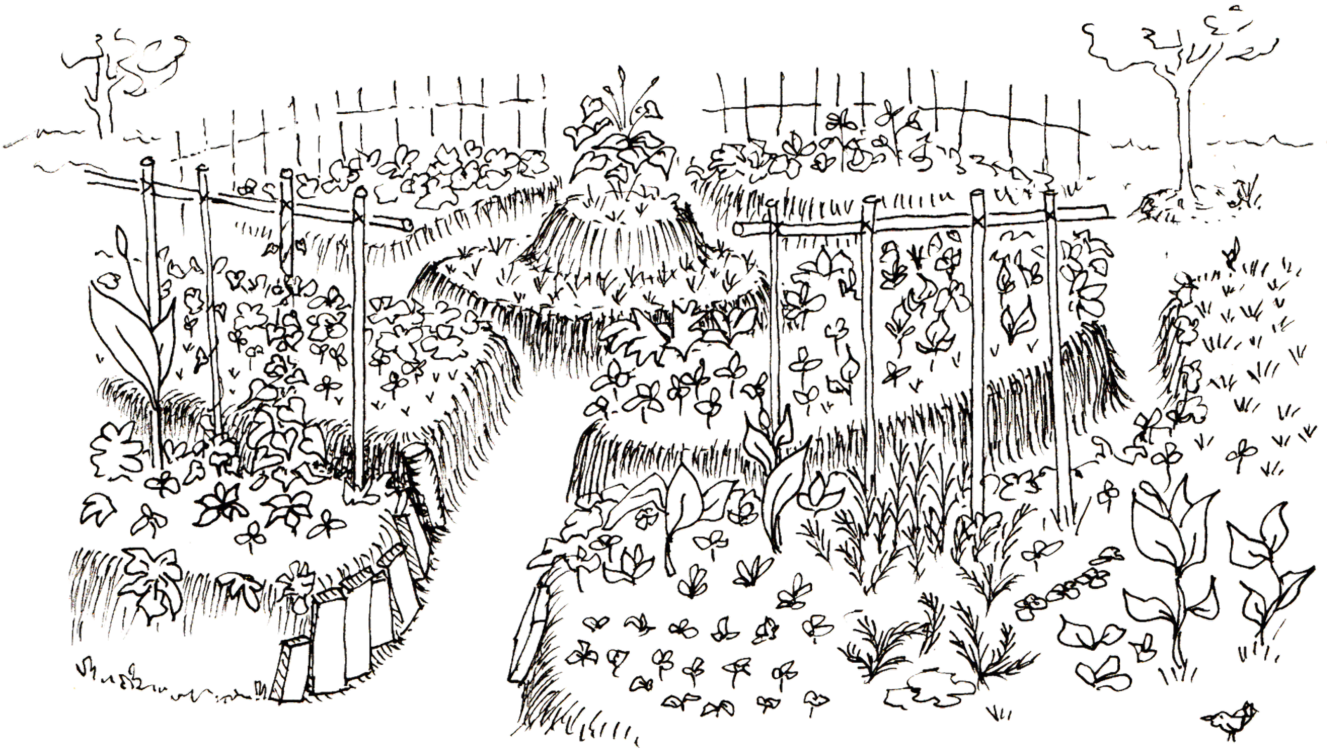
FOOD GROWING IN CAMPS AND SETTLEMENTS:

COLLECTING, STORING AND USING RAINFALL AND GREY WATER



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COLLECTING, STORING AND USING RAINFALL AND GREY WATER

INTRODUCTION:
THE REGENERATIVE APPROACH

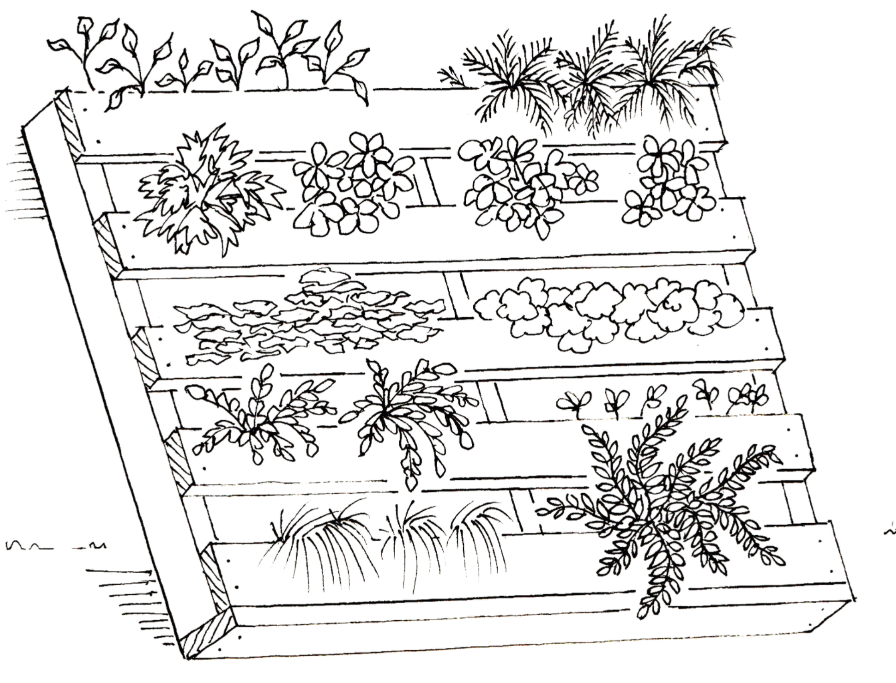
A regenerative approach to camp and settlement design goes beyond the sustainable lens recommended in the Sphere guidelines. It aims to maximise the health and well-being of all inhabitants while ensuring any interventions have a positive impact on the land they are settled in. This includes managing water and water disposal effectively, replenishing soil and vegetation and providing people with access to green spaces and fresh food they can grow themselves.

The Sphere guidelines recommend a site population ratio of 4.5 square meters per person and a settlement to land ratio of 1:3 or 1:4 (with a space 3 or 4 x the size of a dwelling between each one). Following these ratios can provide space for individual or communal vegetable gardens to facilitate the production of fresh food, and create local green spaces to enhance living conditions and improve mental health.

Early involvement and collaboration with local communities in surrounding areas can result in greater land availability and facilitate positive relationships between IDP or refugee and host communities.

Research has shown the benefits of gardening to those living in temporary settlements by providing fresh and nutritious food, meaningful activity, a sense of belonging or home, and feelings of well-being, particularly in the wake of trauma. It has also shown how replenishing soils, creating healthy water cycles, planting trees and minimising waste can have an equally positive impact on both human and ecological health.

A regenerative approach uses planning and good design to make the best use of available resources and minimise the need for expensive inputs brought in from outside. Gardens need water and good soil. Capturing and reusing surplus water and turning organic waste into compost can provide a source of both and reduce the need for safe disposal of these.



1 IDENTIFYING WATER SOURCES

In areas of limited rainfall and high temperatures, nearly all food crops will need additional irrigation water to supplement rainfall. Water is heavy to transport so growing areas should be sited close to identified water sources. Mapping water sources will help identify viable growing plots. It is especially helpful to locate areas where there are multiple or large water sources and areas of standing water. These guidelines focus on harvested rainwater and grey water. These sources can be a very important supplement to:

- Limited seasonal rainfall in order to extend the growing season
- Pumped water from well sources where water-user fees are high

Sources for water irrigation include:

Piped potable water supply	Via wells boreholes, reservoirs, tankers etc	This is often a scarce, expensive and energy-intensive water source and should only be used for irrigation as a last resort. There may also be local restrictions on using piped public water for plant irrigation.
Non-potable natural water sources	Lakes, ponds and streams	Water can be syphoned or pumped to growing areas from streams, lakes and ponds. Extracting water from natural sources often needs a license and care should be taken not to deplete this supply.
Harvested rainwater	Can be collected from most roofs and tents. The larger the roof, the more water collected	Users can often maintain and control systems themselves and it can reduce problems caused by water run-off. However, supply is sensitive to droughts, with long dry spells causing water supply problems at a time when plants need water most. Water should be stored in covered containers to avoid breeding insects that cause vector-borne diseases (e.g. mosquitos). Building cisterns with large storage capacities can bridge dry periods but can have high initial cost.
Grey water	Needs straining or filtering	A constant and reliable source of water with few fluctuations which allows the reuse of valuable water and nutrient resources. Its supply is harder to quantify but is usually proportional to the water usage of the building or household. Users should be trained in safe handling practises.
Standing Water	Includes pooled water from heavy rainfall, spillage from standpipes and poor waste-water drainage	Of variable quality and supply, If the standing water supply is infrequent - such as the result of heavy rainfall, the water should be channelled to the roots of plants which tolerate drought and flood such as fruit trees and bushes, or non-edible plants and shrubs such as reeds. Non edible plants can be harvested for other uses such as mulch, kindling and weaving. Standing water can be a vector for disease, so redirecting it to areas where it can soak away and be taken up by plant growth has added health and wellbeing benefits. Amending the soil to improve drainage can reduce standing water while increasing groundwater supplies.
Urine	When diluted can be used as a plant feed when applied to soil, but not to leaves.	Provides a source of nitrogen, phosphorous, potassium and trace elements for plants. There is a constant and free supply of this resource available, which makes it a great option provided its use can be culturally accepted. Care should be taken in its collection and transport to avoid spillage and bad odours. Users should be trained in safe handling practises.

Designing ways of harvesting or collecting water (grey or rain) is more easily done during camp construction than retrofitting onto ready installed drainage systems so is best included from the beginning.

Examples include adding gutters and water butts to community buildings and ensuring areas for community growing spaces are sited close to water supplies. Once mapped, water sources should be evaluated to ensure they can provide an adequate supply of sufficient quality which is culturally and socially acceptable delivered by an affordable and easily maintainable system.

General principles for evaluating water sources:

- Gauge cultural sensitivity to using harvested grey and rainwater early on, talk with people about their perceptions and preferences.
- Use low tech solutions which are easy to implement and maintain. Where possible, use direct application of grey water as storage requires a treatment component.
- Consider patterns of supply. Grey water can only be collected during periods when a building is in use eg: a school is closed during holidays when no grey water will be produced. Clearly, rainwater can only be harvested during rain events. Use local rainfall data to provide an indication of seasonal patterns and amount of rain, while noting climate change is bringing disruption to these patterns.
- Ensure grey water use is compliant with local regulations and practice. It is sometimes the case that local governing bodies are reluctant to agree to this. Convincing them of the benefits may be important to undertake.
- Consider the scale of grey and rain water harvesting possible. The amount of grey water produced by a building is usually proportional to the number of people using the building or shelter and rainwater harvesting is limited by the size of the catchment roof and the size of the storage container.
- Consider the possible contaminants of a water source. The purpose of a building can affect the contaminants from water collected there. For example, grey water collected from a hospital may contain chemical or clinical wastes which make it unsuitable for use.
- Consider social and cultural acceptability. People may be willing to use grey water from their own homes but not from a public washroom.
- Use of grey water for non-edible crops is seldom a concern so creating green spaces with tree and shrub planting may be an option if watering edible crops with grey water is not supported.
- Consider the type of growing space the water will irrigate. Some water sources may be better used to irrigate trees or bushes rather than vegetable crops. Trees and bushes can often tolerate larger volumes of water at greater intervals and so are better suited to absorb storm run-off and higher volumes of grey water when mulch pits are dug around them.

