

# BLUE SCHOOLS.

LINKING WASH IN SCHOOLS  
WITH ENVIRONMENTAL  
EDUCATION AND PRACTICE

CATALOGUE OF  
TECHNOLOGIES

1<sup>ST</sup> EDITION  
CAMBODIAN CONTEXT

CARITAS

Caritas  
Cambodia  
Switzerland

Swiss Water & Sanitation Consortium



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# ADAPTATION OF BLUE SCHOOLS KIT FOR THE CAMBODIAN CONTEXT

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# INTRODUCTION.

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**A Blue School offers a healthy learning environment and exposes students to environmentally-friendly technologies and practices that can be replicated in their communities. It inspires students to be change agents in their communities and builds the next generation of WASH and environment sector champions.**

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The Catalogue of Technologies aims to support project staff, education authorities and school stakeholders in selecting the appropriate Blue Schools technologies that can be put in place in a particular school. It provides references to low cost technologies with particular focus on sustainable land and water management, gardening and solid waste management. The environmentally-friendly technologies are meant for students to experience at school, learn how they work and be inspired to replicate some of them at home and in their communities.

This catalogue proposes a selection of low-cost technologies for the following topics of the Blue Schools Kit.

For each topic, an introduction is provided to clarify the basic key concepts and the concept that are less common. The purpose of each technology, as well as its advantages and disadvantages are outlined.

This catalogue is a compilation of references from the WASH in School (WINS) community of practice as well as other sectors related to the Blue Schools' topics. It can evolve: Future editions of this Catalogue will benefit from input and feedback from users and experts from around the world. A feedback form is available at the Water and Sanitation Consortium [website: http://waterconsortium.ch/blueschool/](http://waterconsortium.ch/blueschool/)



## **1. My Drinking Water**



## **2. Sanitation and Hygiene**



## **3. Growth and Change**



## **4. From Waste to Resources.**



## **5. From Soil to Food**



## **6. My Surrounding Environment**

Users of this document are also encouraged to refer to the other materials of the Blue Schools Kit i.e. the Concept Brief, the Facilitator's Guide and the Catalogue of Technologies. These can be downloaded on the Swiss Water and Sanitation website.



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- 1.3 Protected hand dug wells
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TOPIC 01

# MY DRINKING WATER.

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**“When the well is dry we will  
know the worth of water.”**

BENJAMIN FRANKLIN







## WATER SOURCES/ UPTAKE

- Rooftop harvesting (1.1)
- Spring and water source protection (1.2)
- Protected hand dug well (1.3)
- Tube well or borehole (1.4)
- Treadle pump (1.5)
- Hand pump (1.6)
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- Solar pump / small distribution systems (1.15)
- Gravity flow water supply systems (1.16)



## WATER STORAGE & DISTRIBUTION

- Water storage tank: brick (1.8)
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## WATER TREATMENT

- Boiling (1.17)
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# MY DRINKING WATER.



Drinking water or water used for food preparation should be free from microbial, chemical and radiological pollutants. The provision of drinking-water that is not only safe but also acceptable in appearance, taste and odour is of high priority.

Unsafe drinking water may be contaminated by faeces and/or toxins, and may also be unacceptable due to suspended solids. Its consumption can result in infectious diseases, such as gastroenteritis, cholera and typhoid, among others. Contaminated water is estimated to result in more than half a million deaths per year.

The selection of the water source has high influence on the water quality. To avoid time-consuming and expensive treatment, if possible sources with high water quality and low health risks should be selected. Groundwater or spring water – if the catchments are adequately constructed and the sources are protected – are generally of higher quality than open surface water. But, even if water of high quality is available at the source, it may become contaminated due to unhygienic transportation and storage containers, or polluted water abstraction tools.

### **CONSEQUENTLY, SAFE WATER PROVISION AT SCHOOL DEMANDS THE ATTENTION OF THREE ASPECTS, RANGING FROM SOURCE TO CONSUMPTION:**

1. Identify an appropriate water source and assure it's appropriate catchment and protection;
2. Identify adequate strategies and options for water distribution, transport and storage;
3. Determine appropriate and feasible water treatment: options and technologies to guarantee user safety.

The following chapters present some innovative approaches to collect water from new sources, outline different options for drinking water storage at the school compound as well as in classroom and describe a number of methods for drinking water treatment that can be practised in schools. It is important to note that technology itself will not solve any problem if not adequately managed and applied.



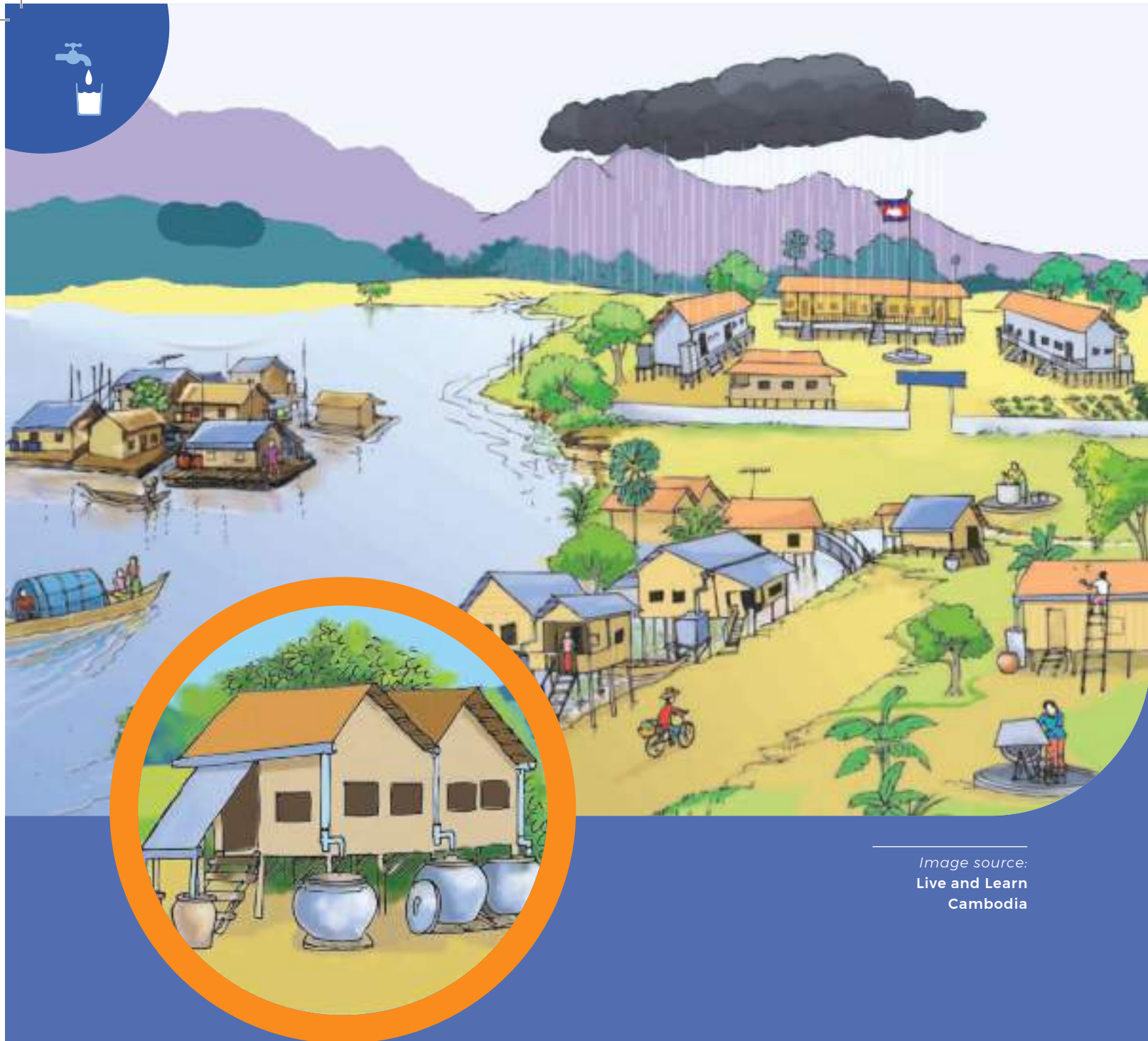


Image source:  
Live and Learn  
Cambodia



## ADVANTAGES

- Excellent alternative water source
- Flexible designs and capacities to suit diverse needs
- Simple, owner-managed technology
- Avoids loss of good quality water
- Restricts flooding



## DISADVANTAGES

- Limitations due to rainfall, size of catchment area and size of tank
- Chance of contamination from air pollution and dirt
- Storage tank construction adds to cost
- Maintenance is essential if water is to be potable

# 1.1

## ROOFTOP HARVESTING

| PRECIPITATION HARVESTING | WATER ACCESS |  
| WATER STORAGE |

### ADDITIONAL RESOURCES:

Appropedia, SSWM Rainwater Harvesting(rural)

SSWM\_Rainwater Harvesting (urban)

(Rainwater Cambodia)

### OUTLINE DESCRIPTION OF TECHNOLOGY

Rainwater Harvesting (RWH) is a method of collecting and conserving surface runoff rain water for storage and use. RWH has been in practice for centuries but gross misuse of existing water sources has led to global awareness and its increased importance of late.

### WHERE CAN IT WORK

Applicable anywhere with rainfall in excess of 300mm annually.

### HOW DOES IT WORK

Rooftop harvesting systems include rain, roof catchment areas, a conveyance system (gutters, downpipes), storage units or tanks (overground / underground), and a distribution system (pipelines, pumps). In addition, there are some aspects such as filter/screens, first-flush diverters, disinfection methods and overflow management pipes required to complete the RWH system. Periodic inspection of the system is imperative to preserve quality, reduce contamination and ensure full use of the system. It does not require skilled labour.

### COST CONSIDERATIONS

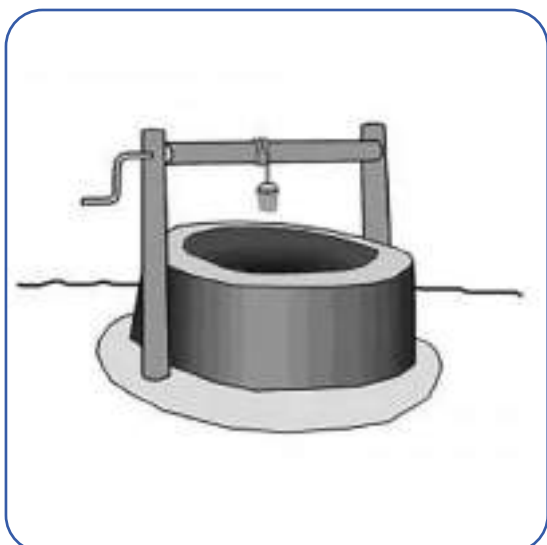
RWH is site specific and it is difficult to give an overall cost estimate. Rain and catchment areas are free of cost, especially if RWH is integrated during construction. The cost of the conveyance system, filters and typically the storage tank, which occupies 30-70% of the total costs, needs to be factored in. A study in India put the cost of constructing RWH at Rs1.30 / litre / household. In 2013, the EPA reported construction cost at approx. USD4 - 6 / gallon (3.78 litres) / person. (SSWM) PITCHAfrica constructed underground storage tanks in Kenya between 2012 and 2015 for USD80 / 1,000 litres of capacity. In Cambodia, the rainwater harvesting from 14 m<sup>3</sup> to 35 m<sup>3</sup> cost between USD1,750 and USD4,500. The cost includes tanks, pipe and first flush system, gutter and labour work ([Rainwater Cambodia](#)).



## 1.2 SPRING AND WATER SOURCE PROTECTION

Water source protection involves the protection of surface water sources (e.g. rivers) and groundwater sources (e.g. spring protection) to avoid water pollution. As many surface water sources are used for drinking water purposes, protection is vital. Generally, three basic strategies exist for protection, prevention, treatment and the restoration of natural ecosystems (UNEP).

*Wateraid SSWM*



## 1.3 PROTECTED HAND DUG WELL

The traditional and still most common method of obtaining groundwater in rural areas of the developing world is by means of hand-dug wells. These are best where the water table is not lower than 6m. A hole is dug until the groundwater level is reached. Inflowing groundwater is collected and extracted with the help of pumps or buckets. Protection of the surrounding areas must be ensured to prevent contamination.

*SSWM*



## 1.4 TUBE WELL OR BOREHOLE

A tube well is a type of water well in which a long 100–200mm wide stainless steel tube or pipe is bored into an underground aquifer. It is important to determine that the aquifer is not contaminated and is being recharged. The lower end is fitted with a strainer, and a pump lifts water for irrigation. The required depth of the well depends on the depth of the water table. *Wiki*



## 1.5 TREADLE PUMP

A treadle pump is a human-powered suction pump that sits on top of a well and is used for irrigation. It is designed to lift water from a depth of 7m or less. The pumping is activated by stepping up and down on a treadle, which are levers that drive pistons creating cylinder suction that draws groundwater to the surface. [Wiki](#)



## 1.6 HAND PUMP

Hand pumps are manually operated pumps. There are many different types of hand pump available, mainly operating on a piston, diaphragm or rotary vane principle with a check valve on the entry and exit ports to the chamber operating in opposing directions. [Wiki](#)



## 1.7 ROPE PUMP

In a rope pump, a loose hanging rope is lowered into a well and drawn up through a long pipe with the bottom immersed in water. On the rope, round disks or knots matching the diameter of the pipe are attached that pull water to the surface. They can be operated by hand, pedals, motors or wind. It is commonly used in developing countries for both community and self supply of water, and can be installed on boreholes or hand-dug wells. Protection of the surrounding areas must be ensured to prevent contamination. [Wiki](#)

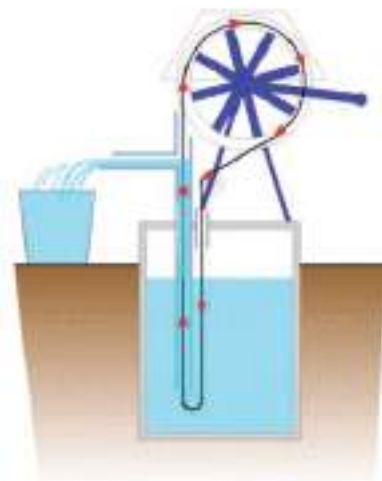




Image source:  
FAO/TECA



#### ADVANTAGES

- Inexpensive to construct
- Easier to construct than ferrocement tanks
- Can be made with local materials



#### DISADVANTAGES

- Small capacity
- Requires maintenance to avoid cracking and leakage



## 1.8

# WATER STORAGE TANK: RING CONCRETE TANK

| WATER STORAGE |

### ADDITIONAL RESOURCES:

Akvopedia IRCWash

Rainwater Cambodia

### OUTLINE DESCRIPTION OF TECHNOLOGY

Ring concrete tanks are a low cost option for storing water gained through water harvesting. They are cheaper than ferrocement tanks and easier to build.

### WHERE CAN IT WORK

In any region where there is access to ring concrete supply.

### HOW DOES IT WORK

Ground tanks should always be designed as rectangular by using brick and cement payment. Depending on the size of the tank, water extraction can be done using gravity equipped with a first flush system and gutter system. Avoid building the tank next to a tree as the roots may undermine the foundations and dry leaves will block gutters. The gutters should be higher than the proposed height of the tank. Do not site tanks where heavy vehicles will pass close to its foundations.

### COST CONSIDERATIONS

The cost for the ring concrete tank depends on the size and cost of the ring concrete, bricks and cement. Ring concrete tanks with the 3 m<sup>3</sup> water storage tank cost USD300, including materials and labour. ([Rainwater Cambodia](#))



*Image source:*  
**Caritas Switzerland**



### ADVANTAGES

- Formwork can be reused
- Inexpensive to construct
- Can be used to store rainwater or food



### DISADVANTAGES

- Moulds become unwieldy at larger sizes.

## 1.9

# WATER STORAGE TANK: FERROCEMENT

| WATER STORAGE |

### ADDITIONAL RESOURCES:

Akvopedia  
Rainwaterharvesting.  
org CWD

NEPCAT Fact Sheets  
(Helvetas Nepal)

### OUTLINE DESCRIPTION OF TECHNOLOGY

Even small 1,000-2,000 litre ferrocement tanks can be effective for the storage of water (or food). They can be constructed with various agricultural waste materials (e.g. dry leaves or grass) in combination with cement and cloth fibre. The larger 5,000-10,000 litre tank (1.13) uses similar principles in its construction.

### WHERE CAN IT WORK

Anywhere with rainfall of 300mm per year or more.

### HOW DOES IT WORK

A 2 m<sup>3</sup> (2,000 litre) ferrocement water tank can be built by forming a cage of steel reinforcement bars, covered with chicken wire mesh. An alternative is to start with an inner form of metal sheets, which is later removed. For smaller tanks, a sack filled with sand is used as the formwork. Once this structure is established, a cement mixture is applied. As ferrocement is much stronger than masonry, the thickness of the walls is in the range of 10-30mm. During curing (at least 10 days, although 30 is better), the cement is kept wet and wrapped in plastic sheet. These tanks are significantly cheaper than plastic tanks, have a lifetime of at least 25 years and are easy to repair in case of cracks. The technology is extremely simple to implement, and semi-skilled construction workers can learn it with ease. Such tanks have been used on a wide scale in Asia and some African countries, and there is huge scope for increased use of rainwater harvesting systems.

