PERMAGARDEN TECHNICAL MANUAL

THIRD EDITION

USAID FROM THE AMERICAN PEOPLE

SCALE Strengthening Capacity in Agriculture Livelihoods and Environment

MERCY CORPS

The biodiversity found in a permagarden allows crops to be harvested on a weekly or even daily basis. These provide valuable nutrients and important sources of income and savings when the harvests are sold.

About SCALE

SCALE (Strengthening Capacity in Agriculture, Livelihoods and Environment) was an initiative funded by the USAID Bureau for Humanitarian Assistance (BHA) to enhance the impact, sustainability, and scalability of BHA-funded agriculture, natural resource management, and alternative livelihoods activities in emergency and non-emergency contexts. SCALE was implemented 2018 - 2022 by Mercy Corps in collaboration with Save the Children.

About PRO-WASH & SCALE

Practice, Research, and Operations in Water, Sanitation, and Hygiene and Strengthening Capacity in Agriculture, Livelihoods, and Environment (PRO-WASH & SCALE) aims to strengthen the design, implementation, and overall effectiveness of key sector-specific interventions. Our work focuses on food and nutrition security activities in emergency, early recovery, risk reduction, and resilience settings. We collaborate with implementing partners to enhance the impact, sustainability, and scalability of BHA-funded WASH, integrated water resources management, agriculture, natural resources management, and livelihood activities. PRO-WASH & SCALE is implemented by Save the Children and Mercy Corps.

PRO-WASH Practices, Research and Operations in Water, Sanitation and Hygiene

SCALE Strengthening Capacity in Agriculture Livelihoods and Environment

Recommended Citation

Cole, T., Brush, W., Pincus, L., Lambert, K., Mayer, J., Mottram, A., Duby, E. (2023). *Permagarden Technical Manual* (3rd ed.). Produced by Mercy Corps under the PRO-WASH & SCALE Award.

Cover Photo Credit

Rudy Kumvuidi Nkombo, Mercy Corps, DRC

Design

Most of the illustrations in this edition were created by Evan Walbridge, Evan Clayburg, and HUB. HUB has also done the overall graphic design of the manual.

Contact

consulting@resiliencedesign.net
prowashandscale@savechildren.org
www.fsnnetwork.org/prowashandscale

Table of Contents

Acknowledgements

The third edition of the *Permagarden Technical Manual* was developed to reflect best practices and lessons learned since the second edition was published in 2017. It includes recommendations on how to apply permagarden techniques beyond the garden site and throughout the wider household compound. It also incorporates a "minimum standards" framework for developing a permagarden and new guidance for practitioners on how to teach permagarden techniques in both emergency and non-emergency contexts. Practitioners will find this new edition aligns closely with the suite of permagarden resources and guidance published in recent years.

Most of the work on this edition was completed under the SCALE Award (2018 – 2022), funded by the USAID Bureau for Humanitarian Assistance (BHA). Final edits to text, graphic designs and formatting were completed under the PRO-WASH & SCALE Award (2023 – 2027), also funded by USAID/BHA.

Many of the practices and key principles used in the permagarden methodology originate from biointensive agriculture (developed by John Jeavons) and permaculture (developed by Bill Mollison and David Holmgren). Additional content for the Permagarden Technical Manual was developed from the trainings implemented by Warren Brush and Thomas Cole in collaboration with African Women Rising. The SCALE team sincerely thanks Warren Brush and Thomas Cole for their expert technical knowledge and for developing the core content of this manual, in addition to detailed editing support along the way. Thank you to Lauren Pincus, who led the revision and editing process of the manuscript and provided additional technical support. Sincere gratitude to Kristin Lambert, Jennifer Mayer, Elin Duby, and Andrea Mottram for contributing technical inputs, ideas, revisions, and further editing support. Finally, SCALE is deeply grateful to all the program staff and farmers who have contributed to the development of these materials through numerous practical training events and technical discussions, and who continue to use sustainable permagarden methods to address the challenges of food security.

Permagarden practices ensure a healthy soil food web by building organic matter, retaining soil moisture, and supporting beneficial organisms.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Introduction to This Manual

What is in this manual?

The *Permagarden Technical Manual* Third Edition explains the key concepts and techniques necessary to create permagarden growing systems. It then explains how these techniques can be incorporated into emergency and non-emergency programs that support home gardens, using a farmer-led process of observation and design. The manual includes an explanation of the purpose and theory behind the Permagarden Approach, which recognizes the important role of soil health, water management, and biodiversity in improving crop production. It outlines the most commonly used practices for developing a permagarden, such as double digging, biointensive planting, intercropping, tree planting, and water harvesting, and provides detailed instructions on how to implement the different practices throughout the home compound. It also discusses how program staff can engage farmers in learning about permagardens and their benefits, and how these same concepts and practices can also be applied to increase the production and resilience of their field crops.

How is this edition different?

Since the *Permagarden Technical Manual* Second Edition was published under the TOPS Program in 2017, the Permagarden Approach has been further refined to extend beyond a kitchen garden to include guidance on integrating permagarden techniques throughout the compound. With a compound-level approach, farmers can harvest and bank more water and expand their production to include an even greater diversity of annual and perennial crops, with the goal of turning the compound into a food forest that builds household resilience in the face of environmental and economic shocks and stresses. This edition also includes updates to reflect the latest best practices and lessons learned since the Permagarden Approach was originally developed.

Biodiversity in a permagarden offers farmers opportunities for more consistent income throughout the year.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

A swale and double-dug garden beds designed and dug on contour. Even in small areas, all permagardens are designed to maximize crop and tree biodiversity, harvest rainwater, and build soil fertility.

Whom is this manual for?

The *Permagarden Technical Manual* Third Edition is a key resource for practitioners working with participants in emergency and early recovery, risk reduction and resilience (ER4) programs to incorporate permagardens into their household growing systems. It is applicable to program staff with a variety of technical backgrounds—including in agriculture, nutrition, health, water, sanitation and hygiene (WASH), protection, infrastructure, and natural resource management (NRM)—who are supporting farmers to achieve food security, nutrition, and market-related goals. The approach is applicable in dryland environments as well as regions that experience heavy rainfall. As the approach integrates a variety of technical sectors, staff are strongly encouraged to engage in cross-sectoral collaboration, learning, and adaptation throughout implementation.

Permagardens can use any available space in a homestead.

Photo Credit: Thomas Cole, contracted by DAI, Rwanda

How to use this manual

This manual contains both the technical and practical information program staff need to support farmers in applying the Permagarden Approach to enhance their food security and/or income generation. The manual first discusses what the Permagarden Approach is and why it is used. It then provides reference material on the importance of soil, water, and biodiversity for crop production. Step-by-step instructions for how to use the techniques mentioned are contained within the Permagarden Techniques section. Links in the text are provided to help the reader navigate between the reference material and the step-by-step instructions. In the last section, the manual recommends training methods program staff can use to conduct permagarden training with smallholder farmers.

This manual is intended to be paired with other technical guidance and training materials found within the *Permagarden Approach Toolkit*. When used in its entirety, the toolkit can support program teams from the initial proposal design phase through to training and ongoing monitoring and learning.

Links to step-by-step instructional material will look like this.

The Permagarden Approach Toolkit

Tool	Description
Proposal guidance	
Integrating Permagarden Approach: A Tip Sheet for Programs (French)	Practical recommendations on incorporating the Permagarden Approach into proposals, including considerations regarding timing, resourcing, staff, overall program design, and monitoring.
Training guidance	
Permagarden Technical Manual Third Edition	This manual, which contains detailed reference material on the soil, water, biodiversity, and design concepts foundational to the Permagarden Approach.
Permagarden Foundations Online Course in English and French	A series of nine instructional videos that introduce foundational permagarden concepts and provide practical guidance on developing and maintaining a productive permagarden.
Permagarden Videos in English and French	Videos demonstrating specific techniques used in the Permagarden Approach.
3-day Permagarden Training Guidelines: Second Edition in English and French	Training materials for program staff who have completed a permagarden training and plan to train farmers.
Permagarden Adult Education Training Resources in English and French	An adult learning principles and participatory training techniques resource for trainers
Monitoring guidance	
Permagarden Minimum Standards Checklist and Guidance	A quality monitoring and management tool. The checklist is used to verify that the minimum standards for a permagarden are in place and that the garden design is working as intended.
Determining the Success of Your Permagarden: Permagarden Monitoring and Evaluation Tools	Quantitative and qualitative tools to capture data on the impacts of permagarden activities.
Learning documents	
How Permagardens and Kitchen Gardens Contribute to Household Food Security: An Assessment of Gardens in Nepal	Findings from a study of the USAID/BHA-funded Promoting Agriculture, Health and Alternative Livelihoods (PAHAL) program's permagarden and kitchen garden activities.
The Permagarden Pathway to Resilience & Food Security: Lessons in Scaling Up from Nepal and Uganda	Webinar covering the Permagarden Approach as part of agriculture, nutrition, and multisectoral programming.
An Impact Assessment of Permagardens in Palabek Refugee Settlement, Northern Uganda	Findings from an assessment conducted by African Women Rising (AWR) to determine the impacts of permagardens developed by South Sudanese refugees in northern Uganda.

Photo Credit: Rudy Kumvuidi Nkombo, Mercy Corps, DRC

The Permagarden Approach

What is the Permagarden Approach?

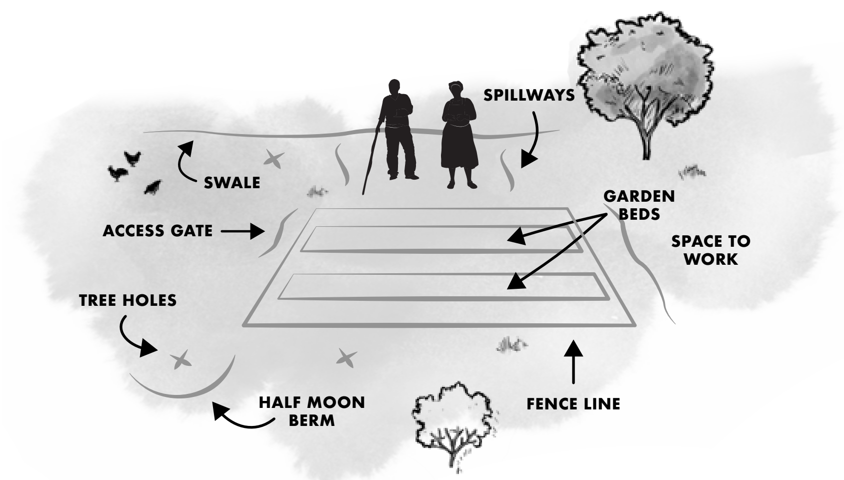
Throughout the world, households struggle to produce enough food. Land degradation, poor soil fertility, little access to water, and a lack of access to inputs all combine to result in consistently low yields for smallholder farmers. In addition, climate change, conflict, poverty, illness, poor governance, and inefficient markets increase the difficulty of households becoming food and nutrition secure. Food security programs continually seek solutions to enhance the availability, access, and use of safe, nutritious food for households who suffer from hunger and malnutrition. Often, these programs promote home gardens as part of the solution for households that rely on subsistence agriculture or food aid. However, gardens are likely to fail if they do not integrate soil and water management strategies that mitigate the impact of the harsh environments in which home garden projects typically operate. Likewise, gardens will only succeed if they are responsive to the needs and desires of the communities in which they are established.

The Permagarden Approach's household-led design process distinguishes it from other home garden approaches.

The design process engages foundational agroecological principles—such as building soil health, improving biodiversity, and managing rain and wastewater effectively—to ensure gardens work with and improve upon the environmental conditions present at the site. An emphasis on agroecological principles allows permagardens to be successful even in the absence of high-quality land, large amounts of water, or expensive inputs. The Approach emphasizes essential soil and water management techniques that can enhance the performance of many newly introduced agricultural technologies, making it an ideal complement to food security program interventions such as irrigation and other mechanized agriculture. Because the garden is designed and built by the household itself, it relies on local inputs that are within reach of household members and produces food and other crops they can use to bolster their food supply and livelihoods. With proper planning and management, high yields of nutrient-dense, seasonal fruits, vegetables, and non-edible crops (such as building materials) can be available year-round.

Minimum Standards details on page 9

Permagardens have been implemented in a diversity of locations, from conflict-affected areas in Northern Uganda to hill communities in western Nepal.[1] This broad applicability is possible because of the Permagarden Approach's reliance on strong community engagement to develop context-specific garden designs and the application of a set of minimum standards.



1 Burns, J. (2019). *How permagardens and kitchen gardens contribute to household food security: An Assessment of Gardens in Nepal*. Produced by Mercy Corps as part of the Strengthening Capacity in Agriculture, Livelihoods, and Environment (SCALE) Associate Award.

The Permagarden Approach has been distilled from the following practices and approaches:

Permaculture
Permaculture is a design science for regenerative land management and human settlement that mimics arrangements observed in flourishing natural ecosystems. Permaculture design principles can be applied to designing a household compound that enhances water efficiencies and healthy soils through the use of local resources and waste streams.

Biointensive agriculture
Biointensive agriculture is an organic agricultural system that focuses on achieving maximum yields from a minimum area of land, while simultaneously increasing biodiversity and sustaining the fertility of the soil.

Agroecology
Agroecology is a farming system focused on food production that makes the best use of the existing ecology without damaging these natural resources.

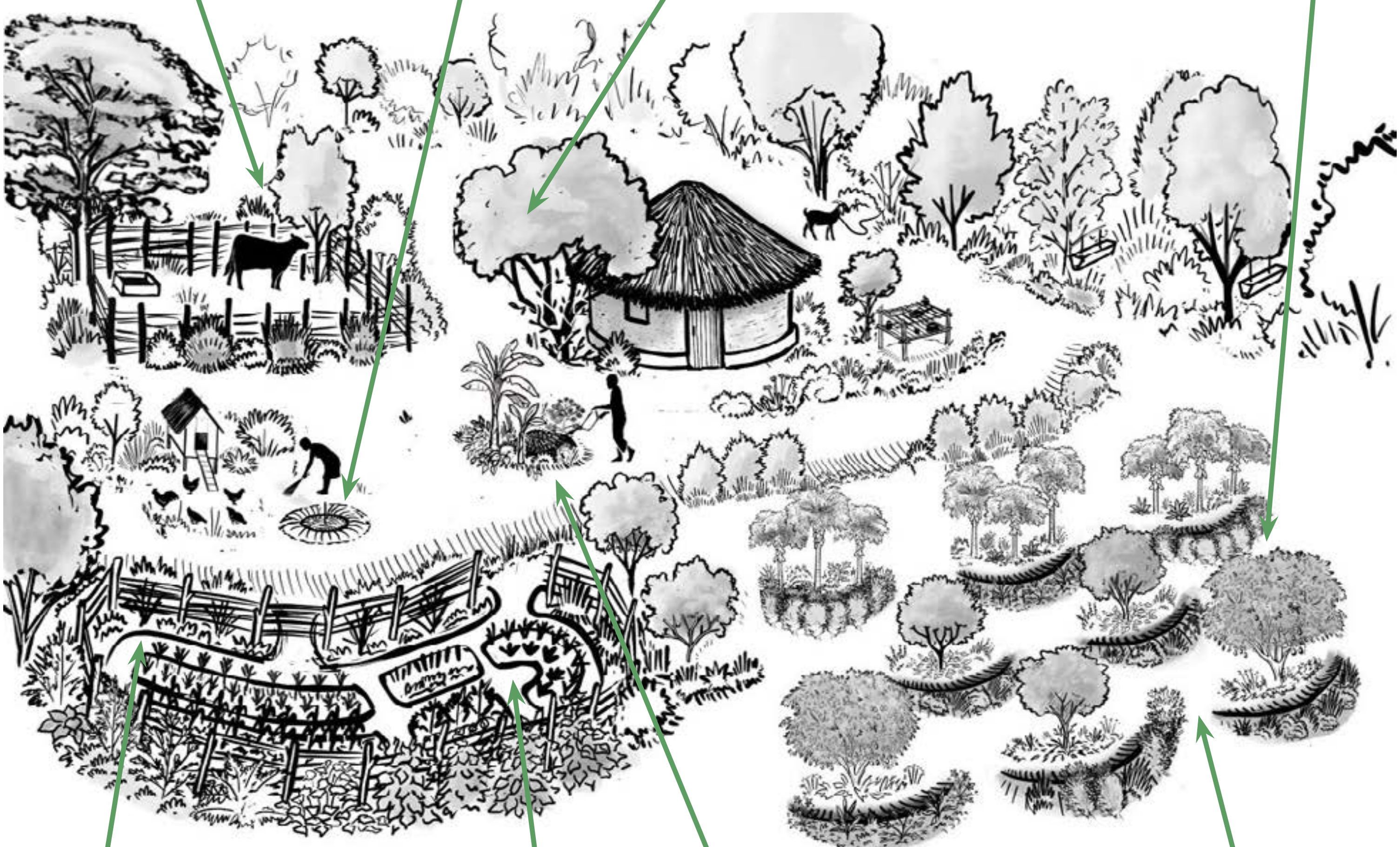
Agroforestry
Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits.

Rainwater Harvesting
Rainwater harvesting is the purposeful collection, storage, protection and use of rain, rather than allowing it to run off of a landscape.

Soil Food Web
The soil food web focuses on fostering the health of microorganisms so they can effectively build soil structure, retain water, increase nutrient uptake, and protect plants from pests and disease.

A resident of Palabek refugee settlement in Northern Uganda explaining the biodiversity and layered planting strategy of their permagarden.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda



Multiple interlinked strategies are designed and implemented based on the unique context of the site

Goals of the Permagarden Approach

Healthy and productive gardens can stabilize a household's food supply and create ready access to sellable resources, thus furthering a program's food security, nutrition, and/or income generation objectives. The Permagarden Approach can contribute to the following essential household assets, all of which are needed to strengthen household resilience to risks:

Ecological – Enhanced natural resources and ecosystem services through:

- Improved soil health
- Improved water availability
- Increased biodiversity
- Nutrient cycling and re-use through diverted waste streams

Economic – Increased income stability through:

- Diversified and intensified production
- Reduced input costs through the use of local resources

Social – Strengthened skill sets, capacity, and confidence of household members through:

- Design driven by and rooted in the knowledge, choices and aspirations of the farmers
- Support for local innovators in becoming leaders
- Building social capital through increased capacity to share food and knowledge

Nutritional – Enriched nutritional status through:

- Increased access to a diverse and culturally appropriate diet throughout the year, especially during the dry or lean seasons
- Improved nutritional content of food through increased nutrient uptake in plants

Energy – Improved energy efficiency through:

- A garden design that reduces the time and energy needed to tend animals and crops

Permagarden Minimum Standards

A set of eight core minimum standards[2] guides practitioners in how to create and maintain permagardens that are healthy, productive, and responsive to community needs regardless of the program context. These minimum standards distill the key agronomic principles and community engagement best practices important for constructing a successful permagarden. Practitioners should integrate all of the following minimum standards equally to achieve the greatest success in their permagarden activities. Program training should be designed to consistently emphasize and repeatedly return to these standards throughout the lifetime of a project to ensure technical quality.

Minimum Standards

Community-led
The permagarden is designed, established, maintained, and informed by farmers to ensure local relevance and ownership.

Resources
The permagarden maximizes the use of locally available natural and man-made materials and waste streams to increase and diversify production and reduce dependence on external inputs.

Design
The permagarden incorporates a context-specific design that optimizes resources and external influences for improved efficiency, production, resilience, and regeneration.

Water
The permagarden integrates multiple strategies to slow, spread, sink, and manage rainwater and other water resources.

Soil health
The permagarden creates a healthy soil food web that supports sustained production and regenerative growth.

Biodiversity
The permagarden integrates plants, trees and animals that work together in ways to support the overall health and production of the growing environment.

Protection
The permagarden includes strategies to protect soil and plants from any negative effects of people, animals, insects, disease, extreme sun and other external influences.

Adaptation
Farmers continually observe and record feedback from the permagarden and surrounding compound and adapt their practices to improve production and resilience to shocks and stresses.

2 Brush, Warren, Thomas Cole, Kristin Lambert and Andrea Mottram. 2021. Resilience Design for Agroecological Production: Minimum Standards. Produced by Mercy Corps as part of the Strengthening Capacity in Agriculture, Livelihoods, and Environment (SCALE) Associate Award.

Scaling up with Resilience Design

Once household members have mastered the Permagarden Approach at the garden level, they can apply these techniques on their larger fields, market gardens, or even throughout their broader community using the *Resilience Design in Smallholder Farming Systems Approach* (RD Approach). The RD Approach was developed by Mercy Corps under the USAID-funded TOPS project and expands the concepts used within the Permagarden Approach to a larger scale. Similarly focused on building healthy soils, managing water, and increasing biodiversity, the RD Approach can be used at the farm, community, or even watershed level. Like the Permagarden Approach, the RD Approach strengthens farmers' capacity to prepare for, adapt to, and recover from shocks and stresses that impact their agricultural production and livelihoods.

Program staff are encouraged to use the Permagarden Approach as an introduction to the RD Approach. By first teaching farmers the permagarden concepts and practices and allowing them time to practice and adapt them on a smaller scale, they will be better prepared to later apply them on larger landscapes. Key permagarden concepts or messages, such as improved soil health and rainwater harvesting practices, can be translated to larger spaces with minimal additional training. If extended into community spaces, entire watersheds can be transformed. Communities can restore degraded soils and repopulate the landscape with native vegetation, such as grasses and trees, and perennial species that can buffer them during times of scarcity. This can mitigate the impacts of climate change and turn formerly unproductive landscapes into productive land that supports the growing of food, medicinal plants, and building supplies that communities need. This approach could also support agropastoralists in arid climates to increase the availability of dry season fodder production for their grazing animals. For communities that suffer from landslides or severe soil erosion—phenomena that are often exacerbated by decades of worsening land degradation—the RD Approach can be used to address the underlying causes of these environmental adversities.

Community members use Resilience Design techniques to improve water flow through important planting areas.

SECTION TWO

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Building Blocks of a Permagarden: Water, Soil, and Biodiversity

Water Management

Why is managing water important?

Water is the most critical element for plant growth. It can also be the most limited and precious resource in agricultural systems and is expected to become even more limited as climate change raises temperatures and drives irregular rainfall patterns.

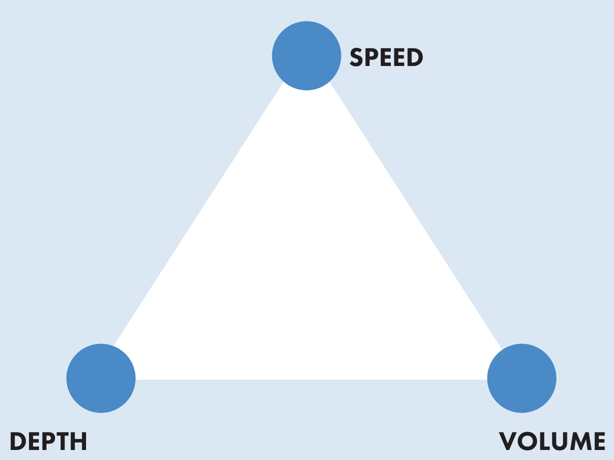
Currently, less than 15% of rainwater that falls globally is used to support agriculture.[3] The question is not how to access more water, but rather how to improve water use efficiency. In some regions, rain is now falling even more heavily than usual during the rainy season, but the vast majority of this water ends up running off the landscape rather than infiltrating the soil. When a mid-season drought occurs, these fields have no water reserves in them to sustain plant growth. During dry seasons, soils are hard and water must be brought from outside sources, such as rivers, boreholes, ponds, streams, or municipal taps to support crop production. In extremely arid regions, every drop of rainwater needs to be conserved throughout the year for crops to grow.

A lot of rain can fall on a small piece of land: 1 liter of water falls on every square meter of land for every 1 mm of rainfall. Even incredibly arid regions, such as the Sahel, will receive on average 150 mm of rainfall annually, which translates to 3,600 liters (180 jerrycans!) of water falling on a small 4 m by 6 m garden plot alone. If protected from runoff and evaporation, this water can greatly bolster the production of a wide variety of crops. Additionally, water from upslope of the plot can be directed into the garden to further increase water supply within the plot.

Beyond capturing rainfall that would otherwise go unused for crop production, water management can also decrease soil erosion. When unmanaged rainfall hits the land and flows over and out of the household compound, it takes the soil with it. Over time, a lot of nutrients and soil are lost due to rain. When water is slowed down, and the process of infiltrating water into the soil is improved, the impacts of erosion are minimized. Soil nutrients and organic matter can stay protected in the soil.

The level of soil erosion caused by water is represented on the soil erosion triangle. A farmer can reduce the amount of soil erosion by slowing the water's speed, by reducing the volume of water moving across the land, or by reducing the depth of water moving across the land. A garden design that manages the rainfall in these ways will capture and store the rain for crop production, in addition to preventing the topsoil – and its nutrients – from flowing off the site.