2 PLANNING WHAT TO GROW

For crops to be tended and watered, they need to be valued by the people growing and eating them. Food is evocative of culture and place and can be a good way for people to feel linked to their past in a new setting. Families and communities will know what they want to grow and eat, but in supporting home gardens consider:

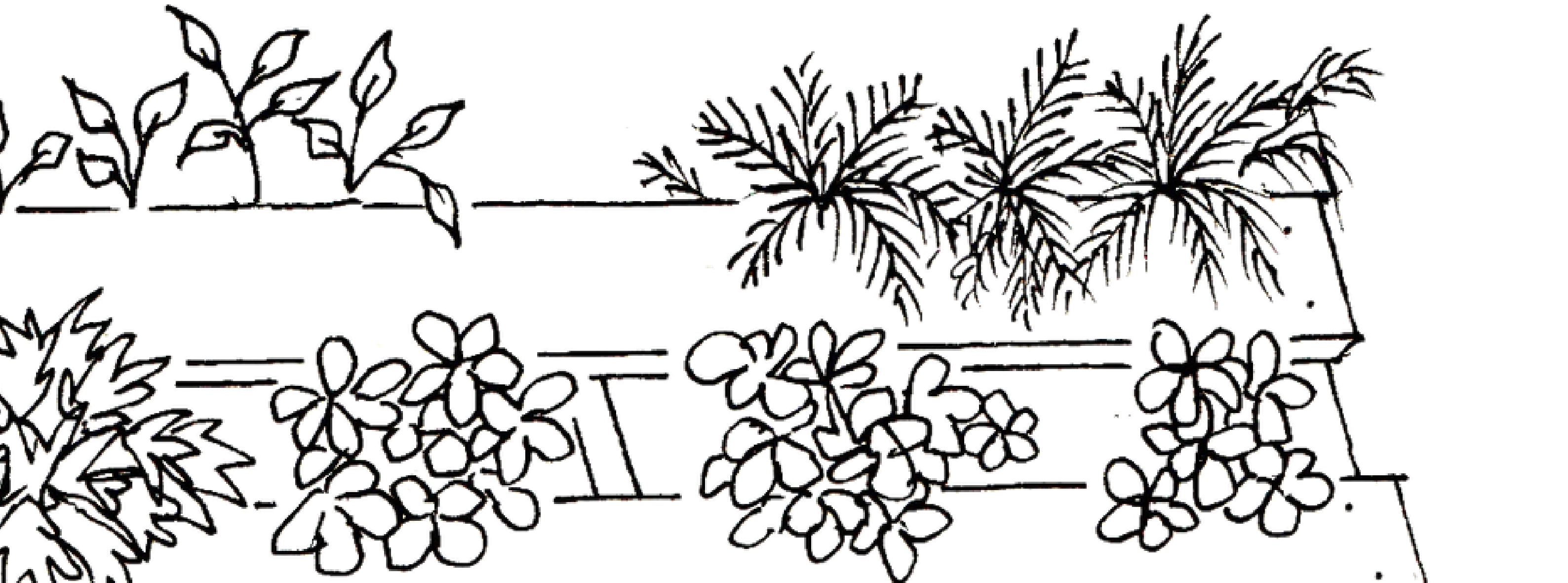
- Have people brought any seeds or seedlings with them?
- Are there any traditional or indigenous seed varieties available?
- Are there any ingredients people are missing, that are not available or too expensive to buy, that could be grown?
- Are there foods that are disliked by the family or community, or culturally inappropriate, that shouldn't be suggested?
- What local knowledge is there about what has successfully been grown in the local climate and in this new area when water is limited.
- How can you make the most of the limited water available?
- Which plants will give the highest yield?
- What plants will best contribute to biodiversity and ecological health?
- Are the suggested plants safe for animals and non-human life?
- What compliments and grows well with the plants suggested?
- Are the selected plants providing balanced nutrition and a range of different food types, e.g. a mix of carbohydrates, protein and different vitamins and minerals?
- Finally, it is useful to match plant water demand with an estimate of water availability and so gauge how much it is possible to grow. See resources for calculating crop water needs.

Select varieties that are most ‘pest’ resistant and use local or host community knowledge of pests in the local area. Find out whether there is any local or camp-based technical knowledge on forms of effective natural pest control. The best pest control is that which is self-regulated and needs no external, human input. For example, choose other plants that can be grown to attract the natural predators of these ‘pests’. Avoid F1 hybrid or genetically modified seeds and look for open pollinated heritage or traditional varieties. Seeds from these crops can be dried and saved to plant the following year, while hybrid (F1I) or modified seeds produce less or no viable seeds year on year. Plan for crops that need most water during months with rainfall or choose a variety of crops that will need water at different times.

- Beans need water most when they are blooming and setting fruit.
- Corn needs water most as the ears are developing.
- Peas need water most as their pods are filling.
- Cucumbers, squash and melons, tomatoes, peppers and aubergine need water most when they are flowering and fruiting (once tomatoes set, they can survive well with reduced water).

Plan for crops according to the time it takes for them to produce food, in order to help stagger a supply of food of mixed nutritional value across the year. Choosing crops with shorter growing periods usually reduces the total water requirement.

See Resources for a table showing growing periods and water needs.



3 ASSESSING WATER NEEDS

Before identifying water sources, it is useful to get a sense of how much extra water different crops will need in peak season when rainfall is lowest. See Resources for methods to estimate the amount of water you will need to irrigate specific crops.

Crops use more water in hot and dry weather than in cooler cloudy weather. Wind also increases water take-up. The table below, adapted from FAO figures, estimates the peak daily water needs of different vegetable and fruit crops against that needed by grass growing wild in the same climate. It is a useful guide to which plants will grow easily with limited irrigation water and which won't.

PEAK WATER NEEDS AS COMPARED TO GRASS GROWING WILD IN THE SAME CLIMATE

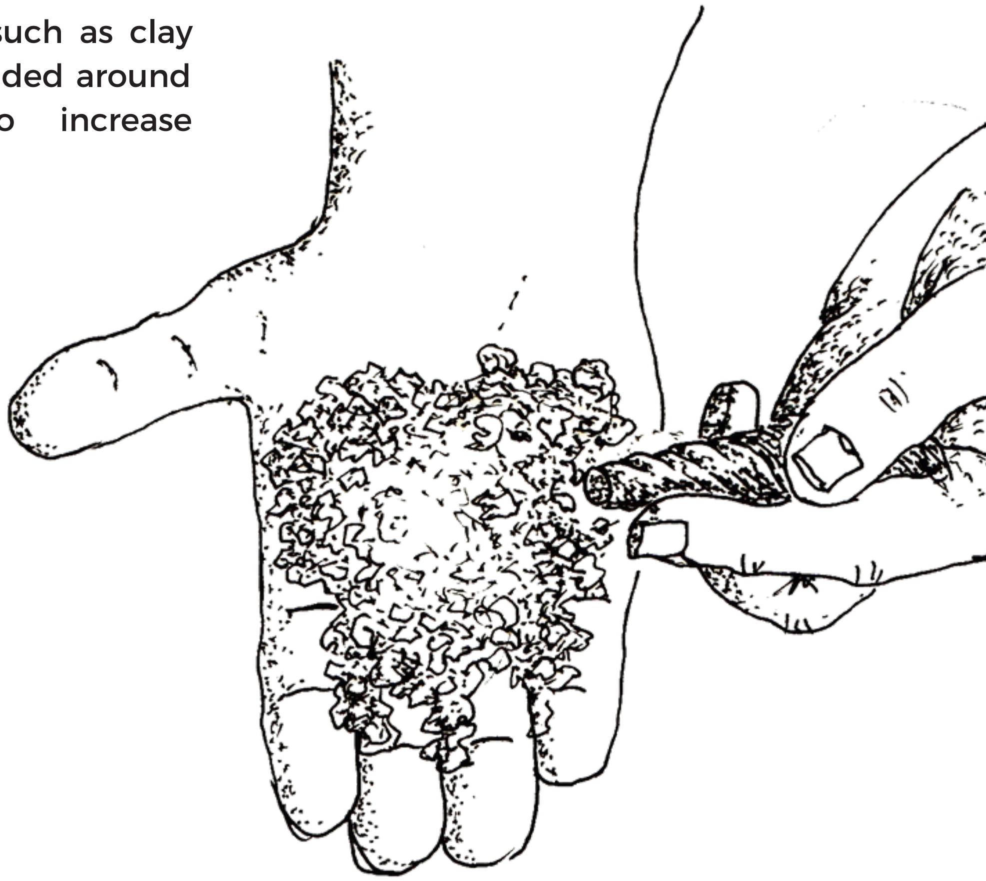
20% LESS WATER NEEDS	Citrus, Olives, Grapes
10% LESS WATER NEEDS	Cucumber, Radish, Squash
SAME WATER NEEDS AS GRASS	Carrots, Crucifers, Lettuce, Melons, Onions, Peanuts, Peppers, Spinach, Tea, Cacao, Coffee, Nuts & Fruit trees
10% MORE WATER NEEDS	Beans, Peas, Maize, Flax, Small Grains, Tomato, Aubergine, Lentils, Millet, Oats, Potatoes, Safflower, Sorghum, Soya beans, Sugar beet, Sunflower
20% MORE WATER NEEDS	Sugar cane, Banana

GOOD TO NOTE

Food tree crops, like those listed in the table, can actually help to regulate water cycles in the longer term. Studies and modelling have shown that in many contexts, the greater the tree cover, the greater and more evenly distributed the rainfall (Meier, 2021).

IDENTIFYING AND UNDERSTANDING SOIL TYPES

Soil type affects how easily soil retains moisture and its ability to allow water into and through the soil. A simple Visual Soil Analysis (VSA), as shown in the table below, can be carried out to help determine the type of soil in an area. Covering all exposed soil with mulch or a ground cover crop, avoiding compaction, and adding compost to soil will increase its ability to retain water over time. When using soil as a filter for waste waters, a high infiltration rate is useful for allowing water to pass from the delivery system into the soil. Low infiltration rate soils such as clay will need sand or gravel added around the delivery system to increase infiltration.