### COST CONSIDERATIONS

Ferrocement tanks: \$26 - \$50 per m<sup>3</sup> storage depending on size (e.g. 11m<sup>3</sup> for \$550, 46m<sup>3</sup> for \$1,200) ([Akvpedia](#)). In Cambodia, the construction of the tanks from 12.5 m<sup>3</sup> to 35 m<sup>3</sup> water storage cost from \$1,750 to \$3,500. The cost include the cost of tanks, pipes and first flush system, gutter and labour work ([Rainwater Cambodia](#)).



Image source:  
[www.niftyhomestead.com](http://www.niftyhomestead.com)



#### ADVANTAGES

- Inexpensive to construct
- Easier to construct than ferrocement tanks
- Can be made with local materials



#### DISADVANTAGES

- Small capacity
- Requires maintenance to avoid cracking and leakage



## 1.10

# WATER STORAGE TANK: PLASTIC BOTTLE

| ECO TEC | WATER STORAGE |

### ADDITIONAL RESOURCES:

Nifty Homestead  
Peace Corps

### OUTLINE DESCRIPTION OF TECHNOLOGY

Used water bottles filled with soil and non-organic waste are used as bricks for the construction of a water tank.

### WHERE CAN IT WORK

Regions where plastic bottles are used and discarded and there are no effective ways of recycling them.

### HOW DOES IT WORK

This tank is constructed using 1.5 litre plastic bottles. The bottles are filled with soil or non-organic waste and used as bricks to construct water tanks and latrines. This concept has been adopted in the community of Mwera in Zanzibar, where two 10,000 litre water tanks have been constructed using 'bricks' made from reused water bottles. The weight of plastic reused to build the tanks was considerably less than a conventional plastic 'SIM tank.' The sustainable water tanks use significantly less cement than a conventional brick tank and are much stronger and more durable than either construction alternative. (*Ecologue*)

### COST CONSIDERATIONS

The tank requires plastic bottles, river sand, cement and reinforcement twine or wire.



### 1.11 PLASTIC SIM TANK

Plastic tanks for storing up to 10,000 litres of rainwater harvesting and water storage can be purchased in most countries. These tanks typically last for 4-5 years. [akvopedia](#)



### 1.12 WATER JAR

Water Jar is universally applicable and can be constructed in part with unskilled labour. Materials are metal frame, chicken wire and sand and cement. In Cambodia, water jar is popular for domestic use in the rural area. [Practical Action\\_Domestic Tank](#)



### 1.13 UNDERGROUND FERROCEMENT TANK

Ferrocement is a system of reinforced mortar or plaster (lime or cement, sand and water) applied over a layer of metal mesh, woven expanded metal or metal fibres and closely spaced thin steel rods such as rebar. It is ideal for constructing above or under ground rainwater storage tanks. (Wiki)

[Practical Action USAID](#)

## 1.14 BLUE PLASTIC STORAGE AND DISTRIBUTION TANK

A properly designed plastic storage and distribution must be affordable, portable, durable and easy to use. It must have a tap to withdraw water in a sanitary manner (reduce contamination by hands or dipping utensils). Yet, it is important that the mouth is still big enough and the tap removable in order to be properly cleaned. It must have a coverable (screw-cap) opening for filling and cleaning.



## 1.15 SOLAR PUMP / SMALL DISTRIBUTION SYSTEMS

Small water distribution systems equipped with solar pumps allow the distribution of safe water to schools and health centres, as well as to the community. *Helvetas Benin*



## 1.16 GRAVITY FLOW WATER SUPPLY SYSTEMS

True to their name, gravity flow systems take advantage of gravity to transport water from a source to a service area located at a lower elevation. From the intake, water is transported continuously by a transmission line to one or several storage tanks. Higher capacity distribution pipelines then supply water to public and/or private tap stands. *NEPCAT Fact Sheets (Helvetas Nepal)*





*Image source:*  
Scott Akerman (CC BY 2.0)



### ADVANTAGES

- Disinfects viruses, bacteria and protozoa
- Commonly known technology
- Can be applied with locally available resources
- Also treats turbid water



### DISADVANTAGES

- Recontamination risk during storage
- Energy-intensive, requires energy (fuel, wood, electricity)
- Time consuming application
- Not suitable for treating large volumes



# 1.17

## BOILING

| WATER TREATMENT |

### ADDITIONAL RESOURCES:

Safe Water School  
Manual SSWM HWTS

### OUTLINE DESCRIPTION OF TECHNOLOGY

Boiling is the world's oldest and most common water treatment technology.

### WHERE CAN IT WORK

The technology is commonly applied at a school/household scale. Due to the effort required to heat up the water, it is never used on a large scale.

### HOW DOES IT WORK

WHO recommends to heat up water to a rolling boil for one minute. Pathogens are sensitive to heat and the disinfection process, which is called pasteurization, starts at 60°C. At a temperature of 100°C it takes about one minute to disinfect the water. Ideally, the water is cooled and stored in the same vessel to minimise the chances of re-contamination. Boiling kills pathogens but does not remove turbidity or chemical pollution from drinking water.

### COST CONSIDERATIONS

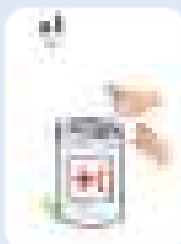
It requires time to collect wood for cooking or fuel or electricity has to be purchased. The energy required to heat up 1L of water from 20°C to 100°C and let it boil for one minute takes about 360 kJ/L. The energy content of hardwood is about 14.9 MJ/kg. If hardwood is burnt with an efficiency of 50%, about 50g of wood has to be burnt to boil 1L of water. The energy content of kerosene or diesel fuel is about 43.1 MJ/kg. If burnt with an efficiency of 50%, it takes about 16ml of kerosene to boil 1L of water.



Wash your hands  
with water and  
soap or ash.



Is your water  
clear?



Put 1 tablet in the  
container.  
Close container.



Wait 30 minutes.



Water is now ready.



Is your water  
dirty looking?



Filter the water  
through cloth.



Add 2 tablets  
to the container.  
Close container.



Wait 30 minutes.



Water is now  
ready.

Image source:  
[www.ifrc.org](http://www.ifrc.org)



## ADVANTAGES

- Disinfects viruses, bacteria and protozoa
- Simple to use
- Low cost
- Provides residual disinfectant (protects water against recontamination)



## DISADVANTAGES

- Challenges in disinfecting *Cryptosporidium*
- Changes water taste
- Highly turbid water needs pre-treatment
- Chlorine is a corrosive chemical and precaution must be taken for handling

# 1.18

## CHLORINATION

| WATER TREATMENT |

### ADDITIONAL RESOURCES:

Safe Water School  
Manual SSWM HWTS  
WATA WHO Helvetas  
Benin

### OUTLINE DESCRIPTION OF TECHNOLOGY

Chlorine is a widely used chemical disinfectant. Different brands of chlorine products are available in local markets. They may contain a concentration of 0.5 to 10% chlorine. Commonly used products are: 1) Liquid sodium hypochlorite ( $\text{NaOCl}$ ), which can be generated from salt using electrolysis (it is, however, not stable and has to be protected from sunlight and heat), 2) Sodium dichloroisocyanurate ( $\text{NaDCC}$ ), usually very stable in tablet form, and 3) Solid calcium hypochlorite ( $\text{Ca(OCl)}_2$ ), known as bleaching powder.

### WHERE CAN IT WORK

Water disinfection with chlorine is broadly applicable. Batch system chlorination can be applied for small to larger water storage containers while continuous chlorination systems also exist for water supply schemes.

Technologies for the local production of chlorine using electrolysis are available (for example WATA) and have been successfully used for water treatment in schools.

### HOW DOES IT WORK

Chlorine reacts within a relatively short contact time of 30 minutes. Water quality influences the inactivation by chlorine as particulate, colloidal and dissolved constituents react with the free chlorine and consume it. Turbid water needs pre-treatment to reach a turbidity of less than 5 NTU. The pH of the water should be between 6.8 and 7.2.

WHO recommends that there should be a residual concentration of free chlorine of  $\geq 0.5 \text{ mg/L}$  after at least 30 minutes contact time. At the point of delivery, the minimum residual concentration of free chlorine should be  $0.2 \text{ mg/L}$  (WHO 2017).

### COST CONSIDERATIONS

A locally purchased bottle of liquid sodium hypochlorite for the treatment of 1,000 litres of water costs about USD0.1 to 0.5.

A mini-WATA, which produces about 500ml of Chlorine in three hours using salt and water, costs USD150. If no electricity is available locally, a solar panel needs to be purchased.



Image source:  
Eawag



### ADVANTAGES

- Removes bacteria and protozoa
- Simple application
- Local production possible
- No requirement for chemicals or energy



### DISADVANTAGES

- Limits effectiveness against viruses
- Recontamination risk during storage
- Quality of locally-produced filters is variable
- Requires regular cleaning if water is turbid
- Fragile materials can lead to filter breakage

# 1.19

## CERAMIC WATER FILTER

| WATER TREATMENT |

### ADDITIONAL RESOURCES:

Safe Water School  
Manual SSWM HWTS

Ceramic Water Filter  
Handbook

### OUTLINE DESCRIPTION OF TECHNOLOGY

Different types of ceramic filters exist (e.g. pot-shaped filter, candle filter). The removal effectiveness depends on the size of the pores in the clay. Ceramic filters usually have a pore size of about 100mm. Pore size and permeability of the ceramic filters are a function of burnable components and the pressure applied during production. The quality of locally-produced filters can be highly variable.

Some ceramic filters are coated with colloidal silver. This leads to a higher disinfection efficiency and contributes to the reduction of recontamination risks in stored water. However, potential adverse health risks of silver leaching are disputed.

### WHERE CAN IT WORK

Ceramic water filters usually are designed to treat a volume of 20 to 30L. They are commonly used at household scale. Ceramic water filters can also be placed in school classrooms.

Ceramic water filters are not ideal for the treatment of very turbid water as the particles in the water clog the filters, leading to a frequent need for filter cleaning.

### HOW DOES IT WORK

Water is filtered through porous ceramic material – either through a candle filter or a pot-shaped filter. Most filters are effective at removing about 99.9% of protozoa and 99.99% of bacteria, but do not remove viruses. The flow rate in ceramic water filters is about 1-2 litres per hour. Insufficient cleaning and unhygienic maintenance of filters can lead to recontamination of the treated water.

### COST CONSIDERATIONS

Ceramic water filters including housing cost between USD20 to 45. The replacement of candles or clay filters cost below USD10.



## How a Biosand Filter Works

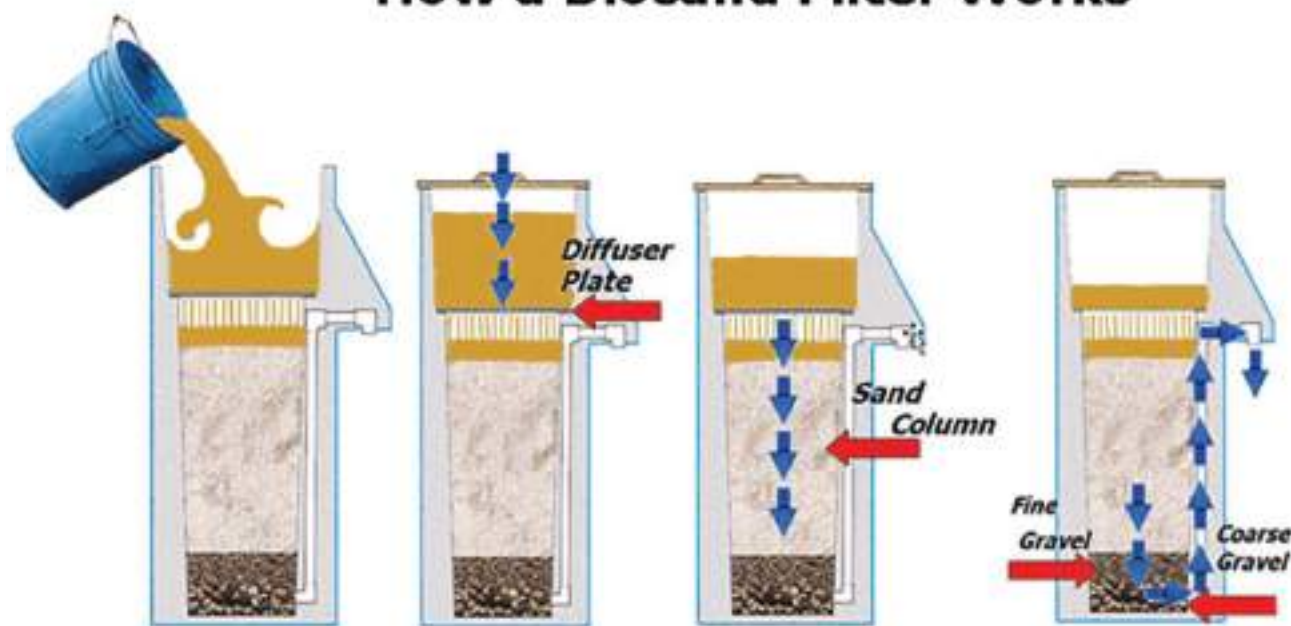


Image source:  
SSWM



### ADVANTAGES

- High removal of protozoa, lower removal of bacteria and viruses
- Simple application
- Local production possible
- No energy or chemical requirements
- Very robust installation and long lifespan



### DISADVANTAGES

- Disinfection efficiency lower than other technologies
- Needs maturity (2-3 weeks) for the biological layer to be effective ("Schmutzdecke")
- Filter clogs at high turbidity (>50 NTU)
- No residual protection against recontamination

## 1.20

# BIOSAND FILTER

| WATER TREATMENT |

### ADDITIONAL RESOURCES:

Biosandfilter Safe  
Water School Manual  
SSWM HWTS

### OUTLINE DESCRIPTION OF TECHNOLOGY

Water in a biosand filter passes through several layers of sand and gravel with different grain size. Microorganisms living in the so-called “Schmutzdecke”, a biologically active layer on the top of the filter, consume bacteria and other pathogens in the water. Biosand filters remove about 90% of bacteria and viruses and about 99% of protozoa. The microorganisms in the biological layer consume organic matter dissolved in the water and therewith also improve the chemical water quality. In addition to predation, sediments, cysts and worms are trapped in the spaces between the sand grains or adsorbed by the material. Biosand filters have a very long lifespan, they may still perform satisfactorily after 10 years. Their installation therefore can be useful in remote areas with limited access.

### WHERE CAN IT WORK

Biosand filters are commonly applied at household scale or can be placed in school yards. Designed as slow sand filters, the technology is also used for water treatment in larger scale water supply schemes.

Biosand filters are not ideal for the treatment of water with a turbidity of more than 50 NTU as the particles in the water will clog the filters, leading to a frequent need for filter cleaning.

### HOW DOES IT WORK

The surface of the filter is always submerged under water. This leads to the formation of the “Schmutzdecke”, the biologically active layer on top of the filter, allowing bacteria and pathogen removal. After passage through the filter, the water is collected in a safe storage bucket.

Cleaning or drying of the filter destroys the “Schmutzdecke”. Two to three weeks of operation are required for the biological layer to build up and for the filter to perform satisfactorily again. The biosand filter designed by CAWST has a recommended flow rate of 0.4 litres/minute measured when the inlet reservoir is full of water.

### COST CONSIDERATIONS

The installation of a household scale biosand filter costs about USD40 to 75.



TOPIC 02

# SANITATION AND HYGIENE.

---

“Hygiene is two thirds  
of health”

LEBANESE PROVERB









## HAND WASHING STATIONS

- Tippy tap (2.1)
- Tap Up hand sink (2.2)
- touch-free hand washing units (2.3)
- Hand washing station (2.4)
- Happy Tap (2.5)



## TOILET FACILITIES

- Single Ventilated Improved Pit (VIP) Latrine (2.6)
- Urine diverting dry toilet ECOSAN toilet (2.7)
- Twin pits for pour flush (2.8)
- Arborloo (2.9)

# SANITATION AND HYGIENE.



Good hygiene and sanitation practices are very important in preventing infectious diseases in general, and water-borne diseases in particular. Hence, this topic focuses on promoting technologies that interrupt and limit the spread of diseases. If technologies are used in everyday life, sound hygiene practices can save lives, especially young lives.

This topic presents a small selection of hand-washing stations and toilet facilities that can be built at very low or medium costs. Most of them are not only appropriate for schools, but can be replicated in students' homes. For an

extended overview of various types of sanitation technologies, consult the [Compendium of Sanitation Systems and Technologies](#) (Eawag). Technologies to store and treat drinking water is covered in Topic 1 and technologies to keep the surrounding environment clean from waste is covered in Topic 4.

The use and maintenance of the infrastructure, as well as good hygiene practices, are key to success. Examples of how it can be introduced and discussed with students in a practical and fun way are demonstrated in the Catalogue of Practical Exercises.



*WaterAid Cambodia*

## 2.1 TIPPY TAP

A tippy tap-style hand sink can be made in several ways. The most common way is to find a container (i.e. a large can, bottle or pot) and drill a hole near the top. A string and pedal are attached to the top of the container, allowing the water to flow out.

*SSWM*



*SSWM*

## 2.2 TAP UP HAND SINK

Hand-washing is hygienic when the user does not contaminate the water outlet. In this case a bucket with a valve added at the bottom serves as a hand sink. The principle is that the water outlet is continuously washed and water is collected in a second bucket. Grey water can be recycled when the bucket is full.