The Soil Erosion Triangle



These water harvesting structures reduce erosion by slowing, spreading, and sinking water deep into the soil.

3 Biazin, B., Sterk, G., Temesgen, M., Abdulkedir, A., Stroosnijder, L. (2012). Rainwater harvesting and management in rainfed agricultural systems in sub-Saharan Africa – A review. Physics and Chemistry of The Earth. Vol 47-48. p. 139-151. https://doi.org/10.1016/j.pce.2011.08.015

How does the Permagarden Approach manage water?

Water management systems designed using the Permagarden Approach aim to control water during the wet season and have it accessible during the dry season. This can be achieved by protecting water from the "three thieves": sun, wind, and slope. Sun and wind steal water from soils through evaporation. They also speed up transpiration in plants. The slope steals rainwater through runoff and erosion.

The Permagarden Approach uses a set of carefully designed interventions to minimize the impact of the three thieves by infiltrating, storing and protecting water in soil. The practice of capturing and storing water in the soil is referred to as "banking water," since water is saved for future use by plants. Water is banked in the soil through a series of interlinked practices that include water harvesting structures (swales, berms, half-moons, and catchment pits), double-dug growing beds, strategic shade, integration of organic material, and mulching. If implemented effectively, this management system allows the farmer to maximize their use of all the water present within their compound. At the same time, water harvesting structures help protect against damage from flooding or runoff events by also diverting excess water.

The Three Thieves of Water

Construct Water Harvesting Structures details on page 75

The four 'S' principles of water management: Slow, Spread, Sink, and Save

Every water management practice used in a permagarden protects water through one or more of the four 'S' principles: Slow, Spread, Sink, and Save.

Slow the water down so it can infiltrate into the soil. As rainwater falls on the land, farmers need to slow the initial impact and movement of the water. Slower-moving water has a much better chance of infiltrating deep into the soil profile than water that flows quickly over the surface of the compound and runs off.

Spread the water across and through the soil so all plants can use it. Water that is spread throughout the soil profile can provide plants and roots with better access to the moisture and nutrients required for optimal production. By moving water from wetter areas to drier areas, farmers can expand the arable places they can grow their crops.

Sink the water deep into the soil. By sinking water deep into the soil, it is accessible to plant roots and safe from evaporation. Water that is banked deep in the soil promotes deep root growth, which can also help plants access nutrients that are stored deeper within the soil.

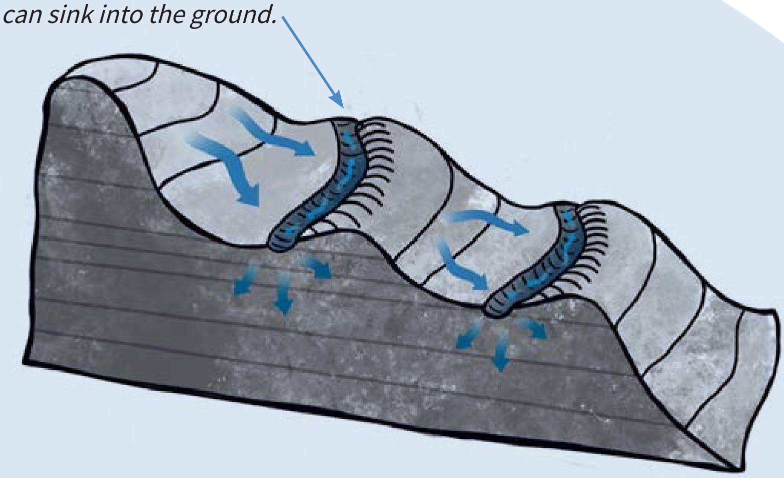
Save the water once it is in the soil. Water that is within the soil is still prone to evaporation by the sun and wind. By integrating organic material into the growing beds, covering the soil with mulch, living plants, shade structures and trees, farmers can protect this water from the thieves of sun and wind.

Understanding the contours of the land

By understanding the flow of water across a landscape, farmers will be able to manage this water more effectively. One way to do this is by understanding and working with the contour of the land. A contour line is defined as a line whose every point shares the same elevation. Even land that looks flat likely has some slope, and a farmer should always find the contour when designing and building water harvesting structures and productive growing areas in and around the compound. Contour lines are measured using a survey tool, such as an A-frame. One cannot accurately find the contour of the land without a survey tool and can unintentionally create structures that pool or drain water in damaging ways.

Build and Calibrate an A-Frame details on page 65

Swales that are dug on contour capture and hold water flowing downhill so that it can sink into the ground.



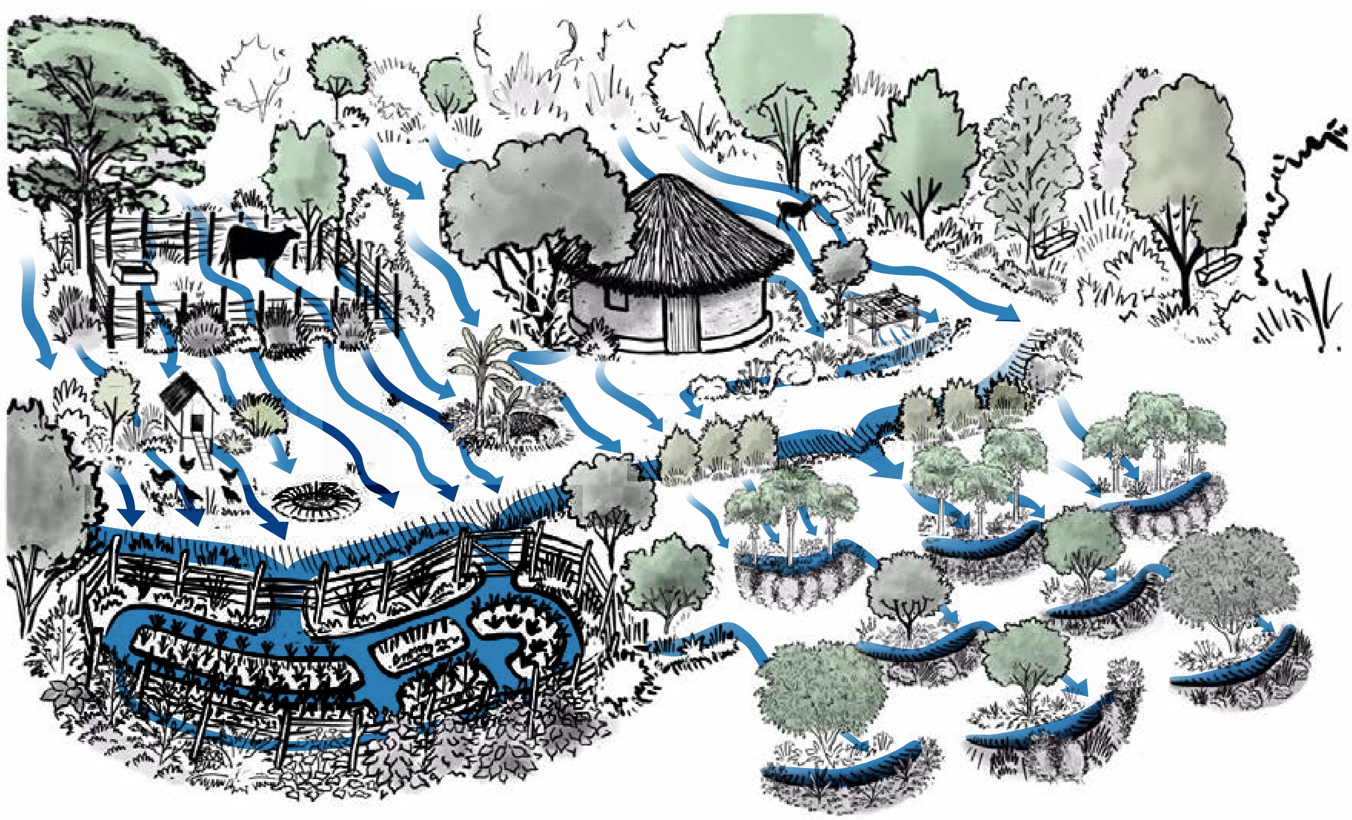
Contour lines connect points that are the same elevation across a landscape.

Water harvesting structures

One of the most distinctive characteristics of the Permagarden Approach is the use of water harvesting structures, such as swales, berms, half-moons, basins, and catchment pits. Water harvesting structures can capture and retain water close to where crops need it, or they can divert flooding or stagnant water to areas where it is less destructive. Water harvesting structures also allow for the efficient reuse of household wastewater, redirecting it so that it does not flow off the land but rather is directed towards a more productive use, such as crop production.

Establishing water harvesting structures for water management first requires understanding the natural flow of rainwater and nutrients across the landscape. In the Permagarden Approach, program staff first teach farmers how to "walk the water" – that is, determine water flow across the compound. With this understanding, farmers can then incorporate water harvesting structures that slow, spread, and sink the water running across their landscape into the soil, especially around permagarden beds. Water harvesting structures are situated in the landscape in such a way that the water entering the top of the compound is directed from one structure to the next until it reaches the bottom of the compound. Each structure fills to its maximum capacity, then any excess water exits through a planned overflow point that directs water to the next water harvesting structure further down the slope. By intentionally directing all water that enters the compound through a system of well-placed water harvesting structures, a farmer can ensure that this water is used for production rather than wasted as runoff. These same structures protect the landscape from flooding and erosion by slowing down water and redirecting it. Water harvesting structures also become important locations to grow crops and trees, particularly within arid regions. Planting beneficial grasses, shrubs, and trees on berms, and annual crops within and around swales, maximizes production and protects the structures from erosion. Continuous mulching protects water harvesting structures from water evaporation. In areas where soils have accumulated salts, rainwater from water harvesting structures can be used to flush salts from the upper layer of soil. The moist, protected bottom of a swale is also an ideal place to produce compost. Farmers can throw garden and kitchen waste into the swales and occasionally mix it to produce a low-effort compost that is situated right next to a growing area. The following section highlights common water harvesting structures used in permagardens.

Construct Water Harvesting Structures detail on page 75

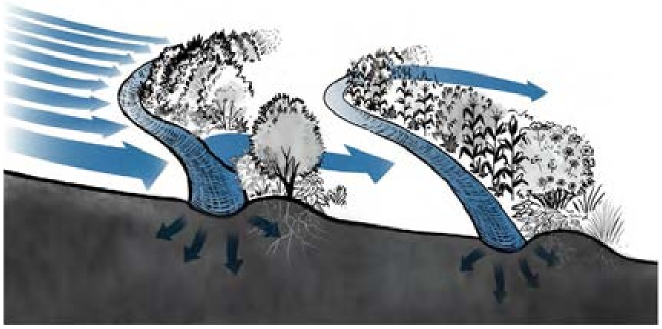


Households can design their landscape to capture water.

Swales

A swale is an on-contour ditch and associated berm, including a spillway and capped ends, that slows, spreads, and sinks rainwater as it flows down a slope. Swales are a good strategy in resource-poor environments due to their minimal cost to construct and maintain and their overall effectiveness in capturing and directing water. Farmers can use the berms — sometimes called bunds — associated with swales to create new growing areas within their compounds. When amended with organic material and mulched, berms become planting areas for perennial grasses, shrubs, and trees, helping to increase plant diversity around the compound. Swales can also protect building structures, gardens, trees, and other productive plants from water damage if they are placed upslope from areas that are in the path of heavy flowing water or depressions that collect water after heavy storms.

When digging swales, it is important to remember to design and construct a spillway that enables water to safely leave the structure after it has filled. With a well-designed and interlinked overflow system, these same structures that harvest water will help to protect the landscape from flooding. The size of the swale depends on the context of the site. Smaller swales can be dug up-slope from the permagarden beds or other planting areas, while longer and larger swales can be constructed at the top of the compound and at other strategic locations to help protect against larger water flows.



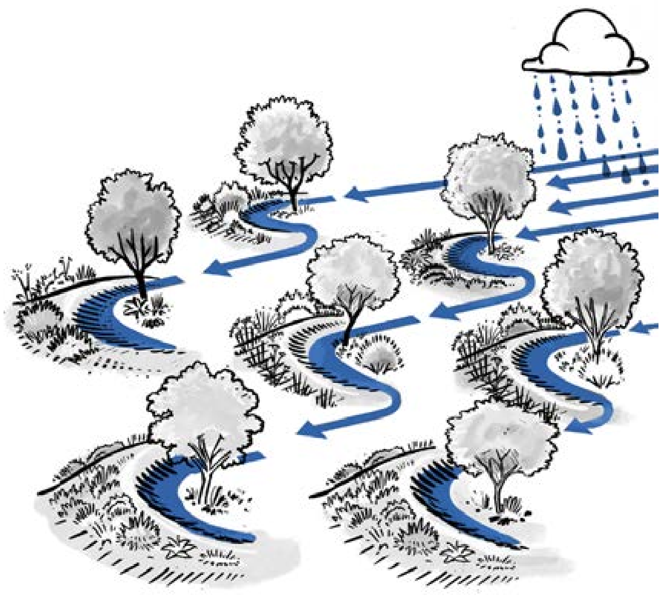
Water flowing down the slope enters the swale and infiltrates into the soil. A spillway integrated into the swale allows excess water to exit and flow into a secondary swale located down slope.

Permagarden beds protected with swales on their upslope and downslope sides.

Half-moon berms

Half-moon berms are a strategy to harvest and retain water around trees or small groupings of plants. In some areas, half-moons are referred to as boomerang berms or smile berms because of their shape. In Francophone areas, they are known as demi-lunes. Half-moons are generally small, 2-3 m curved berms or ridges in the shape of a semi-circle, though in large-scale dryland reclamation projects they can be up to five meters across. The end tips of the half-moon are located along the contour of the slope, pointing uphill to receive the water flowing downhill. The area within the half-moon, and even the berm itself, is often amended with compost, manure, or other amendments and planted with annual and perennial crops. Half-moons are important structures around the homestead as they create viable planting areas that harvest water and nutrients to support useful trees. Multiple half-moons can be placed in a row across a field or at the top a garden to slow and sink rainwater. A second row of half-moons is then placed so that they are staggered between the half-moons in the first row to catch any overflow water that continues down the slope. Some people call this a triangle, net, fish scale, V, or W pattern. By creating this pattern across the landscape, the interlinked overflows between the structures can significantly reduce flooding and erosion.

Farmers construct a half-moon berm around a neem tree in a refugee camp in eastern Chad.



Half-moon berms can be dug around trees in a net pattern to slow and sink water as it flows down the slope.

A woman digging a half-moon berm to retain water around a tree in Niger.

Basins

Basins consist of soil mounded in a circle around a tree base. Basins are often used to hold irrigation water around the base of a newly planted tree, which may be necessary when trees are young and still establishing. Basins differ from half-moon berms in that they are closed and therefore unable to catch rainwater flowing down the landscape. They cannot link to other water harvesting structures. When trees mature, basins can be replaced by half-moon berms.

Catchment pits

Catchment pits — sometimes referred to as cropping pits or planting holes — are small holes dug in the soil to capture and concentrate water and nutrients directly at crop roots. The excavated soil from a catchment pit is placed on the downslope side of the pit, leaving the upslope side open to harvest water flowing downslope. As with a berm, the downslope edge of the catchment pit can be amended with organic materials and planted, increasing the hole's functionality and use to the farmer. In dryland climates of West Africa, catchment pits are frequently called *Zai* pits and are often dug across an entire field, amended with compost or manure, and planted with sorghum or maize. Catchment pits also appear in other traditional agricultural systems, such as the Zimbabwean *Makomba*. To improve the effectiveness of catchment pits, farmers should break up the hardpan below the pits, mix organic materials deep into the planting hole, and orient pits into a triangular pattern across the field to harvest more of the rainfall that flows across the surface.

Diversion ditches

Diversion ditches are ditches that are dug slightly off-contour to either divert excess water away from areas that experience regular flooding—especially around home compounds—or to direct additional water towards growing areas that need it. When designed effectively, diversion ditches redirect problematic water towards large water catchment pits or swales where water can be used productively.

Strategies for protecting water

Once water enters a water harvesting structure or permagarden, the goal is to preserve as much of that moisture as deep in the soil as possible. Especially in hot climates, a lot of water can be lost due to evaporation. These additional water management practices help save water in the soil by protecting it from evaporation and runoff.

Keep soils covered

One practice that maximizes water capture and retention is to keep some form of cover on the soil at all times, such as crop residue, dry mulch, or living mulch. Keeping the soil covered reduces the temperature of the soil, even during hot, dry weather, which slows evaporation rates. This moisture retention can help crops survive through extended dry spells, which are increasingly common during the rainy season. In addition, mulch can lessen weeds, prevent erosion, improve soil structure, and create conditions for a healthy soil biome. Soils should be kept covered with a diversity of mulches during both the rainy and dry seasons. For this reason, burning fields should be discouraged because it destroys the protective cover provided by grasses and shrubs.

Mulch can be derived from dry or living materials. Good dry organic mulches consist of leaves, grass, straw, compost, banana leaves, maize or sorghum stover, beanstalks, and/or other organic materials. Living mulches can be green manures like alfalfa; *Desmodium*; legumes such as lablab, jack bean, or *Mucuna*; or other spreading ground covers like pumpkins. In areas where it is difficult to grow ground covers, farmers might instead plant dense stands of nitrogen-fixing trees along swales or in alley-cropping systems; pruned branches and leaf litter from these trees can act as mulch and add additional organic material to the soil. Beyond providing soil cover, some living mulches can be eaten, sold, or used as fodder for livestock. Ideally, a 3-5 cm layer of dry mulch should be added to the surface of growing areas. Perennial cropping systems, such as banana plantations, can be planted with living ground covers that provide year-round protection for the soil.

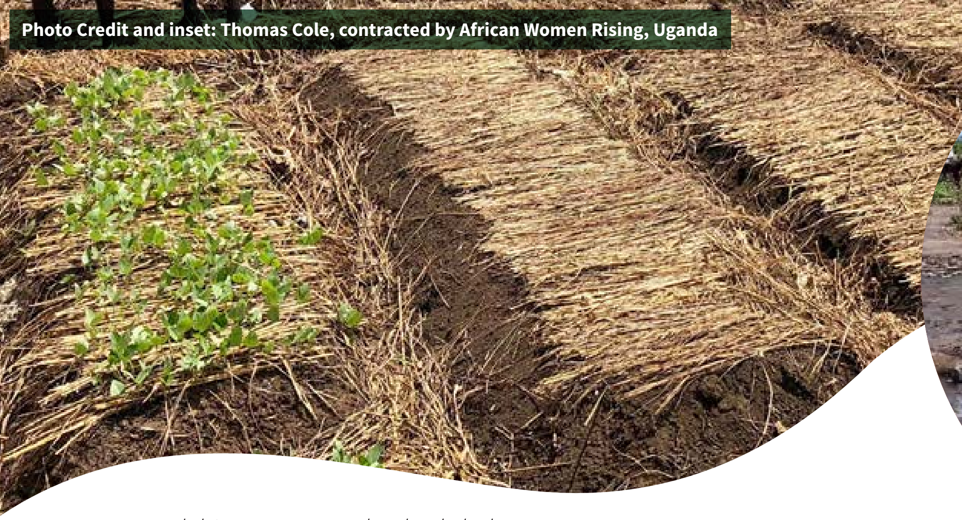
Selecting Living Mulches

Living mulches should be selected carefully so that the right species is chosen for the space.

For example, *Desmodium* is a nitrogen-fixing perennial ground cover that is a useful fertilizer for main crops and can be planted within and around garden beds.

Pumpkins can be grown as a ground cover within crops that typically have wide spacing between and within rows, such as maize and beans.

Living mulch that spreads quickly is especially effective around trees and throughout orchards where there is often ample open space.



Mulching permagarden beds helps to protect the moisture in the soils from evaporation.

Plant a Biointensive Garden details on page 91

Increase soil water holding capacity

Soils with more organic material and good structure (ample pore space) can hold more water than compacted, poor quality soils. Adding compost and other organic amendments to the soil increases absorption and retention of water because organic material increases the biological activity within soil, which promotes the clumping of soil particles together. Removing compaction throughout the entire root zone (up to 60 cm deep in the soil) will also increase the amount of water that a garden bed can hold.

Strategically plant trees

Planting trees in strategic locations limits the exposure of growing areas to intense sun and can significantly reduce evaporation and heat stress on the plants. This is an important strategy in areas with long dry spells and high heat stress. A good example is planting a tree for beneficial shade and nutrient support like the nitrogen-fixing *Faidherbia albida*, which is a tree that drops its leaves in the rainy season and retains its leaves in the dry season when shade is needed.

Trees can shade permagarden beds during the heat of the afternoon to protect soil water from evaporation.

Biointensively plant beds

The practice of biointensive planting (planting different compatible crops close together), when combined with deep soil preparation, provides a rapid covering of the soils with more foliage, which leads to less evaporation and weed growth.

Use shade coverings or trellises

A simple shade cover over the permagarden beds can provide beneficial protection at times of the day when the sun is intense and soil moisture loss is high. Plants that are prone to heat and water stress, such as young plants, will especially benefit from partially shaded conditions. Farmers can plant garden beds partially under existing tree coverage if shade covers are not available. Trellises can also be constructed over swales and planted with spreading and vining plants to shade the water banked within and below the ditch.

Shade structures are an important strategy to protect plants from climate extremes and extend the growing season.

Household wastewater management

In addition to rainwater, farmers primarily use water gathered from a borehole, well, or stream for their permagarden irrigation needs. They can also collect wastewater from around the household and safely reuse it for irrigation in their permagardens. Wastewater is especially useful as a way to extend the growing season through drier times because it is used by households throughout the year. In addition, directing wastewater so that it spreads and sinks into the soil can result in less standing water and reduce the potential for mosquito breeding.

There are multiple strategies households can implement to reuse wastewater. However, the practice of using certain types of wastewater can sometimes be difficult for someone to adopt due to cultural norms or habits. In addition, some donors may require program staff to provide additional information on wastewater use and safety precautions before they support its promotion in garden-related or other activities. It is important to check any project limitations on using wastewater and and communicate to participants the risks of using wastewater inappropriately. Wastewater from bathing, hand washing, or other sources that may contain human pathogens should not be used directly on crops that are intended to be eaten in the near future. If a farmer is not comfortable putting the wastewater directly on the garden bed, they can put it in a swale or a basin to support a tree. The types of water, associated risks, and cultural practices in each household will determine the best strategies to be used.

There are many sources of wastewater that can be identified in most households:

- **Dish washing water**
- **Cooking water**
- **Cleaning water**
- **Bathing water**
- **Clothes washing**
- **Ablution washing**

Direct watering

Non-soapy wastewater from cooking, ablution, and vegetable washing can be a good source of daily water for growing systems next to the kitchen. Instead of being thrown out, the water can be poured directly onto mulched soil around plants. It is important to keep the water off the leaves of plants to avoid contamination. Water with soaps and other impurities should only be put into deeply dug areas, like mulch basins (see below) or swale ditches.

Using ablution water to help irrigate a newly dug tree planting hole

Construct a Mulch Basin details on page 82

Mulch basin

Mulch basins can be used to filter wastewater that contains soap so that it can be used for crop production. A mulch basin consists of a mulch-filled pit and a surrounding berm that is planted with a diversity of plants. Plants on the berm are typically arranged so there is an overstory, an understory, vines, and ground cover. Banana is often used as the overstory plant as it can use higher volumes of water and nutrients, provide shade to other plants, and generate an ongoing source of mulch to feed the system. Other plants that can be considered for the mulch basin are papaya, bamboo, taro, sweet potato, sugarcane, ginger, perennial beans, lemongrass, fodder grasses, and passion fruit vine.

Dish stand

Dish drying racks are found in most compounds and offer an opportunity to harvest the water that drops as the dishes are drying. While racks do not provide a lot of water, it is consistent and can support small plants year-round. The dish drying rack can also provide protective shade during the dry season. There are multiple ways to construct this type of growing system. Water can drop onto a stone covered area that is sloped outward from the dish rack to a nearby planting bed or tree basin. Another strategy would be to double dig a mulched garden bed at the base of the drying rack. Or water can simply be directed away from the dish stand towards a nearby tree or other productive plant.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Dish drying racks can be placed near crops to reuse dish water. Rocks placed under the dish drying rack protect the soil from erosion.

Photo Credit: Thomas Cole, contracted by CARE, Zimbabwe

A mulch basin is a hole that is dug next to a wastewater source and planted with moisture-loving plants.