Soil type and subtype	Moistened soil sample compacted between hands	Infiltration rate for waste water (l/m2/day or mm/day)	Advantages	Disadvantages	Measures
Sand: Gravel, coarse and medium sand	Moist soil will not stick together	50	• Warms up quickly in Spring • Useful filter for waste waters	• Dries out rapidly in sunshine • Nutrients and water can leech away especially with rainfall • Often acidic	• Apply less water more often • Amend soils with compost • Mulch to reduce water loss
Sand: Fine and loamy sand	Moist soil sticks together but will not form a ball	33			
Loam: Loamy sand and sand	Moist soil forms a ball but still feels gritty when rubbed between fingers	24	• Retains water more than sand • Retains nutrients: fertile soils • Good infiltration of air and water	• Can contain stones, impacting on planting, growth and harvesting	• Remove stones • Maintain fertility with compost, green manures and mulch
Loam: Porous silt loam	Moist soil forms a ball which easily deforms and feels smooth between fingers	18			
Silt: Silty clay loam and clay loam	Moist soil forms a strong ball which smears when rubbed but does not go shiny	8	• Retains Nutrients: Fertile • Retain Water: drought resistant • Easier to work with than clay soils	• Water filtration can be poor • Can form a crust, reducing water infiltration • Compacts easily	• Avoid compaction • Mulch to avoid crusting • Amend with compost
Clay	Moist soil moulds like plasticine and feels very sticky when wetter	Unsuitable for infiltration systems	• Clay soils retain water and nutrients • Good for growing crops with high water needs	• Slow to drain • Slow to warm in Spring • Compacts easily • Usually alkaline • Poor infiltration	• Amend soils with compost • Avoid compaction • Improve drainage with raised beds • Add mulch to reduce cracking of soil and improve infiltration

Infiltration figures taken from Reed R, Dean PT (1994). Recommended methods for the disposal of sanitary wastes from temporary field medical facilities. Disasters 18:4. (Table 4.3 in Harvey, Bahri & Reed 2002)

DESIGNING GROWING SPACES

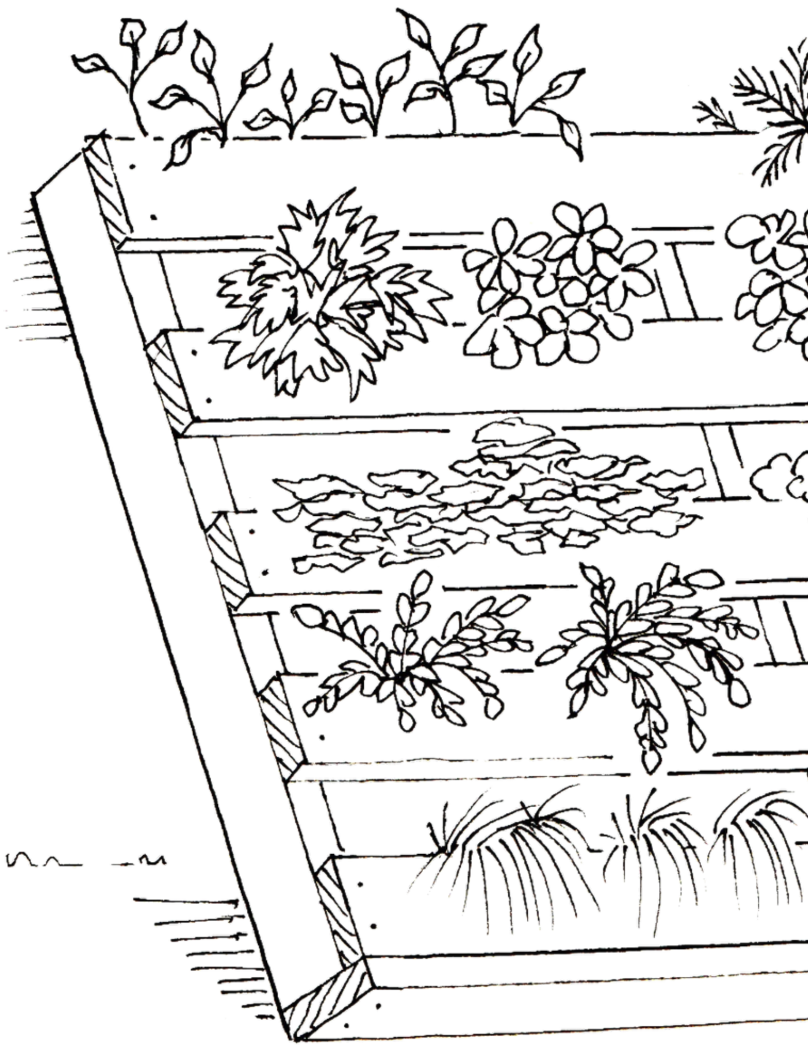
The type and the shape of the growing bed will also make a difference to the amounts of water needed and can make optimum use of small areas. Flat, open beds lose a lot of water through evaporation. A mix of vertical gardens which drain onto other crops planted below, trellises to support beans or climbing plants and create shade for those planted beside them, or sack and mandala gardens, designed to channel and/or filter grey water can save space and use water more efficiently.

Verticle Gardens

Vertical gardens are built upright rather than horizontally, generally in recycled or specially constructed containers and are useful in areas where there is limited space. They are commonly constructed against walls of buildings using tin or plastic containers with holes drilled in the bottom, against fences built from bamboo or in pallets situated vertically, with soil packed down into the middle.

To create a pallet garden:

1. Stretch a piece of plastic or sacking across the bottom side of the pallet and nail it firmly to the sides leaving the top and bottom edge open.
2. Stand it up on end and lean it against a wall, making sure it is secure, by fixing the top end or stacking bricks against the bottom edge. A pallet filled with soil is heavy and could cause damage to people or structures if it fell over.
3. Fill the pallet with compost or good quality soil, that easily drains, and plant between the slats.
4. Water from the top edge and allow the water to drain down to other levels and out through the bottom.
5. Pallet gardens are good for lettuce and green salads, herbs, edible flowers or trailing beans, but not ideal for deeply rooted plants or vegetables.

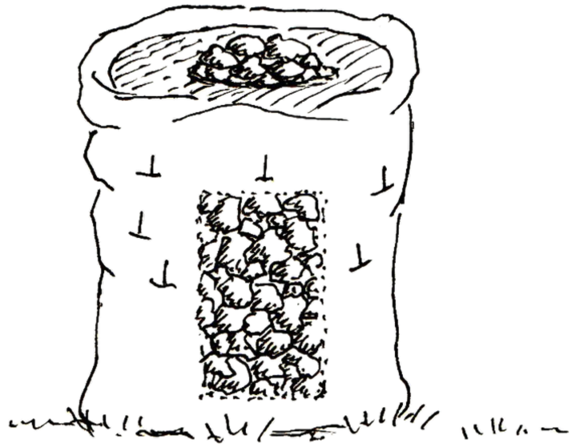


Sack and tower gardens

A sack garden is a free-standing vertical bed that saves space and water and has its own inbuilt water-filtration system for irrigating with greywater. This takes out food particles and allows water to be directed towards the roots of plants. It can be constructed in a hessian or a synthetic sack or bag filled with soil.

To build a sack garden:

1. Place your sack (around 2 metres tall) in the area where it will be used for growing.
2. Fill with soil to a depth of about 30 centimetres
3. Fill a wide tin (around 10 cm wide) with gravel or small stones and turn upside down on top of the soil and in the centre of the sack
4. Pack more soil around the stone column to keep it firmly in place and then remove the tin
5. Refill the tin with gravel and repeat the process, placing this on top of the stone column and packing more soil around it.
6. Continue doing this till you have filled the sack with good soil that has a stable column of gravel through the centre.
7. Cut small, upside down T shapes in the side of the sack.
8. Plant seedlings of leafy vegetables through your t cuts into the side of the sack and root crops into the top
9. Water your sack garden by pouring grey (or other) water into the stone column and allowing it to filter down.
10. The sack should support your garden through a single growing season before it needs to be replaced.



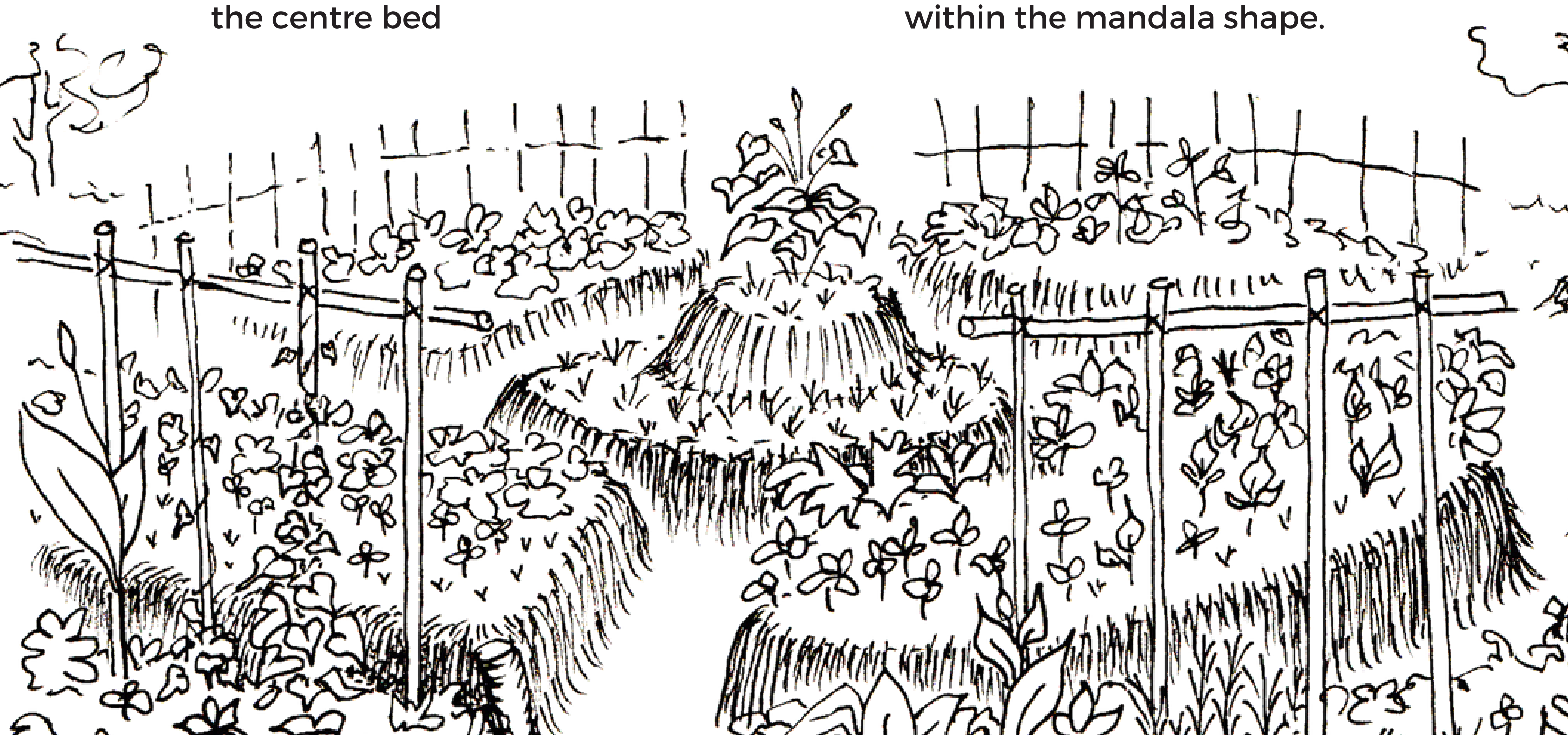
Larger versions of sack gardens, called 'Tower Gardens' can be made in a similar way using cloth (such as shade cloth) wrapped around poles. For more details about tower gardens see resources.