*SSWM*



*EWB Australia in Cambodia*

## 2.3 TOUCH-FREE HAND WASHING UNITS

Touch-free hand-washing units are a new innovation of hand-washing that facilitates touch-free hand-washing with both water and soap in COVID-19 treatment centers. It is essential to minimize the spread of the virus and save lives.

*Engineering without Border Australia*





## 2.4 HAND-WASHING STATION

A semi-permanent or permanent hand-washing station can be constructed in brick and ferrocement.

*Unicef*



*Caritas Switzerland*

## 2.5 HAPPY TAP (LABOBO)

The Happy Tap can be set up in moments without specialised tools or skills. It's just a matter of fitting the plastic pieces together and adding water. Happy Tap is mess-free and its drainage hose ensures grey water is safely collected in containers, rather than splashing onto the ground. This makes it suitable for use indoors or outdoors.

*WaterSHED*



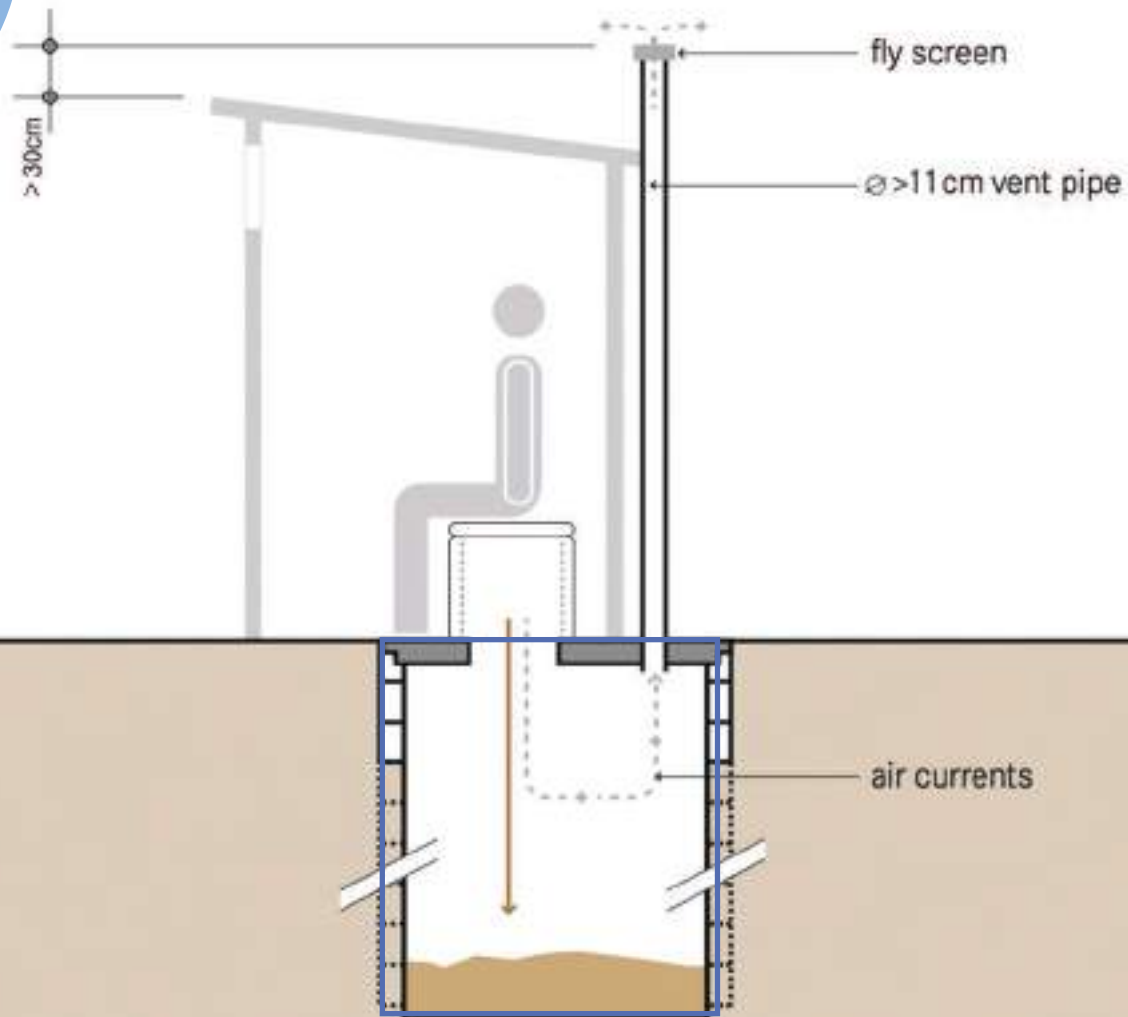
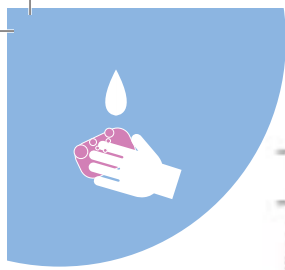


Image source:  
CWPP



#### ADVANTAGES

- Flies and odours are significantly reduced (compared to non-ventilated pits)
- Can be built and repaired with locally available materials
- Low (but variable) capital costs, depending on materials and pit depth
- Small land area required



#### DISADVANTAGES

- Low reduction in BOD and pathogens with possible contamination of groundwater
- Costs to empty may be significant compared to capital costs
- Sludge requires secondary treatment and/or appropriate discharge
- Health risks from flies are not completely removed by ventilation
- Pits are susceptible to failure and/or overflowing during floods

## 2.6

# SINGLE VENTILATED IMPROVED PIT (VIP) LATRINES

| SANITATION |

ADDITIONAL  
RESOURCES:  
COMPENDIUM  
WEDC

### OUTLINE DESCRIPTION OF TECHNOLOGY

The single VIP is a ventilated improved pit (VIP). It is an improvement over the single pit because continuous airflow through the ventilation pipe vents odours and acts as a trap for flies as they escape towards the light. Despite their simplicity, well-designed single VIPs can be completely smell free, and more pleasant to use than some other water-based technologies.

### WHERE CAN IT WORK

Single VIPs are appropriate for rural and peri-urban areas. In densely populated areas they are often difficult to empty and/or have insufficient space for infiltration. VIPs are especially appropriate when water is scarce and where there is a low groundwater table. They are not suitable for rocky or compacted soils (that are difficult to dig), or for areas that flood frequently. Make sure that they provide adequate privacy for boys and girls. Care should be taken that objects, such as trees or houses, do not interfere with the air stream. The vent works best in windy areas. However, where there is little wind, its effectiveness can be improved by painting the pipe black.

### HOW DOES IT WORK

As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are absorbed into the soil surface. In this way, pathogens can be removed prior to contact with groundwater. A minimum horizontal distance of 30m between a pit and water source is normally recommended. The ventilation also allows odours to escape and minimises the attraction for flies. Wind passing over the top creates a suction pressure within the vent pipe and induces an air circulation. Air is drawn through the user interface into the pit, moves up inside the vent pipe and escapes into the atmosphere. The heat difference between the pit (cool) and the vent (warm) creates an updraft that pulls the air and odours up and out of the pit. Flies that hatch in the pit are attracted to the light at the top of the ventilation pipe and are trapped by the fly screen and die.

### COST CONSIDERATIONS

The costs can vary depending on which materials are used (cement, burnt bricks, etc) and are around USD600 to 800.

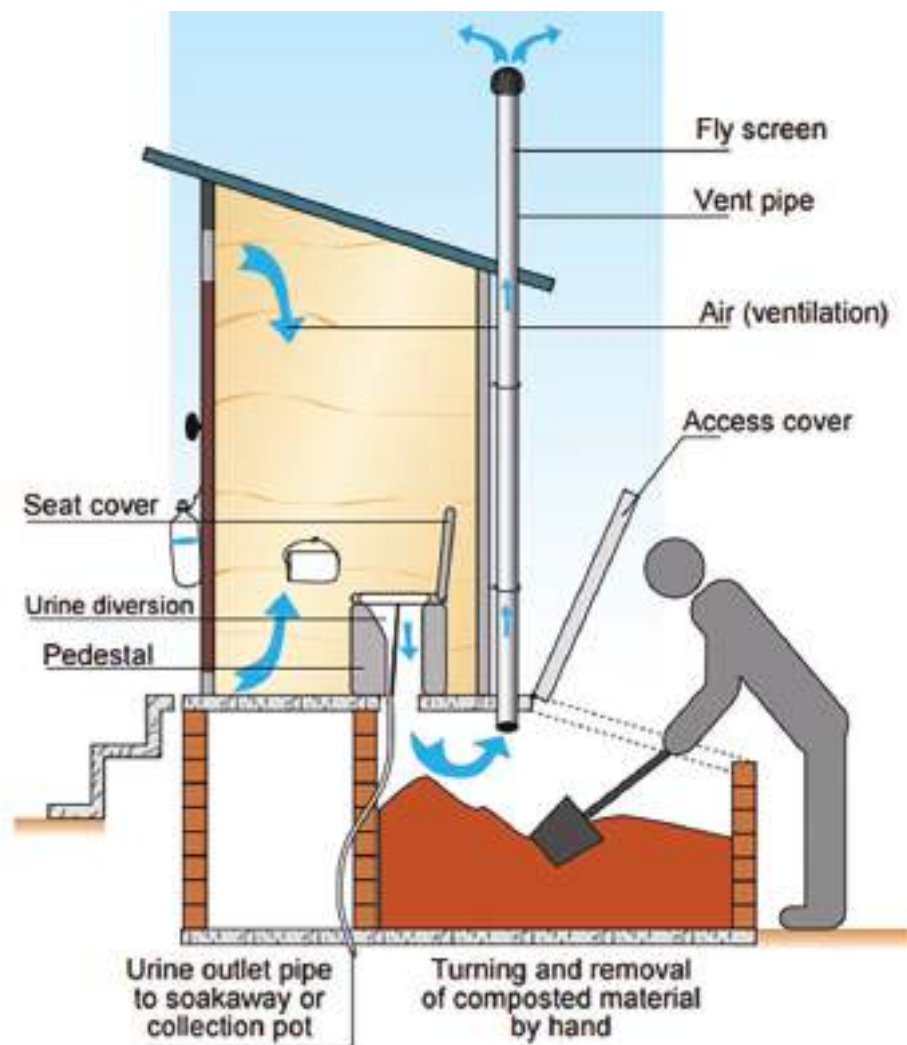


Image source:  
Stiveorchard



## ADVANTAGES

- Low risk of pathogen transmission
- Use of dried faeces as soil conditioner
- Use of processed urine as a fertilizer



## DISADVANTAGES

- Manual removal of dried faeces is requires (cultural barrier)
- Requires constant source of cover material



## 2.7

# URINE DIVERTING DRY TOILET – ECOSAN TOILET

| SANITATION |

ADDITIONAL  
RESOURCES:

ECOSAN  
COMPENDIUM

### OUTLINE DESCRIPTION OF TECHNOLOGY

Urine diverting dry toilets (UDDTs) are used to collect and store urine and faeces separately. Faeces will only dehydrate when the vaults are well ventilated, water-tight to prevent external moisture from entering, and when urine and anal cleansing water are diverted away from the vaults. These toilets can be constructed indoors or with a separate superstructure.

### WHERE CAN IT WORK

Ecosan toilets are suitable for rocky and/or flood prone areas, or where the groundwater table is high.

### HOW DOES IT WORK

The Ecosan toilet is a simple-to-use technology and requires no or low operating costs if self-emptied. It can be built and repaired with locally available materials. These toilets work best with adequate training to be used correctly.

### COST CONSIDERATIONS

Although the costs can vary depending on which materials are used (cement, burnt bricks etc), urine diverting dry toilets are a low-cost option because they require no regular mechanized emptying or desludging. Existing toilets in Africa range from USD400 to 1,200 per unit.

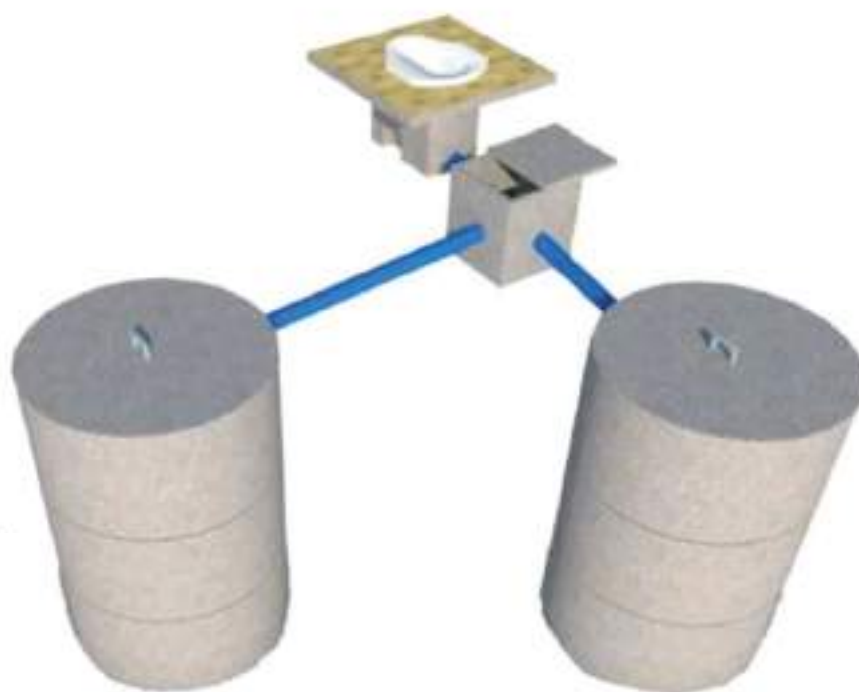


Image source:  
SNV



#### ADVANTAGES

- Low risk of pathogen transmission
- Flies and odours significantly reduced
- Small land area required



#### DISADVANTAGES

- Manual removal of humus is required (cultural barrier)
- Risk of groundwater contamination due to leachate
- Not suitable with a high groundwater table

## 2.8

# TWIN PITS FOR POUR FLUSH

| SANITATION |

### ADDITIONAL RESOURCES:

Twin Pits Manual  
COMPENDIUM

### OUTLINE DESCRIPTION OF TECHNOLOGY

Twin Pits for Pour Flush consist of two alternating pits connected to a pour flush toilet. The waste water is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel.

### WHERE CAN IT WORK

This is a water-based (wet) technology that is ideal for socio-cultural contexts using water rather than toilet paper to clean themselves. It can be located inside the house as the water seal prevents odours and flies.

### HOW DOES IT WORK

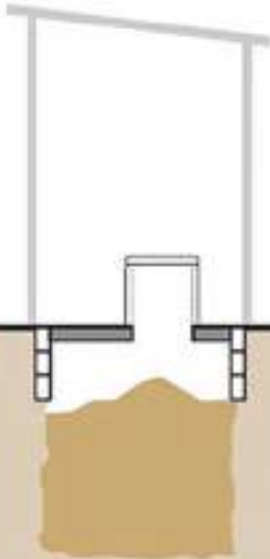
Twin Pits for Pour Flush is a very satisfactory and hygienic sanitation system. The pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely. Therefore the pits should be of an adequate size to accommodate a volume of waste generated over one to two years.

### COST CONSIDERATIONS

Although the costs can vary depending on which materials are used (cement, burnt bricks etc), Twin Pits for Pour Flush are a low-cost option because they require no regular mechanized emptying or desludging. Existing toilets in India (for household usage) are around USD500 per unit.



1



2

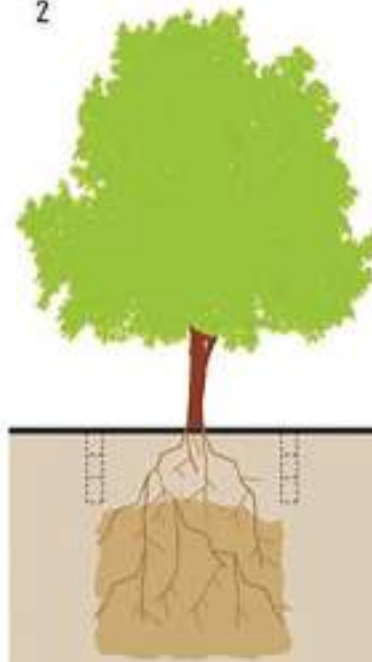


Image source:  
SSWM



## ADVANTAGES

- Low risk of pathogen transmission may encourage income generation (tree planting and fruit production)



## DISADVANTAGES

- Depending on local conditions, the content of a covered pit or Arborloo could contaminate groundwater resources until it is entirely decomposed
- Not suitable with a high groundwater table

## 2.9

# ARBORLOO

| SANITATION |

### ADDITIONAL RESOURCES:

SSWM Arborloo Book  
COMPENDIUM

### OUTLINE DESCRIPTION OF TECHNOLOGY

When a Single Pit or a Single VIP is full and cannot be emptied, “fill and cover”, i.e., filling the remainder of the pit and covering, is a viable low-cost option. The Arborloo is a shallow pit that is filled with excreta and soil/ash and then covered with soil. A tree planted on top of the nutrient-rich pit will grow vigorously.

