2.5 - 4
Type 3: Vertical sub-surface flow		1.5 - 2.5
Type 4: Hybrid system		2 - 2.5

Based on: Rousseau, D.(n.y.). Course 2 Unit 5 Introduction to Constructed Wetlands. Presentation. Delft: UNESCO-IHE.

water purification and treatment

physical, chemical and biological reactions

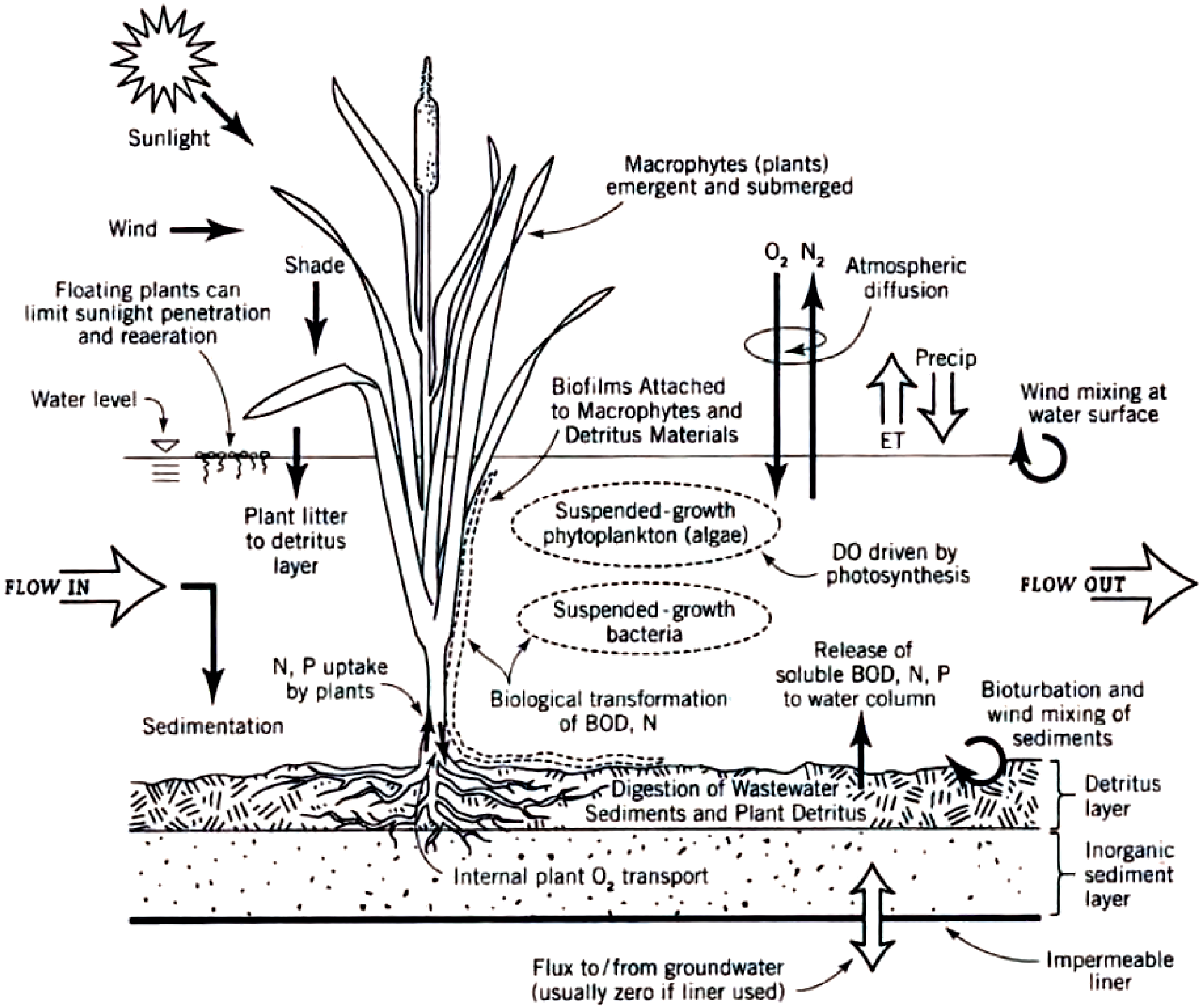


Image from: Chih-Wei,C. (n.y.). Treatment Wetland: A Landscape Architect's Reference. Presentation. Patric Curran Fellowship.

wastewater treatment mechanism

Water Quality Parameter	Physical	Chemical	Biological
Suspended solids	Sedimentation	Not applicable	Microbial degradation
Biological Oxygen Demand (BOD_5)	Sedimentation	UV radiation	Microbial degradation
Chemical Oxygen Demand (COD)	Sedimentation	UV radiation	Microbial degradation
Metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)	Sedimentation	Precipitation, absorption, ion exchange	Microbial uptake, plant uptake
Petroleum hydrocarbons (fuels, oil and grease, alcohols, BTXEX, TPH)	Volatilization	UV radiation	Microbial degradation, plant uptake
Synthetic hydrocarbons (PAHs, chlorinated and non-chlorinated solvents, pesticides, herbicides, insecticides)	Sedimentation, volatilization	Absorbtion, UV radiation	Microbial degradation, plant uptake
Nitrogenous compounds (Organic N, NH_3, NH_4^+, NO_3^-, NO_2^-)	Sedimentation	Absorption,volatilization (ammonia)	Microbial uptake and transfor-mation, plant uptake
Inorganic and organic P	Sedimentation	Precipitation, absorbtion	Microbial uptake, plant uptake
Pathogens (bacteria, viruses, protoza, helminths)	Sedimentation	UV radiation	Die-off, microbial predation

- best type of performance

Based on: Chih-Wei,C. (n.y.). Treatment Wetland: A Landscape Architect's Reference. Presentation. Patric Curran Fellowship.

wastewater treatment performance

Basing on the tests of 107 constructed wetlands, the **vertical sub-surface flow (VSSF) system has the best removal performance**, apart from **nitrogen** in which **hybrid system** perform better**.** The free water surface (FWS) system the worst.

Parameter	FWS	VSSF	HSSF	Combined	VSSF greywater
COD removal (%) chemical oxygen demand	61	94	72	91	90 – 99 (BOD)
SS removal (%) suspended solids	75	98	86	94	90-99
TN removal (%) nitrogen	31	52	33	65	30
TP removal (%) phosphorus	26	70	48	52	30 – 95

Table. Comparison of actual performance for 107 constructed wetlands in Flanders, Belgium (based on measured average concentrations)

Rousseau, D.P. L., Vanrolleghem, P. A., De Pauw, N. (2004). Constructed wetlands in Flanders: a performance analysis. Ecological Engineering, 23 (3), 151-163.

constructed wetlands for Cigondewah

After analysing four types of constructed wetlands, I decided to use a **hybrid system - vertical and horizontal sub-surface flow system,** for the following reasons:

- one of the **smallest amount of used land** (2 - 2.5 m^2 / PE)

- hybrid system has got **beter removal performance**, because of different used methods

- **most nitrogen removed**

- hybrid system has got **better removal performance**, because of different used methods

- flow can have **closed circle** improving denitrification in horizontal system

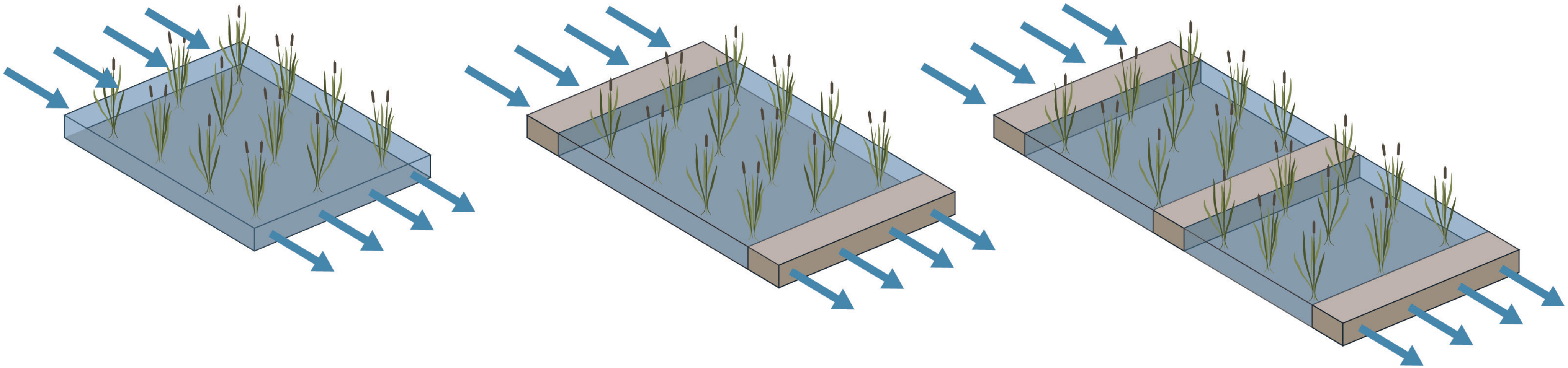
- **no mosquito** problem, important in tropical climate

Challanges:

- water requires **pre-treatment in sceptic tank** to avoid clogging <- advantage less sedimentation in the system

Layout and efficiency

The arrangement of internal components within a single wetland cell have a huge impact on the treatment efficiency of the wetland. The proper designed and controled wetland can prevent poor flows distribution and maximize the efficiency of pollutant removal.