Mandala Gardens

A mandala garden, built in a circle with a raised bed in the middle and a circular bed surrounding it, can provide an optimal design for dispensing grey water and minimising water use. Planting different crops on the inner and outer circles, with bean trellises on the outer edges can offer areas of shade for more delicate plants on the inner circle.

To create a mandala garden:

- Plant a tall raised bed in the middle with either a perforated pipe or a gravel column down the centre of it.
- Terrace this into different levels further supported by stones or gravel on the outside edges to maintain the terrace shape. Plants salad plants in the central level.
- Leave a narrow path, just wide enough for someone to enter, and plant a second horseshoe bed around this, still raised, but lower than the central bed. The path should slope gently outwards, away from the central bed and towards the sides. Plant cabbages, kale, or peas on this circle.
- Leave the gap in the circle or horseshoe so that you can reach the centre bed
- Plant a final horseshoe around the outside, lower than the middle bed but still raised with earth banked up against the sides to stop water run off. Again keep the path narrow and sloping slightly towards the outside edges. Use this outside bed for beans, sun flowers or corn.
- Grey water can be applied down the central column of the first bed and used to drain down to irrigate other plants.
- Further grey or other water can be poured from containers through the gap in the horseshoe, and drain into the two outer circles. If necessary further support the sides of the outer bed to prevent any water run off and keep the water within the mandala shape.



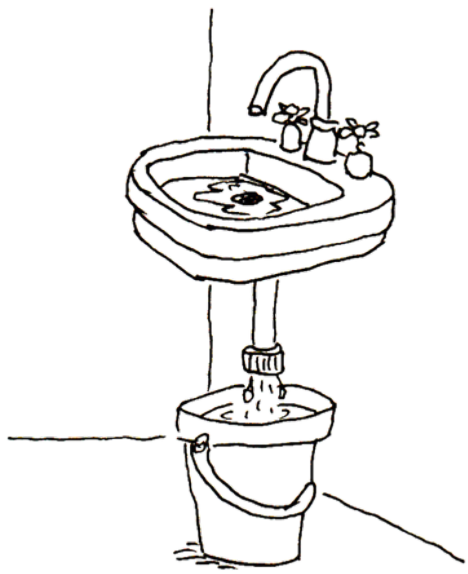
4 GREY WATER

The term grey water covers all water that is collected from the kitchen and bathroom sinks and water used for washing vegetables, pans, clothes, hair and people.

Black water is water from the toilet or raw sewage and needs a very different , more complex and expensive treatment system. This guide does not deal with black water use.
Grey water is most easily collected from individual households for home gardens. It can be collected on a larger scale from community use buildings (such as schools, but only for part of the year when the school is in operation) or from public washrooms. People may feel happier reusing water from their own homes rather than those from less known sources. Grey water from the kitchen can be reused for growing vegetables and fruit trees but will need straining and filtering to remove food particles and grease. Grey water from the bathroom and laundry can also be used providing this is culturally acceptable and the soaps and chemicals used to wash people or clothes are not damaging to crops (see water to avoid section below for more details).

As a general rule water should be directed sub-surface towards the roots of plants and not the leaves, both to avoid crop contamination (roots don't take up contamination) and to reduce water losses through evaporation. Grey water should be used within 24 hours and not stored longer than this; over time, organic particles in grey water can break down, turning the water septic and foul smelling.

Is it safe to use grey water to grow food to eat?
There is no evidence that plants uptake any biological pathogens from grey water, in fact grey water can contain beneficial nutrients useful for plant growth. However, grey water that comes into contact with leaves and fruit above-ground, that are not cooked or peeled, is potentially unsafe. Washing in clean water and/or cooking foods removes and kills pathogens that may be present on their surface. Water should be applied sub-surface or at the roots of crops and not sprinkled or splash over plant leaves and fruit.



Grey water is not clean water so direct skin contact with grey water should be minimised and rinsing with clean water is advised in case of contact.

WATER TO AVOID

- Do not use water with traces of faeces such as laundry water used to wash babies' nappies, or anal cleansing water. Similarly do not use water from medical centres that may be contaminated.

- Do not use water that contains harsh chemicals such as bleach, hair dye and stain removers.

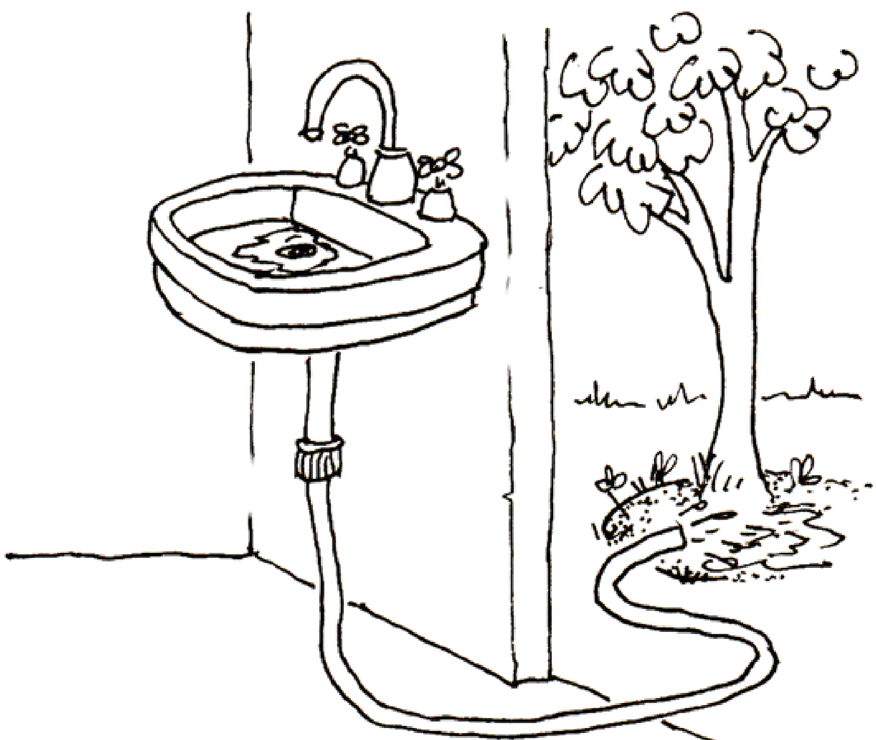
- In stronger concentrations there are some common products that can damage plant growth, so avoid powdered detergents, chlorine bleach and products with boron, borax, salt, sodium, or sodium components.

Plants adapted to grey water
Some plants have been found to produce more in grey water than in tap water, as the food particles or mineral elements from soaps can be beneficial to plants. Tomatoes and peppers in particular seem to benefit as do fruit trees and bushes, cucumbers and melons.

Herbs rarely tolerate grey water and if used with salad vegetables care should be taken not to let the grey water come into contact with the leaves.

In areas where soaps and detergents are used extensively grey water should be interspersed or diluted with rain or with tap water.

Water from the kitchen sink will need straining (see following page).



Collecting, Filtering or straining

From bathroom sinks, showers and baths, water can be collected in a bucket or by diverting shower and sink pipes directly to soil.

Water from the kitchen should be strained or filtered before using. Kitchen water can be kept cleaner from the start by adapting cleaning methods to minimise solids and grease in water; scraping food residues into compost collection or bins before washing and pouring used oils and fats in separate containers will significantly improve the quality of water collected. Straining water from vegetable preparation or washing up can be done simply through a domestic strainer or a plastic bag or with holes punched in the side.

A simple grey water filter can be made from a container filled with sand and gravel. This can be sourced locally, but washed before use and layered up with a finer sand layer between a top and bottom layer of gravel:

1. A 20 cm distribution layer of gravel (grain size 8 – 20 mm).
2. The filter layer of minimum 60 cm of sand (0 – 4 mm).
3. A 20 cm drainage layer of gravel (grain size 8 – 20 mm)

The gravel layer at the top will catch particles of food and can be removed and washed from time to time. The gravel layer at the bottom will prevent sand particles from entering and clogging the outflow and keep water running smoothly. Filters can also be dug into the ground with perforated pipes running from them to distribute the water across a bed and directly to the roots of plants. For subsurface distribution you should evaluate the soil type (see section on soil). Clay soils will clog distribution pipes so will need gravel and sand surrounding any outlets to aid infiltration.