Bathing area drain

Wastewater from daily bathing is an important and consistent source of water that can be reused for productive purposes. The drainage for a bathing area can be designed in such a way that water is safely drained away from the bathing structure and towards a productive use. Bathing water can be directed towards a nearby water-tolerant tree or clumping plant, such as bamboo, which can also provide a privacy screen for the bathing area. Soapy water is best used for productive, non-food plants that can be used as building materials or as a source of organic material.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Small-scale irrigation practices

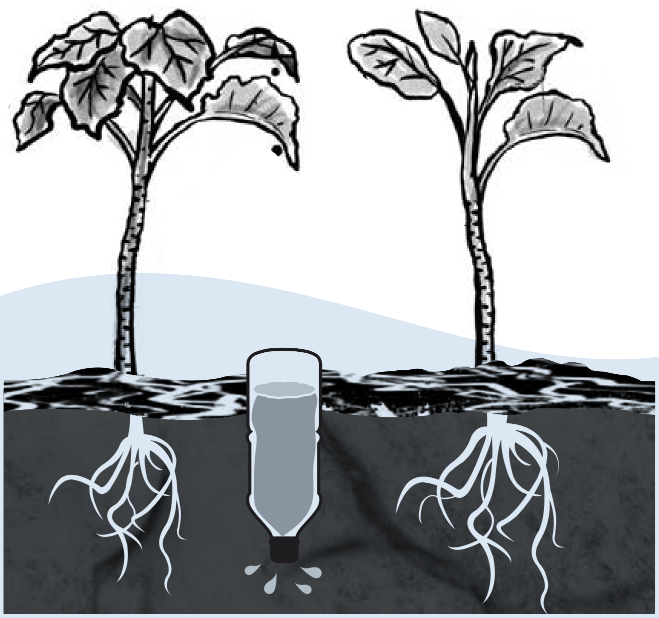
Farmers are sometimes able to gather water from other sources around the household for irrigation, such as from a borehole, stream, or wastewater. There are several small-scale irrigation practices farmers can adopt in addition to constructing water harvesting structures to maximize the effectiveness of this water in the garden while using minimal resources.

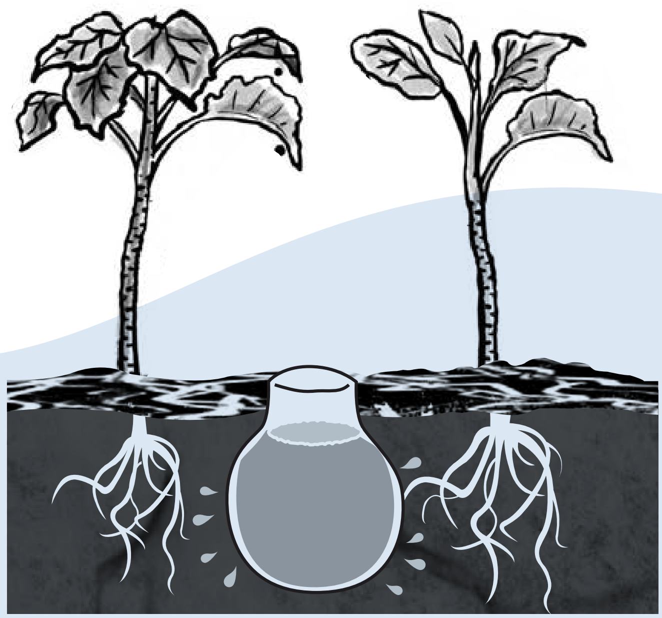
Plastic water bottle

Besides irrigating by watering can or other container in the garden, a plastic water bottle can be used to slowly add water directly into the root zone of a plant. This is a simple, localized form of drip irrigation for a single plant or a group of closely sown plants. A small hole or a group of small holes in the bottom of the bottle allows water to slowly drip or seep into the root zone of the targeted plant or plants. This method is very effective when water is in short supply and needs to be targeted and rationed in the garden. It also works well to help irrigate newly planted trees.

Clay pots

Another good practice for irrigating groupings of plants and trees is to fill unglazed clay pots with water and bury them up to their necks in the nearby soil. The porous pots will provide controlled irrigation to the plants and trees located nearby. This technique works best in the dry season as a way to conserve and use less water while still being able to grow vegetables. In dryland environments, this approach can prove very useful, as the pots need to be filled with water only about twice each week.[4]





4 Kruse-Peeples, Melissa. "How to Use Olla Irrigation." Web blog post. Native Seeds SEARCH, 13 May 2016.

Soil Management

Why is managing soil important?

Households often live and farm on small parcels of marginal land. This land may have been cultivated or occupied for many generations and suffered long-term declines in soil fertility as a result. The same holds true for displaced people living in refugee or internally displaced persons (IDP) camps, which are often situated on marginal lands. These highly degraded landscapes present many challenges for improving or achieving food security. Healthy, well-structured soil is the basis for establishing a productive garden and growing more nutritious crops, particularly on marginal lands.

A healthy living soil will:

- increase crop production;
- improve the nutritional value of crops;
- suppress soil-borne diseases;
- strengthen the ability of plants to resist pests;
- increase nutrient retention of fertilizers;
- minimize water runoff;
- increase water savings within soil; and
- capture and store carbon.

Understanding healthy soil

A healthy soil is full of living organisms, contains lots of organic matter, and has intact pores for water and air to pass easily through the soil profile.

Soil food web

The concept of the soil food web is integral to building healthy soils. The soil food web is the community of organisms — from bacteria and fungi to earthworms and insects — living all or part of their lives in the soil. This community forms a dynamic environment within the soil and creates the conditions necessary for soil to support plant growth. Soil organisms perform many vital functions, including:

- breaking down organic material;
- fixing nitrogen from the atmosphere;
- converting macronutrients in the soils into their plant soluble forms;
- building soil organic matter levels; and
- creating a “glue” that binds soil particles together, thus creating pores that allow for water infiltration, drainage, and storage.

The more food – in the form of decaying plant material containing carbon, macronutrients, and micronutrients – and optimal living conditions within the soil, the more abundant the soil food web will be. Farmers can build a robust soil food web by feeding the soil microorganisms a variety of soil amendments and ensuring the soil is adequately protected from compaction, intense temperatures, moisture loss, and erosion.

Feeding soil with a diversity of organic materials will create a healthy and robust soil food web.

Adding organic amendments to soil will build SOM and improve soil structure.

Soil organic matter (SOM)

Soil organic matter (SOM) is the fraction of the soil, or proportion of the soil, that consists of plants, animals, and microorganisms at various stages of life and decomposition. It can be divided into three components: the living biomass of microbes; fresh and partially decomposed detritus; and humus, which is stable, partially decomposed organic material. SOM can range in age from organisms that are still alive to partially decomposed plant material that is hundreds of years old. SOM includes, for example, partially decayed crop residue in addition to the dark particles within the soil that are no longer recognizable as plant material. Without SOM, soils would be less able to sustain plant growth. SOM increases a soil's ability to retain nutrients, air, and water, and improves its structure and resistance to erosion and crusting. All these factors work together to provide the conditions needed for healthy root growth. As SOM increases, the soil is able to support more plant life, which then returns more carbon to the soil and leads to the formation of more SOM. This cycle is the foundation for building fertile soils.

In a general sense, SOM can be seen as a buffer against extreme conditions. It moderates soil pH, improves water drainage in clay soils and enhances water retention in sandy soils. Without the buffer provided by SOM, crops will more quickly succumb to environmental stresses. However, SOM can rapidly leave the soil when soil is cultivated and SOM is exposed to air through tilling. SOM mineralization - the natural process of SOM decomposition into CO_2 and plant-available minerals - tends to happen quickly in hot tropical climates, making it difficult for farmers to build up stores of SOM in soil. For these reasons, SOM needs to be protected and continuously added to soil to maintain fertility. Decreasing the amount of tillage, adding a variety of organic material to the soil, and keeping living plant cover on the soil are all ways to maintain or increase SOM.

Soil structure

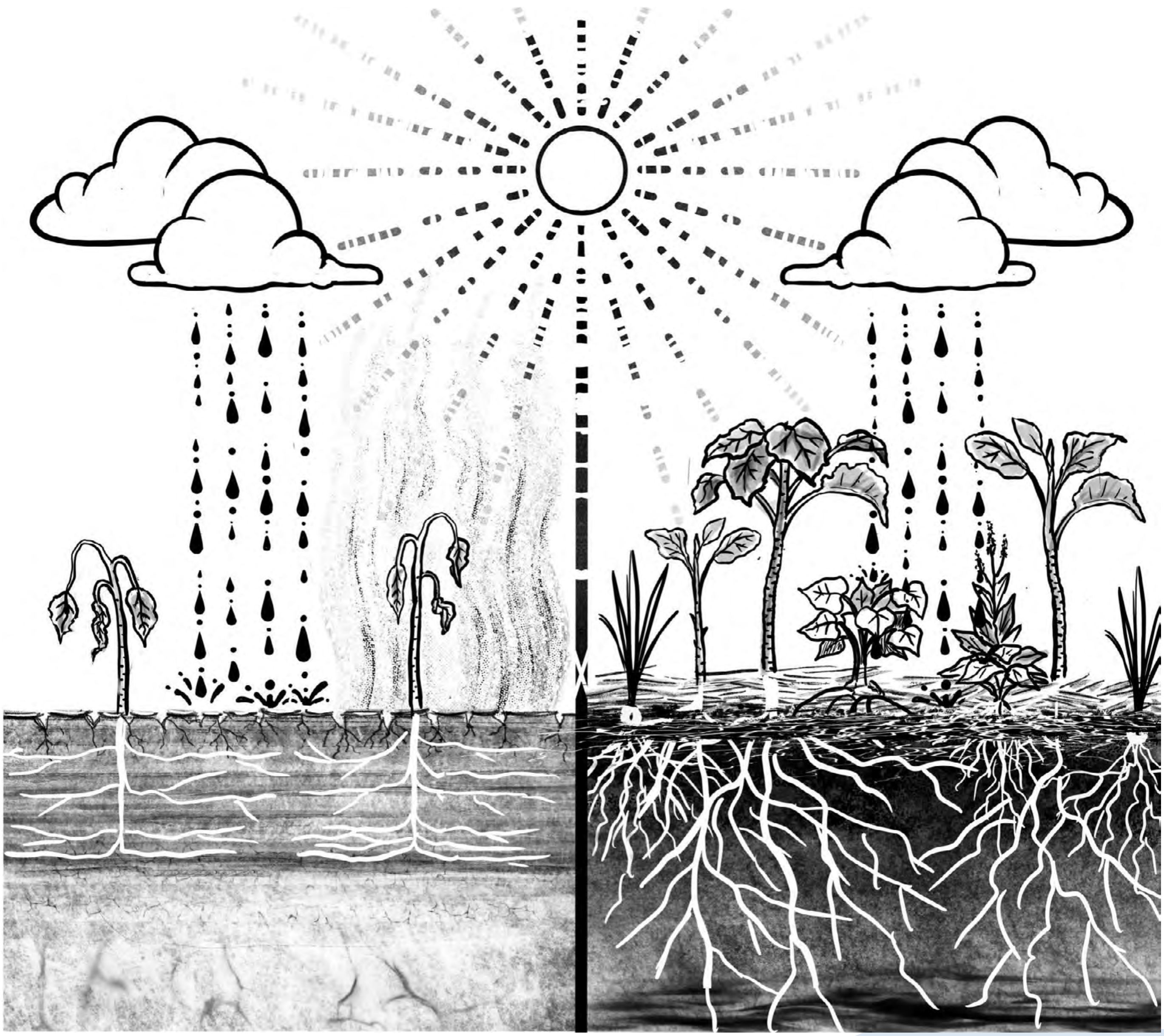
Soil structure, which refers to the way soil particles are aggregated, i.e. clumped, together, is heavily influenced by a farmer's soil or crop management and the soil's inherent texture (sandy, loamy, or clayey). There are many benefits to good soil structure, such as good water infiltration and root growth, enhanced nutrient cycling, and increased biological activity in the soil, all leading to better crop production.

Sandy soils tend to drain water quickly because they contain mostly large soil particles and low amounts of silt and SOM that build soil aggregates (soil particles that are bound together). Soil aggregates are necessary to create the pockets and channels where water can be held. Some clayey soils contain SOM but can easily be compacted, which reduces soil pore space and increases surface water runoff. In general, agricultural practices that compact the soil, such as stepping on wet soil, will destroy existing water and air pores and negatively impact a soil's structure. Practices that protect soil pores, such as using permanent planting beds and pathways, can maintain it. Over time, the structure of both sandy and clayey soils can be improved by building SOM through the addition of organic materials.

How does the Permagarden Approach manage soil?

Permagarden soil management techniques focus on increasing soil fertility and biological activity, reducing compaction, and improving water infiltration and water storage in the soil. The soil management techniques used in permagardens work in concert with the techniques used to manage water to enhance the system's productivity and resilience. The soil management techniques listed here should be used in combination with the construction of water harvesting structures to build soil health and maximize water storage in soils.

Because of the emphasis on continuously building soil health each and every season, permagardens are not limited to sites that already contain healthy soil. Instead, the soil management techniques used to develop a permagarden can be used to rehabilitate degraded soils and, over time, turn an unproductive site into a productive one. With a sound, long-term approach, soil health can be built regardless of initial soil quality.



Deeply prepared, uncompacted, and protected soils promote strong root growth and moisture retention that result in healthy and productive plants.

Double-dug beds break up soil compaction to improve root health.

Deep soil preparation

Deep soil preparation is an important soil management technique used in the Permagarden Approach to promote healthy root growth. Farmers often prepare garden beds that are the depth of the tool normally used to work the land. At best, this means soils are aerated to about 20 cm, the length of the average hoe blade. With successive tillage to the same level, a nearly impermeable subsoil — a hard pan — is created over time that blocks the movement of air and water through the soil profile and stunts the growth of the roots of plants. If plant roots are not able to grow deep into the soil, then they must be planted farther apart so as not to compete with neighboring plants for air, water, and nutrients. When planted farther apart, sunlight easily reaches the soil surface, causing weed germination, moisture loss, and overall weaker, underproducing plants. These issues can be avoided by using deep soil preparation.

If the starting soil is heavily compacted, farmers can use a combination of deep tillage and applying amendments to the subsoil to promote healthy root development and increase water infiltration and storage. This process is often referred to as double digging.

Double-dug beds

When preparing your permagarden beds for the first time, it is important to break up any hardpans and start to build soil fertility by deeply amending the soil. These same principles apply for all growing areas, including tree holes, water harvesting structures, plants along fence lines, and any other growing spaces used.

Double-dug beds break up soil compaction and add amendments to the first 40-60 cm of the soil. In some contexts, double-dug beds only need to be established once and do not need to be re-dug if properly maintained; in areas with poor or heavy soils, beds may need to be dug again after about five years. The beds are amended with a diversity of organic materials at the same time that they are dug. Crops can then be intensively planted within the beds and the beds heavily mulched to provide the soil with adequate cover.

Because double-dug beds require a lot of upfront labor, it is important to plan when and how beds will be dug. Farmers may choose to work in groups or during a cooler part of the day to complete the work. Working when the ground has adequate moisture to be soft, but not waterlogged, will also ease the labor burden. If properly maintained and protected season after season, double-dug beds will require less time to maintain than regular garden beds and continue to produce higher yields for longer.

Often, the process of double digging leads to a bed that is higher than the initial soil level. In areas of high rainfall, an elevated bed can help keep crop roots from becoming water-logged. However, in arid areas, the finished beds should not be raised; rather, they should be kept at soil level, or even slightly sunken, to conserve moisture. Deep soil preparation is still needed, but the finished height of the garden beds should be lower than the initial soil level to prevent water loss from hot winds. The context of each garden will identify which type of preparation is needed.

Prepare and Amend a Double-Dug Bed details on page 85

A sunken double-dug bed created in a dryland environment. Soil evaporation is reduced because the bed is less exposed to the air. The bund added around the edge of the bed traps any available rainwater so that it can percolate downward and be used by crops.

Organic amendments

Locally available soil amendments

Many organic resources exist around the home or the community that can increase the productivity of a garden. Animal manures, crop residues, green and brown leaves, charcoal dust, milling waste, bone dust, biochar, wood ash, coffee grounds, and kitchen waste are all valuable assets that can be used to improve soil quality over the long term. They add micro- and macronutrients to the soil, as well as carbon, which builds soil SOM. They can be added to either the topsoil or subsoil layer of a double-dug bed (depending on their state of decomposition), to a compost pile or pit, or to the berm of a water harvesting structure. Some materials are rich in phosphorus, while others are rich in potassium or nitrogen. Adding a diversity of materials in large quantities to a growing area is the best way to ensure plants will have access to all the nutrients they need and soil health is built over the long term. A resource walk through the community can help identify where a number of these materials might be found, especially in areas where it may prove difficult for individual farmers to access many forms of organic materials. For sites with extremely limited organic materials, farmers should concentrate these nutrients in a small growing area that can slowly be expanded, rather than spreading them out for cultivation over a large area.

Community Resource Walks details on page 70

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

- **Manures** provide small amounts of nitrogen, phosphorus, and potassium, in addition to micronutrients. Manure can be sourced from most animals, including cows, camels, sheep, pigs, chickens, goats, rabbits, horses, sheep, pigeons, ducks and other fowl. It is important to use well-aged (dry) manures in the garden to avoid spreading pathogens that are harmful to humans and "burning" sensitive plant tissues. To be safe for use in the upper 30 cm of a garden bed, manure should first decompose for several months or be composted. When manure is collected for drying, it should be covered or incorporated into compost to preserve nutrients rather than left to dry in the sun. Manure from dogs should not be used in the garden because it is more likely to contain pathogens that can cause illnesses in humans. Fresh manure and animal urine can be used to make a liquid manure tea, which is applied to crop roots or on crop leaves that are not intended to be eaten. Dried and composted manure can be applied in large quantities to a permagarden bed or other growing area before every planting season.

- **Crop residue** from the previous cropping season can be incorporated back into a field or gathered and used as a soil amendment within a garden bed or other growing area rather than being burned. Residues should be chopped into small pieces for faster decomposition. This is especially important for woody materials that take longer to break down. Crop residues should never be burned in a permagarden, however, residues sometimes serve as an important source of livestock fodder and may be in limited supply.

- **Green and dry leaves** are often underutilized resources that can provide essential carbon and nitrogen to the soils. Found in abundance in most communities, these resources can be one of the most significant sources of organic material for a garden. Where possible, farmers should incorporate a diversity of leaves from different plant sources. Green leaves are a rich source of nitrogen, and dry leaves provide the carbon needed to build soil SOM. Easily decomposable green leaves can be incorporated into compost or directly into the bottom of a double-dug garden bed, whereas dry leaves make excellent mulch.

Photo Credit: Thomas Cole, contracted by ACTED, South Sudan

Make and Apply Botanical and Manure Teas details on page 93

Burning animal manures and crop residues releases harmful smoke and wastes a valuable asset that could be used to build soil health.

- **Charcoal dust** can be found in communities that use charcoal for cooking. The small chips and dust that are no longer useful as a fuel can be added to a household sweepings pit or compost pile. They can also be added to the bottom of a double-dug bed along with other soil amendments. Charcoal dust increases water retention, creates habitat for microorganisms, and permanently improves the soil's ability to hold nutrients. This becomes even more important in sandy soils, which inherently do not hold many nutrients, and in subtropical or humid areas where carbon can easily convert to CO_2 and SOM levels decline.

- **Milling waste** can be an important source of carbon for soils. The residues left from milling grains, coffee, beans, cassava, and other crops can be incorporated into the soils or composted to increase levels of SOM.

- **Bone dust and eggshells** contain calcium, a micronutrient used by plants. Older, dried bones of livestock and poultry should be burned in a firepit for a short time then crushed into a powder form and added to garden soils.

- **Biochar** is charcoal made specifically as a soil amendment. Biochar can be made from many different kinds of crop residue, such as maize or sorghum stalks, rice husks, and sugarcane bagasse by burning the organic material in a pit and then covering all but a small airhole with soil to allow it to smolder. In areas with large amounts of crop residue, making biochar is a good way to provide this amendment for both permagarden beds and field crops.

- **Wood ash** can reduce the soil's acidity, which aids in the uptake of nutrients by plants. Wood ash can be found in kitchens that use cooking fires. It is an important source of potassium and supplies trace amounts of phosphorus and magnesium. Wood ash can be applied directly to the soil in a permagarden bed at a rate of no more than 1 kg ash per 10 m^2. Wood ash should be thoroughly mixed into the soil to effectively reduce soil acidity levels.

- **Coffee grounds** are a source of nitrogen and can be added to a compost pile or pit or mixed directly into the soil.

- **Kitchen scraps** provide a diversity of micro- and macronutrients because their composition is always changing. Kitchen scraps can include Irish and sweet potato peelings; the tops of beets and carrots; groundnut or other shells; the stems from kale, chard, and other greens; and the rinds or peels of fruit. In addition to composting, kitchen scraps can be steeped in water to create a nutrient-rich "tea" for irrigation or foliar fertilization. Kitchen scraps can be collected in rubbish pits around the compound, and composted in place, or transferred to a compost pile if available. Kitchen scraps can also be added directly into the subsoil layer (lower 30-60 cm) of a double-dug bed or under the mulch layer in the ditch of a swale.

Routinely adding organic soil amendments to growing areas can demonstrably improve soil health and must be done continuously to replace the SOM and nutrients that are lost during cultivation and natural mineralization processes.

Kitchen scraps and other organic waste can be composted to add fertility back to soils.

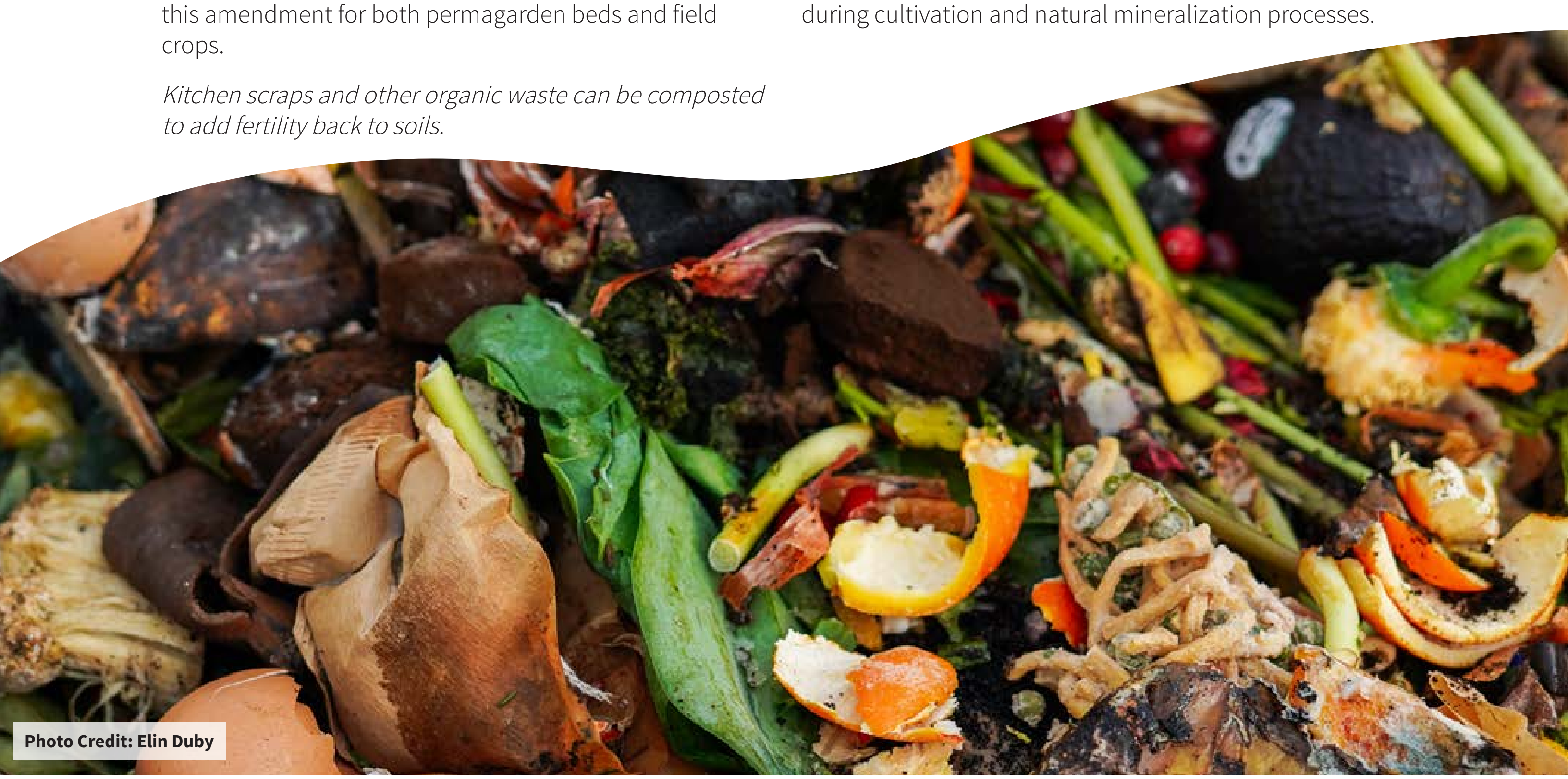


Photo Credit: Elin Duby

Composting locally available soil amendments

Adding compost to soils has numerous benefits. Compost builds SOM, improves soil structure and water retention, moderates soil pH levels, and adds micro- and macronutrients to soils. Decomposition is the natural process of the soil food web slowly breaking down organic materials into microscopic particles. Composting speeds up this process by ensuring there is the right ratio of water, air, green, and brown material in a compost pile or a compost pit for soil organisms to function properly and decompose materials quickly. With proper composting methods, a household can convert all manner of household, livestock, and crop waste into compost in just a few months.