### WHERE CAN IT WORK

Filling and covering a pit is an adequate solution when emptying is not possible and when there is enough space to continuously dig new pits. The Arborloo can be applied in rural, peri-urban and even denser areas if enough space is available (like on most school compounds).

### HOW DOES IT WORK

To decommission a pit, it can simply be filled with soil and covered. The full pit poses no immediate health risk and the contents will degrade naturally over time. Planting a tree in the abandoned pit is a good way to reforest an area, provide a sustainable source of fresh fruit and prevent people from falling into old pit sites. Other plants such as tomatoes and pumpkins can also be planted on top of the pit if trees are not available. A new pit must be dug after the pit is full, this is relatively labour intensive.

### COST CONSIDERATIONS

The Arborloo is the lowest cost sanitation solution presented in this manual. Depending on the materials used for the superstructure, costs can range from USD60 to 150 per unit. The cost might change based on the materials' market price.





TOPIC 03

# GROWTH AND CHANGE.

---



**“To call women the weaker  
sex is libel.”**

MAHATMA GANDHI





## BREAKING THE SILENCE

Examples given in the Catalogue of Practical Exercises



## MANAGING MENSTRUATION HYGIENICALLY AND SAFELY

- Cloth menstrual pads (3.1)
- Menstrual cups (3.2)
- Dedicated latrines and clothes washing (3.3)



## SAFE REUSE AND DISPOSAL SOLUTIONS

- Safe disposal: collecting, transporting and incinerating at a nearby hospital
- Safe disposal (not preferable): incinerating on-site (4.6)

# GROWTH & CHANGE.



As children grow, changes in their bodies occur, accompanied by an evolution of their minds, feelings and understanding of psycho-social differences between males and females. Their needs will also evolve in many ways. This section of the Blue Schools Kit addresses as a priority young women's needs when they reach puberty, namely menstrual hygiene management (MHM). These needs may appear mostly physical, but they also have strong emotional repercussions. Respect for those needs are very important to ensure young women can fully and harmoniously take their place in their families and communities.

This section provides some ideas about how schools can support adolescent girls or female teachers in managing menstrual hygiene with dignity. Adequate sanitary protection materials and water and sanitation facilities make managing menstruation possible, and reduce stress and embarrassment. It can even increase female attendance rates (no missed school days during menstrual periods), or avoid complete drop out of school.

**This section is based on a sound approach to MHM developed by the Water Supply and Sanitation Collaborative Council (WSSCC):**

- Breaking the silence – fostering the understanding that menstruation is a fact of life and a distinct biological female attribute that women should be proud of, not ashamed by.
- Managing menstruation hygienically and safely – ensuring adequate water, cleansing and washing materials and private spaces for managing menstrual flows hygienically and privately, and with dignity, in the home and in public spaces.
- Safe reuse and disposal solutions – ensuring mechanisms for safe reuse, collection and disposal of menstrual waste in an environmentally safe manner.

For more information consult the technical background section of Topic 3 in the Catalogue of Practical Exercises.







# MENSTRUAL HYGIENE MANAGEMENT



WaterAid Cambodia

## 3.1 CLOTH MENSTRUAL PADS

Cloth menstrual pads absorb the menstrual flow during a woman's period and are an alternative to disposable sanitary napkins. They are less expensive than disposable pads, reduce the amount of waste produced and may also have health benefits. Generally, they are made from layers of absorbent fabrics (such as cotton or hemp) which are worn by a woman while she is menstruating. After use, they are washed, dried and then reused. (Wiki)



Green Lady Cambodia

## 3.2 MENSTRUAL CUPS

A menstrual cup is usually made of flexible medical grade silicone and worn inside the vagina during menstruation to catch menstrual fluid. Menstrual cups are shaped like a bell with a stem. Every 4–24 hours, a cup needs to be removed and emptied, then rinsed and reinserted. In general they can be reused for five years or more. They are more practical, cheaper and eco-friendly than pads. (Wiki)

[SSWM](#)



Caritas Switzerland

## 3.3 DEDICATED LATRINES AND CLOTHES WASHING

Girls need to have privacy, particularly during their menstrual cycle. A dedicated latrine with a private area for clothes washing and drying is important.



TOPIC 04

# FROM WASTE TO RESOURCES.

---

**“Let’s be part of the Solution,  
not the Pollution.”**









## ORGANIC WASTE

| Green waste | Brown waste |



### RESOURCE RECOVERY OPTION

- Windrow composting (4.2)
- Vermicomposting (4.3)
- Anaerobic digestion (4.4)



### SAFE DISPOSAL (NOT PREFERABLE)

- Burning



## PAPER WASTE

| Used paper | Used cardboard |



### RESOURCE RECOVERY OPTION

- Reuse the other side



### SAFE DISPOSAL (NOT PREFERABLE)

- Burning



## PLASTIC WASTE

| PET bottle | Packaging |



### RESOURCE RECOVERY OPTION

- Reuse the bottles
- Sell it to recyclers



### SAFE DISPOSAL (NOT PREFERABLE)

- Burying (4.5)



## METAL & GLASS WASTE

| Pieces of metal | Glass bottle |



### RESOURCE RECOVERY OPTION

- Reuse metal and glass
- Sell it to recyclers



### SAFE DISPOSAL (NOT PREFERABLE)

- Burying (4.5)



## MENSTRUAL WASTE

| Women menstruation towel |



### RESOURCE RECOVERY OPTION

- Collecting, transporting and Incinerating in nearby hospital



### SAFE DISPOSAL (NOT PREFERABLE)

- Incinerating on-site (4.6)

# FROM WASTE TO RESOURCES.



Waste is a generic term that refers to something that is no longer used and is discarded. Problems with waste arise if it is not managed appropriately, for instance if dumped illegally or openly burned. Open burning and inappropriate management of waste results in severe threats to human health as well as environmental pollution. This highlights the necessity to safely manage waste at schools and increase knowledge and awareness with students regarding risks but also show pathways for improvement.

Waste is made of different materials. For different materials, different management strategies can be applied that enhance their reuse, recovery and recycling. A precondition for this, however, is that the waste materials are not mixed together. If waste is segregated at source, some materials can be more easily recovered and turned into a valuable product/resource. This can significantly reduce the residual amount of waste that must then be safely disposed.

### **Tasks for a good waste management at the school are:**

1. To identify waste streams and quantity;
2. To separate your waste into the different waste fractions.

For those fractions where no recycling/reuse or treatment is feasible, avoid, reduce, and finally, dispose of it in a safe way when necessary.

The following chapters show different organic waste recycling options as well as treatment and safe disposal options for non-recyclable/recycled fractions.

Check also the Catalogue of Practical Exercises to see what you can do with each fraction.





*Image source:*  
**Konrad**



## ADVANTAGES

- Pit composting is quick, easy and
- Cheap as it does not require investment in materials
- It needs less water so it is useful for dry areas.



## DISADVANTAGES

- More difficult to follow the decomposition process in a pit than with an above ground heap.

# 4.1

## COMPOST MAKING

| SOIL ENHANCEMENT | WASTE MANAGEMENT |

ADDITIONAL  
RESOURCES:

SSWM

### OUTLINE DESCRIPTION OF TECHNOLOGY

There are many ways to make compost. Regular compost, vermicompost, pit humus, terra preta, humanure or ecohumus are all products of the degradation of organic waste. Even though they vary somehow regarding composition and structure, they have similar functions when applied to the soil. The process of high-temperature composting generates heat that kills the majority of pathogens present. The composting process requires adequate carbon, nitrogen, moisture and air. It is generally accepted that a ratio of 50% carbon (dry, brown material) and 50% nitrogen (moist, green material) is enough. Carbon material can be up to 70% of the mix.

Two types of compost making are presented in the next slides (how to use compost is discussed in Topic 5).

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

Compost is produced in shallow pits, approximately 20cm deep and 1.5m by 3m wide. Layers of chopped crop residues, animal dung and ash are heaped, as they become available, up to 1.5m high and watered. The pile is protected from sunshine/ excess rain and left to heat up and decompose. It is watered as needed. After around 15–20 days the compost is turned over into a second pile and watered again. This is repeated up to three times. Compost heaps are usually located close to the garden or homesteads. Alternatively, compost can be produced in pits that are up to 1m deep. Organic material is filled to the full height of the pit. (FAO)

### COST CONSIDERATIONS

Costs are minimal if there is an available supply of organic materials.





Image source:  
Eawag



#### ADVANTAGES

- Allows organic waste recycling
- Improves physical soil property (stability, porosity, water retention)
- Helps ensure a healthy, living and biologically diverse soil environment



#### SUITABLE FOR

- “Green waste”: grass clippings, flowers, vegetable & fruit waste, animal manure
- “Brown waste”: tree trunks, branches, leaves, straw



#### DISADVANTAGES

- Risk of soil contamination if unsorted waste is used
- Smell if compost heap is too wet and not well aerated (not turned regularly)



#### UNSUITABLE FOR

- Mixed waste with glass, plastic, metal
- Meat and fish waste (attracts vermin)

## 4.2

# WINDROW COMPOSTING

| ORGANIC WASTE | SOIL NUTRIENT CULTIVATION |

### ADDITIONAL RESOURCES:

Composting Manual  
ISWA

### OUTLINE DESCRIPTION OF TECHNOLOGY

If you want to do compost on a bigger scale, you can implement windrow composting. Natural biodegradation of organic matter in presence of oxygen by micro-organisms, mostly bacteria and fungi, in order to produce compost. Compost can be then used for soil improvement or as growing media in the school garden.

### WHERE CAN IT WORK

Applicable anywhere. In cold climates composting it is a slow process

### HOW DOES IT WORK

For good composting practice, a 50/50 mix of “green” and “brown” waste is ideal. As composting windrows needs natural aeration, the compost heap should not exceed 1.2m in height to avoid compaction and should be turned periodically (15-20 days). During the degradation process, temperature of up to 70°C can be reached in the centre of the heap. This contributes to its hygienisation by killing pathogens and weed seeds. Moisture in the compost windrow should be maintained so when the material is squeezed in hands, it releases just few drops of water and remains compact. If it is too dry, water must be added. If too wet, addition of dry materials can absorb water or turning the heap during sunny days helps increase water evaporation. Composting, a natural process, takes time and three to six months are necessary before the compost is ready for use. Mature and ready compost has a dark brown colour and smells like wet earth, it can be use in the garden to improve soil quality.

### COST CONSIDERATIONS

Labour costs only





Image source:  
We Compost Cambodia



#### ADVANTAGES

- Allows organic waste recycling and worm production for animal feed
- Improves chemical (nutrients, pH) and physical soil property (stability, porosity, water retention)



#### SUITABLE FOR

- “Green waste”: grass clippings, flowers, vegetable & fruit waste, animal manure
- “Brown waste”: tree trunks, branches, leaves, straw



#### DISADVANTAGES

- Monitoring is needed. For example, worms can drown in cases of excess water in the bin.



#### UNSUITABLE FOR

- Mixed waste with glass, plastic, metal
- Meat and fish waste
- Fats (grease, oil, butter etc)
- Dairy products and salty/vinegary waste



## 4.3

# VERMICOMPOSTING

| ORGANIC WASTE | SOIL NUTRIENT CULTIVATION |

### ADDITIONAL RESOURCES:

Vermicomposting  
Manual ISWA

### OUTLINE DESCRIPTION OF TECHNOLOGY

A process of worm composting takes place in boxes or bins. Worms convert the organic waste into a humus-like, high-quality compost called vermicompost or worm compost. Bins contain a bottom layer of drainage and bedding materials (cardboard, paper) with a hole in the bin bottom to drain excess liquid. Two species of surface earthworms are suitable for worm composting: *Eisenia foetida* and *Lumbricus rubellus*.

### WHERE CAN IT WORK

Broadly applicable. Ideally, vermicomposting bin should be placed in a shady area. Ideal temperatures are between 15 and 22°C.

### HOW DOES IT WORK

After about two weeks of waste composting (time needed to enhance stable vermicomposting conditions), the organic matter is added in shallow layers to the bins that contains earthworms at a density of 5kg/m<sup>2</sup>. The layer of organic matter added should not exceed 10cm in depth to ensure aeration for the worms and avoid overheating of the feedstock given its microbial activity. The worms can be fed with half of their body weight in waste per day. After around 30 days the organic waste is transformed by the worms into a humus-like substance.

### COST CONSIDERATIONS

Labour costs, construction material and worms.



Image source:  
Eawag



### ADVANTAGES

- Generates renewable biogas energy
- Small land area required as systems can be constructed below ground
- Conserves nutrients in the digestate



### SUITABLE FOR

- “Green waste”: grass clippings, flowers, vegetable & fruit waste, animal manure



### DISADVANTAGES

- Incomplete pathogen removal
- Gas leakage may create a risk



### UNSUITABLE FOR

- Mixed waste with glass, plastic, metal
- “Brown waste”: tree trunks, branches, leaves, straw

## 4.4

# ANAEROBIC DIGESTION

FLOATING DOME	TUBULAR	FIXED DOME
DIGESTER	ORGANIC WASTE	
FUEL SOURCE	SOIL NUTRIENT CULTIVATION	

ADDITIONAL  
RESOURCES:  
AD for biowaste

### OUTLINE DESCRIPTION OF TECHNOLOGY

The process through which organic matter is decomposed due to microbial activity in the absence of oxygen and produces an energy-rich gas (biogas) and nutritious digestate. Anaerobic digestion takes place in an airtight reactor tank called a digester.

### WHERE CAN IT WORK

Broadly applicable. Average temperatures of above 15°C are suitable, otherwise insulation is required.

### HOW DOES IT WORK

Particle size reduction to a maximum of 5cm helps for easier anaerobic digestion. Furthermore most anaerobic digestion systems operate with a feedstock of high water content (>84%), i.e. often the addition of water to the waste is required. Around 30 days are necessary to degrade the organic matter and produce significant amounts of methane and carbon dioxide, as well as a slurry-like digestate. Most wet digestion systems are operated continuously, i.e. when a certain volume of feedstock is added, the same amount of digestate exits the reactor. The produced biogas collects in the top part of the reactor where a gas pipe and valve are located that can be connected to a gas stove to use the biogas as a cooking fuel. Biogas can also be fed into a gas generator to produce electricity.

### COST CONSIDERATIONS

Investment costs of anaerobic digesters are moderate. Construction requires skilled labour and expert design to ensure the reactor is gastight. Both biogas and digestate create added value, thus making biogas digesters interesting from an economic point of view.





Image source:  
**SASAHARAMBEE**



#### ADVANTAGES

- Avoids waste dissemination with the wind



#### DISADVANTAGES

- Damages landscape
- None sustainable solution



#### SUITABLE FOR

- Non-reusable/recyclable plastic waste
- Non-reusable/recyclable non-organic and non-hazardous waste



#### UNSUITABLE FOR

- Liquid waste
- Organic waste
- Hazardous/contaminated waste

## 4.5

# BURYING WASTE

| NON-RECYCLED WASTE | SAFE WASTE DISPOSAL |

**ADDITIONAL  
RESOURCES:**  
Manual landfill

### OUTLINE DESCRIPTION OF TECHNOLOGY

Burying or dumping organic and hazardous/contaminated waste poses a threat to the environment as they pollute soil and water bodies. However, when plastic or other non-organic “inert” waste cannot be recycled, burying waste remains the easiest and safest option.

### WHERE CAN IT WORK

Applicable anywhere where land is available to dig and that is neither in areas with very high groundwater levels or bordering surface waters (river, lake, sea).

### HOW DOES IT WORK

A hole is dug and surrounded by a small berm and ditch to avoid rainwater flowing in. The bottom of the hole should be well above (>2m) the highest groundwater level. If possible, a creating a clay layer at the bottom and covering the walls can avoid further water leaching into the surrounding area. Waste is then dumped into the hole and covered with a layer of soil to contain the waste (avoid wind transport as well as birds and vermin). When the hole is full of waste add a final soil cover to build a slightly elevated hill. Then dig a new hole in a new place.

### COST CONSIDERATIONS

Labour costs and soil cover, if not available on site.





Image source:  
Caritas Switzerland



#### ADVANTAGES

- Avoids pathogen dissemination
- Decreases diseases spread
- Avoids groundwater contamination



#### SUITABLE FOR

- Hazardous/contaminated waste



#### DISADVANTAGES

- Threat to air quality and public health when not well managed
- Releases harmful gases



#### UNSUITABLE FOR

- Non-hazardous mixed waste with plastic



## 4.6

# WASTE INCINERATION

| HAZARDOUS WASTE | SAFE WASTE DISPOSAL |

### ADDITIONAL RESOURCES:

De Montfort

#### OUTLINE DESCRIPTION OF TECHNOLOGY

When dealing with hazardous waste that cannot be safely stored or transported to places where it can safely be disposed (e.g. nearby hospital), it can be burnt on-site in a De Montfort incinerator. Care should be taken to keep the temperature at a sufficient level that allows a complete combustion process to ensure pathogen killing and reduce the risk of harmful gas emissions.

Be careful: it is highly discouraged (and even prohibited in most countries) to put non-hazardous plastic waste into the incinerator as incomplete combustion will result in adverse impacts on the environment !

#### WHERE CAN IT WORK

Applicable only in places where skills on how to build, operate and maintain proper waste incinerators are present.

#### HOW DOES IT WORK

Detailed instructions on construction, operation and maintenance are provided in the De Montfort incinerator document.