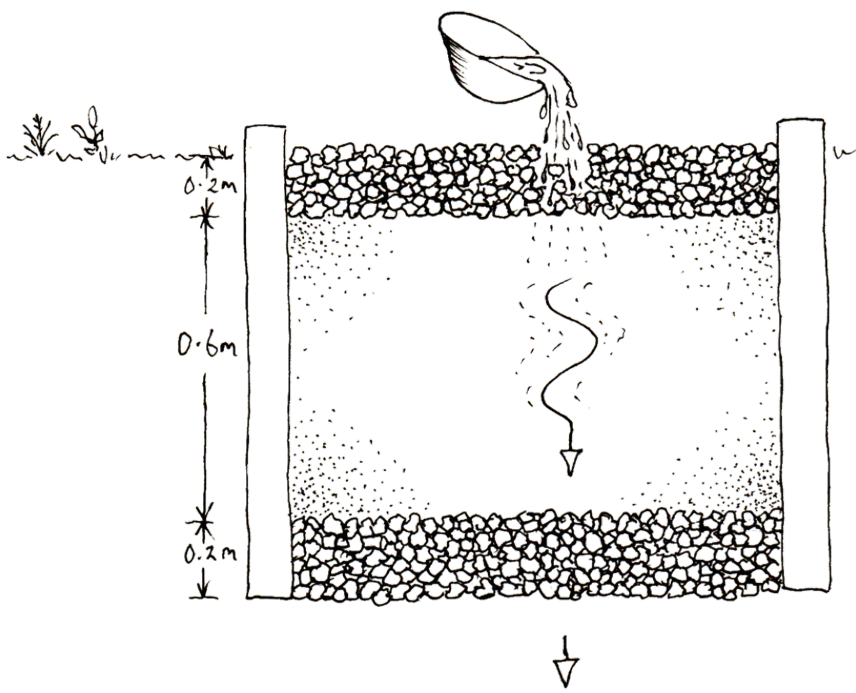
Applying grey water to plants

Grey water can be poured from containers directly onto:

- Mulch pits and mulched soil (see minimising losses)
- Tower gardens (see Resources)
- Sack gardens (see section on designing growing spaces)
- A partially buried perforated plastic bottle (see section on minimising losses)

Or directed by pipes to:

- Sub-surface perforated piping
- Gravelled and/or mulched irrigation channels including swales (see ground water storage section)



5 RAIN WATER HARVESTING

Rain water can be harvested for irrigation from any pitched roof using gutters and stored in tanks above or below ground or directed into rain gardens. Harvested water should only be used for irrigation of plants, other uses such as drinking or bathing would require treatment. Where accommodation is in tents or under tarps, rain water can be collected by placing a bucket or barrel near the lowest point. Gutters can be made from a half section of bamboo or by v clamping metal sheets. Avoid using lead pipes or collecting rainwater from lead or treated timber roofs.

Water supply is limited by:

- The amount of rainfall
- when rain falls (seasonal variation)
- The size of the catchment area and
- The capacity of the storage reservoir

Annual water yield in litres can be calculated as 65% of (annual rainfall x roof area). See www.re-alliance.org/greywater-extra-resources for extra resource links including annual rainfall figures by country.

The bigger the catchment area, the more rain collected. If a roof does not give enough catchment area, additional plastic sheeting (more prone to wind damage) or roof extensions can be used to enlarge the catchment surface.

Larger buildings such as schools, health centres and hospitals can provide greater supplies of harvested rainwater, provided the growing space is nearby.

There are three main options for rain-water storage:

1. Above ground tanks or collection vessels
2. Underground reservoirs
3. Rain gardens and swales - storing water directly in the soil

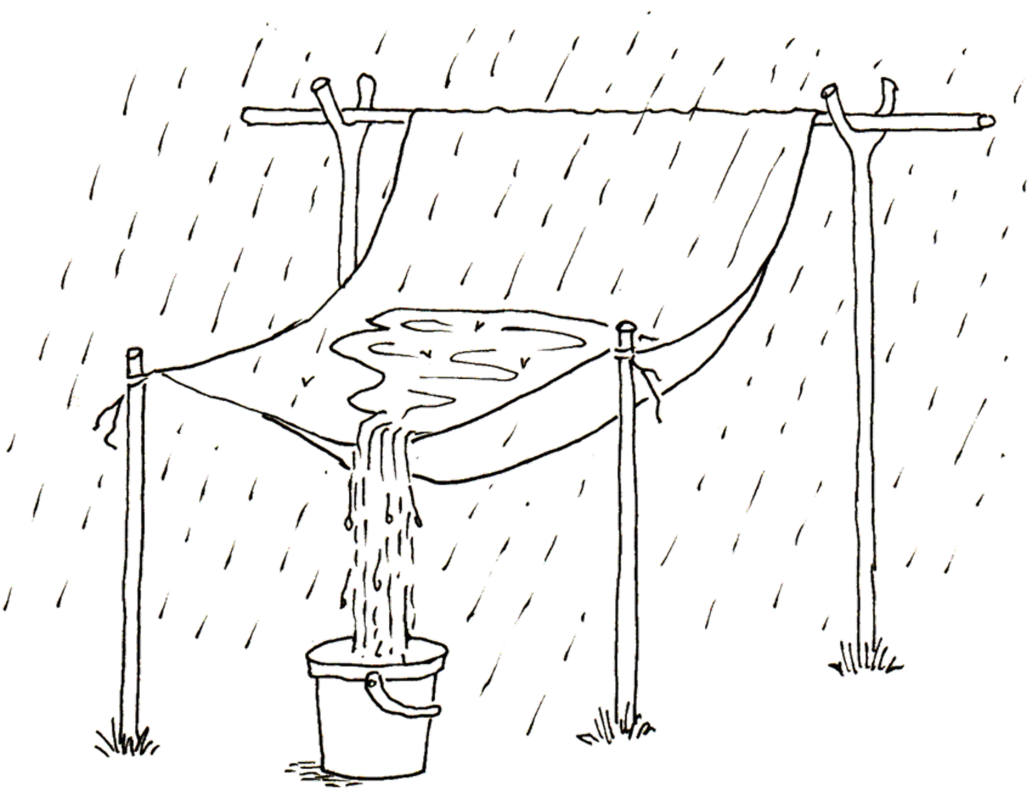
Useful suggestions

- Covering the ends of gutters or pipes and putting lids on collection barrels can help stop debris entering the storage system and keep insects out.
- Rain water can be stored for longer than grey water but uncovered water can be a breeding ground for mosquitoes (disease vectors) or contain algae which, while not bad for plants, can create an unpleasant smell.
- Putting a few drops of oil to float on top of the water or adding some washing up liquid will create a film to help deter mosquitoes. Growing plants such as Citronella near tanks can also help deter mosquitoes, and catch any runoff water.
- In countries where there is extensive rainfall during one season, followed by long dry periods lasting several months, an underground tank or specifically dug reservoir, or ground water storage may be the simplest solution.

Rain water collection tanks can be made from:

Type of tank	Advantages	Disadvantages
Left over olive barrels, plastic bins and IBCs (for household use in areas with regular rainfall)	• Cheap or free • Can be moved around and easily inspected. • Water can be syphoned with a bucket or tap.	• Limited capacity to hold water. • Needs to be protected from mosquitoes. • Could develop algae
Specially constructed reinforced concrete or ferrocement tanks (for storing larger quantities of rain water)	• Can be designed according to space or need with syphon tap. • Can hold much larger quantities. • Keeps water cool	• Requires capital investment for construction. • In cold temperatures concrete can freeze and crack during construction.
A specially constructed underground cistern	• Can be designed to size/need • Keeps water cool • Can also hold ground water run off if placed at the bottom of a slope	• Costly to make • More difficult to inspect • Water needs to be pulled up with a bucket or pump

When sourcing materials for constructing water tanks or reservoirs, be conscious of the sourcing. Are there locally available components that can be used, without using potentially damaging materials with a high carbon footprint such as concrete or plastic?



Soil Water Storage

The easiest and perhaps most efficient way to store water is directly in the soil, by directing water flows to growing areas in order to replenish groundwater levels, and mulching with organic matter so that soil retains moisture and builds its capacity to hold water. By placing growing spaces in lower lying areas that water naturally and slowly flows towards, or carrying out a few simple ground works, water can be captured where it is needed rather than flowing out of a site. While this does not prevent the need for additional watering of plants during peak growing seasons, it does improve ground water levels and prevents good top soil from being washed away.

As we design our farming land or growing space, think about how water moves through the land. Are there natural slopes throughout the space? Where does water flow when it rains heavily? The three aims of working with water and its natural flows are: Slow, Sink and Store.

How can we **slow** the movement of water so that it does not create damage to plants, structures, people or animals as it moves across the land? Landscape designers use methods such as swales and key-line contouring to slow water as it moves down slopes.

We then design-in ways to **sink** water. Often, healthy soil containing a high amount of decomposing organic matter, and with ground cover, naturally sinks a high amount of water. As water slows in its movement, healthy covered soil is able to soak and hold up to its own volume in water. Soil that is open and bare, or heavily tilled, will not soak up very much water.

Some options for helping the soil to **store** water are:

- Rain gardens - flat sunken planted areas that collect rain water
- Swales and bunds - sloped channels and banks that direct water to rain gardens or across and into sloping land, usually covered by mulch.
- French drains - similar to swales but trench is filled with gravel, rock or containing a perforated pipe, or both.
- Mulch basins around trees, and covering any exposed soil with mulch
- Increasing the organic and decomposing matter in soil through composting, which increases the capacity of water that the soil can hold
- Using porous building materials for roads and pathways, and avoiding concrete or asphalt which can encourage flooding

Rain gardens or Sunken Beds

These are depressions in the ground that act as infiltration points for water directed from roofs and paths. Locate the rain garden on low ground where rainwater will feed into it from gutter down-pipes via a swale or piping. The ground can be further lowered by digging out soil and creating berms (small walls) around the area to hold the additional soil.

Guidelines for constructing a rain garden

1. Dig the sunken garden to be at around 10 cm below the surrounding terrain.
2. Digging can be reduced by working with existing natural depressions
3. Make sure soil is loose and drains well. If soil is heavy, add sand and compost to help it drain. If soil does not drain, plants will get too little oxygen and eventually die.
4. Make sure the bottom of the rain garden is flat so that water infiltrates evenly and does not pool.
5. Add mulch to the surface to act as another layer of material to hold water, and prevent heavy rain from disturbing the soil.
6. Direct water from downpipe to rain garden by digging swales covered with mulch or by channelling water through a pipe.