Composting relies on soil microorganisms to break down material. Therefore, it is important to provide the right materials in the right amounts so that the microorganisms can work efficiently.

As a general rule, brown material is dry, brittle, and high in carbon. Brown material can include corn cobs, straw, and dry leaves. Green material is moist, flexible, and high in nitrogen. Green material can include vegetable scraps, fresh crop residues, manure, leaves and weeds that have not gone to seed. A diversity of greens and browns should be used and applied in layers from the top to the bottom of a compost pile. Too much of either green or brown material slows the decomposition process and lengthens the time until the compost is ready.

The basic ingredients for good compost are:

- 2/3 brown materials
- 1/3 green materials
- air
- water
- up to 10% soil

Supplying sufficient water and air for the microorganisms to function is also important. Too much water and they will drown; too little water and they cannot move around between materials. Air is provided to the compost pile every time it is turned.

Compost piles take upfront work to gather the green and brown material and then build the pile. However, this labor can prove worthwhile – a finished compost pile that measures one cubic meter contains approximately ten 20 liter buckets of compost, enough for three 1 m x 5 m beds. In areas where there are not enough materials or labor to make a compost pile, farmers might instead gather the daily household waste from sweeping the compound into a conveniently located pit or swale. This waste often includes items such as fallen leaves, chicken and goat manures, crop waste, and other organic matter that accumulates in the compound. This material should be swept into the pit daily and allowed to decompose. Wastewater should be added as needed to aid in the decomposition process. Via this method, usable compost can be produced after several months. Non-organic waste should be separated from the compost pit and disposed of elsewhere.

How to Build a Hot Compost Pile details on page 88

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Compost recycles nutrients to the soil.

Increasing Biodiversity

Why is increasing biodiversity important?

Plants and animals provide important services for humans and the natural environment, which can increase the resilience of a household. Having many types of trees, shrubs, vines, herbs, vegetables, and animals integrated into the compound can result in multiple, diverse benefits, and provide households with something to eat or sell more consistently throughout the year. Household members can also more easily access materials they need to improve their living conditions (building or fencing materials), health (medicinal plants), or health of their animals (livestock fodder).

In addition to the resources they provide, plants and animals can help the natural environment function better, alleviating some of the problems households experience with decreasing crop productivity, declining soil fertility, and water scarcity. For example, trees can be used to provide shade and decrease soil evaporation for heat-sensitive crops. Animals recycle organic waste into manures that can enrich the soil. Leguminous species can be used to enrich the soils where crops are grown. Flowering species provide food for pollinators and certain species, such as Napier grass and *Desmodium,* can be planted within and around maize plants as pest control. All plants can suppress weeds, reduce erosion, preserve topsoil, add organic material to soil, and keep soil surface temperatures cooler. By planting the right species in the right place, households can also improve the ecological health of their compound.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Tephrosia vogelii is a nitrogen-fixing plant commonly used for green manure and biological pest remedies. It makes a suitable wind-break or shade tree and is used medicinally in many locations.

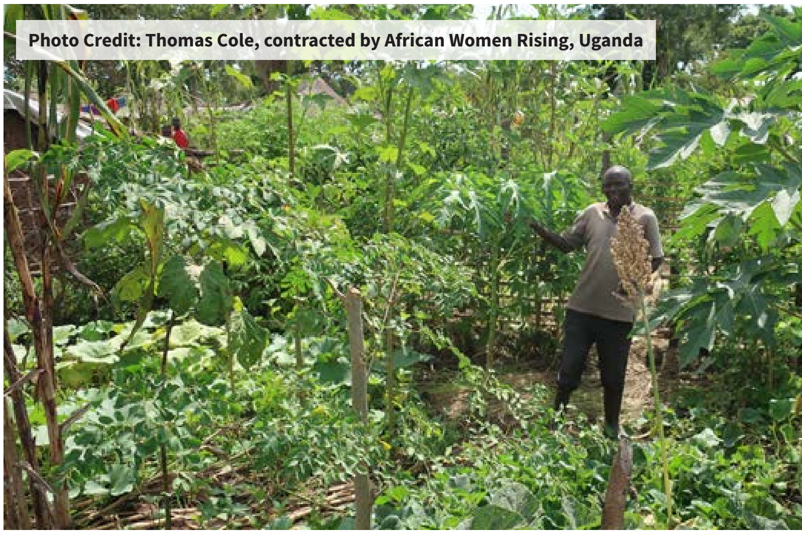
How does the Permagarden Approach increase biodiversity?

The Permagarden Approach increases the productivity of a space in part by stacking annual and perennial plants in layers, much like natural growing systems such as forests. Farmers are encouraged to find ways to use the vertical space above a growing area, in addition to the ground layer. This concept can be seen both within the beds, where crops are intercropped and intensively planted, and outside the beds in areas like the fence line, mulch pits, water harvesting structures and other areas around the home.

Farmers are also encouraged to use a wide array of local varieties, many of which are readily available through local marketplaces or farmer-to-farmer seed exchanges and therefore may be easier for farmers to source each season. Using local varieties requires a shift away from the approach used by many home garden projects that promote a handful of standard vegetables (e.g., carrots, cabbage, onions, and tomatoes); the Permagarden Approach instead encourages farmers to leverage the desirable characteristics of locally-adapted crops and plants. Local varieties, known as landraces, are often able to withstand local environmental conditions and might be moderately resistant to the types of pest and disease infestations present in the area. Farmers are also more likely to be well-versed in how to cultivate them, cook them, and use them for medicine or building materials than non-traditional crops.

Understanding biodiversity

Biodiverse forests can have up to eight layers. Beginning with the canopy, these layers consist of the **overstory** trees (e.g., avocados, jack fruit, *Faidherbia*, acacia), **midstory** trees (e.g., moringa, papaya, guava, *Gliricidia*), **shrubs** (e.g., *Tithonia*, pigeon pea), **herbaceous layer** (e.g., amaranth, eggplant, maize, cowpea, Napier grass), **ground covers** (e.g., sweet potato, pumpkins, *Desmodium*, melons), **clumpers** (e.g., sugarcane, bamboo), **climbers** (e.g, passion fruit, vanilla) and **tubers** (e.g., cassava, potato, taro). The design and process of building out a permagarden allows each of these layers to grow together and support one another for maximum production in a single growing space. Designing and planting annuals and perennials together can take many forms: a food forest, companion plantings and guilds, living fences, border plantings, orchard systems, and/or a single intensive garden bed.



Biodiverse food forests use every available space, including vertical space, to grow food.

Useful Perennial Species

Species name	Environmental, economic, social, and nutritional benefits
Gliricidia sepium	Nitrogen fixing, green manure, fencing, firewood, and shade
Lantana spp.	Nutrient accumulator, insecticide, hedging
Leucaena leucocephala	Nitrogen fixing, green manure, fodder, fencing, medicine, firewood
Moringa spp.	Green manure, food, medicine, firewood
Neem (*Azadirachta indica*)	Green manure, insecticide, medicine, soap, firewood, shade
Tithonia spp.	Green manure, compost material, liquid fertilizer, and fodder
Napier grass (*Pennisetum purpureum*)	Mulch material, compost material, soil stabilizer, and fodder
Pigeon pea (*Cajanus cajan*)	Nitrogen fixing, drought resistant, dry season food source, and fodder
Chinaberry (*Melia azedarach*)	Green manure, insecticide, medicine, soap, firewood, shade

Annuals and Perennials

Annuals are plants that germinate, grow and produce their seeds within a single growing season before dying. Many vegetable crops are annuals and provide important sources of income and nutrition, especially when there is access to rainfall and/or supplemental irrigation. These are the plants most often found in household gardens and must be replanted each growing season.

Perennials are plants that live more than two years. Perennials include a variety of shrubs, trees, grasses, fruits, vegetables, herbs, climbers, and ground covers. Once they are established within a water harvesting structure, perennials can provide ongoing production with minimal maintenance. Perennials draw nutrients from deep subsoil layers and bring them to the surface. They also utilize water that has been banked deep in the soils to continue growing and producing, even in times of water scarcity. Perennials can be planted in orchards, garden beds, swales and berms, and half-moon berms, as well as along living fences, existing walls and fences, infiltration pits, and mulch basins. They can also serve as windbreaks and plot boundary demarcations.


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Biointensive planting creates a closed canopy that reduces weed growth and maximizes bed space.

Plant a Biointensive Garden details on page 91

Biointensive planting

Biointensive planting is a method that maximizes yields in small areas of land by increasing biodiversity. Every garden bed or growing area has the potential to support multiple types of plants if the farmer deeply prepares the soil and increases the available nutrients. The effort put into preparing growing areas this way helps ensure that every plant has enough space above and below ground to allow for full root and leaf growth without creating competition with neighboring plants. This process allows plants to be spaced closer together than normal practice, which can maximize production and reduce moisture loss from the soil. In addition, farmers can use fences, trellises, edges of structures, or sticks to grow plants vertically using these same methods.


Photo Credit: Warren Brush, contracted by Danish Refugee Council, Tanzania

Plants can be grown on a trellis above swales to use all available vertical space in a garden.

Photo Credit: Ezra Millstein, Mercy Corps, Ethiopia

Farmers can exchange locally available landraces to diversify their permagardens.

Moringa oleifera is a multi purpose tree that can provide fertility for soil, nutrition for a family, shade, and fencing material.

Photo Credit: Harvey McDaniel, Wikipedia

Seed and plant stock availability and sources

Farmers can often access landraces through neighbors, friends, and family who have seeds or cuttings. Many perennial plants, such as lemongrass, aloe, bamboo, sweet potato, and sugarcane can be divided or cuttings rooted and replanted. Fodder plants and grasses can similarly be divided and planted strategically to provide food for animals. For productive living fences, plants like dovyalis, *Tithonia*, *Bursera* (for dry regions), *Gliricidia*, *Euphorbia*, *Jatropha*, and *Moringa* are easily propagated. Where possible, farmers should also be encouraged to save seeds and preserve their own plant stock, though local input suppliers might be contacted to provide certain varieties of improved or locally adapted seeds. In addition to the current season, farmers should also be thinking about future planting cycles. There are many effective and affordable traditional approaches to seed saving and preservation[5] for farmers to consider, as well as community seed banks and local seed networks.[6]

The seeds and planting stock used in a permagarden should reflect a household's diverse needs for food and other resources, such as fodder, mulch and other soil amendments, fuel, shade, medicine, and income. Having a variety of crops can diversify household diets and allow for harvesting at many different points throughout the year. When deciding what food crops to plant, households should consider the various harvest stages and what can be planted to supply food or income during the lean season. In most areas, there are many different local varieties of greens, pigeon pea, squashes, beans and other vegetables, as well as tree crops such as moringa, avocado, mango and papaya.

Households also have different preferences based on taste, cooking time, availability, days to harvest, and storage, all of which should be considered when deciding which crops and trees to grow. Some contexts contain more diversity than others; program staff can encourage farmers to think about what local plants and crops can be used to build canopy layers into their compounds rather than focusing on adding specific species.

5 Taruvinga, C., Mejia, D., and J. Alvarez (2014). Appropriate Seed and Grain Storage Systems for Small-scale Farmers: Key Practices for DRR Implementers. Published by FAO. Available at: https://www.fao.org/3/i3769e/i3769e.pdf

6 FAO (2014). Community Seed Banks: Junior Farmer Field and Life School. Available at: https://www.fao.org/3/i3987e/i3987e.pdf

Integrating animals

In addition to plants, permagardens integrate animals into a compound whenever possible. Most households around the world already keep a variety of livestock and poultry. The more diversified the types of animals on a compound are, the more diversified services and products they can provide. Households should be encouraged to think about how the byproducts and benefits animals provide can support the permagarden and wider compound, including:

- Manures
- Waste cycling
- Horns, hooves, skins, feathers
- Traction and transport
- Lean season support
- Easily fungible assets
- Consumption of insect and other pests
- Alarm and protection
- Meat, eggs, and milk
- Income support

Under the Permagarden Approach, farmers look for ways to use animals and their byproducts within the production system whenever possible. For example, farmers might: place small birds, such as chickens or guinea fowl, into crop areas for a punctuated period when plants are mature enough so the birds can consume insect pests; mix a diversity of manures into deeply prepared soils for long-term production; burn and crush animal bones to make a calcium-rich soil amendment; and/or use chickens to cycle kitchen waste into nitrogen-rich manure. When designing a permagarden system, farmers purposefully locate their animal kraals upslope from their growing areas to allow the nutrient-rich manure and urine to passively flow downhill to the crops and trees below.

Farmers also design the permagarden and surrounding spaces so that it better meets the needs of the animals. This helps to ensure good health and optimal conversion of animals and their waste into useful products and services. A steady diet of fodder crops significantly increases both the weight of animals and the quantity and quality of milk from goats or cows kept at the homestead.

Key considerations to think about when incorporating animals into a homestead should include:

- **Strategic shade:** Plant a tree on the west side of a kraal or animal house to increase shade and reduce the intensity and dehydrating nature of the afternoon sun.
- **Year-round fodder:** Plant multiple types of perennial fodder on berms or around the compound so that feed is available at all times of year.
- **Protection:** Ensure animals are safe during both the day and the night.
- **Clean water**: Ensure animals have water at all times.
- **An overall healthy environment:** Keep animals' environment clean by removing waste and bedding regularly, and using it for composting.

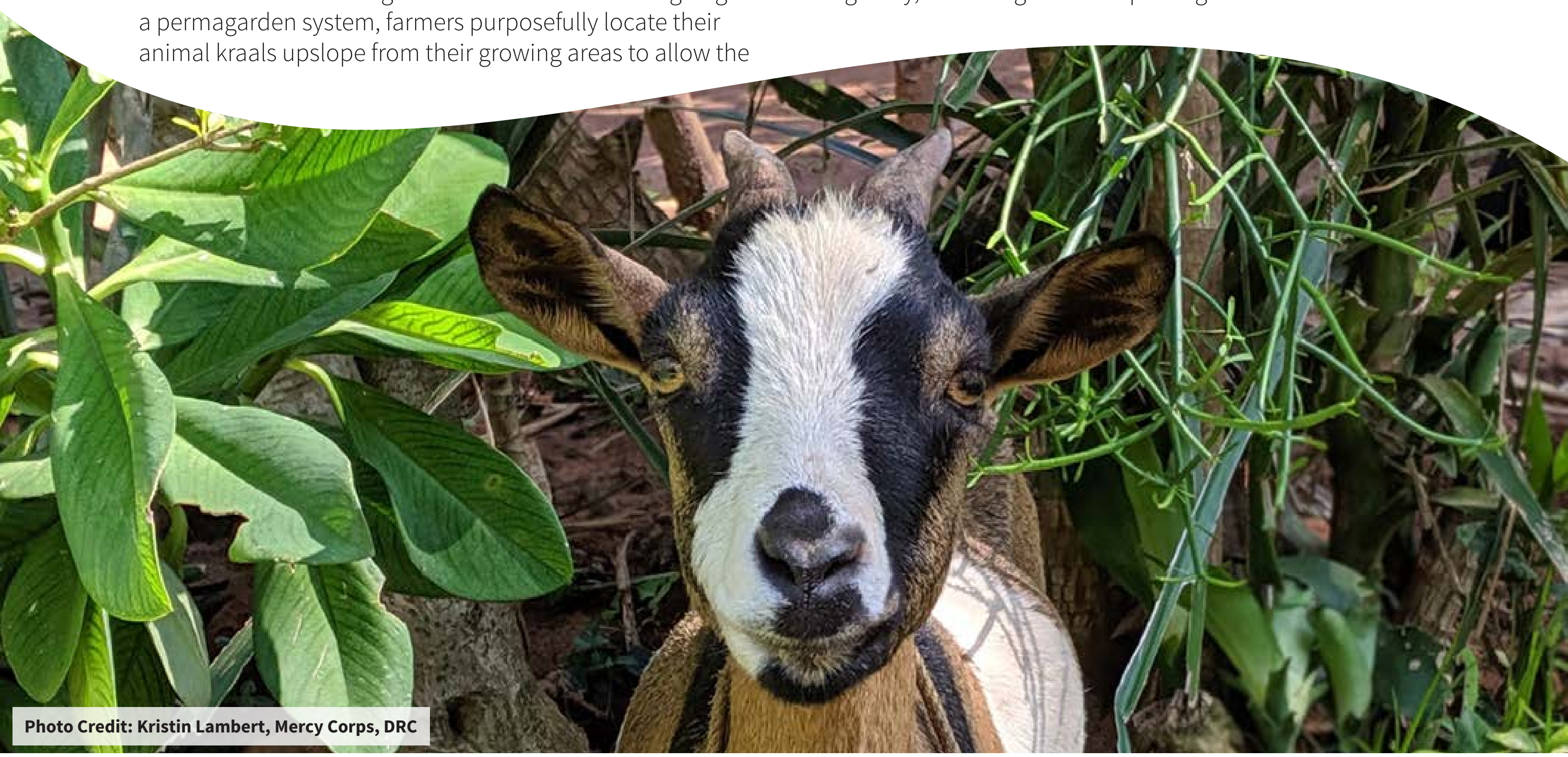


Photo Credit: Kristin Lambert, Mercy Corps, DRC

Photo Credit: Warren Brush, contracted by Mercy Corps, Kenya

SECTION THREE

Photo Credit: Thomas Cole, contracted by HIAS, Chad

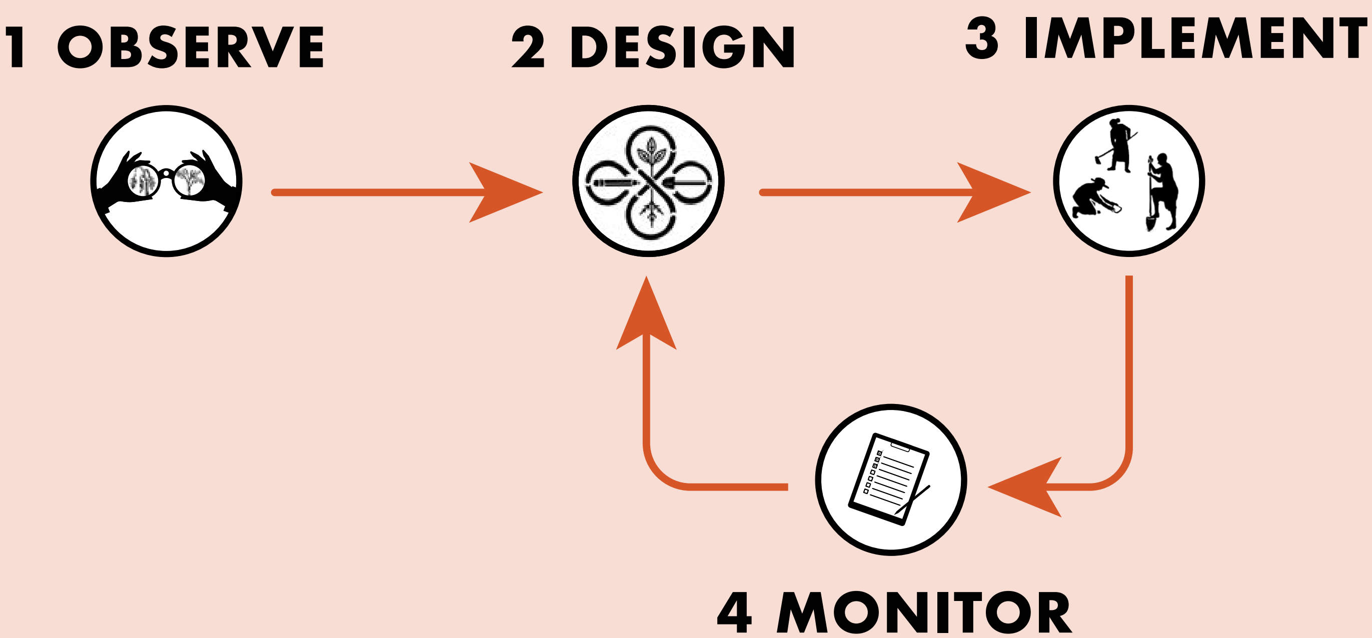
Four Steps to Developing and Maintaining a Permagarden

A Four-Step Process

Program staff can teach farmers how to create a permagarden through a four-step process consisting of observation, laying out the garden design and, finally, constructing the permagarden. By pausing to observe their landscape and create a design before they dig, farmers can develop gardens that are more likely to be productive and to meet their household needs, even when faced with significant resource and environmental constraints. The process outlined in this manual is intended to help program staff strengthen farmers' capacity to build context-appropriate garden designs and to care for their gardens through ongoing learning and adaptation. This process can also build farmers' motivation to cultivate and use locally available plants, animals, and other resources within their compound.

Training farmers in this process is highly participatory. Program staff lead farmers through a facilitated 3-day training whereby farmers have the opportunity to build a demonstration permagarden at a household chosen by the community. Program staff then work with farmers to reinforce key concepts as they establish gardens on their own compounds. Often program participants work together to establish these gardens, and program staff are there to encourage them to think about each one of the minimum standards as they design and construct their gardens.

See Minimum Standards details on page 9



Observe

The first step of the process is for program staff to engage farmers in an observation and reflection process to better understand the context, history, needs, and aspirations within their community and individual households.

This process of reflection is instrumental to the success of every permagarden, no matter where in the world it is located. It is during this period of observation that farmers see how they will use their existing knowledge, and the resources they have around them, to design a garden that works with their landscape. They will also see how the garden can be designed with their own individual household goals in mind. A trained facilitator can guide farmers through these realizations and build their motivation for fully engaging in the process.

The Observe step has four major components:

- Community dialogue
- Resource identification
- Site assessment
- Mapping the compound

Community dialogue

The community dialogue has multiple goals. First, program staff orient farmers by asking questions about the historical context of the land. As farmers reflect on how their community has changed over the years, program staff use the discussion to set farmers' intentions for how they would like their land to be in the future and draw the links between a healthy environment, poverty reduction, and household resilience. A list of guiding questions for this dialogue is found in the Conduct a Community Dialogue section. The themes of this conversation, and the goals put forth by farmers, will be referenced throughout the permagarden design process.

It is important for program staff to remember that each person within a household will have their own goals and opinions, and this diversity of opinions may not be well represented in the community dialogue. For example, household members might think differently about what to eat within the home or what type of livestock or crops are a better investment. Each of these views are equally relevant and it is important that — at some point in the process — all members of a household contribute to the compound design and choice of crops.

Conduct a Community Dialogue Exercise details on page 67

Photo Credit: Kristin Lambert, Mercy Corps, DRC

Community dialogue is a vital first step for community members to articulate their aspirations, goals, and opinions.

Resource identification

Many farmers have been told for decades that expensive inputs must be purchased for plants to grow well. While it is true that plants need nutrients, water, viable seeds, and workable tools, purchased inputs are not the only way for farmers to build healthy, productive gardens. A garden built primarily around purchased inputs may actually undermine the long-term resilience of the growing system both from an environmental perspective (use of synthetic pesticides, for example, can decrease natural insect predators and soil biota over time) and a financial one, as the cost of inputs may prove unsustainable for some farmers. Market and supply chain disruptions due to social unrest or other crises can further limit the productivity of a garden that is dependent on purchased inputs. In every community, however, there is an abundance of resources available that can be used to boost crop production. These resources may be found in places where people discard waste, or they may be growing wild, or their value as a productive input may be unknown or underrecognized by the community.

What are resources?

A resource is something that can be used to improve a site; this includes **natural** resources (e.g., land, soil, water, plants, trees); **man-made** resources (e.g., farm buildings, human labor, tools, containers), and **agriculturally-derived** resources (e.g., food products, mulch).

Often, resources are useful items that are already in farmers' personal or communal possession, such as land, seeds, bicycles, animals, unused organic material, plants, leaves, and tools. They also include social assets, such as helpful people and social networks.

Resource Walk and Discussion: identifying and valuing what is available locally

A resource walk and discussion help to identify locally available resources that are already known to farmers. When program staff invite farmers to walk around their home, neighborhood, or village, farmers often highlight many resources that can be used to construct a permagarden. They identify water sources and flows; plants that could be used in the permagarden; materials for mulching, composting and fencing; and planting material or seed stock. They take note of 'waste' materials that can provide water and nutrients to plants, such as wastewater, kitchen scraps, crop residue, animal manures, and wood ash. As they walk, program staff encourage farmers to note down the location of these resources and gather samples of them for the discussion that will follow. This discussion is driven by farmers and is an opportunity for them to showcase their own individual knowledge about the subject, while also learning from one another. Farmers often end the discussion with a new appreciation for local resources, awareness of their own knowledge about how to use them, and confidence in their ability to build a successful garden without outside assistance.