#### COST CONSIDERATIONS

USD500-1,500 per incinerator



TOPIC 05

# FROM SOIL TO FOOD.

---

**“A society grows great when old men  
plant trees whose shade they know  
they shall never sit in.”**

GREEK PROVERB

**“You can solve all the world’s  
problems in a garden.”**

GEOFF LAWTON

Permaculture Research Institute of Australia







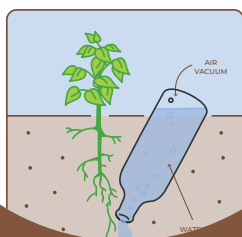
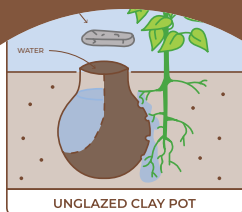
## CULTIVATING AND ENHANCING SOIL

- Using compost (5.1)
- Mulching (5.2)
- Natural pesticides (5.3)
- Urine fertilisation (5.4)
- Natural fertilisers (5.5)
- Liquid manure (5.6)
- Gardening with charcoal (5.7)
- Seed sowing (5.8)
- Crop planning (5.9)
- Making compost (5.1)



## WATER RETENTION

- Mulching (5.2)
- Planting Pits (5.10)



## EFFICIENT IRRIGATION PRACTICES

- Buried pot manual irrigation (5.11)
- Bucket or bottle drip irrigation (5.12)



## SUSTAINABLE HOMESTEAD AND SMALLHOLDER FARMERS VEGETABLE GARDENING

- Keyhole garden (5.13) and banana circle (5.13.2)
- Vertical gardening (5.14)
- Permaculture design (5.15) and permaculture "mandala" garden (5.15.2)



# FROM SOIL TO FOOD.



Growing food is essential for human beings and as the population has expanded, more and more land has been cleared for agriculture and other pursuits. Unfortunately, the land and soil is often exploited in an unsustainable way and loses its productivity within only a few years. People then move on and clear more land to turn it into fields again. This is accompanied by soil degradation, soil erosion, increased water run-off and flooding, and decreased biodiversity, to name a few.

**This topic provides ideas on how to act against such a virulent circle. It shows technologies for growing food that are appropriate for schools and communities, which allow people to:**

- Cultivate soil that can retain water and drain appropriately to keep nutrients in the soil
- Grow food and irrigate efficiently

- Keep trees and forests to retain and infiltrate rain water in the area
- Establish Low External Input Sustainable Agriculture (LEISA) as an alternative to agro-chemicals.

The processes, such as soil erosion, water run-off, flooding etc, are highly linked to sustainable water and land management practices. Thus, ideally the technologies presented in Topic 3 the watershed around my school, should be combined. More information on the problematic processes linked to agricultural production can be found in the technical background of Chapter 7 in the Catalogue of Practical Exercises.



Image source:  
Caritas Switzerland



#### ADVANTAGES

- Promotes soil living micro-organisms that are fundamentally important for creating healthy soils and, consequently, healthy plants and food
- Improves soil aeration
- Improves soil water holding capacity
- Provides plants with essential nutrients and aids in the suppression of plant diseases
- Increases health and productivity of plants



#### DISADVANTAGES

- None

# 5.1

## USING COMPOST

| SOIL ENHANCEMENT |

ADDITIONAL  
RESOURCES:  
SSWM

### OUTLINE DESCRIPTION OF TECHNOLOGY

Compost is organic matter that has decomposed. It is the man-made equivalent of the natural humus that can be observed in forests' soils. The productivity of lean soils can be improved by applying compost. Hence, by applying compost, soil is enhanced through increasing nutrient content and fostering beneficial soil bacteria. This helps improve the physical and chemical properties and contributes to enhance the capacity of the soil to store air and water.

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

Before planting, compost is applied to the soil at a depth of 15-25cm. If the soil is very poor, you can add more compost. Compost releases nutrients slowly and will not damage plants. Throughout the growing season you can add compost mixed with soil as a top dressing (about 1cm). When using compost for potted plants, potting soil can be made with 1/4 to 1/3 of mature compost and the rest soil or sand. Composting improves water infiltration and reduces water run-off. Do not put plants in pure compost. Plants need coarser particles such as sand and soil in order to root properly.

### COST CONSIDERATIONS

Labour costs only





Image source:  
Caritas Switzerland



## ADVANTAGES

- Prevents evaporation
- Retains soil moisture
- Controls soil erosion
- Reduces weed growth
- Helps regulate the soil's temperature (reduces temperature variations)
- Improves soil structure and aeration
- Helps maintain and improve
- Soil fertility (by enhancing organic matter and protecting beneficial soil-living organisms such as bacteria and worms)



## DISADVANTAGES

- Mulching is labour-intensive
- In moist environments, too much mulch can create rotting of the root zone
- Mulch material can introduce new pests and diseases into a field.



## 5.2

# MULCHING

| SOIL ENHANCEMENT | WATER RETENTION |

—  
ADDITIONAL  
RESOURCES:  
SSWM

### OUTLINE DESCRIPTION OF TECHNOLOGY

Mulching is the placing of material on the soil surface to maintain moisture, reduce weed growth, mitigate soil erosion and improve soil conditions. Mulching can help improve crop yields and optimise water use.

### WHERE CAN IT WORK

Mulch can be used in fields before and after planting, as well as around young crop plants. It is especially useful for high-value vegetable crops, growing crops in dry areas during dry-season cropping, and in places where the soil is easily eroded by heavy rains. Where soil erosion is a problem, slowly decomposing mulch material (low nitrogen content, high C/N-ratio) can provide a long-term protection compared to quickly decomposing materials (SSWM). High C/N ratio material for mulching can bind nutrients and cause the malnutrition of plants. Plant growth needs to be observed for signs of nitrogen deficiencies (i.e. yellow/pale leaves).

### HOW DOES IT WORK

Mulch tilling involves covering bare soil with mulch or plant litter to prevent or reduce the evaporation of soil moisture and minimise the erosive energies of rain falling directly onto soil particles. Mulching is different from soil amendment. Materials for mulching are usually crop residue, such as maize stove, sorghum trash and wheat straw. In cases where these are not available, or are eaten up by animals, straw, shredded bark or cardboard, wood chips etc can be used.

### COST CONSIDERATIONS

Where materials are locally available it is a matter of labour costs. If not, mulching can be expensive as it is labour intensive to obtain, transport and disperse.



Image source:  
Caritas Switzerland



#### ADVANTAGES

- Made with locally available plants
- Easy to prepare
- Sustainable and efficient



#### DISADVANTAGES

- Takes some time to prepare and be ready (see alternative if in an emergency)

## 5.3

# NATURAL PESTICIDES

| PEST AND DISEASE CONTROL |

### ADDITIONAL RESOURCES:

Fourthway

#### OUTLINE DESCRIPTION OF TECHNOLOGY

There are many ways to prepare natural pesticides, depending on local resources and the problem that needs to be treated. The recipe presented here uses neem tree leaves, as they are relatively widely available in many countries and an efficient way to control various pests. For other natural pesticides to treat specific pests, refer to the additional resource below.

#### WHERE CAN IT WORK

Applicable anywhere.

#### HOW DOES IT WORK

Collect neem leaves fresh from the tree and chop them up with a machete or knife. Put the leaves in a container and cover them with water. Then put a lid on the container and leave the mixture to rest for three days. Dilute the preparation one part water to one part pesticide before sprinkling it on the plants.

Alternatively, especially if you are in an emergency to treat, you can boil the preparation for 20 minutes (instead of leaving it to rest for three days). In that case, you don't have to dilute the preparation. However, leave it to cool down before treating the plants.

#### COST CONSIDERATIONS

Free of costs



Image source:  
Caritas Switzerland



#### ADVANTAGES

- May encourage income generation because of improved yields and productivity of plants
- Reduces dependence on costly chemical fertilizers
- Low risk of pathogen transmission
- Low cost
- Contributes to self-sufficiency and food security
- Easy to understand techniques



#### DISADVANTAGES

- Urine is heavy and difficult to transport
- Smell may be offensive
- Labour intensive
- Risk of soil salinisation if the soil is prone to the accumulation of salts
- Social acceptance may be low in some areas



## 5.4

# URINE FERTILISATION

| SOIL ENHANCEMENT |

### ADDITIONAL RESOURCES:

SSWM (Small Scale)

SSWM (Large Scale)

SSWM (Urine Storage)

SSWM (Fertilizer  
from Urine)

### OUTLINE DESCRIPTION OF TECHNOLOGY

Stored urine that has been separately collected and stored for six months before use is a concentrated source of nutrients that can be applied as a liquid fertiliser in agriculture and replace all or some commercial chemical fertilisers. This factsheet focuses on small-scale urine use, which refers to the application of urine on small fields, beds, vertical or container gardens, school gardens, plant pots on terraces, rooftops etc. This can be done on a household or smaller community level without sophisticated transport and application infrastructure.

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

The urine is introduced into the soils via small ditches besides the young crops. Then the ditches are covered to prevent ammonia loss to the air. Stored urine should not be applied directly to plants because of its high pH and concentrated form. Instead, it can be: mixed undiluted into soil before planting; poured into furrows, but at a sufficient distance away from the plants' roots and immediately covered (although this should take place no more than once or twice during growing season); and diluted several times, whereby it can be frequently used around plants. The optimal application rate depends on the nitrogen demand and tolerance of the crop on which it will be used, the nitrogen concentration of the liquid, as well as the rate of ammonia loss during application.

### COST CONSIDERATIONS

Costs are primarily the labour costs. It is more pure, reliable and affordable than many chemical fertilisers, which often contain heavy metals. (SSWM)



Image source:  
Caritas Switzerland



#### ADVANTAGES

- Made from raw, local materials
- Increases yields



#### DISADVANTAGES

- Smell can be strong, especially at the beginning of the fermentation process.

## 5.5

# NATURAL FERTILISERS

| PLANT TEAS | SOIL FERTILITY |

### ADDITIONAL RESOURCES:

Fourthway

#### OUTLINE DESCRIPTION OF TECHNOLOGY

Plant teas, or “fermented extracts” could be the subject of a book in itself. It is a natural fertiliser using virtually any green leaves. However, some plants are particularly interesting to use. For example, stinging nettles or comfrey are especially beneficial in many ways. Don’t hesitate to use them if they are locally available in your region.

#### WHERE CAN IT WORK

Applicable anywhere.

#### HOW DOES IT WORK

Collect a variety of leaves (at least three different species, as long as they are not too thick); then chop them finely. Fill a container with the leaves, cover with water and add a handful of wood ash. Leave to ferment for about one week (sometimes much less, especially in warm climates), stir it every day. Usually the mixture is ready when there is no more froth forming on the surface. The scent also becomes less unpleasant when it is ready to use. Dilute before applying to plants (one part of plant tea for two parts of water) and apply it directly on the ground near the roots. Use the mixture within two weeks.

#### COST CONSIDERATIONS

Free of costs.



*Image source:*  
Greendots.ch / Burkina Faso



#### ADVANTAGES

- Made from raw, local materials
- Safe way to increase yields



#### DISADVANTAGES

- Takes some time to prepare and ferment



## 5.6

# LIQUID MANURE

| SOIL FERTILITY |

### ADDITIONAL RESOURCES:

Fourthway  
Greendots

#### OUTLINE DESCRIPTION OF TECHNOLOGY

Liquid manure is an easy-to-make fertiliser from animal droppings, ash and water.

#### WHERE CAN IT WORK

Applicable anywhere.

#### HOW DOES IT WORK

Liquid manure is prepared first by filling a cloth (permeable) bag with a few handfuls of cow dung (or other herbivorous animal droppings) and a small quantity of wood ash. A stone is put in the bag to act as a weight. Then the bag is closed and tied to a stick. A container is filled with water, the bag is placed in the water and held in place by a stick. The mixture is covered and left to ferment in a shady place. It has to be stirred daily for a week before it is ready to use. When ready, it can be applied directly in the garden, diluted (one part liquid manure for two parts of water).

#### COST CONSIDERATIONS

Free of cost, as long as animal droppings are available.



*Image source:*  
**Caritas Switzerland**



#### ADVANTAGES

- Significant improvement in soil nutrients
- Increases crop quality
- Increases crop productivity



#### DISADVANTAGES

- A sustainable biomass is required for the sustainable production of biochar

## 5.7

# GARDENING WITH CHARCOAL

| TERRA PRETA | BIOCHAR GARDENS |  
| SOIL ENHANCEMENT |

### ADDITIONAL RESOURCES:

Permaculture  
research Institute  
of Australia

### OUTLINE DESCRIPTION OF TECHNOLOGY

Biochar is a fine-grained charcoal produced from the slow burning of organic matter in a low- or no-oxygen environment. Biochar is promoted as a soil additive in order to enhance the soil black carbon content and thus the soil water and nutrient retention capacity. Terra Preta, meaning "Black Earth" in Portuguese, is a soil building technique developed by ancient Amazonian civilizations at least 7,000 years ago as a solution to permanently solve the problem of poor tropical soil fertility.

### WHERE CAN IT WORK

Broadly applicable

### HOW DOES IT WORK

Using a trench about 50cm deep by width of desired bed and placing a 10cm layer of charcoal at the bottom, water and nutrient retention is dramatically improved (the remaining space is backfilled with ordinary soil), adding a rudimentary irrigation system (1m length of bamboo with all the bottom 'nodes' removed then drilled with four holes approximately 10cm then 20cm from the bottom of the bamboo, spaced every 1-2m.) creates a refillable water reservoir. This slowly releases the water/nutrients into the soil planting bed.

### COST CONSIDERATIONS

The costs for planting pits mainly consist of labour costs and are estimated to amount approximately USD160 per ha.



Image source:  
Caritas Switzerland



#### ADVANTAGES

- Cheap
- Local seeds are adapted to local conditions
- Possible to easily produce seeds for the next growing season



#### DISADVANTAGES

- Requires skills, knowledge and experience
- Takes labour and time
- Can be disappointing (risk of failure)



## 5.8

# SEED SOWING

| LIVELIHOOD | FOOD AUTONOMY |

### ADDITIONAL RESOURCES:

Seedsavers  
Seedsavers Blog

### OUTLINE DESCRIPTION OF TECHNOLOGY

Growing vegetables from seeds is a cheap way to produce food. The most important thing is to carefully manage the watering as young seedling quickly dry out if not watered enough.

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

There are many methods to sow seeds, depending on the plant's needs and local resources. Always ask for advice when there are no indications on the pack of seeds you purchased. Seeds have four basic requirements in order to germinate: nutrients (i.e. a substratum), water, sunlight (warmth) and oxygen. Either seeds are directly sown in the garden (after having prepared the garden beds with compost) or they are sown in trays or pots:

1. Collect trays or pots
2. Fill them with fine and light soil (compost, sand)
3. Water the substrate
4. Sprinkle seeds on the top and cover with a thin layer of fine compost
5. Cover the tray or pot with a piece of transparent plastic or glass
6. Uncover when the seeds have germinated
7. Transplant in the garden once the plants are big/strong enough (keep them in partial shade for one or two weeks if possible)

### COST CONSIDERATIONS

It's free with seeds that can be easily produced "at home" (such as beans, tomatoes and peppers). Otherwise, small packs of seeds need to be bought, if possible from a local, sustainable source. If you produce your own seeds, you will have to clean and dry them well, and store them in a dry, dark and cool place as much as possible.



Image source:  
Caritas Switzerland



## ADVANTAGES

- Increases soil fertility
- Helps in control weeds
- Allows for varied crop production
- Plant debris provides organic matter  
And nutrients to the soil
- Reduces erosion
- Reduces runoff and enhances  
Infiltration



## DISADVANTAGES

- Requires labour and planning for  
successful implementation
- Expensive to set up
- Cover and intercropping can be difficult  
to justify in areas with food scarcity
- To prevent from bushfires, a buffer zone  
around the field is necessary

## 5.9

# CROP PLANNING

| CROP ROTATION | INTERCROPPING |  
| COVER CROPPING | SOIL ENHANCEMENT |

### ADDITIONAL RESOURCES:

SSWM Crop  
Selection

### OUTLINE DESCRIPTION OF TECHNOLOGY

In many traditional agricultural systems, a diversity of crops in time or space can be found. Knowing that different plants have different requirements for nutrients, good crop planning and management is required to optimise the use of nutrients in the soil.

### WHERE CAN IT WORK

Broadly applicable and can be found practiced across many agricultural traditions.

### HOW DOES IT WORK

Crop rotation means changing the type of crops grown in the field each season or year. It is a critical feature of all organic cropping systems, because it provides the principal mechanisms for building healthy soils and is a major way to control pests and weeds and maintain soil organic matter. Intercropping refers to the practice of growing two or more crops in close proximity: growing two or more cash crops together, growing a cash crop with a cover crop, or other non-cash crop that provide benefits to the primary crop. A cover crop could be a leguminous plant with other beneficial effects, or it could be a weed characterised by its rapid growth and enormous production of biomass. The most important property of cover crops is their fast growth and the capacity of keeping the soil permanently covered.