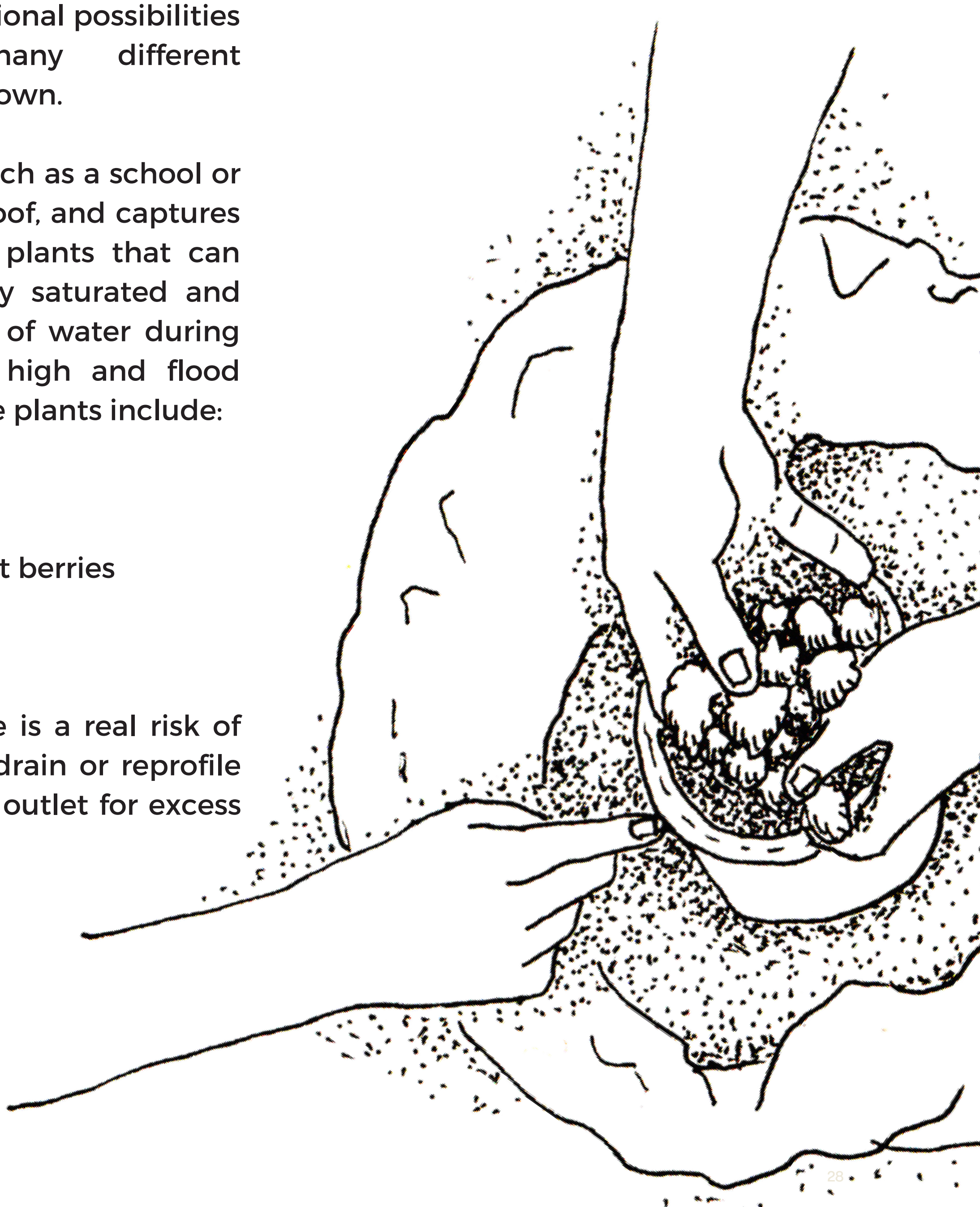
What to plant in a rain garden

For a shallow, domestic-scale rain garden that captures small amounts of run-off, with additional possibilities for watering, many different vegetables can be grown.

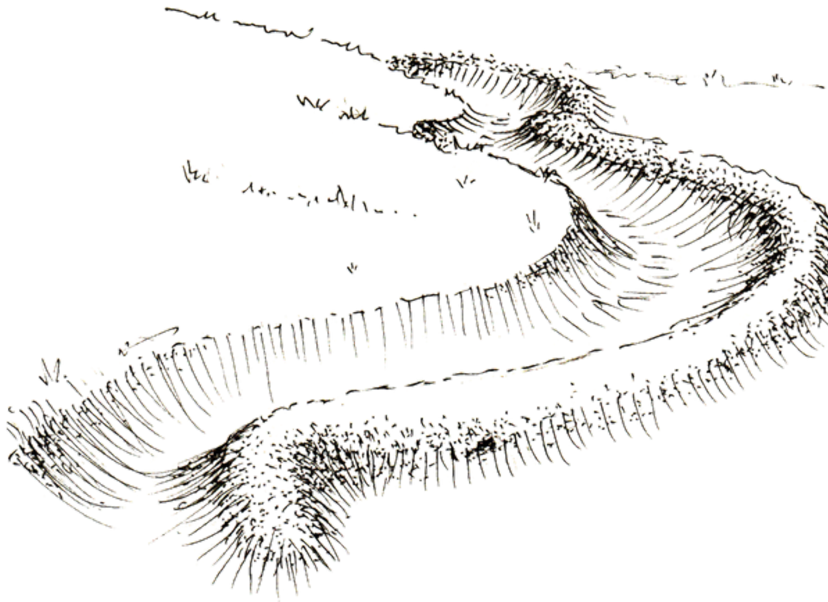
If the roof is large, such as a school or community centre roof, and captures a lot of water, use plants that can tolerate both heavily saturated and dry soil, as volumes of water during heavy rain can be high and flood plants. Some of these plants include:

- chilli piquin
- watercress
- currants and most berries
- asparagus
- rhubarb

In areas where there is a real risk of flooding, build in a drain or reprofile the soil to create an outlet for excess water.



Channelling water through Trenches, Swales and Berms



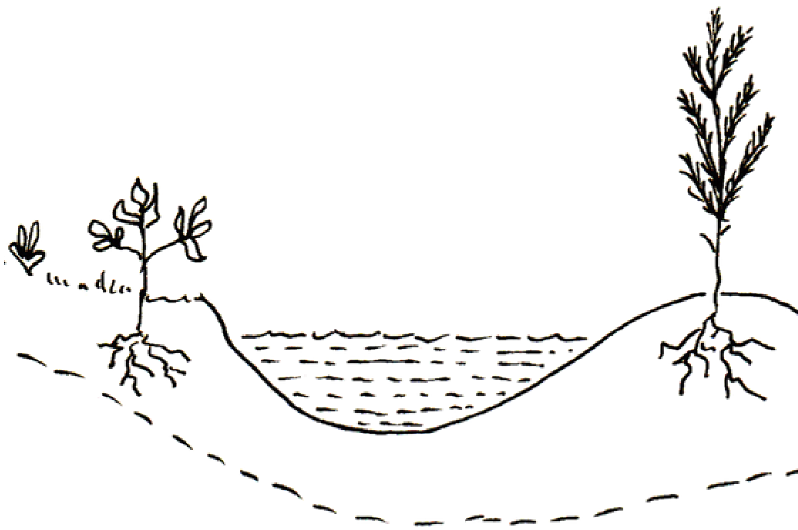
Raising or lowering ground levels to capture and direct water can be done on a small or large scale. In a large community growing area creating swales, (ditches that follow the contours of the land) and berms (raised areas created with the soil that from the trench) will prevent water from flowing away from an area and allow it to infiltrate the soil where you need it most.

Using an A Frame, water level, or surveying level to identify the contours of the land and then digging trenches along contours will conserve water for growing on land that is uneven and ensure good soil is not washed away (see resources for further details on A Frames). Berms and swales can be stabilised by planting along them, so that the roots hold the structures in place. In desert or low rainfall areas it is better to plant within the trench, where in areas of higher rainfall it is more common to plant along the berm.

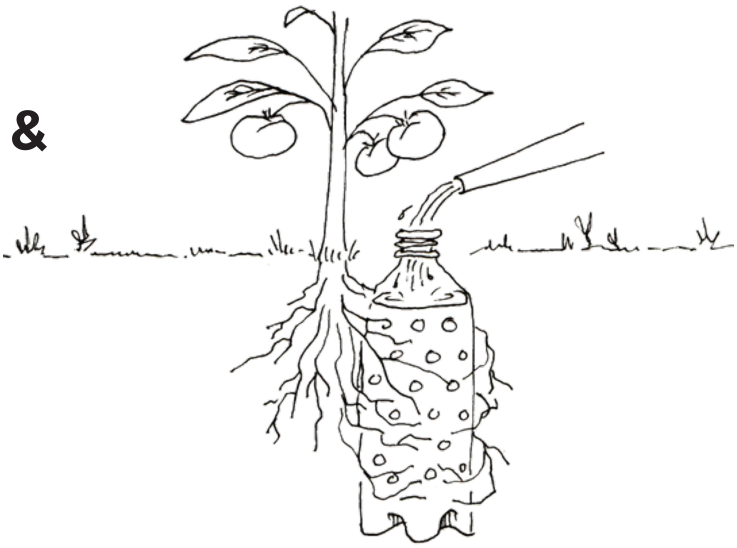
Vetiver grass is commonly used in soil stabilisation. It is a densely tufted bunch grass with strong roots that hold structures in place and it can provide a wind break for more vulnerable plants. It also produces good animal fodder and protects against pests and weeds

Swales can be lined with rocks or gravel to further help keep their shape and to slow down run off and filtration into the soil.

Bunds, like berms, are walls or ridges built from excess soil but are generally constructed with clay soils to stop water flowing onto a site in times of flooding.



6 MINIMISING LOSSES & INCREASING YIELDS



Growing in conditions of limited water makes it even more important to minimise water loss through evaporation and target water towards the roots of growing plants.

Burying a specially designed clay pot, sturdy plastic bottle or pipe with holes punched in the sides alongside a small seedling when it is planted will direct grey water towards the roots of a plant and keep it way from the leaves. Plastic bottles should not be left in the soil for longer than a season to avoid breakdown into microplastics which can be detrimental to human, animal and soil health.

Creating a small mulch basin around the base of a plant will also direct the flow of water immediately downwards, while a berm built from the soil behind this will stop water from overflowing. Mulch basins can be covered with straw or leaves to prevent evaporation in this area, and grey water then tipped in from a bucket to filter down slowly. Watering in the morning or in the cool hours of the evening will further minimise evaporation losses.

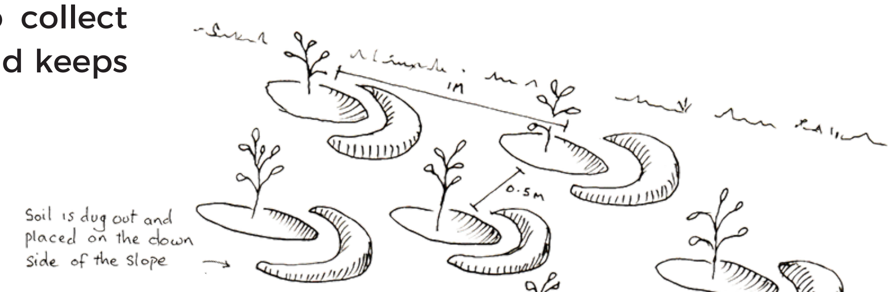
Planting intensively in deep or well composted soil, will encourage roots to grow deeper to find water, cut down the area needing to be irrigated and reduce transpiration and evaporation.

Covering plants with a light weight cover can provide a means to collect dew as it drops onto the soil and keeps it moist. It can help prevent insect damage if insects don't get trapped inside but can restrict plant growth if the cover is too heavy.