1. Multiple inlets and outlets

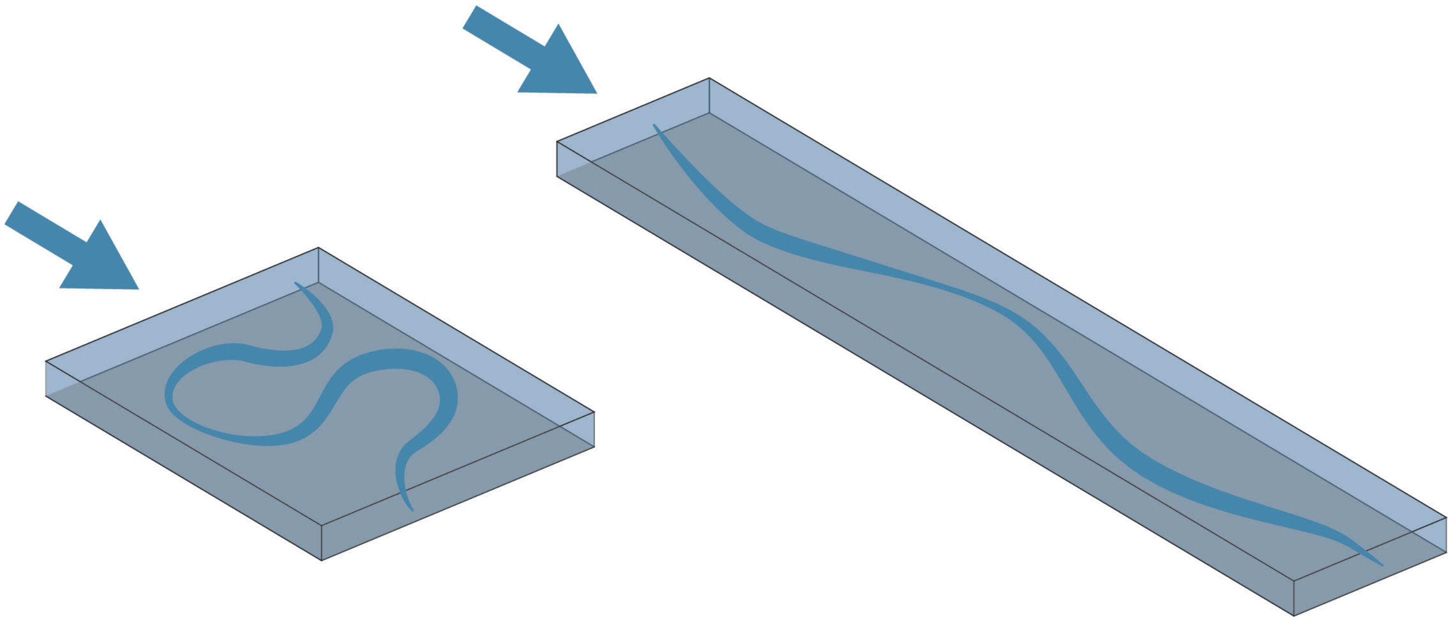
2. Adding inlet spreader ditch and outlet collector ditch

3. Adding the middle redistribution ditches to improve flow distribution in longer cells

Image. Maximizing flow distibution.

Based on: Zhang, Y. (2012). Design of a Constructed Wetland for Wastewater Treatment and Reuse in Mount Pleasant. Logan, Utah: Utah State University.

Layout and efficiency



1. In wide wetland the water is purified slower.

2. In narrow wetland the water is purified faster and more efficient

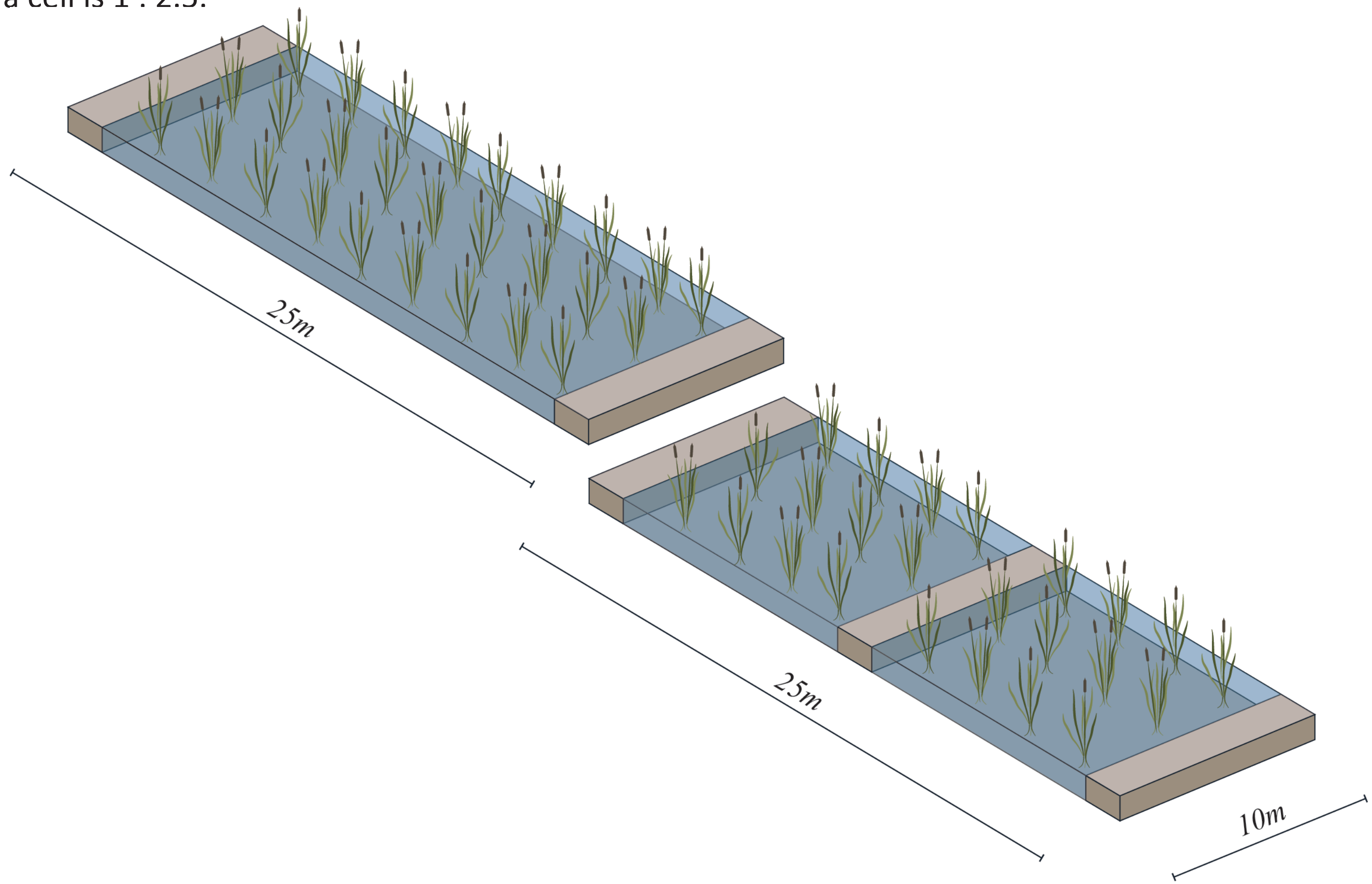
Image. Velocity of flow

Based on: Chih-Wei,C. (n.y.). Treatment Wetland: A Landscape Architect's Reference. Presentation. Patric Curran Fellowship.

constructed wetlands

Layout and efficiency

For a better water treatment and distribution it is important to separate wetlands into smaller cells. It allows to grade easier the quality of water and purify it better on diferent contamination level in each cell. The best ratio of such a cell is 1 : 2.5.