### COST CONSIDERATIONS

Extra expenditures include the cost of the cover crop seed as well as labour and time for planting. Also, special or alternative equipment may be needed to handle the greater amounts of residue present in no-till systems. (SSWM)





Image source:  
Caritas Switzerland



## ADVANTAGES

- Increased water infiltration can help soil regeneration
- Design of planting pits is very flexible
- High acceptability
- The soil does not need to be deep
- Due to the manure placed in the pits, termites can be attracted, transporting further nutrients from deeper soils to the top layers



## DISADVANTAGES

- High labour requirements for construction and maintenance
- During very wet seasons, water logging is possible and organic debris needs to be placed in the pits to soak up excess water
- Already shallow soil gets even thinner where pits are dug (apply compost in the pits when possible)



# 5.10 PLANTING PITS

## ZAI PITS

| SOIL ENHANCEMENT |  
| WATER CONSERVATION |

### ADDITIONAL RESOURCES:

Echo SSWM  
Planting Pits

### OUTLINE DESCRIPTION OF TECHNOLOGY

Planting pits are used as a precipitation harvesting method to prevent water runoff, thereby increasing infiltration and reducing erosion.

### WHERE CAN IT WORK

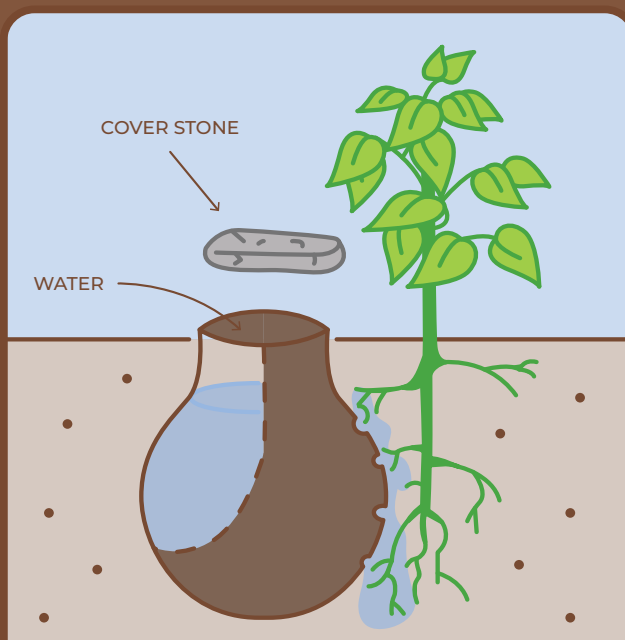
Planting pits are most suitable on soil with low permeability, such as silt and clay. They are applicable for semi-arid areas for annual and perennial crops, such as sorghum, maize, sweet potato, bananas etc. Due to their easy application and quickly observable improvement of crop growth, the implementation of planting pits is usually well adopted by farmers.

### HOW DOES IT WORK

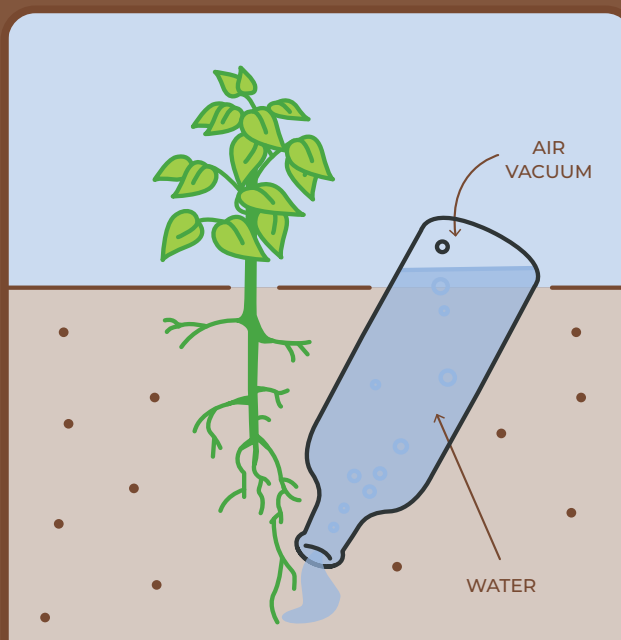
The method involves digging holes into the ground (ideally at the beginning of the dry season) in which plants such as millet or sorghum can be sown later on at the start of the rainy season. The pits measure between 10-20cm in depth and 20-40cm in diameter, and are spaced approximately 1m apart. In addition, excavated earth is formed to a small ridge down-slope of each hole and, if available, organic fertiliser or compost is added to the pits. The described arrangement of the planting pits ensures an efficient collection and concentration of rainfall, runoff and nutrients and therefore makes it possible to bring degraded land back into cultivation. To optimise the situation on the fields, planting pits are often used in combination with contour stone bunds.

### COST CONSIDERATIONS

Most costs arise because of the time needed to dig the holes and fill them with organic matter. They are therefore strongly dependent on the structure of the soil. Roughly 20 to 70 person days per hectare are needed to dig the holes and another 20 person days are required for fertilisation. Usually, no equipment costs arise because digging can be done with common tools already available.



UNGLAZED CLAY POT



BOTTLE UPSIDE DOWN



#### ADVANTAGES

- Increased water infiltration can help soil regeneration
- Design of planting pits is very flexible
- High acceptability
- The soil does not need to be deep
- Due to the manure placed in the pits, termites can be attracted, transporting further nutrients from deeper soils to the top layers



#### DISADVANTAGES

- High labour requirements for construction and maintenance
- During very wet seasons, water logging is possible and organic debris needs to be placed in the pits to soak up excess water
- Already shallow soil gets even thinner where pits are dug (apply compost in the pits when possible)

## 5.11

# BURIED POT MANUAL IRRIGATION

## CLAY POT OR PIPE IRRIGATION BOTTLE | IRRIGATION

| WATER CONSERVATION |

### ADDITIONAL RESOURCES:

SSWM\_Manual  
Irrigation

### OUTLINE DESCRIPTION OF TECHNOLOGY

Manual irrigation systems are very simple but effective methods for making water available to crops while minimising evaporative loss. Manual irrigation systems are easy to handle and there is no need for technical equipment. However, it is important they are constructed correctly to avoid water loss and crop shortfalls. The systems allow for high self-help compatibility and have low initial capital costs. They can be used in almost every area, but they are especially adapted for arid areas where evaporation rates are high. Porous clay pots and pipes are a means of water application that conserve water by applying water directly to the roots of plants, thereby limiting evaporation losses.

### WHERE CAN IT WORK

Manual irrigation methods are appropriate for small-scale farming or backyard gardening irrigation in dry and arid climates where water is scarce.

### HOW DOES IT WORK

A very basic subsurface (see also subsurface drip irrigation) method consists in placing porous clay jars (or pots) in shallow pits dug for this purpose. Soil is then packed around the necks of the jars so their rims protrude a few centimetres above the ground surface. Water is poured into the jars either by hand or a flexible hose connected to a water source. As the walls of the pots are porous (make sure to use unglazed pots), the water can seep slowly out and reach the roots of the plants. The jars can be made of locally available clay: they are of no standard shape, size, wall thickness or porosity. Instead of a clay or earthenware pot, the sweet monkey orange fruit (*Strychnos spinosa*) can be used when it has been dried and the top cut off. (SSWM)

### COST CONSIDERATIONS

Minimal. The system simply requires a supply of clay pots, bottle or gourd-type containers and labour.

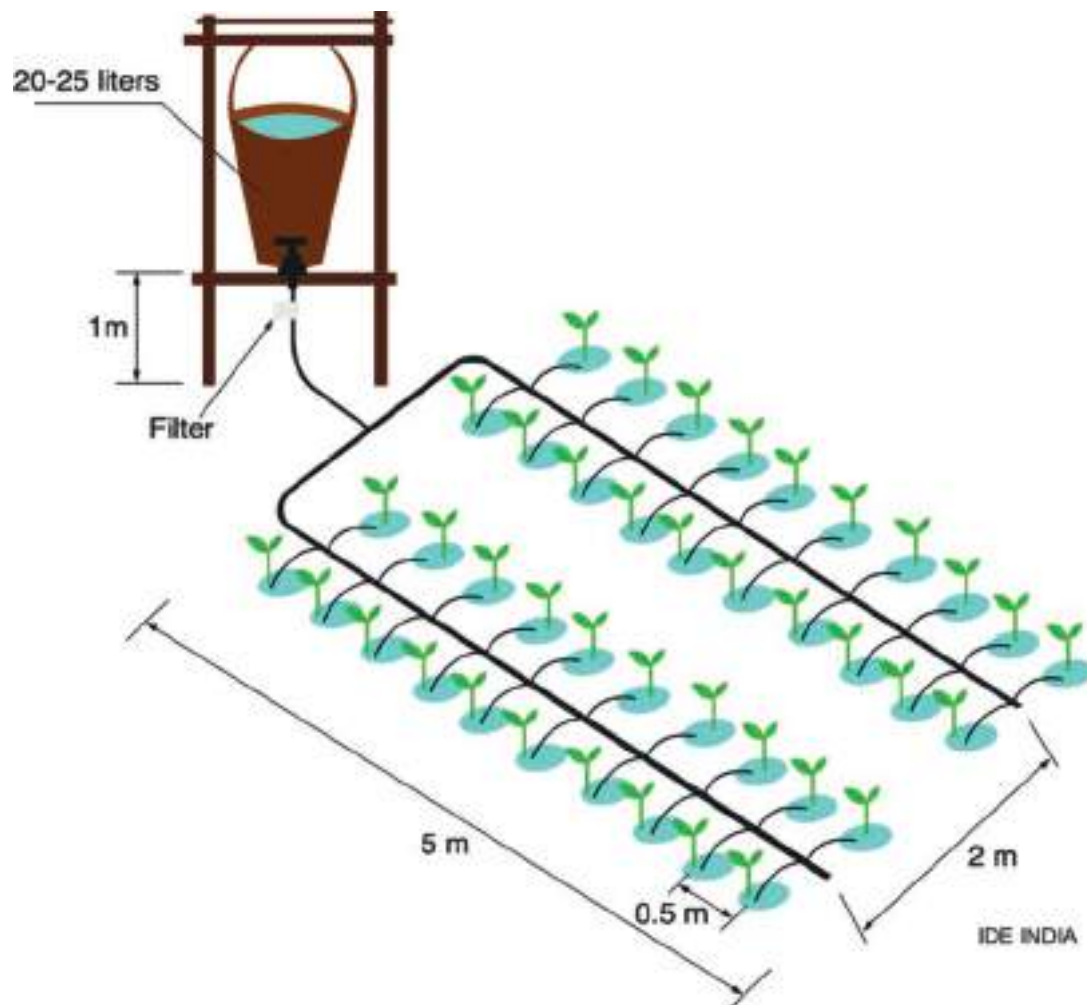


Image source:  
IDE INDIA



### ADVANTAGES

- Increased vegetable production
- Inexpensive
- No water wastage and irrigation time
- Minimises evaporative loss (if covered)
- Fewer weeds grow because water is directed to crops
- Water drips slowly so soil nutrients are not washed away
- Manure teas can be fed through pipes



### DISADVANTAGES

- System can get clogged and functions better with a filter system
- Training is required so that minimal amounts of water are used
- Fields need to be fenced as animals can damage the system
- A reliable water source is required



## 5.12

# BUCKET OR BOTTLE DRIP IRRIGATION

| WATER CONSERVATION |

### ADDITIONAL RESOURCES:

SSWM\_Drip  
Irrigation SSWM\_  
Manual Irrigation

SSWM\_Subsurface  
Drip Irrigation

### OUTLINE DESCRIPTION OF TECHNOLOGY

Even when rainfall is low or erratic, the bucket drip irrigation system enables farmers to nourish and grow the crops they need

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

A 20-litre drip bucket is placed 1m above the ground on poles. The drip bucket is attached to a long hose that criss-crosses the crop field. The bucket is filled manually. Simple gravity provides enough pressure to force the water through the hose. Water drips through the holes in the hose, directly onto the roots of the plants. 100-200 plants can be grown using just one drip bucket system (SSWM).

### COST CONSIDERATIONS

A standard kit can range between USD15 and USD85 depending on the size.



*Image source:*  
**Terre des Hommes**  
(Bangladesh)



#### ADVANTAGES

- Easy to maintain once built
- Facilitates year-round vegetable production
- Increases quality and diversity of vegetables
- Can provide protection against flood water intrusion



#### DISADVANTAGES

- Labour intensive to build a raised garden
- Requires additional soil to build up height of plinth

## 5.13

# KEYHOLE GARDEN

## KITCHEN GARDEN

| SOIL ENHANCEMENT |  
| WATER CONSERVATION |

### ADDITIONAL RESOURCES:

Nifty Homestead  
WOCAT

### OUTLINE DESCRIPTION OF TECHNOLOGY

The keyhole garden model of homestead vegetable cultivation enhances the resilience of families living in areas with climate-related hazards, such as flooding and drought. Keyhole gardens have been shown to increase vegetable production in all seasons, thereby improving household food autonomy and dietary diversity.

### WHERE CAN IT WORK

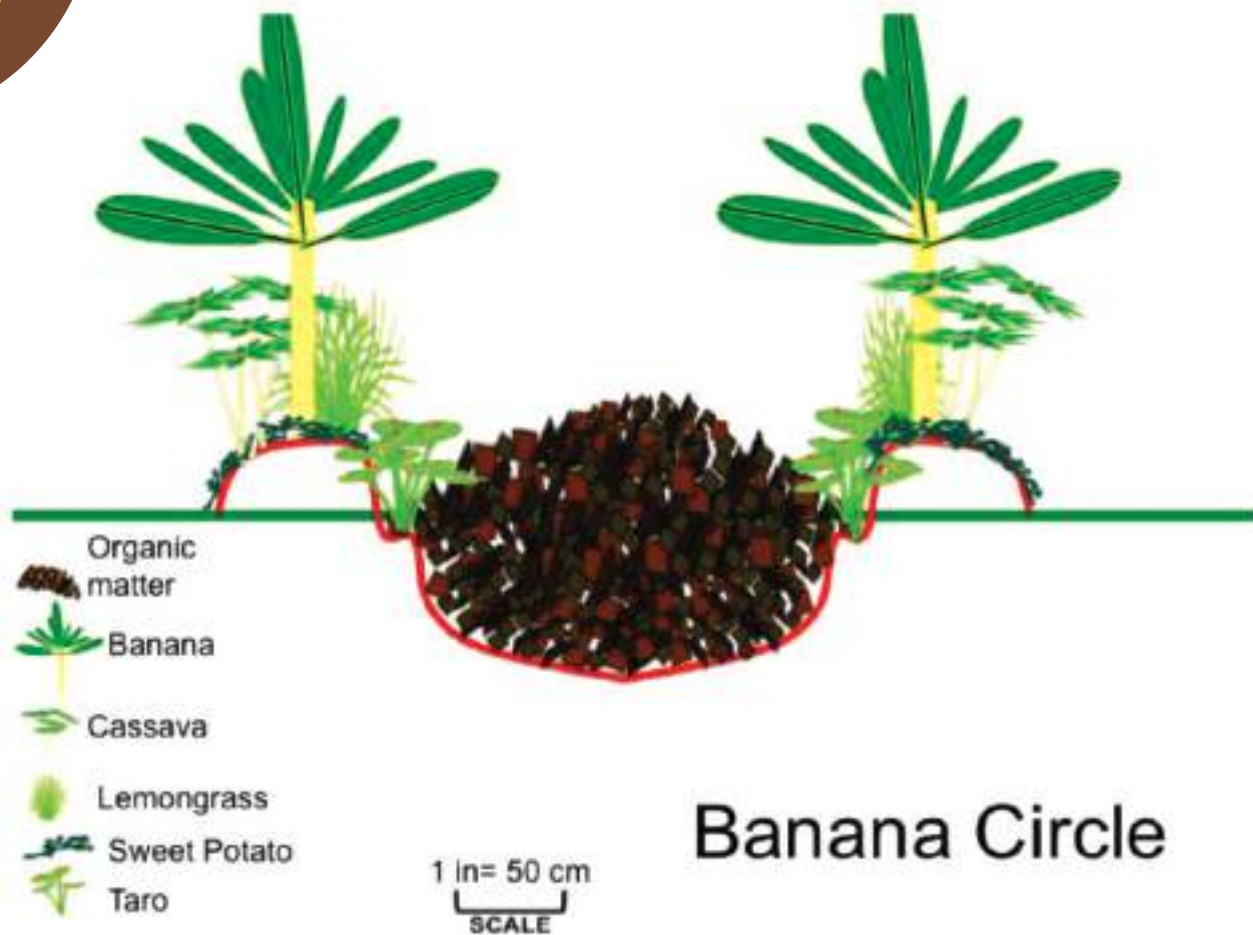
Applicable anywhere.

### HOW DOES IT WORK

A keyhole garden is typically a 3m wide circular raised garden with a key-hole-shaped indentation on one side. The indentation allows gardeners to add uncooked vegetable scraps, grey water and manure into a composting basket that sits in the centre of the bed. In this way, composting materials can be added to the basket throughout the growing season to provide the plants with nutrients. The upper layer of soil is hilled up against the centre basket so the soil slopes gently down from the centre to the sides. Most keyhole gardens rise about one metre above the ground and have walls made of stone. The stone wall not only gives the garden its form, but helps trap moisture within the bed. Keyhole gardens originated in Lesotho and are well adapted to dry arid lands and deserts. In Africa, they are positioned close to the kitchen and used to raise leafy greens such as lettuce, kale and spinach; herbs; and root crops, such as onions, garlic, carrots and beets. Keyhole gardens are ideal for intensive planting, a technique in which plants are placed close together to maximise production.