Using trees or bushes as windbreaks or planting climbing plants and trellises at the edge of a bed will provide shade and reduce sun and wind evaporation for smaller plants growing alongside.

Mulching

In larger open areas, all soil should be covered with a mulch to prevent evaporation and to form a barrier to stop weeds from crowding out a plant. Cardboard, newspaper, fallen leaves or hulls can all be used if there is little wind, and this will slowly rot down to become organic matter in the ground. Plastic sheeting can be used to cover a bed before planting but will deprive the soil of oxygen once it is being used for growing and needs to be replaced with an organic mulch. Keep mulch two inches away from the base of the plant to avoid the possibility of rot.



Composting and Increasing soil nutrition

Adding organic matter helps open up soil allowing roots to go deeper and find more water at lower depths. If the soil is sandy, adding compost also allows it to hold more water.

Compost increases soil nutrition which helps plants produce better yields with the same amount of water. A household will produce a small amount of compost from vegetable waste but creating a larger community compost scheme has the added benefits of increasing community collaboration and reducing household waste.

Avoid adding synthetic nitrogen into the soil as it encourages leafy green growth and increases a plant's need for water without increasing its yield.

Urine has been used for generations to irrigate plants and is a good source of natural fertiliser. Plants and soil process toxic substances and there is no evidence that urine fertiliser is harmful when fed to roots of plants without contact with leaves. However, it may not be either culturally or legally acceptable and before advocating it, it is important to check whether there are any local guidelines on this.

It may be fine for family use but sometimes not acceptable for produce that is intended to be sold. Users should be trained in the safe application of urine: when collecting urine, keep it separate from other bodily waste to keep it sterile. Use it fresh and always dilute it for plants at least 10:1 and up to 50:1 for use on tender plants and seedlings. Trees and shrubs can tolerate undiluted urine.

Some widely distributed plants such as Nettle and Comfrey can be foraged and made into an organic, natural fertiliser. These are rich in nitrogen and other essential elements needed for healthy plant growth.

How to make nettle and comfrey fertiliser:

1. Fill a large bucket with nettle and/or comfrey leaves. Make sure to wear gloves when harvesting, and leave plenty behind to regrow.
2. Fill the bucket with water and let the leaves soak. Cover the bucket with a lid or sheeting.
3. Put the bucket somewhere away from people, as the mixture gets smelly. Leave for two weeks or more.
4. After two or more weeks, strain the liquid into containers. When watering plants, use a 1:10 ratio of herbal fertiliser to water. Do not use directly on plants.

7 MOBILISING COMMUNITIES

Supporting food growing initiatives in camps and settlements entails working closely with communities to manage limited sources of water and building on and enhancing local expertise. A camp or settlement and local host community may have a large number of resident farmers, and possibly agricultural or horticultural technicians, academic specialists and extension workers. Identifying these at an early stage and working with them to discuss and adapt practices to suit the confines of a camp context can quickly mobilise a group of skilled and interested participants.

Start from what they know – and provide an environment for them to share knowledge and discuss the value of a regenerative approach. Try to establish a local group to lead new developments and support each other.

Establish demonstrator sites – where some of the techniques above can be applied for others to see them working. Farmers are always the best teachers of farmers and people will change their own practices if they can see how others work better.

Try to uncover indigenous knowledge of seeds and varieties – As these crops are often better adapted to local conditions than newer adapted varieties and encourage seed saving across the camp.

Involve local host communities who may have additional access to land, good knowledge of climate and soils which will be conducive to creating and maintaining regenerative practice.

Home gardens
Home gardens are often the easiest to manage. Families are more likely to use grey water when they know where it comes from and it is more easily transferred from kitchens and bathrooms to growing spaces located outside. Grey water lends itself more easily to the smaller kitchen gardens grown around a dwelling, and the range of plants grown can be quickly adapted to household needs and water availability. Small-scale rainwater harvesting systems made and fitted to dwellings will reduce problems from water run-off and increase the supply of water for irrigation. With limited encouragement and sharing of seeds groups of households will often get involved in food growing and food sharing festivals and competitions.

School gardens

Schools provide a good opportunity for children to learn about food growing and water conservation while school washrooms and kitchens provide a source of grey water that can be harvested and reused. There can be greater health hazards with the way young children handle grey water, so greater precautions need to be introduced such as water diversion systems which avoid the handling of water (see section below for more). Children can be taught cultivation and water harvesting techniques that they can later share with their families and households. However, schools have long periods when they are closed, when kitchen and washrooms are not producing grey water, and when children will need to be mobilised to come back into the garden to tend to plants. Unless school holidays fall within the rainy season, irrigating plants in this period can prove a real problem and need a backup source of water.

Community Plots

Larger growing areas are often welcomed by communities, who need more space to grow food for their families and offer a source of income if food can be grown at scale. However, a larger plot will require greater community collaboration to enable people to come together over larger tasks such as ground management and irrigation practices.

Community gardens should be sited close to buildings such as community centres or communal washrooms to provide sources of harvested grey and rainwater.

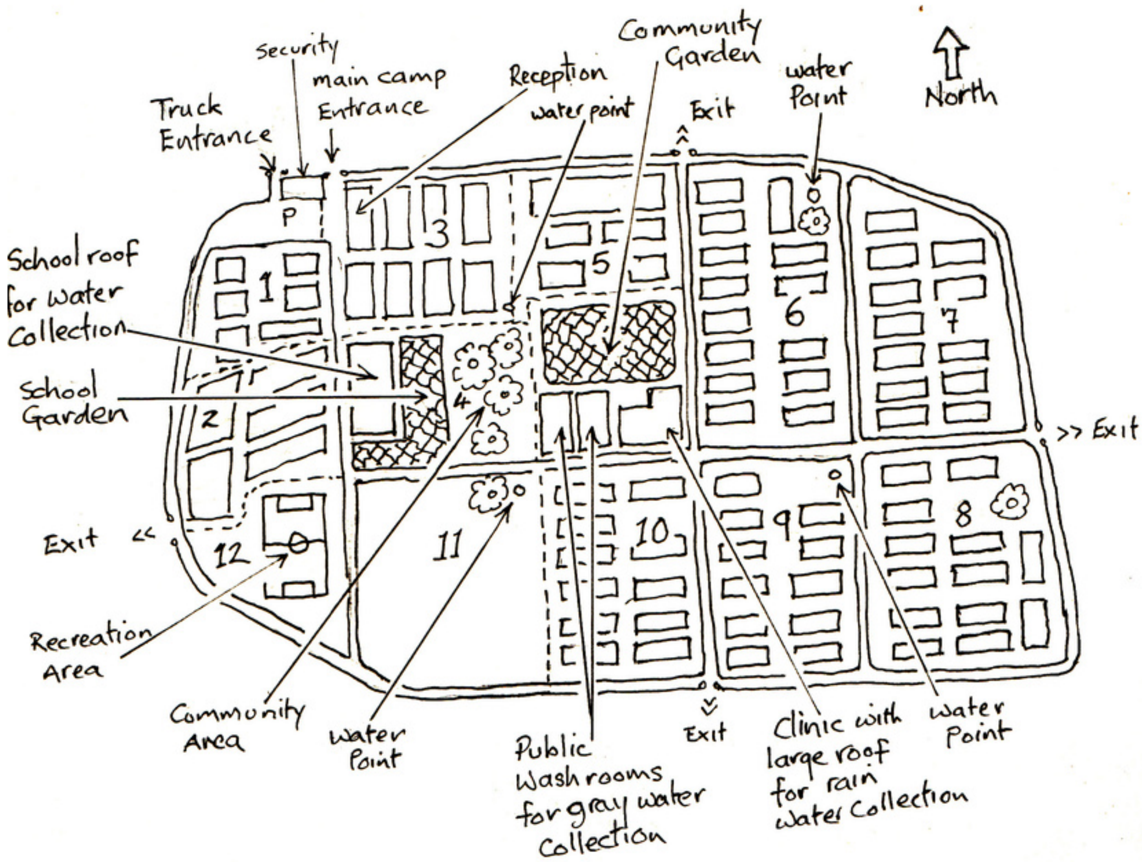
Cultural acceptability of grey water use from communal wash points will need to be established in advance and be managed effectively to ensure drainage continues to function efficiently. Swales and small scale drains can help to increase the water stored in the soil, and tanks can be built to store rain water harvested from roofs. But local committees will need to manage water points and intervene in any local disputes.

Grey water diversion devices for community gardens and schools

One of the simpler forms of community- level collection and application of grey water, which removes the need to handle and transport water, are grey water diversion devices. A pipe diverts grey water from sinks subsurface to well-draining soil or a gravel-filled trench via gravity. This system does not filter the grey water at source and so the pipe and outlet must be large enough to allow material such as hair and lint to pass. The soil irrigated directly with grey water filters the solids and allows sub-surface infiltration. In this system, the soil treats the grey water and so consideration must be given to the type and depth of soil available to allow infiltration. Because diversion devices do not filter-out suspended solids and fats generated in kitchens, it is only suitable for water from bathing or showering, laundry or hand washing. Water from school and community kitchens would require filtering before application.

Camp and settlement level water management

At any macro level the local administration or the settlement committee will need to build and manage large scale drainage systems, ideally at the time a camp is first constructed to maximise possibilities for saving water. This might include earth works and ground levelling to direct water run-off, using paid community labour or incentivisation schemes to ensure growing sites make maximum use of different water sources. Mapping different water sources and planning growing areas across a whole site with residents in advance or looking for opportunities to retrofit once a site has been established can help build on existing expertise within a camp and make best use of whatever water is available.



FURTHER RESOURCES

Sample Planting Guide

This sample planting guide, from the University of California's Master Gardener program, shows a bed with a range of vegetables which ripen at different times, provide shade and windbreaks and make maximum use of limited space and limited water.

(Growing A Thriving Vegetable Garden With Less Water, University of California, 2015)

Total Growing Periods and Total Water Needs of different crops

The table below adapted from FAO figures shows average growing time per crop from the quickest to the slowest to mature and some water needs. Choosing crops with shorter growing periods usually reduces the total water requirement.