Conduct a Resource Identification
Exercise details on page 69

Photo Credit: Warren Brush, contracted by Danish Refugee Council, Kenya

A resource discussion is driven by farmers and is an opportunity for them to showcase their own individual knowledge about the subject while also learning from one another.

Types of resources to consider

Water:
Farmers may identify a number of different water sources that can be used for permagardens during their walk:

- **Water Points:**
  Village boreholes, municipal taps, and nearby streams, ponds, and rivers

- **Rainwater:**
  Direct rainwater and underutilized runoff water from roofs, hillsides, roads, and compacted surfaces and pathways from within and nearby the compound

- **Wastewater:**
  Kitchen, bathing, handwashing, ablution, dish drying, and clothes washing water

Waste:
Organic waste often contains a variety of nutrients plants need to grow well. Community and household waste streams are an important, yet underutilized, potential source of these nutrients. They include animal manures, crop residues, green and brown leaves, charcoal dust, milling waste, bone dust, biochar, wood ash, coffee grounds, and kitchen waste, as well other forms of organic waste identified by farmers. Some organic waste materials, such as human and dog excrement, contain pathogens that are harmful to humans and should never be used for crop production. All manures should be composted or left to dry before they are used in the first 30 cm of a garden bed.

Animals:
Animal resources include cows, goats, donkeys, chickens, rabbits, and other small mammals and fowl. Livestock and fowl are nutrient cyclers and important sources of meat, milk, bones, feathers, blood, manures, traction, transport and other daily uses. They can also provide an important income source as they are easily sold in the market.

Trees:
Trees provide many important products and services, such as food, fodder, fuel, soil amendments, fencing, medicines, cooling and shade, erosion control, and potential marketable products.

Plants:
Plants have a wide variety of uses and functions that can be considered when building a permagarden. These include nutrition, income, ceremony, brewing, dry season varieties, soil fertility, fodder, medicines, and construction.

Seeds and planting material:
Quality seeds, seedlings, and other plant material can be procured from a mix of formal and informal sources to construct a permagarden. Seeds for many culturally appropriate and widely grown crop varieties are readily available within informal seed markets and other community outlets. Neighbors, friends, and extended family may also have plant material they have saved and multiplied and are willing to share, sell, or barter. Additional context-specific sources of local seeds may also be explored. In many dryland communities, for instance, farmers use the seeds of valuable fodder species found in the piles of manure located around the homestead. Even after several years of drought, these seeds remain viable and germinate when given moisture.

People:
Neighbors or other community members often have valuable knowledge that can be tapped to develop a permagarden. Model farmers and others with garden expertise in the community can help demonstrate best practices and innovations. During a resource walk, farmers can take inspiration from the successful techniques they observe. They can also connect to successful sellers in the marketplace to learn important information about what can be grown and sold on a regular basis for steady income.

Tools:
A permagarden can be created with only a few basic tools. The essential tools include a hoe, bucket, pick, machete, twine, and an A-frame. Additional tools that are helpful to have include rakes, watering cans, empty grain sacks, hand pruners, and digging bars.


Photo Credit: Thomas Cole, contracted by Mercy Corps, Kenya

Manure piles can be reservoirs of valuable seeds ready to germinate.


Photo Credit: Elin Duby, contracted by Mercy Corps, DRC

Farmers often know of numerous local plant and animal resources that can be readily found within their community.

Site observation

The resource walk is often coupled with a site observation process. During the site observation, program staff walk with farmers again around the site to observe and discuss key features of the landscape. Farmers note the main structures present on the site, any existing vegetation, important pathways, and water points. They also spend time observing how external influences, such as sun, wind, slope, animals and humans are affecting the site and complete an activity called “walking the water.”

External influences include any element that impacts the compound or garden site, either natural (e.g., sun, wind, and slope) or man-made (e.g., roads, domestic animals, or even other humans). Observing these factors closely will help inform the farmers’ approach to designing their garden; for instance, they may decide to incorporate features to protect plants from external influences that could negatively impact growth, such as a harsh afternoon sun.

When “walking the water,” farmers spend time learning how water flows across that particular landscape. Starting at the top of the compound, farmers look for signs of water flowing downhill to determine the direction of the slope. They note any signs of damage caused by water — for example a walkway that has been washed away, a channel cut by gully erosion, or a compound wall that has been damaged — and if the water flowing downhill is causing nutrients to flow downhill too. Runoff may be particularly nutrient-rich if it is passing through a fertile area like an animal pen or a composting site. Program staff can also instruct farmers on how to use an A-frame to mark the key contours of the site at this time. This information is used later to plan the placement of water harvesting structures.

Conduct a Site Assessment details on page 71

Components of a site observation

1. Location and orientation of household structures
2. Existing plants, trees, domestic animals, and waste resources
3. Influence of external influences: sun, wind, and slope
4. Understanding water flow by “walking the water”


Photo Credit: Thomas Cole, contracted by HIAS, Chad

Farmers participate in a “walk the water” exercise.

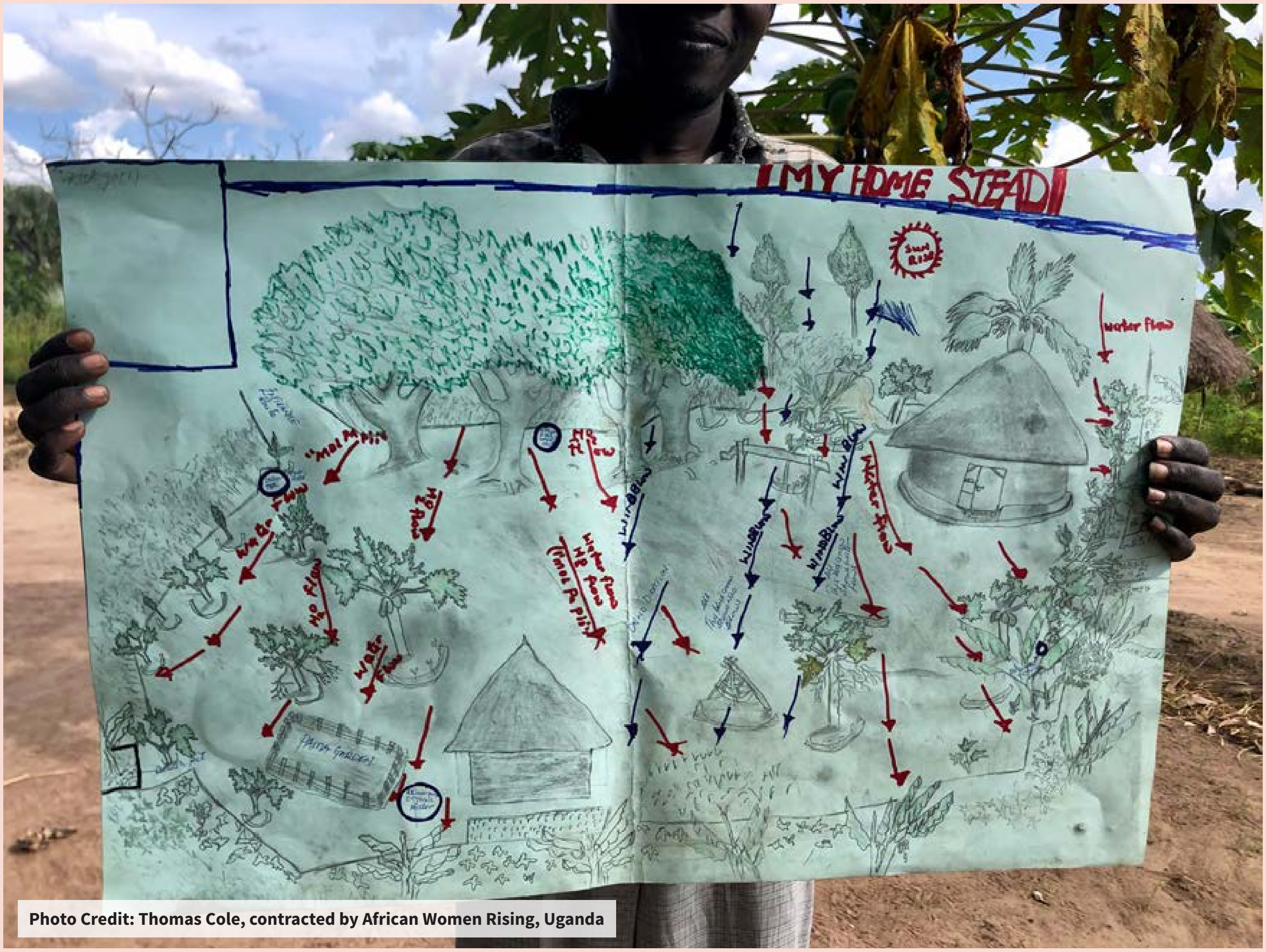


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Farmers create maps to better understand elements within their environment and to ensure their design works with these elements.

Mapping the site

The last step in the observation process is for farmers to develop a site map that ties all the observations together. The map contains important structures, animal kraals, water points, pathways, and existing vegetation. It also identifies the locations of the key resources farmers found throughout the site and any external influences they noted. Sun, wind, slope, and water flow can be depicted using arrows. The map can be done on paper with pens or on the ground with sticks and rocks, depending on what is available. Program staff can use this initial map as the base for the eventual permagarden design map that will contain all the decisions farmers make.

Design

A permagarden design is a plan for creating a garden that encourages healthy production by taking into consideration landscape characteristics that can impact plant growth, such as sun, wind, and slope. Each permagarden design is specific to the site where the permagarden will be located. The design maximizes the use of locally available resources and is created with the goals and needs of the household in mind. To develop a permagarden design, program staff work with farmers to determine how the observations they made around their community can be used to plan a garden that supports plant growth. These decisions are then recorded on the map of the site.

Leading a design discussion

Program staff should use a set of guiding questions to help farmers analyze the observation data they collected.

1. How can the resources we identified be used to meet the basic needs of the plants in the permagarden?
2. How much labor is required to use these resources and are there ways to reduce this burden? How can we reduce the workload required to maintain the garden for household members who do the most work?
3. Is the slope stealing our water and nutrients by moving them downhill, away from our garden? What do we need to do to bring water and nutrients to the garden and store them there for future use?
4. Are the other external influences we identified helping or harming the plants in the garden? How can we ensure we protect our garden and turn challenges into solutions?
5. Where should we place garden elements in our compound to use resources most efficiently? Are there unused spaces that can be used to increase production?

Program staff use this discussion to help farmers develop a strategy to manage water within the compound and around the permagarden beds, to build soil health within the beds, and to increase biodiversity wherever possible. The design should protect plants from any negative impacts of sun, wind, and slope that may be present in the landscape and any people or animals that may introduce risks.


Photo Credit: Elin Duby, contracted by Mercy Corps, DRC

Farmers design the permagarden together in the DRC.

Creating a garden design with farmers

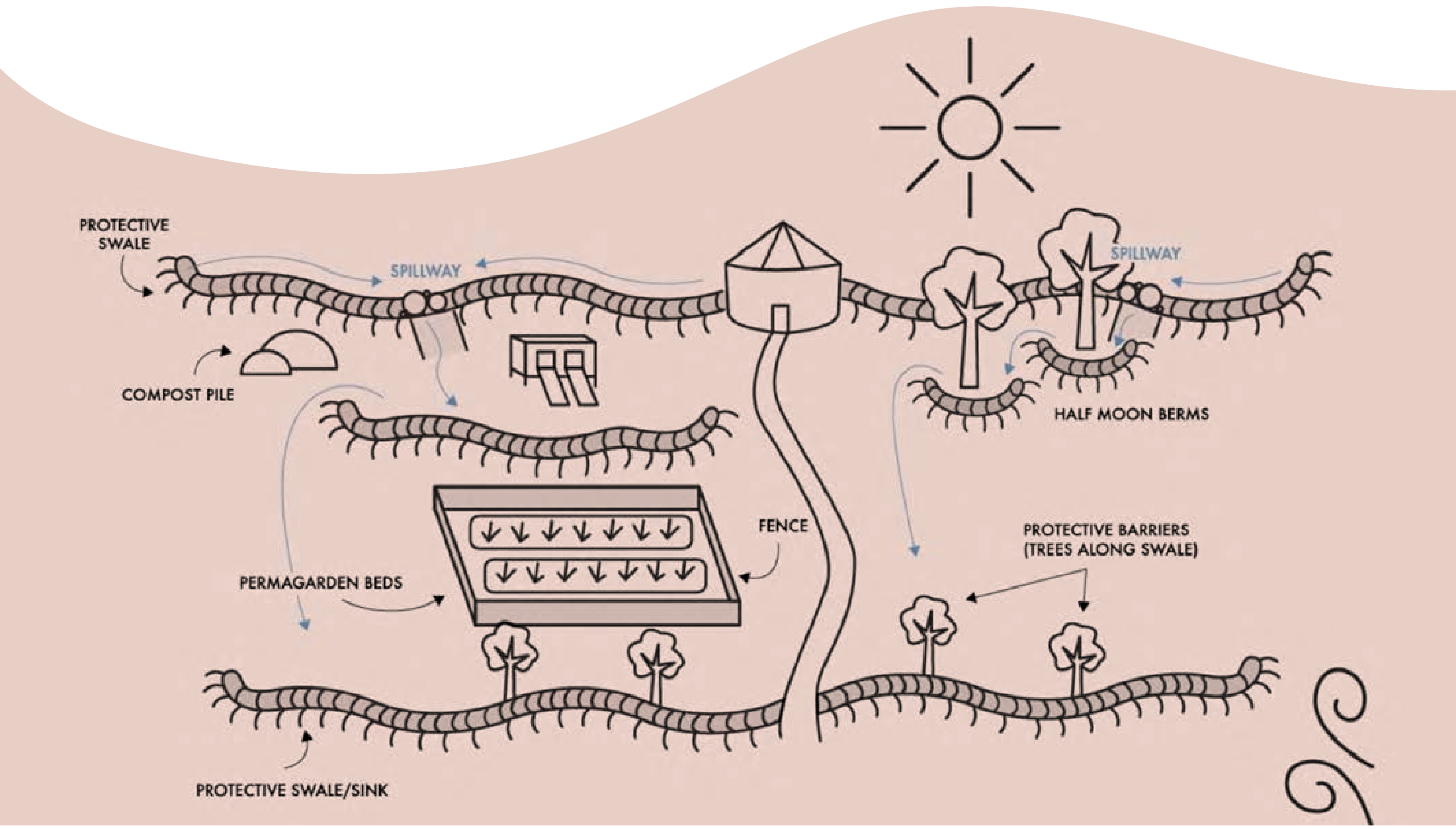
Program staff can guide the design discussion by suggesting that farmers first decide where the permagarden beds should be placed and noting that on the map. Following this decision, farmers can decide where the swales and other water harvesting structures will be placed. Program staff should remind farmers to map the water flow from the highest water harvesting structure on the site to the lowest and think about how to create spillways that pass water from one structure to the next.

Program staff can then suggest farmers decide where to place composting areas and animal pens so they work with the location of the garden beds and the water flows present on the site. An important part of the design process is recognizing the value of the waste streams in the household and community. Much of the discarded water, organic waste, and animal manures that are commonly found in a compound can be used to support the growth of plants and animals. During the design process, farmers make a plan for how to use these resources.

The group will then decide what strategies can be used to protect plants from external influences, such as strong sun and winds, people, and grazing animals. Last, program staff can lead farmers in a discussion around what should be planted in each growing area so that the nutritional and economic needs of the household are met. Although it can be helpful to work loosely in this order, in reality, the discussion will frequently jump around as ideas are added to the map.

Steps to creating a garden design

1. Determine the location of the permagarden beds.
2. Situate water harvesting structures within the landscape.
3. Determine the location of composting areas and animal pens.
4. Add protection elements, such as fencing, shade trees, and wind blocks.
5. Create a planting plan.



Creating a garden map helps farmers make sure they are using their space and resources efficiently.

Situating the permagarden beds

Permagarden beds are most frequently situated so they are easily accessible to the kitchen, but they can be located anywhere near the home that is suitable to the household. Pemagarden beds should always be oriented so they are perpendicular to the slope and along the contour. The size of the permagarden is dependent upon the amount of water available and the level of energy the farmer is willing to commit. Permagarden beds can be as small as 2 m^2 (e.g., 1 m by 2 m) in land-constrained areas, such as urban and peri-urban plots or in refugee or internally displaced person (IDP) settings, or as large as 100 m^2 (e.g., 10 m by 10 m). In times of the year with limited water, the farmer may choose to use fewer garden beds; likewise, the farmer can add more beds if they have greater access to water and are motivated to do so.

It is important to start small because a permagarden that is larger than a farmer can manage will quickly discourage them from continuing. Once the farmer has the understanding and skills to manage the garden effectively, then they can explore increasing the size.

Choosing the best location for the garden is important. Ideally, the chosen permagarden site should have the following:

- at least 4 hours of sunlight a day (in dryland settings, partial sunlight is often preferred);
- linkages to rainwater harvesting structures within the compound;
- close proximity to a source of nutrients to fertilize the permagarden beds; and
- protection from extreme winds, livestock, or other damaging elements.

Designing for optimal water flow

Program staff should encourage farmers implementing the Permagarden Approach to actively control water flow throughout their compound. During the design phase, a farmer will first determine where runoff water enters their compound and how this water proceeds to flow through the site. As water flows across the land, it can also carry nutrients from other areas, including topsoil, manure, and organic material. In dry regions, the aim of the permagarden design is to channel as much of this nutrient-rich water as possible into and across the garden area.

Once there, it can sink into the soil and be "banked" for future use by crops. In wet regions, the aim of the garden design is to help mitigate flooding by diverting excess water away from the garden. In addition to the appropriate use of swales, berms, and other water harvesting structures, water flow can be controlled through deep soil preparation, mulching, the planting of vegetation, and one-rock check dams. Using a combination of these techniques can significantly increase the amount of water infiltrated and banked in the soil.[7]

Construct Water Harvesting Structures details on page 75

7 Bot, A., & Benites, J. (2005). Creating drought-resistant soil. In FAO Soils Bulletin 80, *The importance of soil organic matter: Key to drought-resistant soil and sustained food production* (Chapter 5). ISBN 92-5-105366-9

Designing for nutrition

Food security and nutrition programs often aim to augment household diets by encouraging consumption of nutrient-rich fruits and vegetables, especially brightly colored orange or yellow fruits and vegetables and dark leafy greens. Many also promote increased consumption of healthy animal-source foods, nuts, and legumes. However, many households consider these foods unaffordable and/or may have low access to them, particularly during the peak hunger season. Permagardens should be designed so they mitigate some of the challenges to healthy eating that exist within the region of interest.

When thoughtfully designed, a permagarden can provide households with access to a wide variety of healthy foods throughout the year. To start, planting decisions can be made so that the garden improves household access to fruits and vegetables by containing a wide diversity of these foods:

- Brightly colored fruits and vegetables, especially orange, yellow, and dark green traditional leafy vegetables, which have higher levels of vitamins and minerals than light colored vegetables, such as onions
- Vegetables and fruits with edible seeds that are high in fat, protein and minerals (for example, pumpkin seeds or melon seeds)
- Legumes and nuts that are high in proteins, vitamins, and minerals

Successional planting techniques can be used to extend harvest periods throughout the season and prevent the food losses that result from the crop maturing all at once.

Dry season food shortages can be reduced through several methods: planting crops that mature during the dry season, such as pigeon pea; keeping garden plots alive longer with shade structures and wastewater; and seeking out perennials that produce food for consumption or material that can be sold or exchanged for food items when gardens are not producing.

Household food access can be improved by using a combination of these strategies; however, this may not be enough to improve household nutrition. For household nutrition to improve, each individual in the household must consume a greater variety of healthy foods. Program staff can encourage this by pairing permagarden training with lessons about food planning, purchasing, and consumption, ideally including hands-on activities to prepare and eat balanced meals as a household.

Permagardens can improve access to diverse, nutritious foods.

Linking strategies

Permagarden designs come to life when soil, water, biodiversity, and protection strategies are linked together. For example, the overflow from each water harvesting structure should be mapped so that there is a plan for how it will travel from the top to the bottom of the site. Along the path of the water flow, points can be found to plant species that use the banked water and add biodiversity to the compound. A plan can then be devised to improve soil fertility wherever new plants will be placed, which could mean a compost pit or animal pen is placed nearby. Finally, a plan can be developed to protect these crops and animals from harsh winds, sun, flowing water, grazing animals, and humans. This could mean a fence, windbreak, shade tree, or protective swale is added — all of which are additional opportunities to increase biodiversity at the site and will need their own soil fertility and protection plan.

10% rule

Multiple small interventions linked throughout the compound can significantly increase a household's resilience. This is called the 10% rule. If a farmer increases the productive capacity of each growing bed, tree, or other useful crop by just 10%, this combined benefit can help to stabilize food availability and income.

A whole compound approach

In an ideal permagarden design, the entire household compound is considered for its potential to produce crops, trees, and other valuable products. Program staff can encourage farmers to expand beyond their initial garden beds by:

- Adding a half-moon water harvesting structure to an existing tree.
- Mulching additional plantings outside the garden beds.
- Designing a spillway from a swale so that water flows to a second productive area, such as a high value tree, a half-moon basin, or mulch basin.
- Situating the sleeping area of domestic animals up slope from a water harvesting structure to capture nutrients flowing downhill.
- Situating a granary or other household structure so that it serves as a windbreak or shade structure for garden beds.
- Expanding production by growing vertically on existing fences and/or walls.
- Discarding wastewater from kitchen, bathing, and washing into an intensively-planted mulch basin for year-round production.
- Establishing trellises for climbing plants to grow over swales to create additional productive space and protect water resources from evaporation.
- Directing excess moisture from dish racks into a garden or tree planting.
- Adding tree plantings near latrines, or former latrines, to use these nutrients and create a canopy to provide visual screening.
- Integrating perennial plants whose leaf litter and prunings can be added to soil to build fertility.
- Adding a mulch basin near a bathing area to use this water for tree and crop production.
- Situating shade trees so they cool the gardens, animals, household structures, cooking and dishwashing areas, and provide gathering spots during the afternoon.
- Capturing rainwater from rooftops in a pit or swale so it can be used for plant growth.
- Sweeping waste from the compound into a pit so it can compost and serve as a soil amendment.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

When a farmer is comfortable implementing permagarden techniques, program staff can encourage them to expand to new areas of their compound.

Implement

Program staff can lead farmers through the following steps to transfer their designs onto their compounds. It is not necessary to follow the steps exactly in this order but doing so can help ensure structures do not need to be dug again due to a miscalculation. Program staff can also design their training around these steps as a way to organize the activity.

Steps to constructing a Permagarden

1. Draw garden design onto the soil.
2. Mark out and peg the key contour lines.
3. Dig the water harvesting structures and spillways.
4. Double dig the garden beds.
5. Amend and level the garden beds.
6. Dig and construct the fences.
7. Plant, water, and mulch the garden beds, water harvesting structures, and fences.
8. Reinforce the spillways.
9. Add any additional elements, such as mulch pits, animal pens, wastewater basins, and new trees, to the compound.

The first step is to transfer the design map onto the soil with a stick or hoe. This step helps ensure that all the elements of the permagarden are the appropriate size and in alignment with one another. Program staff and farmers can use a stick to scratch an outline of each design element into the soil, being sure to mark the garden beds, pathways, fence lines, access gates along the fence lines, water harvesting structures and spillways, and tree holes. Often, these initial markings will need to be redrawn to allow for adequate space to walk around the garden beds, kneel down when working, and use tools within the garden. Program staff should encourage farmers to think about how large a space is needed to accommodate mature plants within the permagarden beds, water harvesting structures, and fence lines. By encouraging farmers to mark these elements in the ground before digging, program staff can help farmers save time and labor that would be spent digging structures again that are not well-situated.

With the permagarden design satisfactorily transferred to the soil, program staff and farmers can mark out and peg the key contour lines that will be used to orient the water harvesting structures and beds to the contour. Program staff can take this opportunity to remind farmers that the A-frame must be calibrated each time it is newly used to ensure it is accurately identifying the contour line. Starting at the top of the compound, program staff can guide farmers through the process of digging the water harvesting structures and linking them through spillways. This is a good opportunity to discuss the proper dimensions of a swale, half-moon berm, and spillway with farmers and to demonstrate how to create sloped sides and a level bottom. After the main water harvesting structures are in place and linked, program staff can demonstrate how to orient the permagarden beds along the contours of the slope, then double dig, amend, and level them. Prior to planting the beds, the group should construct a fence around the beds to protect the young plants that will be growing there. After a protective fence is in place, farmers can plant, water, and mulch the beds. If time allows, the spillways can be reinforced with rocks and/or planted grasses, additional structures can be dug, and new trees can be planted. These activities can also be saved for a follow-up training when farmers return to the site to observe the status of the garden.