### COST CONSIDERATIONS

The cost is variable based on the availability of plants, a supply of compost and materials are necessary to define the perimeter form of the garden.



*Image source:*  
A Permaculture Design  
Course Handbook



### ADVANTAGES

- Produces lots of food in a small area
- Can be integrated in a mandala garden
- Allows safe use of grey water and/or humanure in the compost pit



### DISADVANTAGES

- Requires additional work



## 5.13.1

# BANANA CIRCLE

## MULTI-LAYER GARDEN

| SOIL ENHANCEMENT |

| WATER CONSERVATION |

### ADDITIONAL RESOURCES:

Permaculture Design  
Handbook

### OUTLINE DESCRIPTION OF TECHNOLOGY

Banana circles can be seen as a variation of the keyhole garden, only in a bigger size that is appropriate for planting bananas and/or papayas (together with other plants)

### WHERE CAN IT WORK

Applicable anywhere (with appropriate adaptations).

### HOW DOES IT WORK

The first step is to dig a two metre diameter (and roughly 70cm deep) hole. The earth that has been dug is piled around the circle. This creates the planting bed. Rough composting material is piled in the hole. The bananas and a variety of other plants are planted in the bed on the ridge of the circle. A path can be created to access the compost and feed it regularly to maintain fertility over time.

### COST CONSIDERATIONS

The cost is variable based on the availability of plants.



Image source:  
SSWM



#### ADVANTAGES

- Local reuse of compost and reclaimed water from household or school waste
- Low cost
- Minimal agricultural area required
- Contributes to food security
- Simple and easy to understand
- Can be watered with grey water



#### DISADVANTAGES

- Regular watering or irrigation system has to be in place.

## 5.14

# VERTICAL GARDENS

## CONTAINER GARDENS

| GREY WATER |  
| MANAGEMENT | FOOD PRODUCTION |

### ADDITIONAL RESOURCES:

SSWM (Greywater Towers) SSWM (Vertical Gardens)

### OUTLINE DESCRIPTION OF TECHNOLOGY

Vertical gardening aims to advance the productivity levels of urban and sub-urban agricultural production sites, where most often available space is the biggest agricultural limitation. Plenty of different design solutions are available. The design of vertical garden depends on the available materials, space and local preferences, as well as the creativity and imagination of the users. Crops that can be grown comprise food and non-food crops (e.g. ornamental plants, medical plants). (SSWM)

### WHERE CAN IT WORK

They can be placed on yet unused places, such as the roof of houses, balconies, on the top of walls or just hung up. Where space is available, earth beds of larger surface may even be installed, but require some expert design to control water drainage and infiltration.

### HOW DOES IT WORK

As a growing media soil, compost, vermicompost, terra preta compost, as well as aquaponic and aeroponic solutions can be used. The crops can be grown in sacks, bags, flowerpots and all kinds of available receptacles like bins, cans, tins, bottles, tanks or boxes.

### COST CONSIDERATIONS

Limited to the cost of bag, soil, gravel, compost and plants





*Image source:*  
Caritas Switzerland



#### ADVANTAGES

- Creates sustainable life supporting systems going beyond carbon neutrality and sustainability



#### DISADVANTAGES

- Extra work and studies to understand and apply principles and techniques



## 5.15

# PERMACULTURE DESIGN

## OBSERVATION AND DESIGN

| PATHWAYS BEYOND SUSTAINABILITY |  
| REGENERATIVE FARMING SYSTEMS |

### ADDITIONAL RESOURCES:

Wikipedia Holmgren  
Permaculture  
Principles

Permaculture  
Research Institute  
Permaculture Design  
Course Handbook

### OUTLINE DESCRIPTION OF TECHNOLOGY

Permaculture is a system of agricultural and social design principles centred around simulating or directly utilising the patterns and features observed in natural ecosystems. The word permaculture originally referred to "permanent agriculture", but was expanded to also stand for "permanent culture" as it was understood that social aspects were integral to a truly sustainable system.

### WHERE CAN IT WORK

Applicable anywhere.

### HOW DOES IT WORK

The co-inventor of permaculture, Bill Mollison, said, "Permaculture is a philosophy of working with, rather than against, nature; of protracted and thoughtful observation rather than protracted and thoughtless labour; and looking at plants and animals in all their functions, rather than treating any area as a single product system.

Hence, permaculture is primarily a landscape design technique that aims to create beneficial links between all the elements of a household or farm. There are three ethical values guiding every permaculture design:

1. Care for the earth
2. Care for the people
3. Fair share

### COST CONSIDERATIONS

The cost depends on the permaculture design that is planned



TOPIC 06

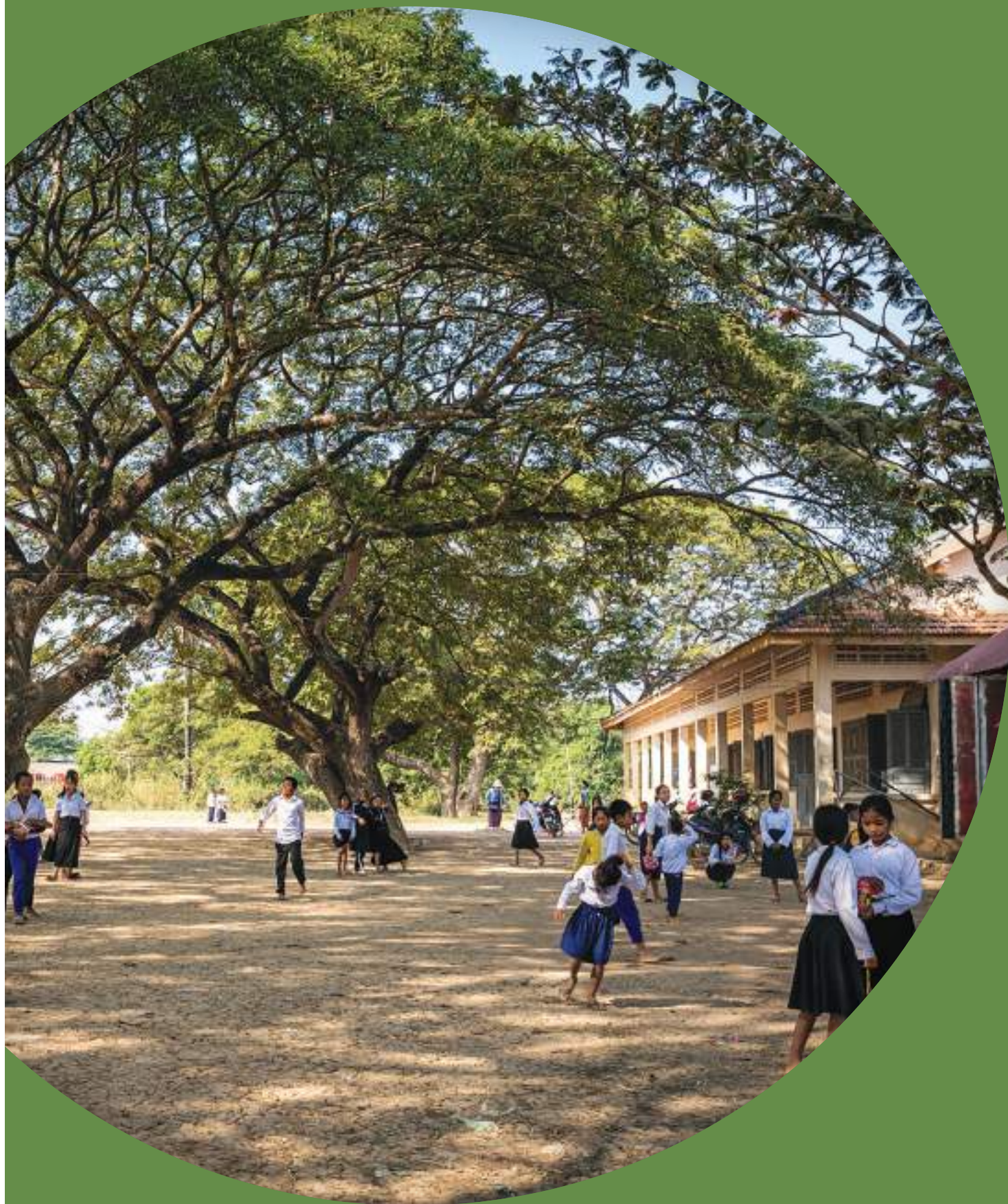
# MY SUR- ROUNDING ENVIRON- MENT.

**“Water is the driving force  
of all nature.”**

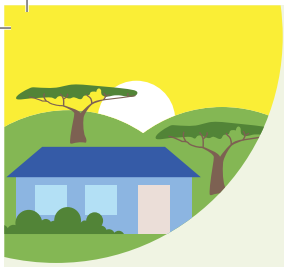
LEONARDO DA VINCI











## EROSION CONTROL

- Infiltration pond (6.1)
- Reforestation (6.2)



## FLOOD MANAGEMENT



## TREES AND REFORESTATION

- Agroforestry (6.3)
- Farmers managed natural regeneration (6.4)
- Reforestation (6.2)



# THE RIVER BASIN AROUND MY SCHOOL.



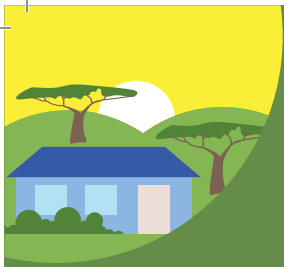
A river basin is very similar to a watershed. It is a hydrological term that defines a certain area of land where precipitation collects and drains off into a common outlet, such as a river, bay or other body of water. It contains all surface and groundwater in that area. Other terms in use are catchment area, catchment basin, drainage area and river basin.

A river basin is characterised by its topography, shape, size, soil type and land use. Problems such as flooding, soil erosion or water table decrease arise if water and/or land is not managed appropriately. Activities such as deforestation, intensive agricultural practices, overuse or pollution of water bodies or inappropriate spatial planning can result in severe threats to human health. This can affect downstream populations in terms of quality and quantity of water available. This highlights

the necessity to safely manage water and land, and thus creates increased knowledge and awareness with students regarding risks, but also shows pathways for improvement to the river basin around their school.

The technologies presented in this chapter can be applied around a school or in the community to improve erosion control, increase water infiltration and water retention in the soil, increase water availability and, all together, contribute to better flood management. In general, reducing water runoff where rain falls contributes to reducing flooding.

The following chapters show different technologies, some with considerable costs in terms of investment and labour.



*Image source:*  
**Forestry project,**  
**Caritas Switzerland**



#### ADVANTAGES

- Facilitates groundwater recharge
- Improves soil moisture
- Increases agricultural productivity
- Can be used to recharge shallow wells, boreholes and springs
- can reduce salinity in groundwater



#### DISADVANTAGES

- Can silt up easily due to lost vegetation cover in catchment area
- De-silting requires time and money
- Maintenance requires communal effort
- High evaporation rates
- High cost of construction if done at scale

# 6.1

## INFILTRATION PONDS

| FLOOD MANAGEMENT | PRECIPITATION HARVESTING |  
| WATER INFILTRATION | WATER RETENTION |

### ADDITIONAL RESOURCES:

SSWM\_Microbasins  
SSWM\_Ground  
Water Recharge  
SSWM\_Soil Aquifer  
Treatment

### OUTLINE DESCRIPTION OF TECHNOLOGY

An infiltration basin or pond is a facility constructed within highly permeable soils that provides temporary storage of storm water runoff. An infiltration basin does not normally have an outlet to discharge excess water. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage for both storm water quality and quantity management.

### WHERE CAN IT WORK

Infiltration basins have been used globally to manage water resources. Care should be given in areas prone to mosquitoes because of the risks of standing water.

### HOW DOES IT WORK

Ponds are formed by digging generally to a depth of 1-4m, deep enough to avoid excessive algae growth and shallow enough to avoid anaerobic conditions developing in the base of the pool. Intake surfaces or structures should be formed so as to minimise input of silt to the ponds. Sedimentation basins can reduce silt load before water enters the infiltration pond. Where possible, maintaining good cover of indigenous grasses in the runoff area can significantly reduce silting.

### COST CONSIDERATIONS

Costs are variable based on size and location.





*Image source:*  
**Forestry project,**  
**Caritas Switzerland**



### ADVANTAGES

- Facilitates groundwater recharge
- Improves soil moisture
- Can be used to recharge shallow wells, boreholes and springs



### DISADVANTAGES

- Needs some nursing at initial stages and management, as well as protective measures in the long-term
- considerable costs if done at scale



## 6.2

# REFORESTATION

| INTEGRATED WATER RESOURCE MANAGEMENT | EROSION CONTROL |  
| WATER INFILTRATION | WATER RETENTION |

### ADDITIONAL RESOURCES:

Wikipedia

### OUTLINE DESCRIPTION OF TECHNOLOGY

Planting trees is a very important tool for integrated water resource management. When trees are planted in sufficient numbers and larger areas, reforestation can occur. This results in decreased soil erosion, and increased water infiltration and retention in the area. This is especially important where human activities have resulted in deforestation of land, be it for construction of houses and cities or agricultural activities. Without plant cover, erosion can occur and sweep the land into rivers. The agricultural plants that often replace trees cannot hold onto the soil and many of these plants, such as coffee, cotton, palm oil, soybean and wheat, can actually worsen soil erosion. As land loses its fertile soil, agricultural producers move on, clear more forest and continue the cycle of soil loss. Reforestation and tree planting can break this vicious cycle.

### WHERE CAN IT WORK

If appropriate, tree species (native) are chosen, it is applicable anywhere in the world where soil conditions and water availability allow. Watering in the initial phase may be necessary.

### HOW DOES IT WORK

Please refer to slides 6.5, 6.4 and 6.9 in the Catalogue of Practical Exercises concerning deforestation visit the forest (important of forest) and tree planting solutions.

### COST CONSIDERATIONS

The costs are moderate, depending on the tree seedlings used. The main costs are labour-oriented.



*Image source:*  
**Forestry project,**  
**Caritas Switzerland**



### ADVANTAGES

- Yield enhancement and diversification
- Soil and fertility conservation / regeneration
- Soil's moisture and evaporation regulator (shade, windbreak)
- Homestead self-reliance and resilience strengthening
- Biodiversity protection and increase adaptation to climate change and DDR



### DISADVANTAGES

- Requires training, research and planning
- Relatively long-term strategy if starting from the beginning
- The trees must be pruned and taken care of regularly (but management also means more yield)

## 6.3

# AGROFORESTRY

### GENERAL

| SUSTAINABLE FARMING SYSTEM |  
| REGENERATIVE AGRICULTURE |

#### ADDITIONAL RESOURCES:

The Farmers'  
Handbook Concept  
of Food Forest

### OUTLINE DESCRIPTION OF TECHNOLOGY

In summary, agroforestry is a productive, diverse agricultural method where crops are mixed with trees. Trees provide enhanced fertility, protection, animal fodder and shelter, fuel, timber, fruits and other benefits.

### WHERE CAN IT WORK

Applicable anywhere.

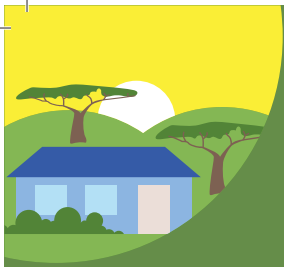
### HOW DOES IT WORK

There are many forms of agroforestry. The basic principles are to plant different kinds or species of trees (diversity) and create different layers with various trees sizes. Alley cropping is the most common agroforestry system, and perhaps the easiest way to start. In this system, rows of diverse trees are planted either on flat land or along contoured lines on a slope. In between these trees, crops such as cereals or vegetables are planted.

### COST CONSIDERATIONS

At a small scale the costs are limited to the cost of plants and labour. At a community scale, external funding and expertise would usually be required to establish nurseries and kick-start production.





*Image source:*  
Caritas Switzerland



## ADVANTAGES

- All the advantages of reforestation, but potentially quicker than planting new trees (by the use of existing, well-adapted and established plants)
- Allows the use of natural resources (existing trees)



## DISADVANTAGES

- Important to talk and exchange with appropriate community members when initiating change (not necessarily a disadvantage).



## 6.4

# FARMERS MANAGED NATURAL REGENERATION (FMNR)

### REFORESTATION

| LANDSCAPE REGENERATION |  
| ECOSYSTEM CONSERVATION | LIVELIHOOD |

#### OUTLINE DESCRIPTION OF TECHNOLOGY

FMNR is a way to regrow vegetation cover with existing tree strains in arid and overgrazed regions. This technology can be applied on large areas.

#### WHERE CAN IT WORK

This technology can be applied successfully anywhere, but it is especially relevant in arid, semi-desert regions, where free-range cattle are overgrazing land.

#### HOW DOES IT WORK

In semi-arid regions, living tree stumps can often be observed. Often there are hardly recognisable as such because they have been repeatedly grazed upon by cattle. These strains often have a few rods growing from them. One can select the healthiest rod and cut the others to help the tree grow only one future trunk. It is important to protect the future tree with mesh.

Observing the trees around is the best way to identify the appropriate species to conduct this activity. It is also very important to speak with local farmers to explain the scope and objectives of this technology, so they can agree, participate and support the process. This method has very good potential for rapid forest regeneration, which plays a crucial role in protecting natural ecosystems and supporting livelihoods.