	Crop type	Total growing period (in days)		Total Water Need of crop (mm/total growing period)
		Lower range	Upper range	
Growing period of between 1 and 4 months	Radish	35	45	No FAO data
	Spinach	60	100	No FAO data
	Green Onion	70	95	No FAO data
	Green Bean	75	90	No FAO data
	Lettuce	75	140	No FAO data
	Sweet Corn (Maize)	80	110	No FAO data
	Pea	90	100	350-500
	Rice	90	150	450-700
	Dry Bean	95	110	No FAO data
	Squash	95	120	No FAO data
Growing period of between approximately 3 and 4 months	Alfalfa	100	365	800-1600
	Carrot	100	150	No FAO data
	Cucumber	105	130	No FAO data
	Millet	105	140	No FAO data
	Potato	105	145	500-700
	Barley / oats / wheat	120	150	450-650
	Cabbage	120	140	350-500
	Mellon	120	160	400-600
	Pepper	120	210	600-900
	Sorghum	120	130	450-650
	Maize Grain	125	180	500-800
	Sunflower	125	130	600-1000
Growing period of between 3 months to 1 year	Aubergine	130	140	No FAO data
	Peanut	130	140	500-700
	Soybean	135	150	450-700
	Tomato	135	180	400-800
	Flax	150	220	No FAO data
	Lentil	150	170	No FAO data
	Brown Onion	150	210	350-550
	Sugarbeet	160	230	550-750
	Cotton	180	195	700-1300
	Citrus	240	365	900-1200
	Sugarcane	270	365	1500-2500
	Banana	300	365	1200-2200

Calculating daily peak irrigation needs during dry periods

This is useful to know so that you can estimate whether you will have enough water to sustain crops in dry periods.

Before starting you will need to know the

- type of crop
- the climatic zone the crop is to be grown (See FAO guidance on climatic zones below)
- and total area of crop

These tables were created based on FAO guidance figures.

1. Identify daily water need of crop in question relative to grass using the table on page 13 or the following page.
2. Determine daily water needs in mm by reading figure from chart below based on climatic zone and temperature. These figures are not per plant, but per square mm of soil.

	Temperature Low (less than 15°C)					Temperature Medium (15°C - 25°C)					Temperature High (over 25°C)				
	-30%	-10%	Same as grass	+10%	+20%	-30%	-10%	Same as grass	+10%	+20%	-30%	-10%	Same as grass	+10%	+20%
Climatic Zone	Daily water needs in mm														
Desert Arid	2.8 - 4.2	3.6 - 5.4	4 - 6	4.4 - 6.6	4.8 - 7.2	4.9 - 5.6	6.3 - 7.2	7 - 8	7.7 - 8.8	8.4 - 9.6	6.3 - 7	8.1 - 9	9 - 10	9.9 - 11	10.8 - 12
Semi Arid	2.8 - 3.5	3.6 - 4.5	4 - 5	4.4 - 5.5	4.8 - 6	4.2 - 4.9	5.4 - 6.3	6 - 7	6.6 - 7.7	7.2 - 8.4	5.6 - 6.3	7.2 - 8.1	8 - 9	8.8 - 9.9	9.6 - 10.8
Sub-Humid	2.1 - 2.8	2.7 - 3.6	3 - 4	3.3 - 4.4	3.6 - 4.8	3.5 - 4.2	4.5 - 5.2	5 - 6	5.5 - 6.6	6 - 7.2	4.9 - 5.6	6.3 - 7.2	7 - 8	7.7 - 8.8	8.4 - 9.6
Humid	0.7 - 1.4	0.9 - 1.8	1 - 2	1.1 - 2.2	1.2 - 2.4	2.1 - 2.8	2.7 - 3.6	3 - 4	3.3 - 4.4	3.6 - 4.8	3.5 - 4.2	4.5 - 5.4	5 - 6	5.5 - 6.6	6 - 7.2

For example, to calculate daily water needs of **squash** in **summer** in **Syria**:

- From table 1 we see that squash needs -10% less water than grass.
- From table 2 we see that in semi-arid climates with daily temperatures of over 25°C it will need between 7.2 - 8.1 mm of water per day per square mm of soil, this figure will next be multiplied by the area of crop.

PEAK WATER NEEDS AS COMPARED TO GRASS GROWING WILD IN THE SAME CLIMATE

20% LESS WATER NEEDS	Citrus, Olives, Grapes
10% LESS WATER NEEDS	Cucumber, Radish, Squash
SAME WATER NEEDS AS GRASS	Carrots, Crucifers, Lettuce, Melons, Onions, Peanuts, Peppers, Spinach, Tea, Cacao, Coffee, Nuts & Fruit trees
10% MORE WATER NEEDS	Beans, Peas, Maize, Flax, Small Grains, Tomato, Aubergine, Lentils, Millet, Oats, Potatoes, Safflower, Sorghum, Soya beans, Sugar beet, Sunflower
20% MORE WATER NEEDS	Sugar cane, Banana

	Temperature Low (less than 15°C)					Temperature Medium (15°C - 25°C)					Temperature High (over 25°C)				
	-30%	-10%	Same as grass	+10%	+20%	-30%	-10%	Same as grass	+10%	+20%	-30%	-10%	Same as grass	+10%	+20%
Climatic Zone	Daily water needs in mm														
Desert Arid	2.8 - 4.2	3.6 - 5.4	4 - 6	4.4 - 6.6	4.8 - 7.2	4.9 - 5.6	6.3 - 7.2	7 - 8	7.7 - 8.8	8.4 - 9.6	6.3 - 7	8.1 - 9	9 - 10	9.9 - 11	10.8 - 12
Semi Arid	2.8 - 3.5	3.6 - 4.5	4 - 5	4.4 - 5.5	4.8 - 6	4.2 - 4.9	5.4 - 6.3	6 - 7	6.6 - 7.7	7.2 - 8.4	5.6 - 6.3	7.2 - 8.1	8 - 9	8.8 - 9.9	9.6 - 10.8
Sub-Humid	2.1 - 2.8	2.7 - 3.6	3 - 4	3.3 - 4.4	3.6 - 4.8	3.5 - 4.2	4.5 - 5.2	5 - 6	5.5 - 6.6	6 - 7.2	4.9 - 5.6	6.3 - 7.2	7 - 8	7.7 - 8.8	8.4 - 9.6
Humid	0.7 - 1.4	0.9 - 1.8	1 - 2	1.1 - 2.2	1.2 - 2.4	2.1 - 2.8	2.7 - 3.6	3 - 4	3.3 - 4.4	3.6 - 4.8	3.5 - 4.2	4.5 - 5.4	5 - 6	5.5 - 6.6	6 - 7.2

3. Calculate peak daily water needs based on area and crop type (examples shown use high temperatures in semi-arid climates).

Crop	Area (m2)	Water requirement (average mm per day) from previous chart	Daily water requirement (litres) = Area x water requirement
Onion	4	8.5	34
Cucumber	1	7.6	7.6
Spinach	2	8.5	17

Visit re-alliance.org/greywater-extra-resources to see the full links and for more resources.

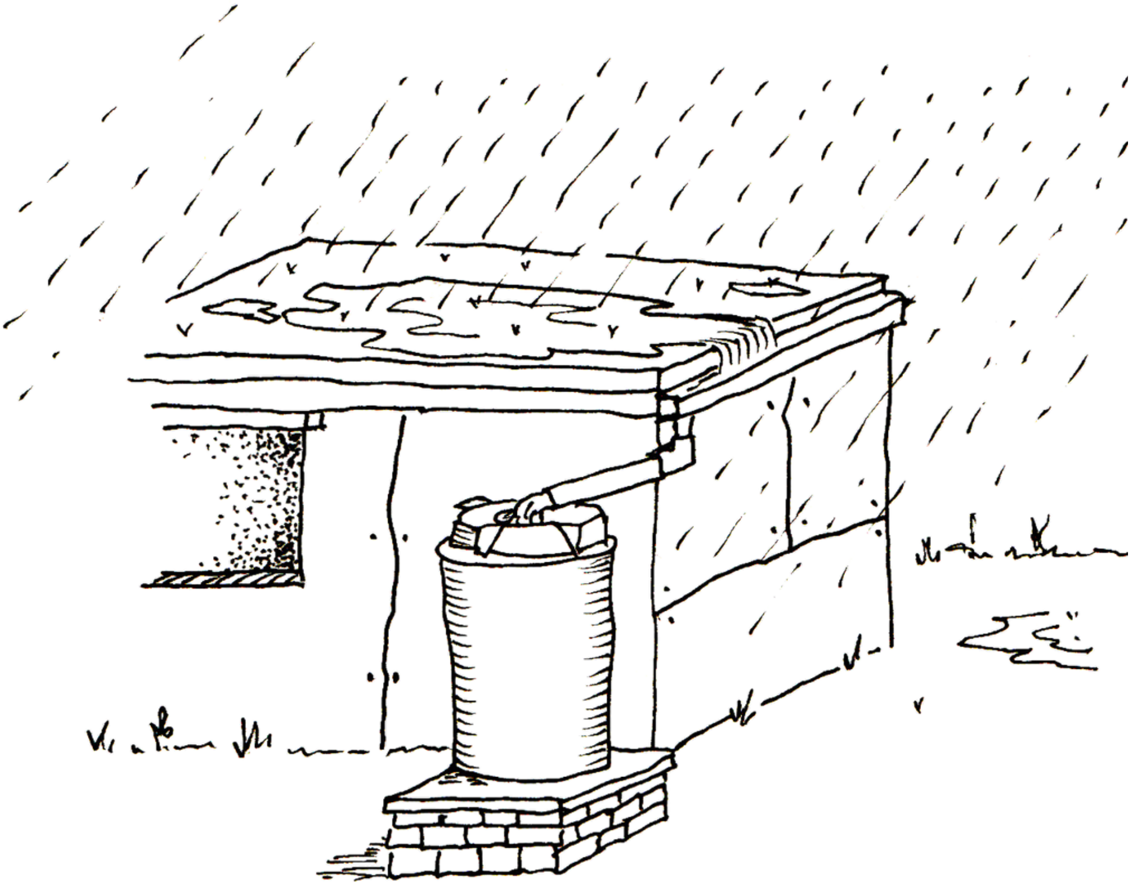
Further Information on Sack Gardens, or Tower Gardens
For an overview including photographs, detailed instructions and maintenance advice see the 'Sustainable Sanitation Water Management Toolbox: Grey water towers' overview here.

For research and case studies of tower gardens see 'Sustainable Sanitation Alliance (Susana) Case Study - Grey water tower for peri-urban areas, Arba Minch, Ethiopia', here.

Rainwater Harvesting
For an estimate of rainfall data anywhere globally refer to the Climate Portal of the Worldbank https://climateknowledgeportal.worldbank.org, where you can select your country of interest for climatic details like precipitation.

For technical solutions for rainwater harvesting, including gutter, pipe and storage design options see 'Practical Action, Rainwater Harvesting information sheet', here.

A Frame Construction and Use
See Practical Action Brief, The A Frame, here.



FOOD GROWING IN CAMPS AND SETTLEMENTS:

COLLECTING, STORING AND USING RAINFALL AND GREY WATER

Re-Alliance (UK) &
Malteser International (Germany)
2022

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