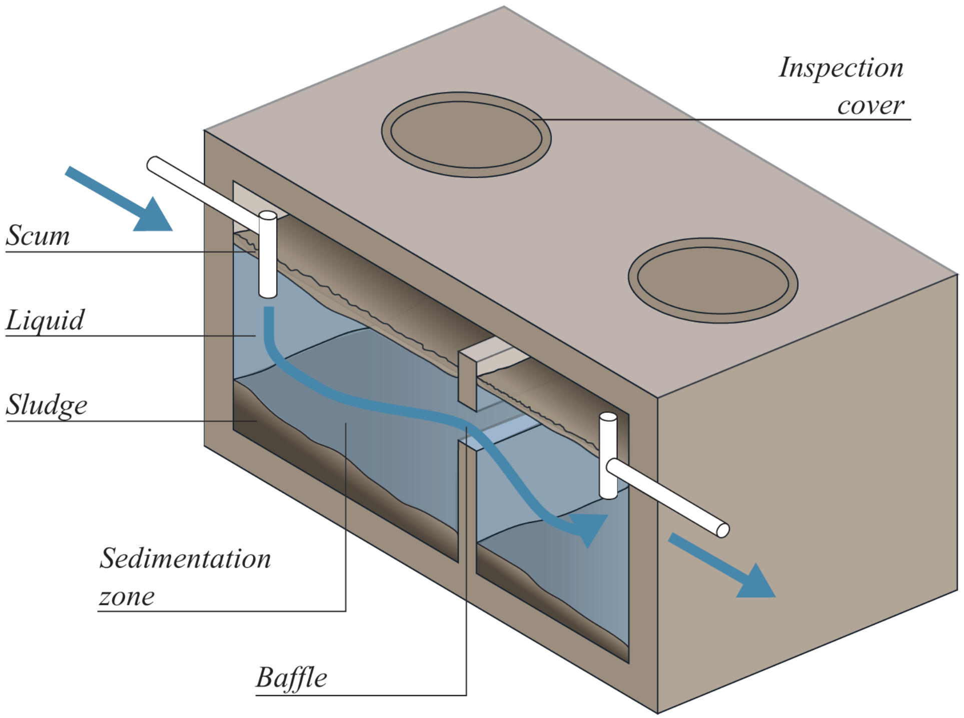


Based on: Zhang, Y. (2012). Design of a Constructed Wetland for Wastewater Treatment and Reuse in Mount Pleasant. Logan, Utah: Utah State University.

pre-treatment sceptic tank

first step of water treatment

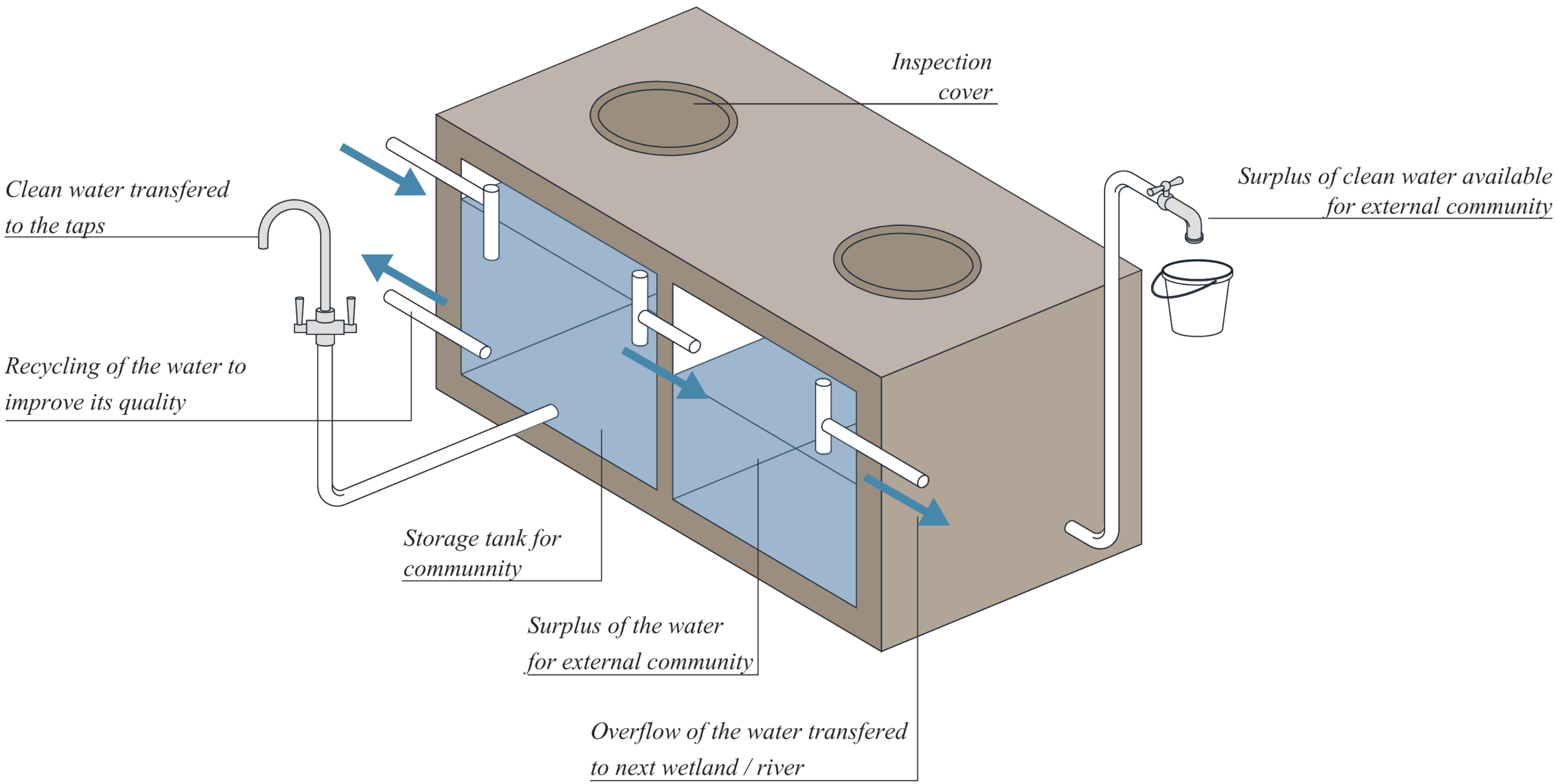
In constucted wetlands - especially sub-surfaced ones - it is important to provide a pre-treatment of the water in a sceptic tank. Thanks to it the sedimentation process happenes before the water enters the wentland avoid clogges of the pipes and voids in the wetland bed. Additionaly, the sceptic tank regulates the flow of the water to the wetlands.



water storage tank

opportunity for internal and external community

Purified water from the constructed wetlands is going to be used through hydraulic system by community. However, as the water is purrified constantly, its surplus can be used by external community in the collecting areas. Water is going to be significantly better quality than the one extracted by locals from the wells.



amount of required land for constructed wetlands in Cigondewah

Amount of required land for wetlands in Cigondewah:
- in Cigondewah it is needed to purify water 2 times:
    1. after taking it from poluted river
    2. purifing domestic graywater to use it again
- each water treatment requires pre-treatment in sceptic tank and storage tank at the end

Hybrid sub-surface wetlands:
For **hybrid sub-surface wetlands** the amount of used land is **2 - 2.5 m^2/ PE.**
Amount of land needed for one hybrid wetland for 200 people:
= 2.5 m^2 x 200 people
= **500 m^2**

Pre-treatment sceptic tank for wetlands:
The same amount of water as is being purified in the wetlands should be charged into the system from the river. This means that the sceptic tank should have the size of the water flowing through wetlands.

Size of pre-treatmentsceptic tank = 100 l x 200 people
= 0,1 m^3 x 200 people
= 20 m^3

amount of required land for constructed wetlands in Cigondewah

Water storage:
Average daily demand of water for whole community (acording to 2-2.5 m^2/ PE):
= 100 l x 200 people
= 0,1 m^3 x 200 people
= 20 m^3

The water flow is constant and the river is never dry. In case of emergency or maintanance lets assume that the stored water needs to be sufficent for 5 days:
Size of the water storage required = 20m^3 x 5 days
= **100 m^3**

Additionaly the overflow of the water from the storage will be stored in the wells of the same size providing additional supply of the water for external community.

Recycling of the flow:
The flow of water in hybrid sub-surface wetlands have closed - recycling improving denitrification in horizontal system. The water from te water storage is constantly getting backto the beginning of the wetlands where it is purified again.

constructed wetlands - case study

Shanghai Houtan Park

Built on a brownfield of a former industrial site, Houtan Park is a regenerative living landscape on Shanghai's Huangpu riverfront. The park's constructed wetland, ecological flood control, reclaimed industrial structures and materials, and urban agriculture are integral components of an overall restorative design strategy to treat polluted river water and recover the degraded waterfront in an aesthetically pleasing way.

American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

constructed wetlands - case study

Shanghai Houtan Park

The site is a narrow linear 14-hectare band located along the Huangpu River waterfront in Shanghai, China.

The **water of Huangpu River is highly polluted** with a national water quality ranking of Lower Grade V, the lowest grade on a scale of I–V and is considered unsafe for swimming and recreation and devoid of aquatic life.