Build and Calibrate an A-Frame details on page 65

Photo Credit: Warren Brush, contracted by Mercy Corps, Timor-Leste

Pegging a contour with an A-frame in Timor-Leste

Digging an on-contour swale

Double digging garden beds

Leveling double-dug garden beds

Constructing a productive fence around a permagarden

Working together to implement the permagarden design

Recapping the steps needed to create a permagarden

Creating protection through fencing

The importance of strong fencing around a permagarden cannot be overstated. Without this simple structure, damage from wildlife, livestock, wind, and people is inevitable. Besides providing basic protection, a fence can serve a multitude of other functions, particularly if a "living fence" is planted. A living fence uses trees, shrubs, vines, grasses, and other plants as part of the fence. In addition to forming a physical barrier around the garden space, these plants can provide shade and wind protection for the garden and food, fodder, fiber, and green manure for the household. Intensively packing the fence with a wide variety of plantings provides additional resources to the farmer while taking advantage of a space that is generally not used.

Living fences reduce the need to rebuild the fence each year, but they take time to become fully established. As this lengthy period cannot be avoided, a strong fence built of local materials should be integrated with the living components of the fence. Commonly found local materials, such as wood, bamboo, thatch, and thorny branches are integral to this process.


Photo Credit: Thomas Cole, contracted by HIAS, Chad


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Protecting a newly planted tree with fencing in Djabal refugee camp, southeastern Chad


Photo Credit: Kristin Lambert, Mercy Corps, DRC


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Living fences can be made with a variety of different plants to further enhance the yields attained by farmers.

Construct a Living Fence details on page 98

Multi-purpose plants to incorporate into a living fence

	Additional Uses / Benefits							
Tree/Shrub	Leguminous nitrogen fixer	Material for green manure and compost	Fodder	Firewood	Poles and other building material	Food	Protection	Pest control
Gliricidia sepium	✓	✓	✓	✓	✓			
Kai Apple *(Dovyalis caffra)*						✓	✓	
Leucaena leucocephala	✓	✓	✓	✓	✓			
Sesbania grandiflora	✓	✓	✓	✓	✓			
Tephrosia vogelii	✓	✓		✓				✓
Pigeon pea *(Cajunus cajan)*	✓							
Sisal, Acacia species					✓		✓	
Vetiver, Elephant, Napier grasses, alfalfa, sugarcane		✓	✓					

Biointensive planting methods used in permagardens

The planting methods used in permagarden beds take advantage of the uncompacted soils present in double-dug beds to maximize diversity in a small space. The methods discussed below are often used in conjunction with one another to optimize productivity. They can also extend the harvest season so households have access to garden produce for longer.

Use of a household plant nursery and transplanting

Plant nurseries can benefit farmers in several ways. First, plant nurseries can reduce water use when plants are young because seedlings are closely grouped together in a shallow vessel. Nurseries also allow for greater protection of young plants, less overall seed use, and more uniform spacing in a garden bed when plants are transferred. Seedlings can be started while other crops are occupying bed space so the time between harvests is reduced.

Transplanting is used to select the healthiest seedlings and transfer them to the prepared garden bed. This results in less wasted space in garden beds from seedlings that did not survive. When deeply preparing the beds by using methods such as double digging, farmers can space plants closer together than they are used to. Less space is needed between the plants because the deeply prepared beds allow the roots to go down deeper into the soil rather than being forced sideways in search of nutrients.

Plant a Biointensive Garden details on page 91

Biointensive planting

In conjunction with deep soil preparation, biointensive planting uses a triangular approach to planting crops, rather than the usual square or rectangular pattern found in most gardens. Triangular planting means that seeds or seedlings are placed in slightly offset rows from each other so that the distance between any two seeds/seedlings is equal and an imaginary triangle can be formed between any three sets of seeds/seedlings spanning at least two rows. This pattern allows for a greater density of plants per square meter and creates a closed canopy when crops mature. In traditional square or rectangular planting, space is often left unused between rows. Uncovered soils are prone to weed growth, moisture loss, and erosion and are a missed opportunity for crop production. Alternatively, a closed canopy optimizes sun exposure to the leaves and shade over the soil, increasing photosynthesis and decreasing moisture loss from evaporation. No bed space is left unused in biointensive planting. Deep soil preparation is preferred for biointensive beds because it allows roots to grow downward with less stress and alleviates competition for soil space in the upper region of the bed.

Crop rotation

Crop rotation is the practice of moving different varieties of crops from one bed to another, or from one place in a bed to another place in the same bed, from season to season. Rotating crops in this way can diversify the way nutrients are used and added to the soil. Crops are rotated in a way that nutrients are taken from different zones of the soil, and in different quantities, depending on where their roots primarily grow. For example, nutrients that are out of reach for root crops can be pulled from deep within the soil profile by deeper rooted crops, like melons. As roots grow and die within the soil, they add additional SOM to the soil, which feeds soil life and improves soil structure. Crop rotation can also reduce disease and pest pressures because changing the crop family regularly makes it likely a non-host plant will be planted in that soil the subsequent season. Since permagarden beds do not change location season to season, the farmer only needs to change what was planted in each bed according to a good crop rotation plan. Crop rotation plans often recommend rotating between leaf then fruit then root then legume crops.

Rotate Crops
details on page 74

Intercropping

Intercropping is the practice of growing two or more crops in the same space at the same time. Intercropping pairs together plants with differing yet complementary characteristics so that the space both within the soil and above the bed is used fully; for example, pairing plants with erect growth patterns together with those that have spreading growth patterns and plants with taproots together with those that have branching roots. Groups of plants that grow well together are known as companion plants. A common companion planting is known as the "Three Sisters," which consists of maize, climbing beans, and pumpkins. Frequent intercropping of beds can take the place of crop rotation since having a high plant diversity present in each bed can also reduce disease and pest pressures and diversify how nutrients are used within the soil.

Some of the important practices of intercropping include:

- Planting shallow- and deep-rooted plants together to optimize root space within the soil profile.
- Mixing slow- and fast-growing crops in the same space to limit root and sunlight competition.
- Growing heavy feeders with light feeders and/or nutrient-fixers (e.g., climbing beans with maize).
- Incorporating aromatic plants that might repel certain pests from the growing area.
- Planting flowering plants that attract beneficial insects ('good' bugs that eat 'bad' bugs).
- Growing plants that serve different functions, e.g., spreading plants to serve as ground covers, tall crops to provide shade, etc.

Succession planting

Succession planting can mean either planting crops at staggered dates to harvest at different times, or planting a new crop in the bed as soon as the last one is harvested. With proper management, succession planting allows for an extended harvest season and, sometimes, a continuous harvest of vegetables. When crops do not all mature at once, it allows households to gradually sell them for additional income. It can also reduce food loss.

Example of succession planting with amaranth

STEP 1. Gather local amaranth seed.

STEP 2. Smooth and prepare the first ⅓ of the length of a garden bed.

STEP 3. Broadcast seeds or plant seeds in grooves 10-15 cm apart. Cover and water seeds.

STEP 4. Wait two weeks.

STEP 5. Repeat seeding, covering and watering on the next ⅓ of the garden bed.

STEP 6. Wait two weeks.

STEP 7. Repeat for the final ⅓ of the bed.

STEP 8. Harvest from the first ⅓ of the bed.

Plant health

A healthy plant is the product of a healthy growing environment. Maintaining a healthy soil, minimizing water stress, and creating a biodiverse environment that suppresses plant diseases and reduces pest infestations all contribute to the health of a plant. In addition, regular weeding and pruning — the removal of unnecessary parts of the plant to promote growth — are two key management practices that keep plants healthy. At times, however, plants need extra protection or a boost of food in order to stay healthy.

Liquid fertilizers

There are many ways to fertilize plants using recipes that farmers can make themselves. Some of these are botanical and manure teas that can be applied after the plant starts growing in order to provide easily accessible nutrients. Botanical and manure teas can be made from manures, vegetable waste, fish and animal offal, and plant leaves that are gathered locally. The inputs are steeped in water, the solid materials removed, and the liquid applied to crop leaves or around the base of the crops. Crops, trees and other useful plants growing throughout the household compound can be fed with some form of liquid fertilizer every 2-3 weeks to help support plant growth, improve yields, and resist pests.

Make and Apply Botanical and Manure Teas details on page 93

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Organic pest and disease control

Healthy plants have more pest and disease resistance than plants that are weakened by poor growing conditions. Many strategies exist to manage pests in ways that prevent problems before they appear:

- Building healthy, fertile soil
- Using disease-resistant seeds adapted to the local context
- Timely sowing of seeds and transplanting
- Using good garden hygiene, such as regularly cleaning tools and removing diseased plants
- Rotating crops
- Using companion planting and intercropping
- Creating habitats for beneficial insects

Incorporating all of these steps into a permagarden can help reduce or eliminate some of the pest and disease problems that commonly afflict farmers' crops. They are part of what is called Integrated Pest Management (IPM), an approach to pest control that is based on prevention, proper insect or disease identification, and cultural, physical, and/or botanical interventions.

Only when a problem becomes too severe should a farmer consider options that target specific pests and diseases. Broad spectrum, non-toxic pesticides and pest repellants can be made from locally-available materials and can be used to deter certain pests should an infestation occur.

Make and Apply Organic Pesticides details on page 95

Monitoring and Feedback

Garden monitoring process for farmers

After the permagarden is constructed, farmers and program staff can begin the very important task of monitoring the garden. For farmers, monitoring the garden means observing how plants are responding to the various elements of the permagarden design and making adjustments when necessary. As farmers incorporate design elements into their landscape and experiment with how to combine permagarden soil, water, and biodiversity techniques, they make important observations that can lead to a more productive permagarden next season. Farmers use this process of observation and adaptation whenever they go to their fields to check the status of their crops. However, under the Permagarden Approach, this process of observation and adaptation is much more intentional. It involves observing once again how sun, wind, and slope are positively or negatively impacting plant growth and making a plan to adapt the growing conditions within the garden accordingly. For farmers, the garden monitoring process also involves finding spaces where the garden can be incrementally expanded. Program staff can lead farmers through a structured exercise, using the Permagarden Minimum Standards Checklist discussed below, to help them form a plan of action based on these observations.[8]

Program staff train farmers to use the Permagarden Minimum Standards Checklist.

8 Brush, Warren, Thomas Cole, Kristin Lambert and Andrea Mottram. 2021. Permagarden | Technical Checklist Guidance. Produced by Mercy Corps as part of the Strengthening Capacity in Agriculture, Livelihoods, and Environment (SCALE) Associate Award.

Garden monitoring process for program staff

For program staff, monitoring the permagardens established under the program should be a part of their overall program monitoring and evaluation plan. Staff can use the permagarden monitoring process in several different ways, all of which can help ensure the project's initial objectives are met.

Mid-project garden monitoring can lead to important adaptations in the program activities

Consistently monitoring the permagardens established under the program is a good way to identify if any modifications are needed to the program activities to make them more successful. After farmers begin to establish their permagardens, staff can use a monitoring process to keep track of garden quality throughout the program area. If issues are identified with garden quality, a robust monitoring process will help identify the cause, or causes, of this low quality. The monitoring process may reveal that farmers are struggling with a particular permagarden technique, such as failing water harvesting structures. Or the monitoring process could reveal that garden quality varies geographically, such as district to district, suggesting that different implementation areas are facing different circumstances that make it harder for a particular group to successfully maintain a permagarden. These insights will allow for a corrective course of action to be taken mid-project. Program managers may decide to offer a selective training again to participants, or strengthen the skills and follow-up protocols of trainers, or host a community dialogue to address a community-wide issue that has been identified, such as stigma against certain permagarden techniques or a shortage of necessary organic materials. The course of action to be taken will depend upon the issues uncovered by the monitoring process.

The insights gained from monitoring garden quality are especially important when projects are scaling up from a pilot to a larger implementation area. Often, when projects are expanded beyond the pilot stage, staff encounter new challenges that make it difficult to maintain the quality that was achieved during the pilot. Perhaps staff have less time to offer support to the households in the project or perhaps the trainers are not as well trained. Monitoring helps identify these challenges early so a plan can be put in place to overcome them.

Garden monitoring can reinforce staff, partner and household capacity to design and manage permagardens

Monitoring garden quality is an excellent opportunity to continue strengthening the capacity of all stakeholders to develop and maintain a productive permagarden. When program staff conduct a monitoring visit, the process should be a participatory experience that invites observations from household members as well. Bringing tools, such as a hoe, to the garden can allow the program staff to demonstrate corrective actions for the community while all are gathered. These ongoing "hoe-in-hand" sessions offer an additional opportunity to demonstrate permagarden techniques to farmers and enable program staff to ensure the technical standards of each activity are being met.

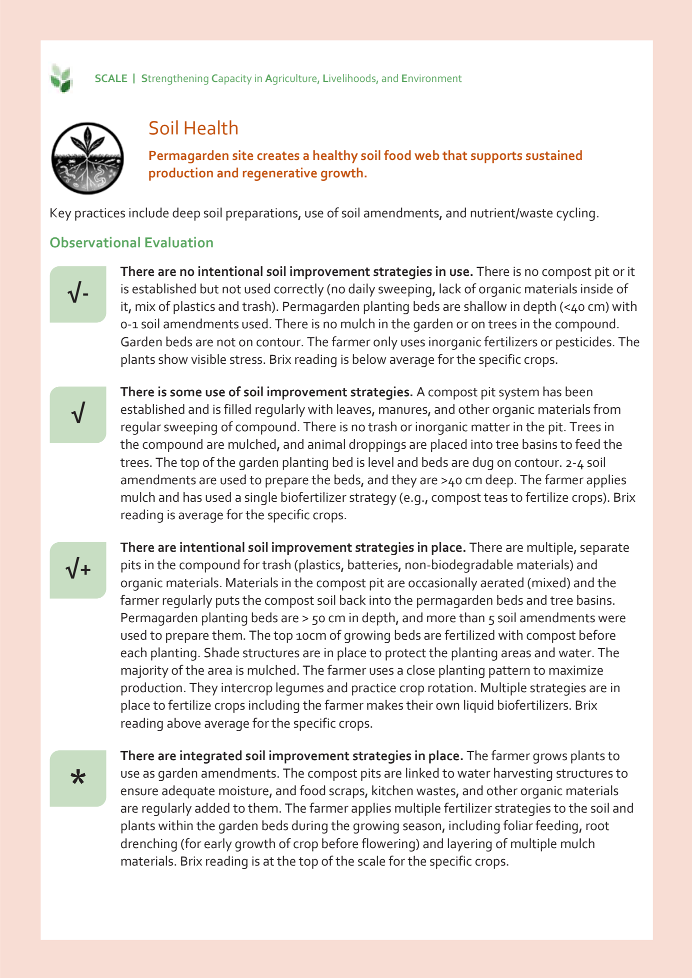
Photo Credit: Elin Duby, contracted by Mercy Corps, DRC

Program staff can use the Permagarden Minimum Standards Checklist to monitor garden quality and adapt their program activities accordingly.

Monitoring visits are also a time when local officials, extension staff, or program partners can be invited to observe how the permagarden techniques introduced to the area are resulting in greater crop productivity or a restored landscape. The insights discussed, and the solutions generated, can increase stakeholders' understanding of the core permagarden principles and improve program buy-in if stakeholders see positive changes resulting from implementing permagarden techniques.

Monitoring gardens with the Permagarden Minimum Standards Checklist

The Permagarden Minimum Standards Checklist is a helpful resource for guiding both program staff and farmers through a garden monitoring process. The checklist includes sections on design, water management, soils, biodiversity, and protection, and prompts program staff and farmers to assess how well each of these components is integrated into the permagarden. Once completed, the checklist serves as a quick summary of the strengths and weaknesses of the garden, organized by minimum standard. From this assessment, an action plan can be made to strengthen any components that are currently underperforming or underrepresented in the permagarden in order to improve its overall functioning. Program staff should use the Permagarden Minimum Standards Checklist with farmers and other relevant stakeholders (such as extension agents) to continue to reinforce important permagarden concepts. It can serve as an important capacity strengthening tool by engaging farmers in an observation exercise and active discussion around each minimum standard, its importance to the overall functioning of the garden, and steps that could be taken to improve the current garden design.



SCALE | Strengthening Capacity in Agriculture, Livelihoods, and Environment

Soil Health

Permagarden site creates a healthy soil food web that supports sustained production and regenerative growth.

Key practices include deep soil preparations, use of soil amendments, and nutrient/waste cycling.

Observational Evaluation

√- **There are no intentional soil improvement strategies in use.** There is no compost pit or it is established but not used correctly (no daily sweeping, lack of organic materials inside of it, mix of plastics and trash). Permagarden planting beds are shallow in depth (<40 cm) with 0-1 soil amendments used. There is no mulch in the garden or on trees in the compound. Garden beds are not on contour. The farmer only uses inorganic fertilizers or pesticides. The plants show visible stress. Brix reading is below average for the specific crops.

√ **There is some use of soil improvement strategies.** A compost pit system has been established and is filled regularly with leaves, manures, and other organic materials from regular sweeping of compound. There is no trash or inorganic matter in the pit. Trees in the compound are mulched, and animal droppings are placed into tree basins to feed the trees. The top of the garden planting bed is level and beds are dug on contour. 2-4 soil amendments are used to prepare the beds, and they are >40 cm deep. The farmer applies mulch and has used a single biofertilizer strategy (e.g., compost teas to fertilize crops). Brix reading is average for the specific crops.

√+ **There are intentional soil improvement strategies in place.** There are multiple, separate pits in the compound for trash (plastics, batteries, non-biodegradable materials) and organic materials. Materials in the compost pit are occasionally aerated (mixed) and the farmer regularly puts the compost soil back into the permagarden beds and tree basins. Permagarden planting beds are > 50 cm in depth, and more than 5 soil amendments were used to prepare them. The top 10cm of growing beds are fertilized with compost before each planting. Shade structures are in place to protect the planting areas and water. The majority of the area is mulched. The farmer uses a close planting pattern to maximize production. They intercrop legumes and practice crop rotation. Multiple strategies are in place to fertilize crops including the farmer makes their own liquid biofertilizers. Brix reading above average for the specific crops.

* **There are integrated soil improvement strategies in place.** The farmer grows plants to use as garden amendments. The compost pits are linked to water harvesting structures to ensure adequate moisture, and food scraps, kitchen wastes, and other organic materials are regularly added to them. The farmer applies multiple fertilizer strategies to the soil and plants within the garden beds during the growing season, including foliar feeding, root drenching (for early growth of crop before flowering) and layering of multiple mulch materials. Brix reading is at the top of the scale for the specific crops.

Photo Credit: Elin Duby, contracted by Mercy Corps, DRC

Considerations When Applying the Permagarden Approach in Emergency Contexts

Program staff can also successfully apply the Permagarden Approach in an emergency context, such as within a refugee/IDP camp or informal settlement community.[9] When planted with quick-growing greens, such as amaranth and cowpeas grown for their leaves, permagardens can provide farmers with access to fresh greens within ten days. This is often a welcome addition to food aid distributions that lack fresh produce and are frequently insufficient in meeting a household's daily nutritional requirements. However, emergency contexts can present additional challenges and considerations that impact program design and roll-out. Program staff are encouraged to coordinate closely with colleagues responsible for camp management, protection, peacebuilding, and other relevant entities to ensure the Permagarden Approach is appropriate, safe, and beneficial for their context before determining how, or whether, to move forward.

Limited access to space

Space can often be an issue in heavily populated refugee camps or settlements where residents have to negotiate access to land. The biointensive planting methods used in the Permagarden Approach may be more suitable to producing yields in small spaces than other types of vegetable garden designs, but program staff should confirm in advance that farmers will have access to the space they need to grow vegetables. A "whole compound" approach can be taken if space is limited, which includes using vertical space such as rooftops, walls, and posts to grow vegetables. It is important to check any rules or regulations that may dictate how these spaces are used before farmers are encouraged to grow vegetables there.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

A permagarden established by a resident of Palabek refugee settlement.

Limited access to resources

Program staff should also investigate if the resources required to build a garden are already available to farmers or if they need to be provided. Before determining there are no suitable organic materials, seeds, planting materials, or water resources accessible in the project area, it is good to conduct a resource walk with potential participants. A resource walk may uncover resources that were not thought of before, such as kitchen waste and cooking water, that may be more accessible to participants in the long-term than project-procured inputs. Often organic waste streams, such as animal manures, can be found that can be diverted to garden production, which has the additional benefit of creating a cleaner and safer environment for participants. Program staff can also use this time to discuss with participants where gardens should be established, if gardens should be communal or not, and how shared resources, such as tanked water, should be distributed.

Photo Credit: Ezra Millstein, Mercy Corps, Ethiopia

During a resource walk, program staff can also inquire about participants' access to seeds and other planting materials. These may be absent if participants had to flee their last residence. Participants may also find themselves in a new situation where they are unfamiliar with local varieties and crops. Program staff may have to procure seeds and other planting material if they are currently inaccessible. It is important to engage participants at this stage to inquire what crops they prefer to grow and what they would consider acceptable substitutes if their preferred varieties are not available. Rather than procuring seeds for a standard set of vegetables, such as tomatoes, cabbages, and onions, project staff can begin a dialogue with participants to identify what crops would be most beneficial for them to grow in their permagardens and discuss how planting material for these crops should be obtained. Program staff may also need to provide agricultural tools if households lack them; however, there might be restrictions on what tools are allowed, or are socially acceptable, in regulated settlement areas where people remain vulnerable to violence.

9 Cullis, A. 2020. An impact assessment of permagardens in Palabek Refugee Settlement, northern Uganda. African Women Rising. Available at: https://www.fsnnetwork.org/resource/impact-assessment-permagardens-palabek-refugee-settlement-northern-uganda

Farmer skill levels and ability to engage in physical activity

Within the population of a refugee camp or settlement, participants may have varying levels of experience with farming – some may not have previously engaged in farming activities, some may come from a very different ecological context, and others may have different agricultural objectives, e.g., pastoralists. Regardless, even seasoned farmers can learn valuable lessons about the importance of soil health, biodiversity, and water management from a permagarden training. These lessons often translate to other crops and agricultural activities. Prior to beginning a training, program staff should consider participants' prior experiences, skills, and knowledge and how these can best be leveraged in a garden program. Training material can be adapted to fill any gaps in knowledge that program staff identify. In addition, displaced populations may be suffering from diminished health and physical capabilities and garden designs should be adapted accordingly.

Social dynamics

Migratory populations, or populations in the midst of a crisis, often have complicated social dynamics. Program staff may unintentionally exacerbate tensions between two groups if social dynamics are not considered during program design. Implementers should consult with colleagues who have a deep understanding of the history and ongoing social tensions in an area to determine how scarce resources — such as water, project inputs, and training sessions — should be distributed. Program staff can reduce the possibility of causing conflict between community members by continuously engaging relevant community members in the decision-making process. It may also be necessary to extend the program to the host community or spend extra time ensuring program benefits are fairly and transparently distributed.

Short time frames

Emergency programs often operate on short timeframes that do not allow for garden development across multiple seasons. Program staff will have to determine if the labor involved in establishing permagarden beds is appropriate for their situation. Double-dug and amended garden beds can be labor-intensive to establish. However, they can also produce greater yields more quickly than other types of garden beds, particularly when planted with quick-growing greens. They will also require less watering than shallow, unamended, and unprotected beds. Permagardens may succeed in emergency contexts where other garden activities have failed because permagardens are designed to provide crops with the support they need to grow in suboptimal soil and water conditions. Therefore, program staff should evaluate participants' motivation and willingness to establish a permagarden for healthy crop growth during the current season, regardless of whether or not the permagarden will be used for multiple seasons. Likewise, program staff may find that establishing perennials and living fences is inappropriate in some emergency contexts, but that they provide valuable shade, nutrition, and organic material in others. Short timeframes may also impede a project's ability to engage in a garden monitoring process in the same way a multi-year project could. If this is the case, program staff can find new ways of encouraging participants to actively learn from one another, such as by arranging participant visits to other gardens that have been established by the project and using the Permagarden Minimum Standards Checklist.

Even if participants are unlikely to harvest from the permagarden beds for multiple seasons, implementers can still consider teaching permagarden skills so that households have the ability to grow food more successfully wherever they end up. If done properly, participants will learn resilient agricultural practices that can provide for their long-term wellbeing in addition to their immediate nutritional needs.

Just a month into arriving at Palabek refugee settlement, this farmer already has access to highly nutritious greens to augment their food aid rations.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Design is the foundation of a resilient production system in both emergency and development contexts.

Photo Credit: Rudy Kumvuidi Nkombo, Mercy Corps, DRC

Conclusion

The Permagarden Approach differs from other home garden approaches because it uses a design process that emphasizes and links techniques that prioritize healthy soils, sound water management, biodiversity, and good protection of soils and plants. The Approach is context-specific and farmer-led, which ensures that garden designs are informed by the knowledge, aspirations, and desires of the community members themselves. Rather than an emphasis on applying external inputs to boost production, the Permagarden Approach focuses on agronomic practices and inputs that are readily available to households.