#### COST CONSIDERATIONS

A sharp knife | Mesh to protect the strains (or any other locally available

#### ADDITIONAL RESOURCES:

Prior to the experiment, make sure to thoroughly research FMNR in order to fully understand the principle. FMNR is a concept that has been discovered and developed by Tony Rinaudo, from World Vision Australia.

Wikipedia Farmer Managed Natural Regeneration (FMNR) FMNR (Video)

# LIST OF REFERENCES AND ADDITIONAL RESOURCES

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A lot of the technologies presented in the catalogue are accompanied by useful hyperlinks you can open by right clicking on it. Here is the list of resources:



<b>1.1 Rooftop harvesting</b>	<ul style="list-style-type: none"><li>• <a href="http://www.appropedia.org/Rainwater_Harvesting_(Practical_Action_Technical_Brief)">http://www.appropedia.org/Rainwater_Harvesting_(Practical_Action_Technical_Brief)</a></li><li>• <a href="https://www.sswm.info/archived-perspective-notice">https://www.sswm.info/archived-perspective-notice</a></li><li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(rural)">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(rural)</a></li><li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(urban)">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(urban)</a></li><li>• <a href="http://www.icimod.org/nepcat">http://www.icimod.org/nepcat</a></li><li>• <a href="https://www.samsamwater.com/library.php?cat=rwh">https://www.samsamwater.com/library.php?cat=rwh</a></li></ul>
<b>1.2 Spring and water source protection</b>	<ul style="list-style-type: none"><li>• <a href="https://www.wateraid.org/uk/publications/protection-of-spring-sources-technical-brief">https://www.wateraid.org/uk/publications/protection-of-spring-sources-technical-brief</a></li><li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/groundwater-sources/water-source-protection">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/groundwater-sources/water-source-protection</a></li><li>• <a href="http://www.icimod.org/nepcat">http://www.icimod.org/nepcat</a></li></ul>
<b>1.3 Water storage tank: brick</b>	<ul style="list-style-type: none"><li>• <a href="http://akvopedia.org/wiki/Brick_cement_tank">http://akvopedia.org/wiki/Brick_cement_tank</a></li><li>• <a href="https://www.ircwash.org/sites/default/files/217-81IR-6933.pdf">https://www.ircwash.org/sites/default/files/217-81IR-6933.pdf</a></li></ul>
<b>1.9 Water storage tank: ferrocement</b>	<ul style="list-style-type: none"><li>• <a href="http://akvopedia.org/wiki/Classical_ferrocement_tank">http://akvopedia.org/wiki/Classical_ferrocement_tank</a></li><li>• <a href="http://www.rainwaterharvesting.org/methods/modern/fctanks.htm">http://www.rainwaterharvesting.org/methods/modern/fctanks.htm</a></li><li>• <a href="https://www.ircwash.org/sites/default/files/217-82IR-6932.pdf">https://www.ircwash.org/sites/default/files/217-82IR-6932.pdf</a></li><li>• <a href="http://lib.icimod.org/record/33883">http://lib.icimod.org/record/33883</a></li><li>• <a href="https://www.samsamwater.com/library.php?cat=rwh">https://www.samsamwater.com/library.php?cat=rwh</a></li></ul>
<b>1.10 Water storage tank: plastic bottle</b>	<ul style="list-style-type: none"><li>• <a href="http://nellhamilton.com/sustainable-east-africa/projects/plastic-bottle-water-tanks-mwera/">http://nellhamilton.com/sustainable-east-africa/projects/plastic-bottle-water-tanks-mwera/</a></li><li>• <a href="https://insteadin.com/blog/plastic-bottle-homes/">https://insteadin.com/blog/plastic-bottle-homes/</a></li><li>• <a href="https://www.youtube.com/watch?v=zcOkeJgANK8">https://www.youtube.com/watch?v=zcOkeJgANK8</a></li></ul>
<b>1.11 Plastic SIM tank</b>	<ul style="list-style-type: none"><li>• <a href="http://akvopedia.org/wiki/Plastic_water_tanks">http://akvopedia.org/wiki/Plastic_water_tanks</a></li></ul>
<b>1.13 Underground ferrocement tank</b>	<ul style="list-style-type: none"><li>• <a href="https://pdf.usaid.gov/pdf_docs/pnaeb709.pdf">https://pdf.usaid.gov/pdf_docs/pnaeb709.pdf</a></li></ul>
<b>1.14 Blue Plastic storage and distribution tank</b>	<ul style="list-style-type: none"><li>• <a href="http://www.obelink.n">www.obelink.n</a></li></ul>
<b>1.15 Solar pump / small distribution systems</b>	<ul style="list-style-type: none"><li>• <a href="http://waterconsortium.ch/publications/mini-water-system-networks/">http://waterconsortium.ch/publications/mini-water-system-networks/</a></li></ul>

<b>1.16 Gravity flow water supply systems</b>	<ul style="list-style-type: none"> <li>• <a href="http://lib.icimod.org/record/33883">http://lib.icimod.org/record/33883</a></li> <li>• <a href="http://www.icimod.org/nepcat">http://www.icimod.org/nepcat</a></li> </ul>
<b>1.17 Boiling</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf</a></li> <li>• <a href="https://www.sswm.info">https://www.sswm.info</a></li> <li>• <a href="https://www.hwts.info">https://www.hwts.info</a></li> </ul>
<b>1.18 Chlorination</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf</a></li> <li>• <a href="https://www.sswm.info">https://www.sswm.info</a></li> <li>• <a href="https://www.hwts.info">https://www.hwts.info</a></li> <li>• <a href="https://www.antenna.ch/en/activities/water-hygiene/">https://www.antenna.ch/en/activities/water-hygiene/</a></li> <li>• <a href="http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/">www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/</a></li> <li>• <a href="http://waterconsortium.ch/results/local-production-of-chlorine-for-water-treatment-and-disinfection-purposes/">http://waterconsortium.ch/results/local-production-of-chlorine-for-water-treatment-and-disinfection-purposes/</a></li> </ul>
<b>1.19 Ceramic water filter</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf</a></li> <li>• <a href="https://www.sswm.info">https://www.sswm.info</a></li> <li>• <a href="https://www.hwts.info">https://www.hwts.info</a></li> </ul>
<b>1.20 Biosand filter</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.biosandfilters.info/">https://www.biosandfilters.info/</a></li> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf</a></li> <li>• <a href="https://www.sswm.info">https://www.sswm.info</a></li> <li>• <a href="https://www.hwts.info">https://www.hwts.info</a></li> </ul>



<b>2.1 Tippy tap</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-home/simple-handwashing-devices">https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-home/simple-handwashing-devices</a></li> </ul>
<b>2.4 Hand washing station</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.rotaryindiawashinschools.com/Downloads/Documents/GroupHWfacilitiesinschoolDesignManual_10212016112035AM.pdf">http://www.rotaryindiawashinschools.com/Downloads/Documents/GroupHWfacilitiesinschoolDesignManual_10212016112035AM.pdf</a></li> </ul>
<b>2.5 Happy Tap (Labobo)</b>	<ul style="list-style-type: none"> <li>• 20200417_HappyTap-full-scale-results_V8.pdf (watershedasia.org)</li> <li>• (2) Watch   Facebook</li> </ul>
<b>2.6 Single Ventilated Improved Pit (VIP) Latrines</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf</a></li> <li>• <a href="http://www.flowman.nl/wedcschoolsanitation20081007.pdf">http://www.flowman.nl/wedcschoolsanitation20081007.pdf</a></li> </ul>



<b>2.7 Urine Diverting Dry Toilet – ECOSAN toilet</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.wecf.eu/english/publications/2006/ecosan_reps.php">www.wecf.eu/english/publications/2006/ecosan_reps.php</a></li> <li>• <a href="http://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf">www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf</a></li> </ul>
<b>2.8 Twin Pits for Pour Flush</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf">www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf</a></li> </ul>
<b>2.9 Arborloo</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fill-and-cover/-arborloo">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fill-and-cover/-arborloo</a></li> <li>• <a href="http://www.ecosanres.org/pdf_files/PM_Report/Appendix1_The_Arborloo_book_a.pdf">www.ecosanres.org/pdf_files/PM_Report/Appendix1_The_Arborloo_book_a.pdf</a></li> <li>• <a href="http://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf">www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sep/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf</a></li> </ul>



<b>3.1 Cloth Menstrual Pad</b>	<ul style="list-style-type: none"> <li>• Greenlady Cambodia</li> <li>• Social Package   Greenlady Cambodia</li> </ul>
<b>3.2 Menstrual cups</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/humanitarian-crises/camps/hygiene-promotion-community-mobilisation/hygiene-promotion-community/menstrual-hygiene-management">https://www.sswm.info/humanitarian-crises/camps/hygiene-promotion-community-mobilisation/hygiene-promotion-community/menstrual-hygiene-management</a></li> </ul>



<b>4.1 Compost making</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-pit-humus-and-compost">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-pit-humus-and-compost</a></li> </ul>
<b>4.2 Windrow composting</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Decentralized_Composting/Rothenberger_2006_en.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Decentralized_Composting/Rothenberger_2006_en.pdf</a></li> <li>• <a href="http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management">http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management</a></li> </ul>
<b>4.3 Vermicomposting</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/W4/Manual_On_Farm_Vermicomposting_Vermiculture.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/W4/Manual_On_Farm_Vermicomposting_Vermiculture.pdf</a></li> <li>• <a href="http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management">http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management</a></li> </ul>
<b>4.4 Anaerobic digestion</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Anaerobic_Digestion/biowaste.pdf">https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Anaerobic_Digestion/biowaste.pdf</a></li> </ul>
<b>4.5 Burying waste</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.bvsde.paho.org/bvsars/i/fulltext/manual/manual.html#manu">http://www.bvsde.paho.org/bvsars/i/fulltext/manual/manual.html#manu</a></li> </ul>
<b>4.6 Waste incineration</b>	<ul style="list-style-type: none"> <li>• <a href="https://mw-incinerator.info/en/401_operation.html">https://mw-incinerator.info/en/401_operation.html</a></li> </ul>



<b>5.1</b> <b>Using compost</b>	<ul style="list-style-type: none"><li>• <a href="https://www.sswm.info/sswm-university-course/module-3-ecological-sanitation-and-natural-systems-wastewater-treatment-1/use-of-compost">https://www.sswm.info/sswm-university-course/module-3-ecological-sanitation-and-natural-systems-wastewater-treatment-1/use-of-compost</a></li></ul>
<b>5.2</b> <b>Mulching</b>	<ul style="list-style-type: none"><li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/mulching">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/mulching</a></li></ul>
<b>5.3</b> <b>Natural pesticides</b>	<ul style="list-style-type: none"><li>• <a href="http://www.fourthway.co.uk/posters/pages/pesticide.html">http://www.fourthway.co.uk/posters/pages/pesticide.html</a></li></ul>
<b>5.4</b> <b>Urine fertilisation</b>	<ul style="list-style-type: none"><li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-stored-urine">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-stored-urine</a></li><li>• <a href="https://www.sswm.info/humanitarian-crises/prolonged-encampments/sanitation/use-and-or-disposal/urine-fertilisation-(large-scale)">https://www.sswm.info/humanitarian-crises/prolonged-encampments/sanitation/use-and-or-disposal/urine-fertilisation-(large-scale)</a></li><li>• <a href="https://www.sswm.info/content/urine-storage">https://www.sswm.info/content/urine-storage</a></li><li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fertiliser-from-urine-(struvite)">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fertiliser-from-urine-(struvite)</a></li></ul>
<b>5.5</b> <b>Natural fertilisers</b>	<ul style="list-style-type: none"><li>• <a href="http://www.fourthway.co.uk/posters/pages/planttea.html">http://www.fourthway.co.uk/posters/pages/planttea.html</a></li></ul>
<b>5.6</b> <b>Liquid manure</b>	<ul style="list-style-type: none"><li>• <a href="http://www.fourthway.co.uk/posters/pages/liquidmanure.html">http://www.fourthway.co.uk/posters/pages/liquidmanure.html</a></li><li>• <a href="https://www.facebook.com/283460171679419/videos/2378762677956/">https://www.facebook.com/283460171679419/videos/2378762677956/</a></li></ul>
<b>5.7</b> <b>Gardening with charcoal</b>	<ul style="list-style-type: none"><li>• <a href="https://permaculturenews.org/2010/05/25/back-to-the-future-terra-preta-%E2%80%93-ancient-carbon-farming-system-for-earth-healing-in-the-21st-century/">https://permaculturenews.org/2010/05/25/back-to-the-future-terra-preta-%E2%80%93-ancient-carbon-farming-system-for-earth-healing-in-the-21st-century/</a></li></ul>
<b>5.8</b> <b>Seed sowing</b>	<ul style="list-style-type: none"><li>• <a href="https://www.seedsavers.org/learn">https://www.seedsavers.org/learn</a></li><li>• <a href="http://blog.seedsavers.org/blog/how-to-store-seeds">http://blog.seedsavers.org/blog/how-to-store-seeds</a></li></ul>
<b>5.9</b> <b>Crop planning</b>	<ul style="list-style-type: none"><li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/crop-selection">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/crop-selection</a></li></ul>
<b>5.10</b> <b>Planting pits</b>	<ul style="list-style-type: none"><li>• <a href="https://c.ymcdn.com/sites/echocommunity.site-ym.com/resource/collection/27A14B94-EFE8-4D8A-BB83-36A61F414E3B/TN_78_Zai_Pit_System.pdf">https://c.ymcdn.com/sites/echocommunity.site-ym.com/resource/collection/27A14B94-EFE8-4D8A-BB83-36A61F414E3B/TN_78_Zai_Pit_System.pdf</a></li><li>• <a href="https://www.sswm.info/content/planting-pits">https://www.sswm.info/content/planting-pits</a></li></ul>

<b>5.11 Buried pot manual irrigation</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/manual-irrigation">https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/manual-irrigation</a></li> </ul>
<b>5.12 Bucket or bottle drip irrigation</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/drip-irrigation">https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/drip-irrigation</a></li> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/subsurface-drip-irrigation">https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/subsurface-drip-irrigation</a></li> </ul>
<b>5.13 Keyhole garden</b>	<ul style="list-style-type: none"> <li>• <a href="https://insteadof.com/blog/keyhole-garden/">https://insteadof.com/blog/keyhole-garden/</a></li> <li>• <a href="https://qcat.wocat.net/en/wocat/technologies/view/technologies_1722/">https://qcat.wocat.net/en/wocat/technologies/view/technologies_1722/</a></li> </ul>
<b>5.13.1 Banana circle</b>	<ul style="list-style-type: none"> <li>• <a href="https://treeyopermacultureedu.wordpress.com/chapter-10-the-humid-tropics/banana-circle/">https://treeyopermacultureedu.wordpress.com/chapter-10-the-humid-tropics/banana-circle/</a></li> </ul>
<b>5.14 Vertical gardens</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/greywater-towers">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/greywater-towers</a></li> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/vertical-gardens">https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/vertical-gardens</a></li> </ul>
<b>5.15 Permaculture Design</b>	<ul style="list-style-type: none"> <li>• <a href="https://en.wikipedia.org/wiki/Permaculture">https://en.wikipedia.org/wiki/Permaculture</a></li> <li>• <a href="https://permacultureprinciples.com/">https://permacultureprinciples.com/</a></li> <li>• <a href="https://permaculturenews.org/">https://permaculturenews.org/</a></li> <li>• <a href="https://treeyopermacultureedu.wordpress.com/">https://treeyopermacultureedu.wordpress.com/</a></li> </ul>



<b>6.1 Infiltration ponds</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/micro-basins">https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/micro-basins</a></li> <li>• <a href="https://www.sswm.info/content/surface-groundwater-recharge">https://www.sswm.info/content/surface-groundwater-recharge</a></li> <li>• <a href="https://www.sswm.info/content/soil-aquifer-treatment">https://www.sswm.info/content/soil-aquifer-treatment</a></li> </ul>
<b>6.2 Reforestation</b>	<ul style="list-style-type: none"> <li>• <a href="https://en.wikipedia.org/wiki/Reforestation">https://en.wikipedia.org/wiki/Reforestation</a></li> </ul>
<b>6.3 Agroforestry</b>	<ul style="list-style-type: none"> <li>• <a href="https://www.permaculturenews.org/resources_files/farmers_handbook/volume_4/4_agroforestry.pdf">https://www.permaculturenews.org/resources_files/farmers_handbook/volume_4/4_agroforestry.pdf</a></li> <li>• <a href="https://permaculturenews.org/2011/10/21/why-food-forests/">https://permaculturenews.org/2011/10/21/why-food-forests/</a></li> </ul>
<b>6.4 Farmers Managed Natural Regeneration (FMNR)</b>	<ul style="list-style-type: none"> <li>• <a href="https://en.wikipedia.org/wiki/Farmer-managed_natural_regeneration">https://en.wikipedia.org/wiki/Farmer-managed_natural_regeneration</a></li> <li>• <a href="http://fmnrhub.com.au/">http://fmnrhub.com.au/</a></li> <li>• <a href="https://www.youtube.com/watch?v=afjVaehQRxg">https://www.youtube.com/watch?v=afjVaehQRxg</a></li> </ul>

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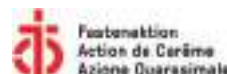




# BLUE SCHOOLS.

LINKING WASH IN SCHOOLS  
WITH ENVIRONMENTAL  
EDUCATION AND PRACTICE

## THE SWISS WATER AND SANITATION CONSORTIUM



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