American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

Shanghai Houtan Park

Constructed Wetland and Regenerative Design
Through the center of the park, a **linear constructed wetland**, **1.7 kilometers long** and **5–30 meters wide** was designed to create a living machine to treat contaminated water from the Huangpu River. Cascades and terraces are used to oxygenate the nutrient rich water, remove and retain nutrients and reduce suspended sediments;

Different species of wetland plants were selected and designed to **absorb different pollutants** from the water. Field testing indicates that **2,400 cubic meters per day of water can be treated from Lower Grade V to Grade III**. The treated water can be used safely throughout the Expo for nonpotable uses, and save half a million US dollars in comparison with conventional water treatment.

American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

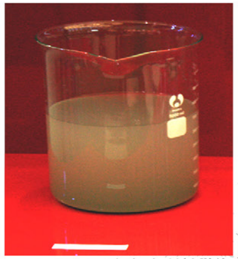
Type	Organisms
Emergent aquatic plants	*Acorus calamus*, *Oenanthe javanica*, softstem bulrush (*Schoenoplectus tabernaemontani*), *Alismaplantago-aquatica*, water chestnut (*Eleocharis dulcis*), wildrice stem (*Zizania latifolia*), *Sagittaria sagittifolia*, *Sheathe monochoria*, *Monochoi avaginali* S, *Cyperus alternifolius*, *Oryza sativa*, *Phragmite saustralis*, *Lythrum salicaria*, *Triarrhercas acchariflora*
Submerged plants	*Hydrillaver ticillata*, *Vallisineria natans*, *Potamogeton distinctus*, *Myriophyllum spicatum*, *Potamogeton crispus*, *Ceratophyllum demersum*, *Elodea canadensis* Michx
Aquatic animals	Chub, *Mallotus villosus*, *Parabramis pekinensis*, Mandarin fish (*Siniperca chuatsi*), freshwater shrimp, mussel, corbicula, snail, tadpole

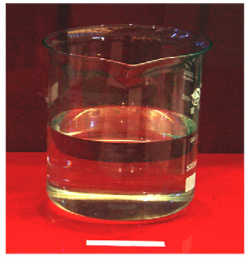
Table. Organisms used in the wetlands of Houtan Park, Huangpu River, Shanghai

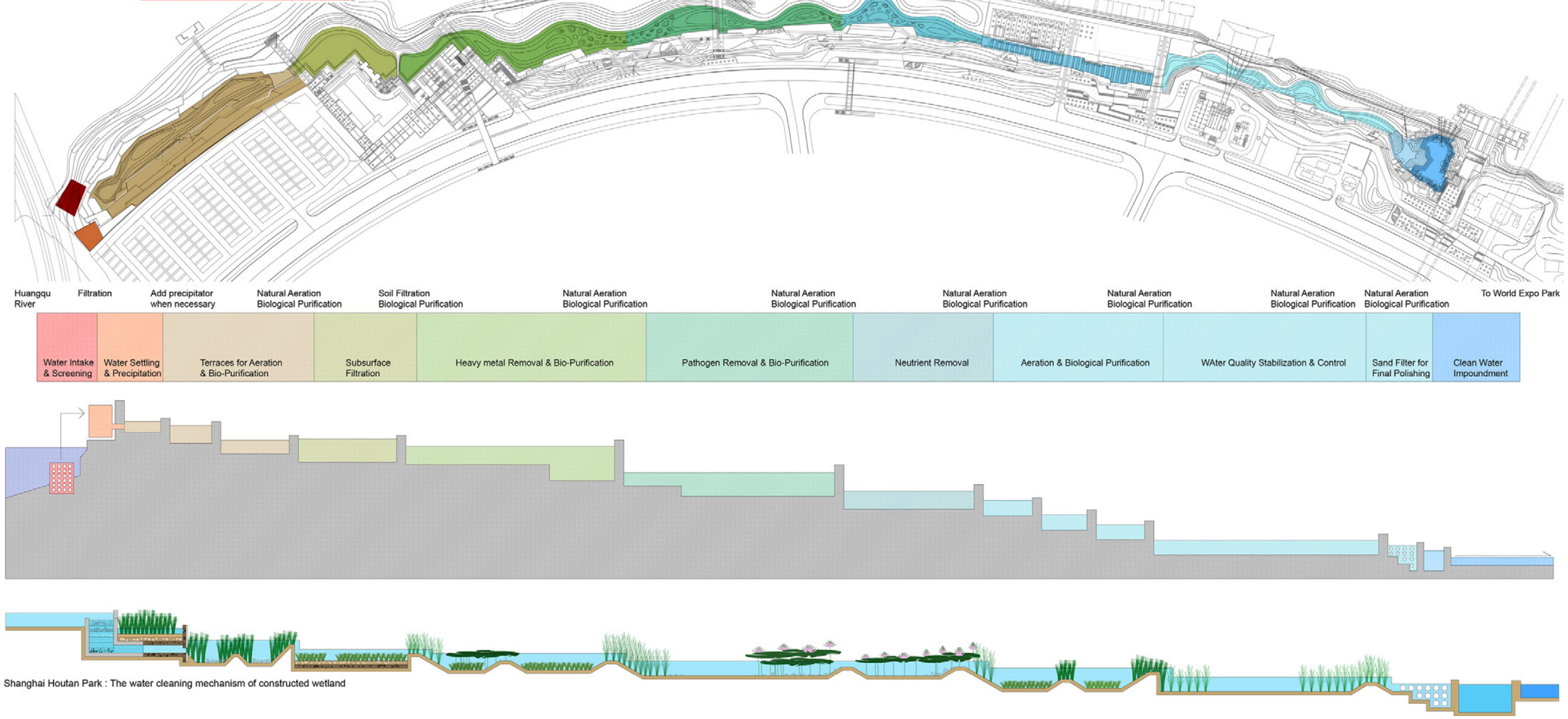
Wang, X., et al. (2015). Ecologial restoration for river ecosystems: comparing the Huangpu River in Shanghai and the Hudson River in New York. In: Ecosystem Health and Sustainability. Volume 1 (7) Article 23

constructed wetlands - case study

Shanghai Houtan Park





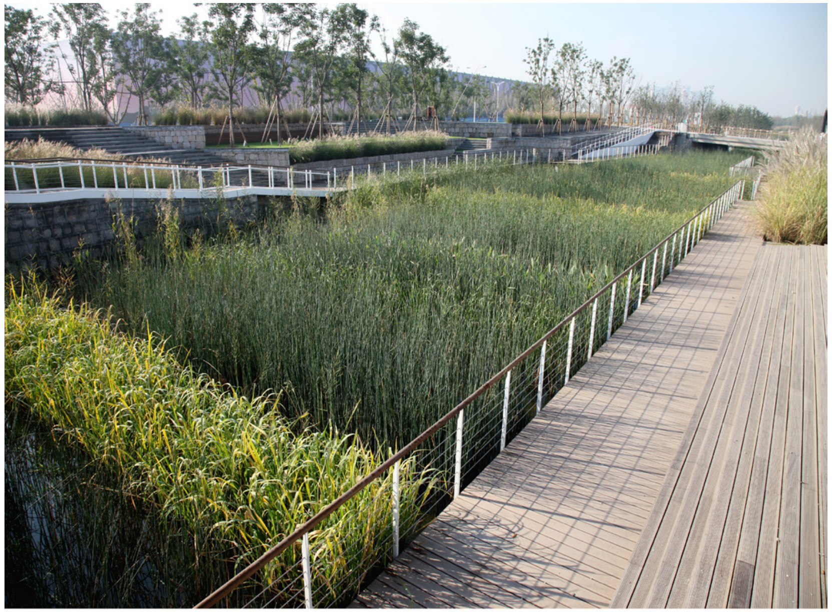


Shanghai Houtan Park : The water cleaning mechanism of constructed wetland

American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

constructed wetlands - case study

Shanghai Houtan Park



American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

constructed wetlands - case study

Shanghai Houtan Park

American Society of Landscape Architects. (n.y.) Shanghai Houtan Park: Landscape as a Living System. Retrieved from: https://www.asla.org/2010awards/006.html

wetland plants

choice of emergent plants

Bambusa bambos

Bambusa bambos:

Appearance:
- growing fast, strong wood
- average diameter 10-18 cm, 20-30cm tall
- dark green colour, thick walls, nodes slightly swollen

Habitat:
- tropical climate, grow along river banks or river valleys
where the soil is rich and moist, rainfall 2000-2500mm/ year, dense clumping

Uses:
- house construction, scaffolding, rafters, thatching, roofing
- handicrafts
- cooking utensils and fencing; shoots and seeds are edible, leaves are used as fodder
- medicine
- high heating value - can be used as a fuel

Bioclimatic use:
- as a wind breaker

Schroder, S. (2011, October 20). Bambusa bambos. Guadua Bamboo. Retrieved from: https://www.guaduabamboo.com/species/bambusa-bambos

wetland plants - bamboo

Bambusa bambos

Bambusa bambos:

Features:
- releasing 35% more O_2 than most of the trees
- grows fast
- does not need pesticides or fertilizers
- easily plend in the surrounding
- dense root system
- rustic plant - can resist many environmental stresses
- high heating value - can be used as a fuel
- very high removal efficiency of TSS, COD, BOD_5, N, P, K, Cu

(higher than 99% for set-up of 1520 m^2, 1.2-1.5m deep)

Arfi, V., et al. (2009). Initial efficiency of a bamboo grove–based treatment system for winery wastewater. Desalination, 246 (1-3), pp 69-77

System:
- filtration: water goes through the soil
- clean gray water - waste water that does not contain sewage or toxic chemicals
- micro-organisms degrade the organic matter

BRITER-WATER. (2013, October 17). Innovative system uses bamboo to treat wastewater. CORDIS. European Commission. Retrived from: http://cordis.europa.eu/news/rcn/36167_en.html

wetland plants - common reed

Phragmites australis

Common Reed:

Appearance:
- grow fast and extensivly
- hight from 2 to even 6m, leaves 20-50 cm long and 2-3 cm wide

Habitat:
- grows in most places in the world from temperate to tropical climate
- on wetlands in damp ground, can survive many years without the water

Uses:
- in construction for thatching roofs, fences, lattices,
- handcraft: baskets, sandals, mats
- source of fiber for yarn
- medicine
- high biomass - used as a fuel

Bioclimatic use:
- as a wind breaker

wetland plants - common reed

Phragmites australis

Common Reed:

Features:
- grows fast
- does not need pesticides or fertilizers
- dense root system
- rustic plant - can resist many environmental stresses
- well capability to treat dye-rich textile wastewater in hybrid sub-surface wetlands - colour removal (70-90%), COD (84%), TOC (89%), sulphate (88%), high Ag removal

Bulc, T. G., & Ojstršek, A. (2008). The use of constructed wetland for dye-rich textile wastewater treatment. Journal of Hazardous Materials, 155(1), 76-82.

System:
- water level fro 15 cm above to 15 cm bellow the ground
- filtration: water goes through the soil

wetland plants - cattail

Typha latifolia

Cattail:

Appearance:
- grow fast, 1 to 3 m high
- long , thin leaves, joinless steams with flowering spikes

Habitat:
- widespread species around the globe
- wet muddy soil, nearby the water reservoirs

Uses:
- handcraft: baskets, sandals, mats, furnitures
- seads can be used as a fiber for silk yarn
- high biomass production - used as a fuel

Features:
- dense root system
- well capability to treat wastewater in constructed wetlands from nitrogen, phosphorus, carbon and heavy metals: Cd, Cu, Pb, Zn

M., S., L., & M. (2005). Cattail population in wastewater treatment wetlands in estonia: Biomass production, retention of nutrients, and heavy metals in phytomass. Journal of Environmental Science and Health. Part A, Toxic/hazardous Substances & Environmental Engineering, 40(6-7), 1157-66.

System:
- filtration: through all kinds of wetlands
- clean waste water

wetland plants - yute

Corchorus oliterius

Yute:

Appearance:
- grow fast
- fairly branched, 1.5 m high

Habitat:
- grows in tropical climate of Asia and Africa, can be planted in the wet soil

Uses:
- handcraft: baskets, sandals, mats
- yute fiber for yarn
- leaves and fruits edible

Features:
- does not need pesticides or fertilizers
- dense root system
- best hight for minimize risk of bacterial contamination of plants is 90 cm and more
- well capability to treat wastewater in sub-surface wetlands from COD, NH_4^+ and PO_4^{3-}

Coulibaly, L., Savané, I., & Gouregrave, G. (2008). Domestic wastewater treatment with a vertical completely drained pilot scale constructed wetland planted with Corchorus oliterius. African Journal of Agricultural Research, 3(9), 587-596.

System:
- filtration: water goes through the soil in sub-surface wetlands
- clean waste water

wetland plants - mendong

Frimbistylis globulosa

Mendong:

Appearance:
- grow fast, 1 m high
- long , thin leaves like a grass

Habitat:
- tropical areas of Asia, Indonesia, damp areas around water

Uses:
- handcraft: baskets, sandals, mats,
- high biomass production - used as a fuel

Features:
- well capability to treat wastewater in all constructed wetlands from BOD, COD, nitrite and ammonia

Sunoko, H. R., & Izzati, M. (2014). APLIKASI SISTEM VERTICAL DAN HORIZONTAL SUB SURFACE FLOW WETLAND DALAM PENGOLAHAN KEMBALI EFFLUENT IPAL PERUSAHAAN OBAT DAN OBAT TRADISIONAL. Jurnal Riset Teknologi Pencegahan Pencemaran Industri, 5(1), 29-36.

System:
- filtration: through all kinds of wetlands
- clean gray water

electricity

renewable energy from the nature

electricity

use of electricity in Indonesia

Acording to the statistics of IEA Statistics, the electric power consumption in 2014 in Indonesia was **812 kWh/ capita/ year.**

According to IEA Statistics OECD/IEA 2014 (http://www.iea.org/stats/index.asp

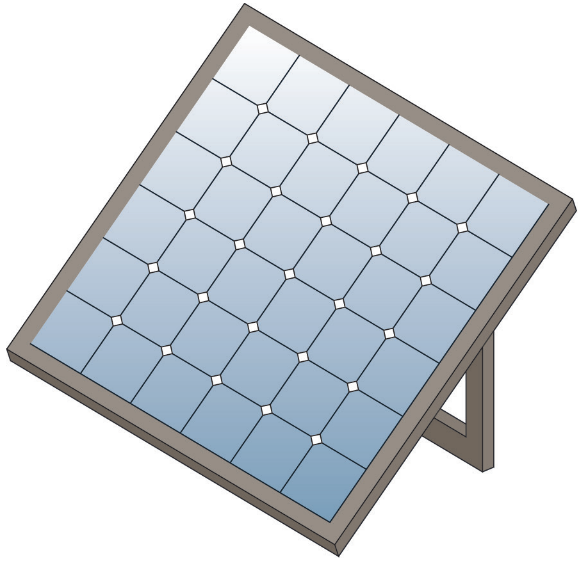
Energy power per capita = 812 kWh/ (365.25 x24 h) / capita
= 0.093 kWh/ 1 hour/ capita
= 93 watts/ capita

Estimating that in one house lives maximum 10 people:
Energy power need for community = 0.093 kWh x 10
= 0.93 kWh / 1 hour

Energy power need for 8 people/ day = 0.93 kWh x 24h
= 22.32 kWh/ day

sun energy - photovoltaic cells

calculations



Estimation made for **20% efficent** photovoltaic panels:
20% efficent 1 square meter PV cell can produce 200 watts for 1 hour of sun radiation under perfect conditions = **0.2 kW of energy.**

Scheckel, P. (2013). The homeowner's energy handbook : Your guide to getting off the grid. North Adams, MA: Storey Publishing.

Table: Solar Irradiance and energy gained from PV pannels in Bandung Indonesia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Solar Irradiance (kWh/m^2/day)	4.11	4.18	4.71	4.76	4.69	4.53	4.81	5.18	5.49	5.24	4.72	4.55
Energy gained from 1 m^2 PV panels of 20% efficiency/ day (kWh/m^2/day)	0.82	0.84	0.94	0.95	0.94	0.91	0.96	1.04	1.10	1.05	0.94	0.91

Based on : Solla Irradiance figures. Solar Electricity Handbook 2017. http://solarelectricityhandbook.com/solar-irradiance.html

sun energy - photovoltaic cells

calculations

Energy gained by 1 m^2 PV panels in less sunny month/ day = **0.82 kW / m^2/ day**

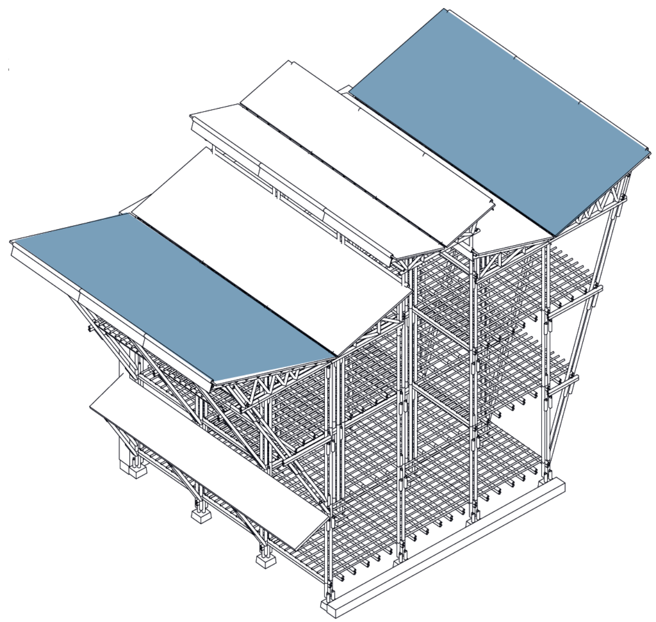
Energy gained by 1 m^2 PV panels in average during the year/ day = **0.95 kW / m^2/ day**

Amount of PV panels needed to supply household/ day:
Required area of PV panels/ day = 22.32 kW/ 0.82 kW/ m^2
= 27.22m^2

The photovoltaic panels will be installed in each house on the most extended roof top slopes over the extended balconies allowing fron natural ventilation under them and avoiding heating up the households.