In addition to providing guidance on how to design and build a permagarden, this manual can be referenced for ongoing maintenance and technical feedback, both of which are important to the success of a long-term, well-functioning growing system around the compound. Collaborating with and learning alongside farmers as they put these core agronomic principles into practice is a critical way program staff can support farmers to innovate in the face of new and complex challenges. Ultimately, this can lay the foundation for farmers to meet the diverse needs of their households and strengthen their resilience over time.

Glossary

A-frame: A tool used to identify the contour of the land. Often built by smallholder farmers from materials found within their local community.

Basin: Soil mounded in a circle around a tree base. Basins are primarily used to hold irrigation water around the base of a newly planted tree and can be opened up, or replaced with a half-moon, to receive rainfall when it is available.

Berm: A small raised barrier of soil placed downslope of a water harvesting structure, or around a mulch basin, to stop water from flowing downhill. The berm allows water to sink into the ditch so that it can be stored in the soil. Berms are planted with perennials and mulched to prevent them from eroding.

Biochar: Charcoal produced from plant matter to be used as a soil amendment. Biochar can be made from any number of different kinds of crop residue, such as maize or sorghum stalks, rice husks, and sugarcane bagasse.

Biointensive agriculture: An organic agriculture system that focuses on sustainably maximizing output with minimal land, while also increasing biodiversity and maintaining soil fertility.

Brown compost material: Brown material used for composting is high in carbon and low in nitrogen. It is generally dry and brittle. It includes maize cobs, straw, dry leaves, crop residues and other organic material that has dried out.

Calibrate: A process to confirm an instrument is measuring accurately. In this case, to ensure the A-frame accurately captures the contour of a landscape.

Contour: The contour of the land refers to the points within the landscape that are all at an equal elevation. An A-frame can be used to mark these points and join them into a line, which can be used to dig a water harvesting structure that is "on contour." By being on contour, the water is encouraged to infiltrate into the soils rather than running downslope.

Design: A permagarden design is a context-specific plan for improving garden productivity on a site by creating an environment that meets the needs of the plants in the garden and the goals of the farmer. A permagarden design works with the existing landscape, structures and external influences present on the site and optimizes the use of locally available resources.

Diversion ditches: Ditches that are dug slightly off of the contour in order to either divert excess water away from areas that experience regular flooding, such as home compounds, or direct additional water into growing areas.

Double digging: A form of deep soil preparation where the topsoil is first removed and the subsoil loosened and heavily amended in a step-by-step manner. Double-dug beds are usually loosened and prepared to a depth of 40-60 cm into the soil.

Dry mulch: Dried organic material, such as leaves or grasses, that can be used to cover bare soil. Mulch can regulate soil temperatures, protect soil from erosion, suppress weed growth, and add organic material to the soil.

Fodder: Any agricultural foodstuff used specifically to feed domesticated livestock. Fodder is given to livestock rather than foraged by the animals for themselves.

Food forest: A low maintenance perennial system. A food forest is designed to maximize food production through a multi-layered agroforestry system that incorporates trees, shrubs, herbs, vines, and other perennials. Food forests contain plant layers that mimic natural forests with plants that are useful to humans and provide stability and resilience.

Green compost material: Green material is moist, flexible, and high in nitrogen. Green materials can include vegetable scraps, fresh crop residues, manure, leaves and freshly pulled weeds that have not gone to seed.

Green mulch: Plants, such as *Desmodium* or *Mucuna*, that are planted to protect and enrich the soil. Green mulch plants protect bare soil while they are growing and then are incorporated into the soil when green to build soil organic matter.

Guild: A community of plants that grow and support each other by recycling nutrients back into the soil, providing shade and conserving water, attracting beneficial insects, repelling pests and diseases, building soil health, and preventing erosion.

Half-moon berm: A semi-circle shaped berm that begins and ends on the same contour that is placed on the downslope side of a tree, or other plant, to trap water and nutrients as they move downslope. Also called a smile berm or demi-lune in French.

Open-pollinated seeds: Open pollination describes plants that have been pollinated naturally, either by cross-pollination or self-pollination. Cross-pollination methods include pollination by wind, water, or pollinators like bees or other insects. In self-pollination, a plant has both female and male parts and can pollinate itself. Open-pollinated seeds, also called "true to type" or "true to seed," are a result of the natural pollination of two plants of the same variety. When planted, open-pollinated seeds should have the same characteristics as the parent plant. This is in contrast to hybrid seeds, which are the result of manually pollinating two different varieties to achieve a new variety with characteristics from both.

Overflow: Excess water exiting a water harvesting structure that has filled to capacity. Overflow water is directed by a spillway to a safe and productive location, such as a banana plantation, additional garden, or another water harvesting structure.

Overstory: The top layer of foliage. In a forest, the overstory is the canopy created by the tallest trees.

Peg: To mark the points of the land with an object, such as a stick or flag. In the Permagarden Approach, you might use sticks to peg the points of the contour line.

Pits: Small dug-out pieces of land used to catch rainwater. Also referred to as holes.

Slow, spread, sink, and save: A principle used in the Permagarden Approach to prevent erosion and bank water in the soil for future use. Water is slowed down through the use of water harvesting structures and allowed to spread out evenly over an area so it can sink deep into the soil.

Soil amendments: Any materials added to soil to improve its fertility, water holding capacity, or structure. For example, compost, organic material, fertilizer plants, charcoal dust, or green mulch. Most effective when chopped or shredded to speed up decomposition.

Soil compaction: Compaction happens when soil particles are pressed together, reducing pore space that holds air and water within the soil. This happens through tillage or when wet or moist soil is driven on or stepped on, either by animals or humans. Farmers should try to avoid compaction in their permagardens as much as possible, as compaction reduces the air and water necessary for biological life in soils.

Soil macronutrients: Elements found in relatively large amounts in soil, including nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. Plants need relatively large amounts of macronutrients to grow well. Farmers can increase the amount of macronutrients in soils by adding organic material.

Soil micronutrients: Elements found in relatively small amounts in soil, including iron, manganese, boron, copper and zinc. Plants require small, but essential, amounts of micronutrients to grow well and avoid yield losses due to micronutrient deficiencies. Farmers can increase the amount of micronutrients in soils by adding organic material.

Soil organic matter: Plant and animal residues, soil organisms, and other substances found within the soil that help support healthy and productive plants.

Soil texture: The proportion of sand, silt and clay-sized particles within the soil.

Spillway: The channel through which the overflow water in a water harvesting structure travels. Spillways lead overflow water to a safe and productive location, such as a banana plantation, additional garden, or another water harvesting structure.

Subsoil: The layer of soil under the topsoil.

Swale: A ditch dug on contour, with a berm on the downslope side created with the soil from the ditch. Swales are used to capture rainwater and should be placed where they can slow down water that is damaging the landscape as it runs downhill. The water that is collected in a swale can be used for a productive purpose, such as in a permagarden.

Topsoil: The uppermost layer of soil. This layer has the highest concentration of organic matter and biological activity.

Wastewater: Water that is normally thrown out or discarded by a person or household, such as water used for washing clothes, bathing, ablution, or cooking. Also called "greywater."

Water harvesting structures: An earthen structure used to capture and retain water close to where it is needed by crops. Water harvesting structures can also be used to divert water away from areas prone to flooding so that it can be directed towards a more productive use, such as crop production.

Waterline: The maximum height within the berm that water will reach before it overflows through its designated spillway. The waterline is found by marking the contour that is at the height of the spillway on the inside of the berm. Measuring the waterline ensures that the water will flow through the spillway as intended rather than through a depression in the berm or an uncapped end.

APPENDIX

Permagarden Techniques

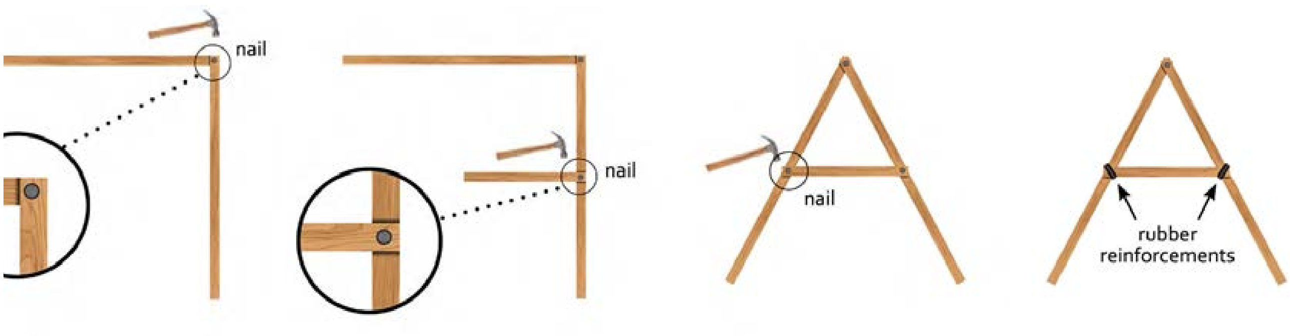
HOW TO

Build and Calibrate an A-frame

1. BUILD AN A-FRAME

STEP 1

Make an "A" with the wood and secure the connections with nails and/or rubber (tire rubber is ideal) (make sure to stretch the rubber tight).

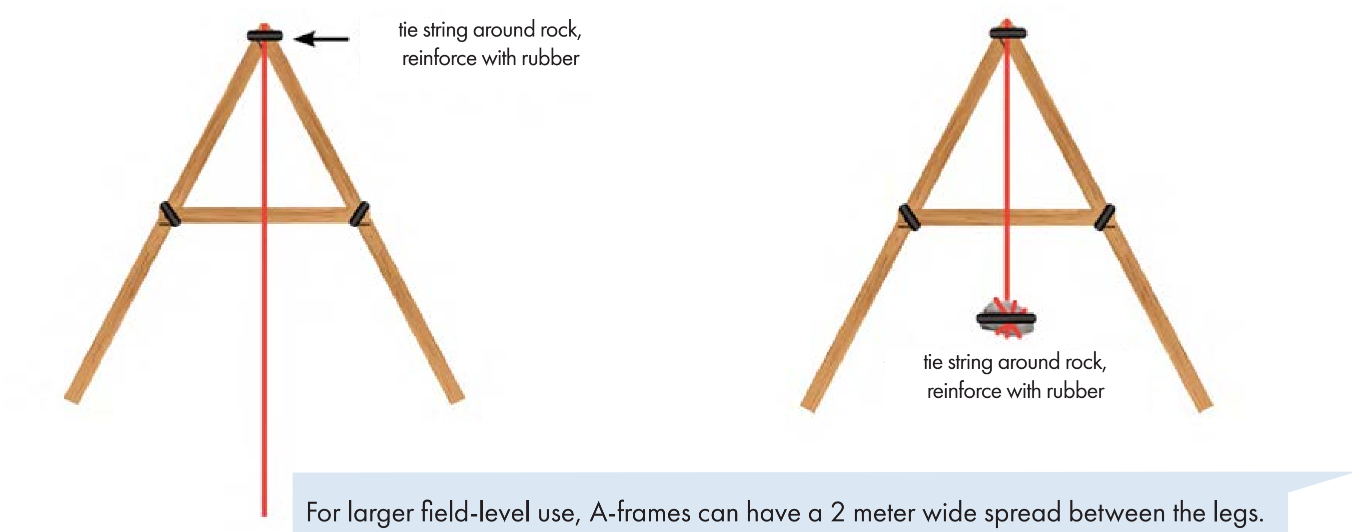


STEP 2

Tie a piece of string at the top of the "A" so that it hangs straight down. Secure the string to the wood with a piece of rubber so that it does not become loose when used in the field.

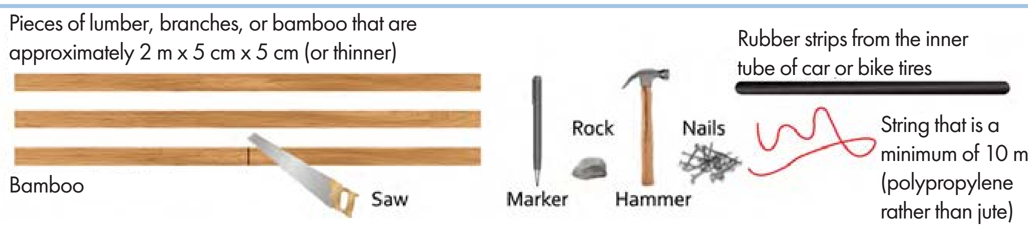
STEP 3

Find a stone to serve as a weight and tie it securely to the string. It should hang 5-6 cm below the crossbar of the A-frame. Be sure the crossbar is smooth at the areas that intersect the string (i.e., no bumps, splinters, or holes) so that the string does not catch the wood as it sways.



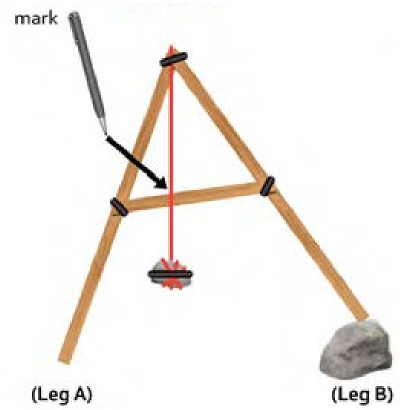
For larger field-level use, A-frames can have a 2 meter wide spread between the legs. For household use, A-frames can have a 1 meter or less spread between the legs.

MATERIALS NEEDED

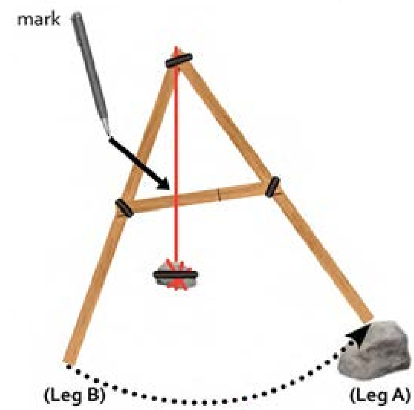


2. CALIBRATE AN A-FRAME

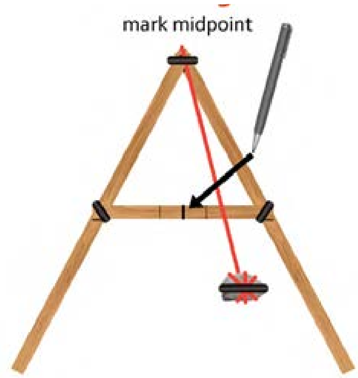
STEP 1
Place the A-frame so that both legs touch the ground. Elevate one leg of the A-frame about 3-5 cm off the ground using a stone or piece of wood. In the soil, mark where the leg of the A-frame and the stone/ wood support under the other leg is resting on the ground. These markings will allow the A-frame to be rotated later and then returned to the same spot. Allow the string and rock to naturally stop swinging and then use a pencil or charcoal to mark the exact place on the crossbar where the string falls. Do not carve the mark with a knife because then the string will not swing freely as is needed.

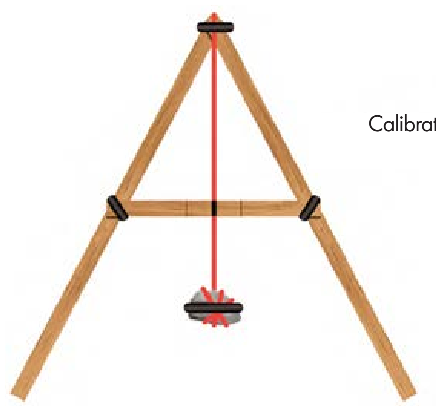


STEP 2
Rotate the A-frame legs 180° so that the elevated leg is now on the mark on the ground and the leg from the ground becomes elevated. Be sure to place the legs on the existing marks on the ground. After the string and rock stop swinging, mark the exact place where the string stops along the crossbar of the A-frame with charcoal or a pencil. There should now be two charcoal or pencil lines on the crossbar.



STEP 3
Use a string, piece of paper, or blade of grass to measure the distance between the two marks. Fold it in half to find the halfway point. This is called the "center-mark." Mark the center-mark with pencil or charcoal. This center-mark completes the calibration.





Calibrated A-frame

HOW TO

Conduct a Community Dialogue Exercise

The first step in the observation process is an open dialogue between the community and program staff members.

During this community dialogue, the following questions are discussed:

- How has the landscape changed over time here and how has this affected your community?
- What are the shocks and stresses you currently face in this community?
- What are your community's future goals and aspirations?
- For the hosting household: What are your family's specific goals? What information is important for us to understand about your surrounding area and the challenges you face?

It is important that the dialogue is participatory and involves all community members, including those with quieter voices or members who may be more marginalized within the community.

After concluding the community dialogue, consider doing a Sponge Demonstration with the group.

Photo Credit: Warren Brush, contracted by Danish Refugee Council, Kenya

SPONGE DEMONSTRATION

A practical way to explain the Permagarden Approach

The sponge demonstration is an ideal activity to use after the Community Dialogue to help participants understand the basics of the Permagarden Approach and get them excited about what they can achieve.

STEP 1

- Choose an area with bare land on a slight slope where you can draw two side by side 1 m x 1 m squares.
- Explain to participants that these squares represent two plots, one "improved with permagarden techniques" and one "unimproved."
- Assign one participant to represent the improved plot and one staff member to represent the unimproved plot.
- Starting with the improved plot, add different examples of water harvesting and mulching strategies and explain that you are creating a "sponge" in the soil:
    - » Create micro swales using a hoe or a stick (be sure to close or cap the ends of the swale by mounding the soil up).
    - » Create mini check dams using small rocks.
    - » Create micro half-moon berms and infiltration pits.
    - » Add lots of mulch to the whole plot.
- For the unimproved plot, ask participants what local practices are used to prepare fields and mimic these on the soil surface. For example, you may add some manure on the surface, burn plant material, or dig shallowly.
- To make it more participatory and engaging, involve participants in creating the two plots (see image below).

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Photo Credit: Thomas Cole, contracted by Mercy Corps, DRC

STEP 2

- Ask one participant to take a watering can and pour water over each plot to mimic the first rainfall of the year. This can be repeated several times if adequate water is available.
- Ask the other participants what they see happening on each plot. How are they different? Encourage participants to come and feel the soil under the mulch on the improved plot.
- Discuss with the group what they observed and why.
- Encourage participants to continue to observe the sponge demonstration site throughout the day and keep checking on the difference between how the two plots react to the sun.

HOW TO

Conduct a Resource Identification Exercise

The resource identification process consists of two activities: a resource walk and a discussion. To orient the group before beginning the resource walk, consider introducing the topic with a Basic Needs Discussion.

Basic Needs Discussion

An easy way to explain the basic resources needed for a garden.

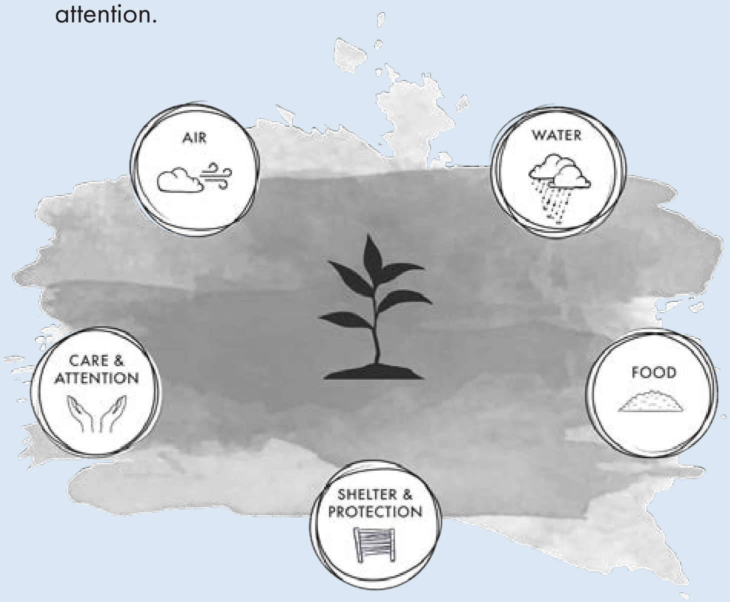
The Basic Needs discussion is a great introduction to the resource identification process. It helps participants think through the basic resources needed to grow healthy plants and introduces them to the concept of providing care for their plants, much in the same way they would their children.

STEP 1

Ask participants what a baby needs to be healthy. If one of the participants in the group has a baby with them, use that baby as an example. Encourage as many participants as possible to speak.

STEP 2

Ask participants what a plant needs to be healthy. Draw out how the needs of the plants are the same as for a baby: clean water, air, food and nutrition, shelter or protection, and care and attention.



NOTE

The basic needs discussion is also a great place to start introducing some key soil health concepts in the Permagarden Approach. For example, just like a child needs a diversity of foods to be healthy, soil also needs to be fed with a diversity of nutrients (different manures, fertility plants, diversity of plants and mulches). Just like a child needs protection from the sun, soils need protection in the form of mulches.

Photo Credit: Thomas Cole, contracted by HIAS, Chad

1. RESOURCE WALK

Invite participants to walk around the demonstration compound and the surrounding area to identify and/or collect resources that can be useful for the permagarden.

This includes:

- Water sources
- Culturally useful plants
- Plants that could be used in the permagarden
- Materials for mulching
- Composting and fencing materials
- Planting material or seeds

Encourage participants to also look for useful 'waste materials' that can be used in the garden, for example:

- Wastewater
- Organic waste
- Crop residue
- Animal manures
- Wood ash
- Bones

Photo Credit: Warren Brush, contracted by Danish Refugee Council, Kenya

2. RESOURCE DISCUSSION

After the resource walk, gather participants together and ask them to share information about the resources they have collected and how they are useful to the garden. To encourage all voices to be heard, first ask a woman to share and then a man and continue alternating.

Once all community members have shared, encourage them to also identify social resources such as help with labor from neighboring farmers.

HOW TO

Conduct a Site Assessment

The site assessment consists of two activities: a site observation and discussion followed by a "walking the water" activity.

1. OBSERVATION AND DISCUSSION

Together with participants, take a walk around the compound to observe certain characteristics of the site. The site observation can be combined with the resource walk if needed. Take note of the following:

- Main structures
- Existing vegetation, including trees
- Pathways
- Water points

Discuss:

- How do external influences on the site such as sun, wind, slope, animals and humans affect the site?

Ask participants questions, such as:

- *Where does the sun rise and where does it set?*
- *What parts of the compound are exposed to the hot afternoon sun? How could this impact plants growing at this site?*
- *What direction do strong winds typically come from? How could this impact the plants growing at this site?*
- *Is there a slope on the land? Can you see any signs of erosion or flooding or areas where water is concentrating?*
- *Are there any places where plants are growing really well?*
- *Is there protection from harsh elements such as wind, sun and strong rains for plants on this site?*
- *Is there protection from damage by livestock, wild animals and potential theft?*

Photo Credit: Thomas Cole, contracted by HIAS, Chad

2. WALKING THE WATER

STEP 1. Together with participants, walk to the highest point of the landscape and identify where water is entering the site.

STEP 2. Split participants into smaller groups of 4-5 people per group. Instruct them to imagine that they are water flowing over the landscape, moving down the slope like water. What path would they follow? Encourage participants to look for signs of erosion and places where water pools as they move down the landscape to the lowest point.

STEP 3. When the groups have reached the bottom of the landscape, gather them together to discuss their observations.

Use the following discussion questions:

- Where did you see erosion in the landscape? What is contributing to this erosion?
- Where do you see places where water is pooling? What features in the landscape allow water to pool here?
- Are plants growing in places where you see erosion or water pooling? What is the plant growth like in those areas?

STEP 4. Do the walk again as a large group. During the walk, discuss the observations made and use a stick, shovel, or hoe to lightly trace the pathway of the water.

HOW TO

Design a Permagarden

1. ANALYSIS OF OBSERVATION DATA

Together with the participants analyze the data from the observation process using the following questions:

- *How can the resources we identified be used to meet the basic needs of the plants in the permagarden?*
- *How much labor is required to use these resources and are there ways to reduce this burden? How can we reduce the workload to maintain the garden for household members who do the most work?*
- *Is the slope stealing our water and nutrients by moving them downhill, away from our garden? What do we need to do to bring water and nutrients to the garden and store them there for future use?*
- *Are the other external influences we identified helping or harming the plants in the garden? How can we ensure we adequately protect our garden and turn challenges into solutions?*
- *Where should we place production elements in our compound to use resources most efficiently? Are there unused spaces that can be used to increase the amount of growing areas?*

Photo Credit: Thomas Cole, contracted by HIAS, Chad

2. CREATION OF A DESIGN MAP

After the analysis of data, hand out paper to participants to do the design. The design can either be added to the existing map of the compound or, if there is not enough space on this map, the map of the compound can be kept next to the design map to ensure the design works with the landscape and takes the external influences present on the site into consideration.

If there is no paper, the design can be drawn on the ground.