Smaller roof top is 30.90 m^2 and bigger 33.66 m^2, which makes them a perfect
locate the PV pannels

The surpluses and deficits will be regulated by the energy storage batteries.



solar batteries

storing the energy from photovoltaic panels

In Indonesia the average annual sun radiation difference is very small. The surpluses and deficits are small enough, that community does not need to worry about sudden lack of energy. For this reason signifficant amount of additional energy can be stored in the solar batteries and be shared with external community.

For one dwelling an integrated battery system of 4 absorbed glass mat batteries can store 11.0 kWh. The size of the system is about 1m x 1.5m x 0.5m. The lifespan of batteries is about 10 years.
It is important that efficency of the bateries is only about 70%.

Based on product of Giant Power. http://www.giantpower.com.au/off-grid-system-large-residential-43.2kwh-agm

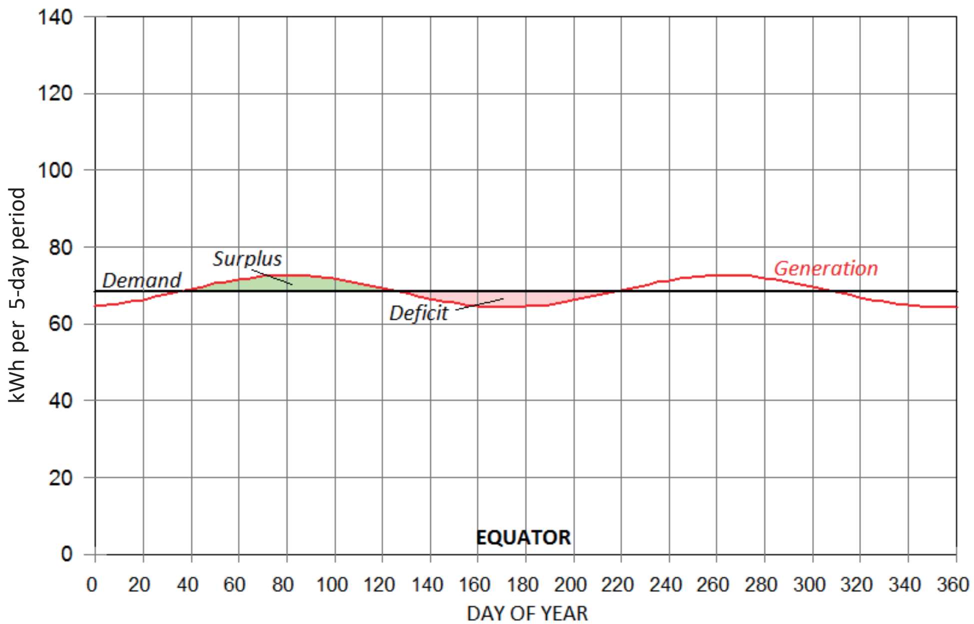


Image. Surpluses and deficits of energy around equator thruout the year.

Retrieved from: http://euanmearns.com/how-much-battery-storage-does-a-solar-pv-system-need/

biogas gained from human feces

Biogas is a product of the decoposition of organic mater by anaerobic (without oxygen) bacteria.

Biogas is a mixture of about 60% of methane and 40% of CO_2 with small amounts of H_2S, moisture and siloxanes.

How much m^3 of biogas can produce human waste:
One adult will produce 0.4 kg of feces per day which can produce 0.6 m^3 of biogas.

House, D. (2010) The Complete Biogas Handbook.

Biogas gained from 250 people/ day = 0.6 m^3 x 250
= 150 m^3 / day

There are other materials producing biogas like grease from sceptic tanks, wetland plants waste, kitchen waste, etc. However, they are not included in calculations beacause their supply varies throughout a year. Nevertheless, yearly energy yield can be significantly higher.

Scheme of biogas

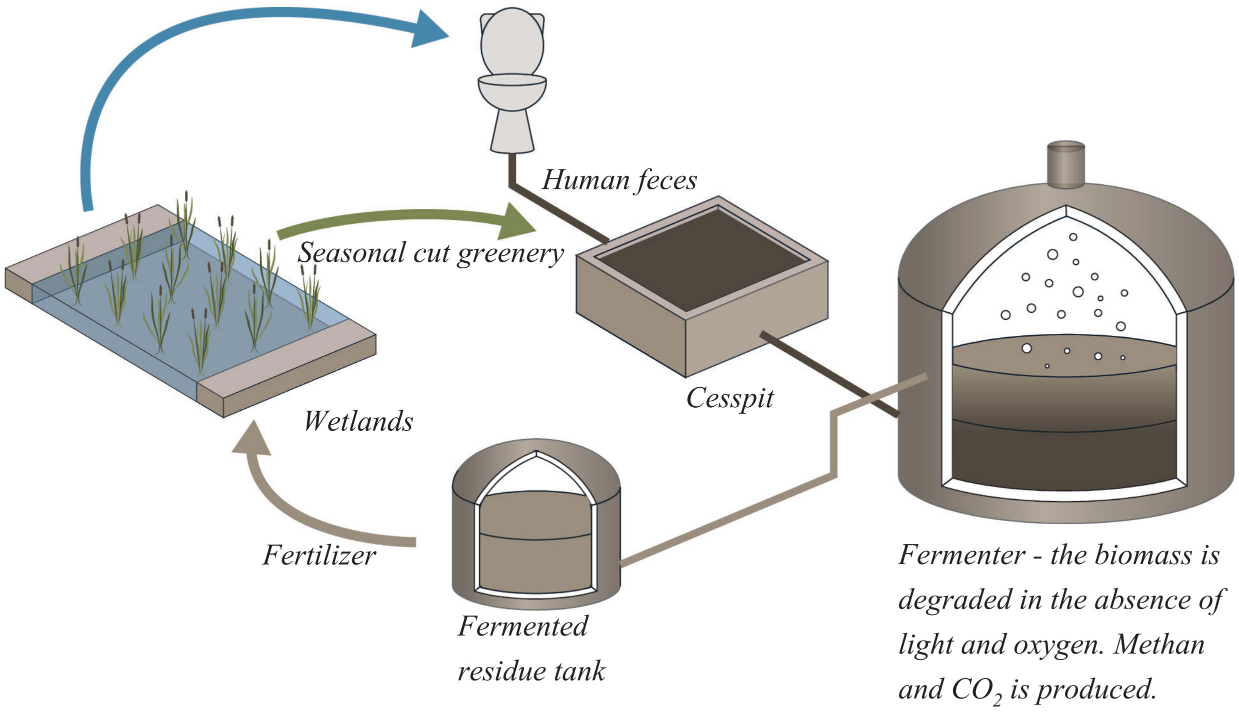


Image. Biogas plant

fermentation process efficiency rises with the temperature

For the production of the biogas the temperature is a significant factor. At higher temperatures, biogas production and methane content is greater than that at low temperatures.

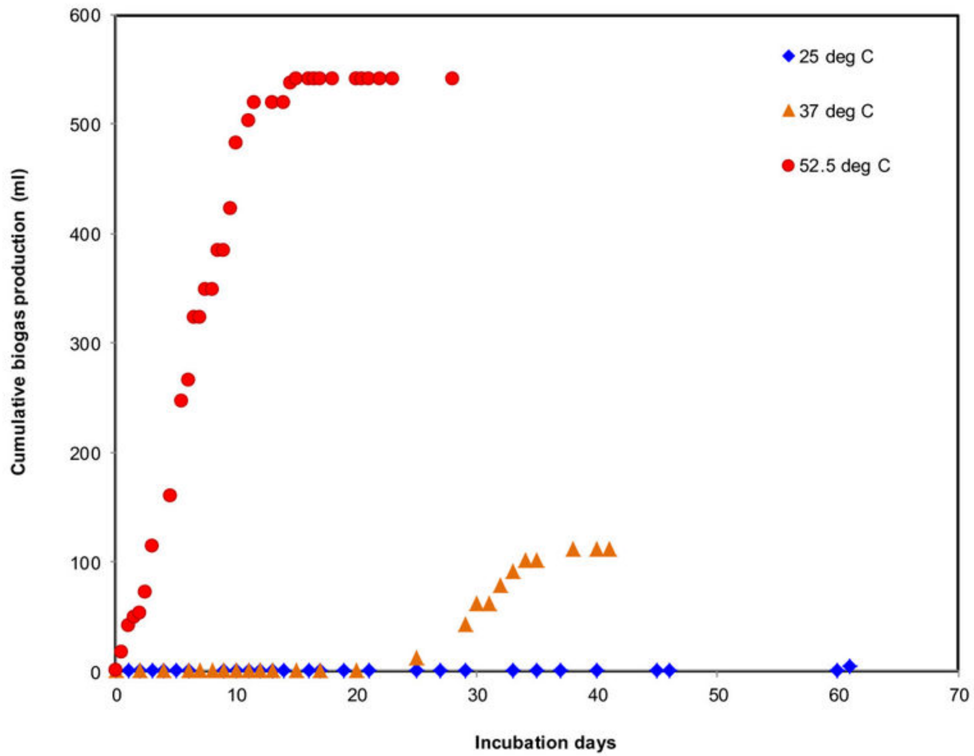


Image. Impact of temperature on biogas production. At higher temperatures, biogas production and methane content was greater than that at low temperatures.

Pandey, P. K., & Soupir, M. L. (2011). Escherichia coli inactivation kinetics in anaerobic digestion of dairy manure under moderate, mesophilic and thermophilic temperatures. AMB express, 1(1), 1-10.

first 25 day crucial for fermentation process

The research showes that the highest amount of the biogas is produced in first 25 days. For this reason it is important for the excreta to be located in biogas tank as fast as possible.

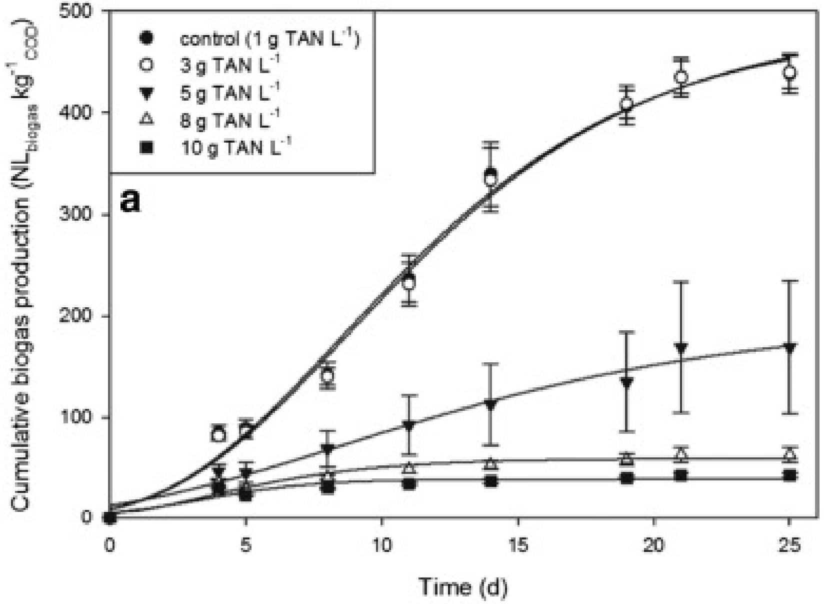


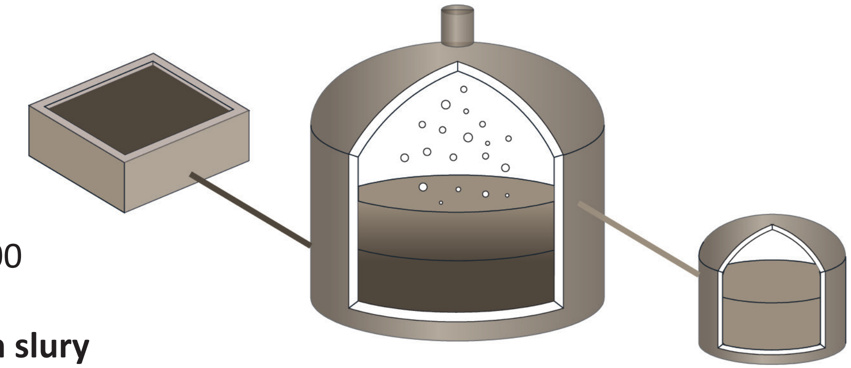
Image. Cumulative biogas production during biomethane potential tests with nonacclimated inoculum (NAI)

Concentrations selected in the experiment:
- 3 g TAN (total ammonia nitrogen) L−1 is the expected maximum concentration for **diluted excreta in low-flush toilets**,
- 5 g TAN L−1 would be a medium value for undiluted human excreta,
- 8 g TAN L−1 should be considered as a high value for undiluted excreta

Colón, J., Forbis-Stokes, A. A., & Deshusses, M. A. (2015). Anaerobic digestion of undiluted simulant human excreta for sanitation and energy recovery in less-developed countries. Energy for Sustainable Development, 29, 57-64.

biogas requirements

The size of biogas plant depends on 3 factors: daily feed, retention time, digester volume



Amount of excreta/ capita/ day:
- 0.4 kg of feces
- 0.8 l of urine

Amount of fermentation slury from 200 people/ day
= 0.4kg x 200 + 0.8 x 200
= 80 kg + 160 l
= **240 l of fermentation slury**

Hydraulic retention time: **40 days**

Colón, J., Forbis-Stokes, A. A., & Deshusses, M. A. (2015). Anaerobic digestion of undiluted simulant human excreta for sanitation and energy recovery in less-developed countries. Energy for Sustainable Development, 29, 57-64.

Digester volume = daily feed x retention time
= 240 l x 40 days
= 9600 l
= **9,6 m^3**

Taking into account that seasonaly there can be additional content added of around 6 m^3 the digester volume should be **15.6 m^3**

self-sustaining in water

water flow diagram

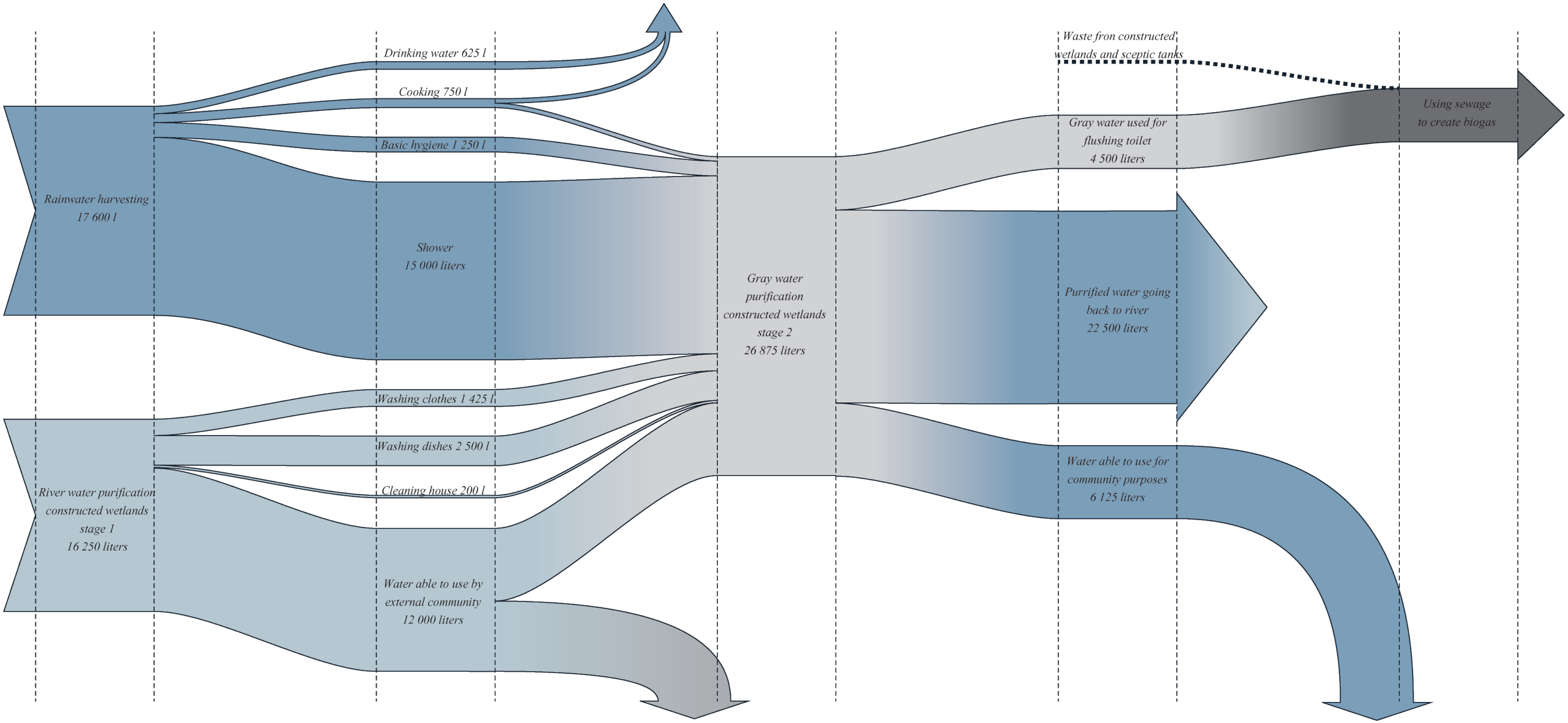
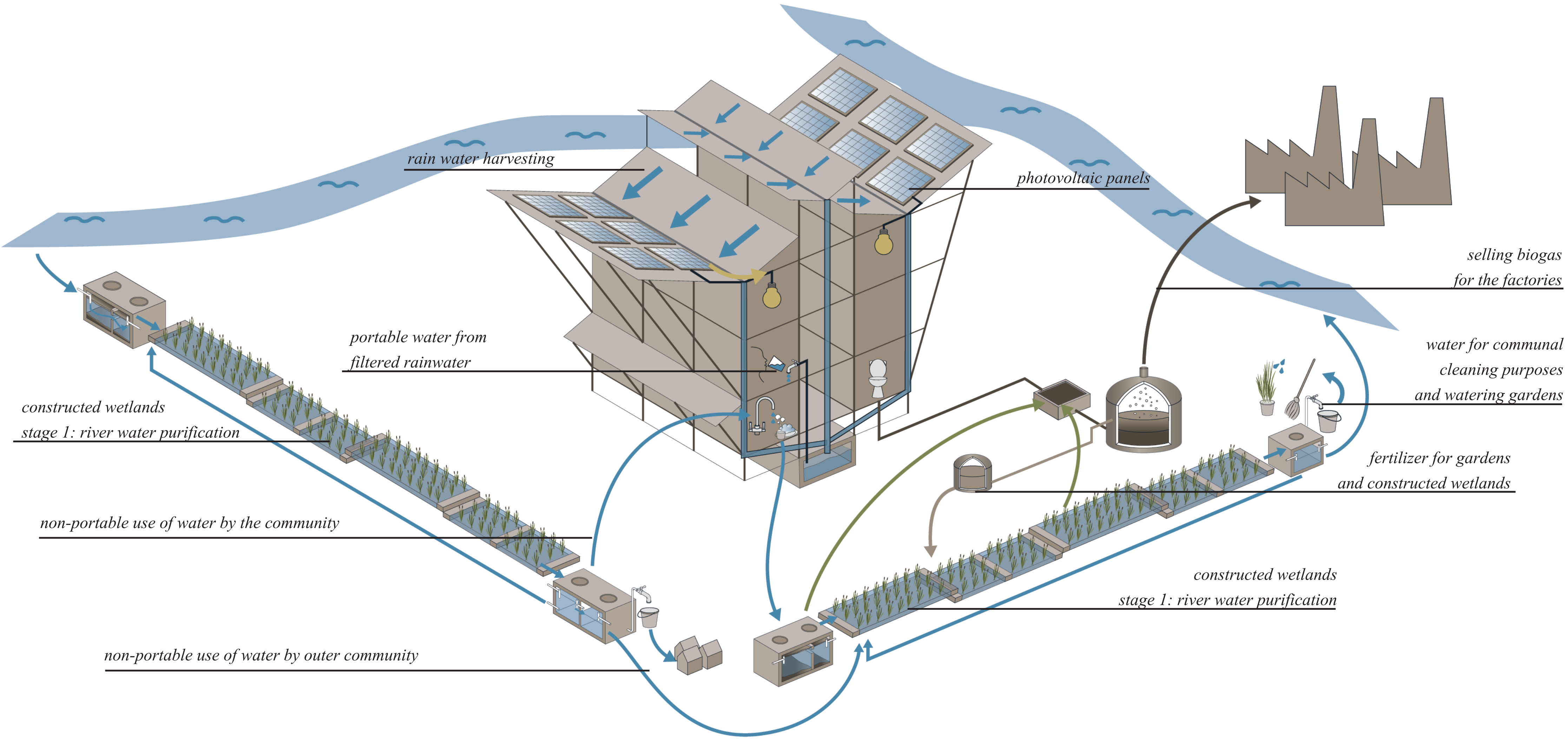


Diagram. Water flow diagram made for 250 people living in the community
+ additional water for the external community

into the climate

self-sufficient in energy and water village



ecological garden

---

use of fertilizer to grow healthy food

monthly amount of fertlilizer

calculation amount of required plots

Amout of fertilizer in a month = **15,6 m^3**

Retention day of fertilizer in open air : **30 days**

Best fertilizer for the bigger plans like fruit trees is a solid on.
However, for the vegetable gardens it is more important to use
a liquid fertilizer in the proportions 1: 5 fertilizer to water.

Area of crops needed for use solid fertlizizer monthly

= amount of fertilizer/ thicknes of fertilizer layers
= 15.3 m^3 / 0.02 m
= 765 m^2

Area of use of solid fertilizer needed for bannana tree plantation

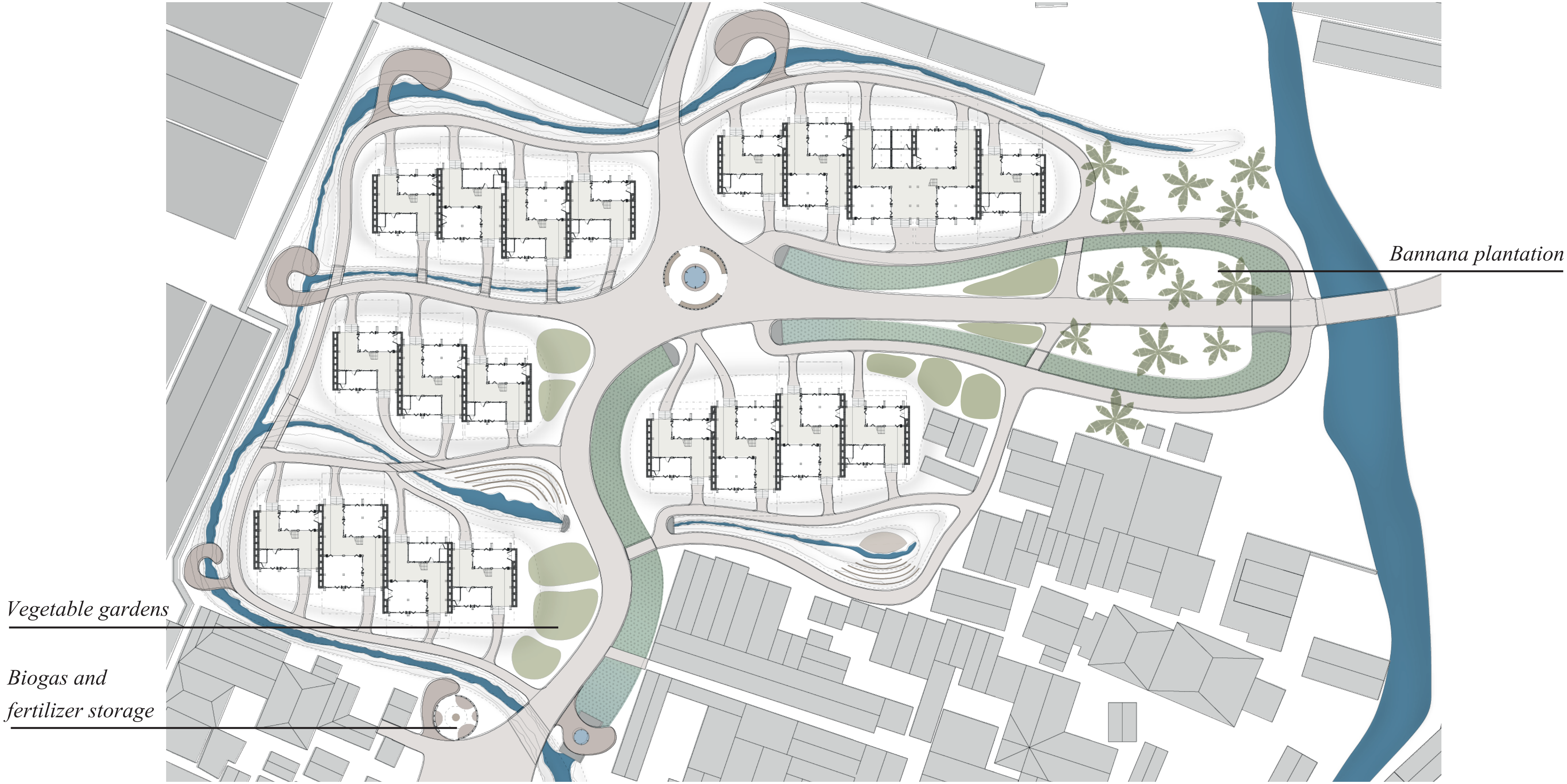
= 612 m^2

Areaof use of liquid fertilizer needed for vegetable gardens

= (765 m^2 -612 m^2) x 5(amount of water needed to desolve)
= 765 m^2

use of biofertilizer to grow vegetables

urban location



favourable plants for biogas fertilizer

banana tree, bell peppers, cabbage, eggplants, lettuce, peppers, pumpkins, raddish, sweet potatos, tomatos, zucchini