To identify the best location for the Permagarden beds, ensure the plot:

- Receives at least 4 hours of sunlight a day
- Is located near the kitchen
- Is linked to rainwater harvesting structures within the compound
- Is protected from extreme winds, livestock, or other damaging elements.
- Is close to a source of nutrients to fertilize the growing beds

In addition, there are many external influences that may affect the garden, such as the intensity of the sun throughout the day or the slope of the land. Additional considerations when selecting a garden site include:

- Choosing a site with partial shade in hotter climates to limit exposure to intense afternoon sun
- Placing the garden downslope from a chicken coop or kraal (while still protecting the garden from animals) to allow the slope to bring manure and nutrients into the garden during a rain
- Placing the garden away from the trash pit or other hazardous materials

2. CREATION OF A DESIGN MAP

A design map should feature the following key elements:

- Garden beds (oriented along contour)
- Water harvesting structures:
  - » Protective swale for the garden beds (upslope from the garden beds)
  - » Possible additional swales, for example at the top of the site to add extra protection and at the bottom of the site to act as a sink
  - » Other water harvesting structures, such as half-moon berms, or wastewater management techniques, such as mulch basins
  - » Spillways to ensure overflow can be managed
- Composting areas
- Protection for plants:
  - » Shade structures
  - » Trees or other protective barriers for shade and windbreak
  - » Fencing around mulch basins and garden beds
- Planting list based on the needs of the household

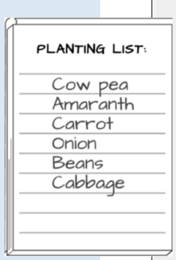
To identify the best plants to be grown to meet household needs, discuss what plants can provide the household with:

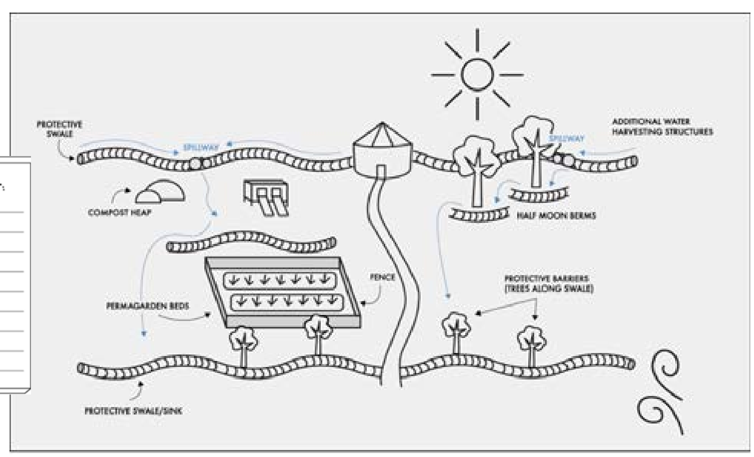
- Something to eat or sell throughout the year, including the lean or dry season. Consider:
  - » Crops that can grow in the dry season
  - » Crops that can be processed, dried or stored
  - » Perennial crops that can give stability over time, such as fruit trees
- Fencing material to protect growing areas
- Medicine
- Fodder for animals (if they have any)
- Mulching materials
- Shade from the afternoon sun for sensitive crops
- Food for pollinators
- A source of plant nutrients that can be added to the compost pile or dug into garden beds (such as tithonia)
- Pest control

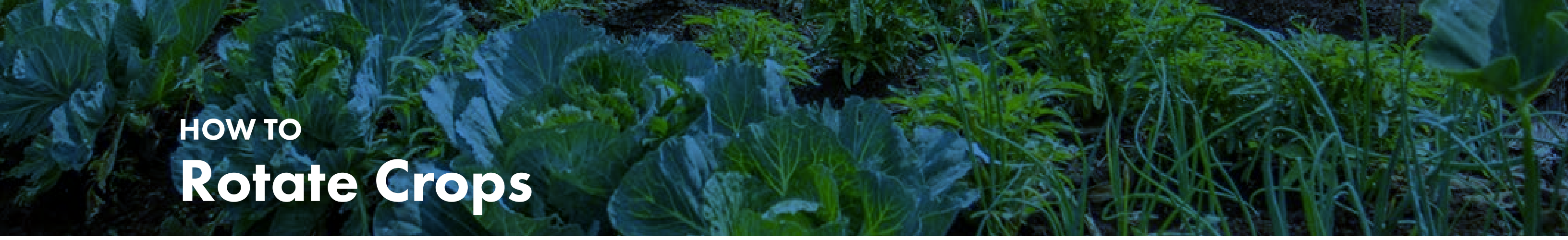
When selecting plants for these different categories, also take into consideration plants that can meet several different needs, for example a moringa tree whose leaves, branches, and seeds can be used as mulch, fodder, or consumed as a vegetable.

NOTE

Encourage participants to choose the crops they prefer for the permagarden beds. Projects focused on food and nutrition security often encourage farmers to grow a standard set of crops. When farmers are allowed to choose what they would like to grow, they often select a different set of crops. Farmers like to choose plants they know how to grow and that they know will not create extra problems for them if they have to buy seeds in the future or figure out how to sell any surplus they have.







HOW TO

Rotate Crops

Crop rotation is the practice of moving different varieties of crops from one bed to another, or from one place in a bed to another place in the same bed, from season to season. Permagarden growing beds make crop rotation simple. Rather than change the location of the beds, change what is planted in the bed each season. A good rotation plan that optimizes nutrient use is leaf then fruit then root then legume. Before planting any new crop, it is recommended to amend the topsoil with additional compost to replace the nutrients that were removed from the previous crop.

Crop rotation helps balance plants' use of soil nutrients. As different crops have different nutrient needs, rotation allows successive crops in the growing beds to use the nutrients available to them most efficiently. Following a good crop rotation plan will also help to break pest and disease cycles, which will yield healthier, stronger plants and reduce or eliminate the need for pesticides to treat problems.

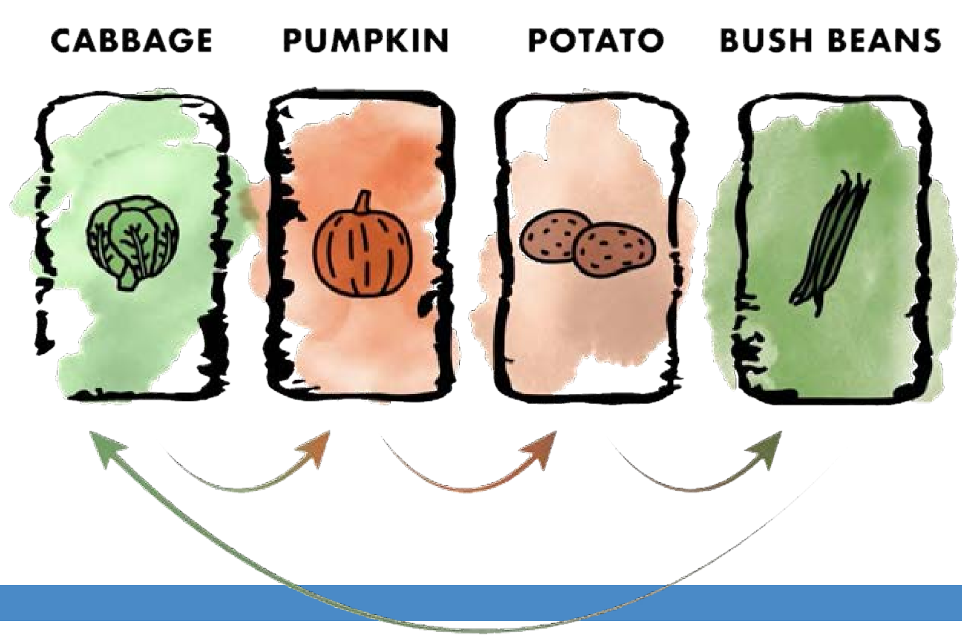
STEP 1
In the first season, plant **LEAF** crops such as amaranth, broccoli, cabbage, cauliflower, chard, kale, or spinach. These crops use lots of nitrogen so will do well in a newly prepared and amended growing bed.

STEP 2
In the second season, plant a **FRUIT** crop such as cucumber, eggplant, gourd, Irish potato, melon, pepper, pumpkin, squash, or tomato that require less nitrogen than many leaf crops and more phosphorus for flower development.

STEP 3
In the third season, plant a **ROOT** crop such as beets, carrots, garlic, leeks, onions, radishes, shallots, sweet potatoes or turnips. Root crops require less nitrogen than leaf and fruit crops and more potassium for root development.

STEP 4
In the fourth season, plant a **LEGUME** such as beans, groundnuts or peas. Legumes will add nitrogen back into the soil through the process of atmospheric nitrogen fixation.

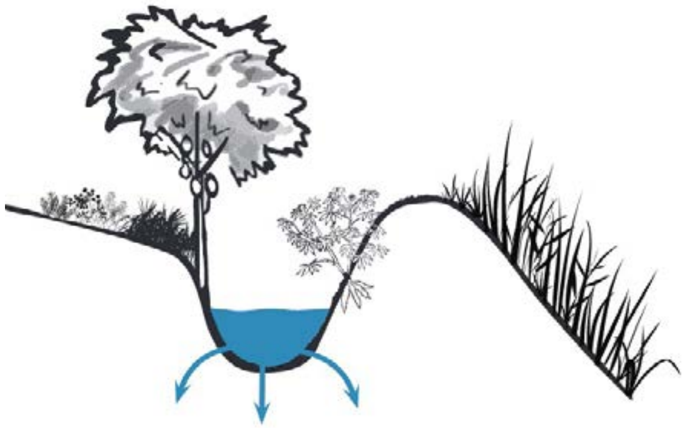
STEP 5
In the firth season, start the process over again by planting a **LEAF** crop.



HOW TO

Construct Water Harvesting Structures

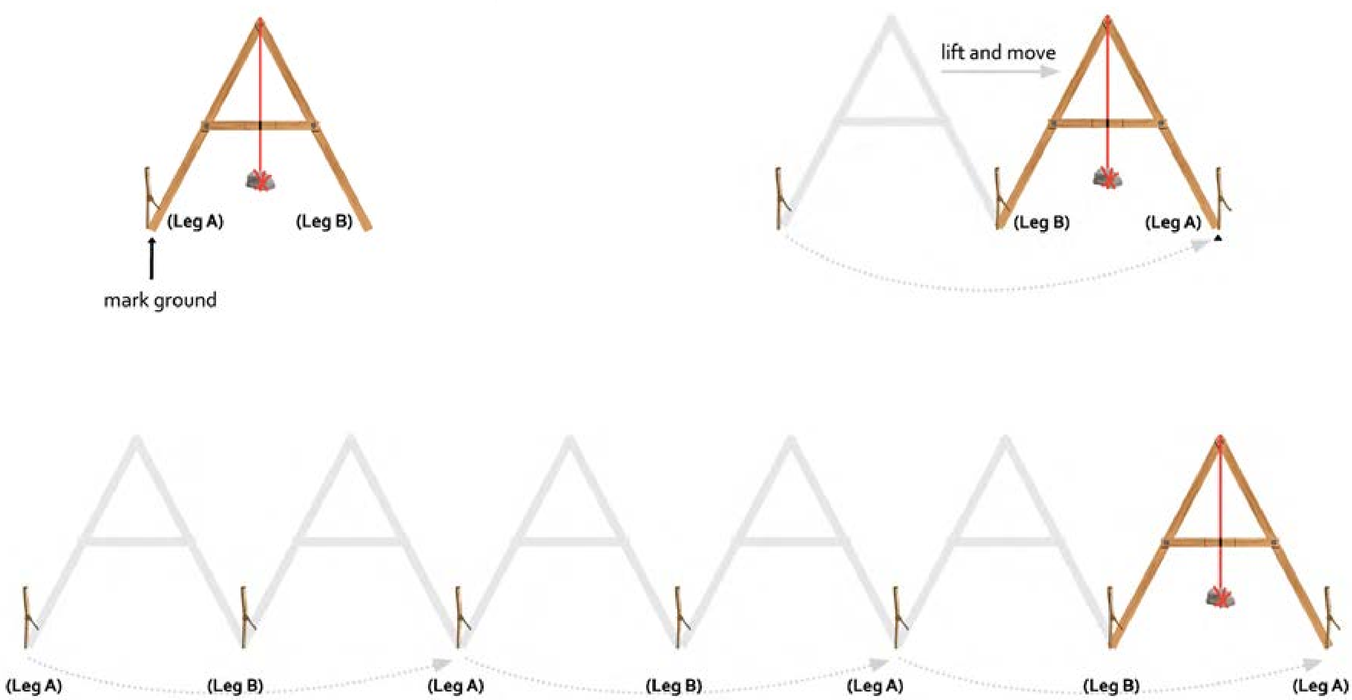
1. CONSTRUCTING THE SWALE AND BERM



STEP 1
Determine the area where the swale should be placed. The swale should spread water out over a broader part of the compound and/or protect a growing system from upslope water flows.

STEP 2
Determine the size of the swale. Larger swales should be located at the top of a compound to accommodate larger water and sediment flows. Smaller swales should be located above garden beds and other planting areas to protect the growing area and provide it with water.

STEP 3
Use a recently calibrated A-frame to mark the contour across the slope.



Repeat the lift, move, mark process

STEP 4
Before digging the swale, remove any topsoil from where the ditch and berm will be constructed and save it downslope. Mark the area where the spillway will be located and do not disturb or remove the topsoil from that specific area. See further instructions for constructing a spillway below.

STEP 5
Start the swale by digging a ditch on the downslope side of the contour line, using the line as a guide. Pile the excavated soil on the downslope side of the ditch to create a berm. At the spillway, dig the ditch BUT do not place the soil on the downslope area, leaving that area with a ditch but no berm. This will serve as our overflow spillway.

STEP 6
Shape the swale by ensuring the walls of the ditch are gently sloped and the bottom of the ditch is flat and on contour.

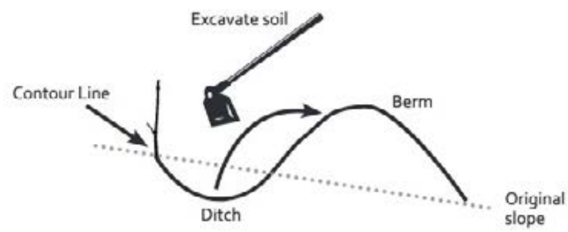
STEP 7
Ensure the berm is well rounded, i.e., does not have vertical edges, and follows the contour. Once the berm is well shaped, the previously saved topsoil can be spread over the berm.

STEP 8
Close, or cap, the ends of the swale by digging an infiltration pit in the bottom of the ditch and using the excavated soil to create an extended berm that wraps up slope and closes the end of the swale. Do this on both sides.

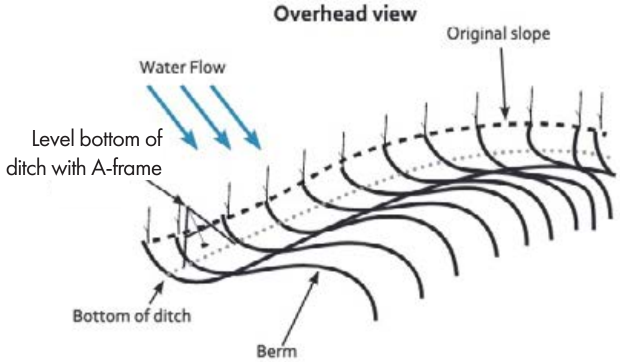
STEP 9
Use an A-frame to check that the flat bottom of the ditch is level across the entire swale. Adjust the depths as necessary for high points. Low points will eventually fill with silt and can be left.

DIGGING THE SWALE

Side view



Overhead view



NOTE
Sometimes there are obstacles, like tree stumps, along the contour line. Go around obstacles by either going downslope from the obstacle and raising the A-frame's legs with stones to the proper height or going upslope behind the obstacle and digging into the ground where the legs would go to maintain contour then continue until you arrive back to the contour at the original grade.

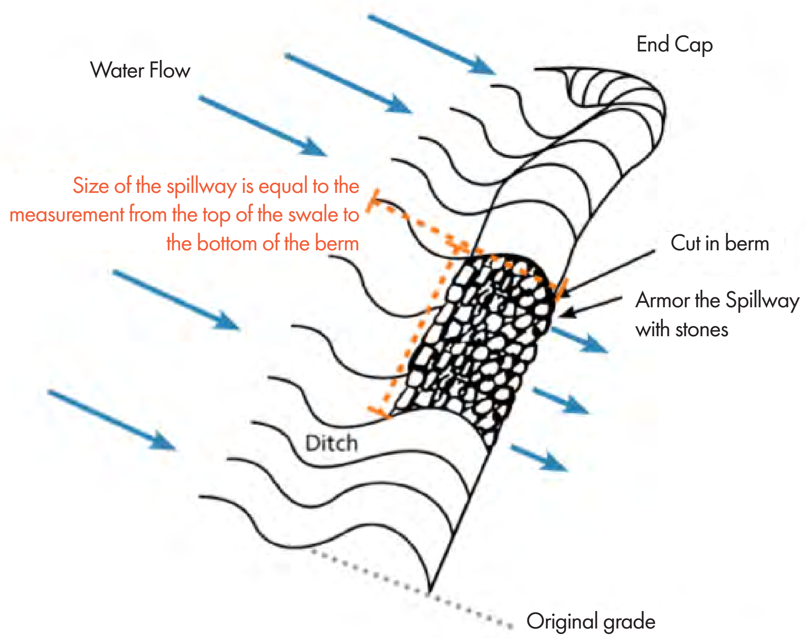
Photo Credit: Thomas Cole, contracted by World Dance, Rwanda

2. CONSTRUCTING A SPILLWAY

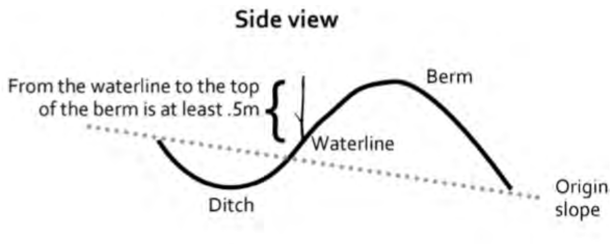
STEP 1
Determine where to locate the spillway. Identify where there is a natural downslope path below the berm where water can overflow to the next water harvesting structure.

STEP 2
Measure the size of the swale ditch and berm from the upslope side of the ditch (beginning at the cut) to the downslope toe of the berm. If needed, make a cut in the berm for the spillway that is equivalent to this measurement. See the image below for more detail. This distance is best measured and marked with sticks even before the ditch is dug and the berm created. Preserving the soil, and any plants or grasses growing in the soil where the spillway will be, will help reduce erosion of the spillway in the future.

STEP 3
Reinforce the spillway with stones, existing grass or plants, replanted grass or grass seeds, or other materials that will help protect the spillway from erosion.

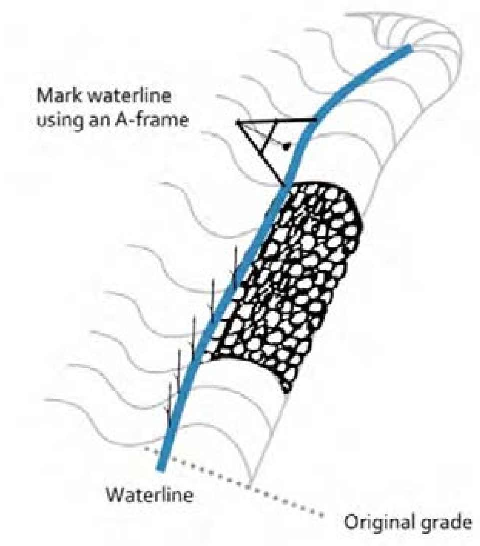


3. FINISHING THE BERM



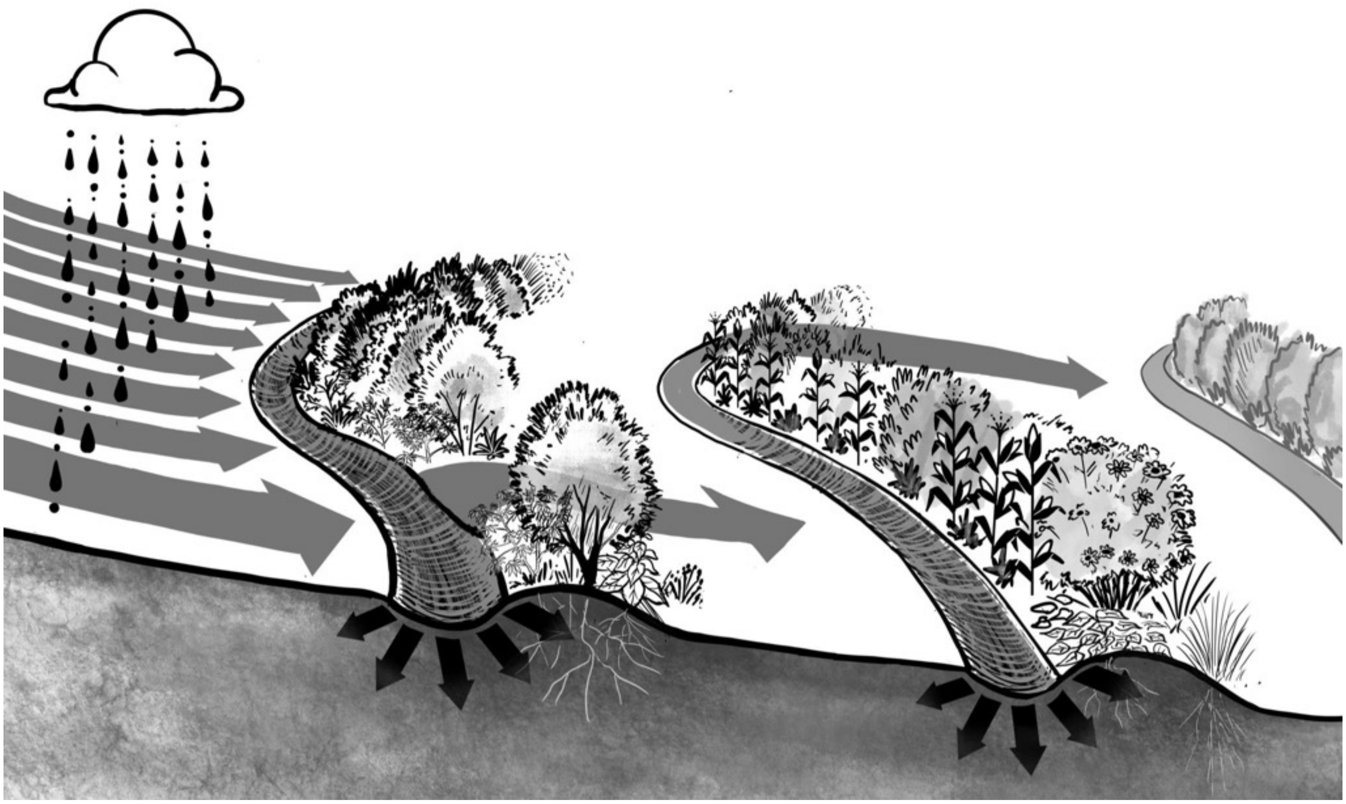
STEP 1

Once the spillway is constructed, determine the waterline by marking a contour line that starts at the flat part of the spillway, i.e., the original grade, and continues along the inner side of the berm. Check that the height of the berm above the waterline is a minimum of half a meter all the way along the berm.



STEP 2

Amend, plant, and mulch the berm. Make sure the soil is not too dry or too wet for planting. Incorporate any soil amendments to be used, remove rocks and break up large soil clods, and then plant seedlings or seeds along the berm. Biointensively plant the berm with perennial shrubs, trees, and grasses to help its long-term structural integrity. Water any seedlings or seeds as needed. Apply mulch to all parts of the berm, including the bottom of the ditch. Mulch materials can include animal manures, cut branches, leaves, grasses, sticks, other organic matter, or stones.



4. BUILDING A HALF-MOON BERM

STEP 1

Determine where to locate the half-moon. Half-moons can be used to support existing trees or newly planted trees. Check to make sure there is enough space around an existing tree to construct a half-moon that follows the existing crown of the tree. For new trees, half-moons are approximately 2-3 m from tip to tip and 0.5 to 1.5 m from the tree hole to the lowest downslope part of the berm.

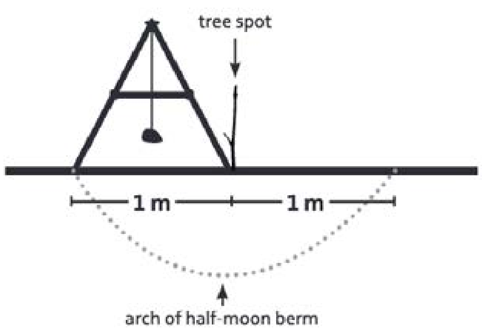
STEP 2

Use an A-frame to find the tips of the half-moon.

For a new tree: Mark the spot where the tree hole will be. Use an A-frame to find a contour line. Measure one meter out from the tree hole on either side to determine where the two tips of the half-moon should be.

For an existing tree: The tips of the half-moon are located at the outer point of the tree crown. Identify a point on one side of the tree crown that is approximately in line with the tree. Use the A-frame to find another point on the opposite side of the crown and mark that place as the other tip of the half-moon.

Marking the half-moon berm for a new tree



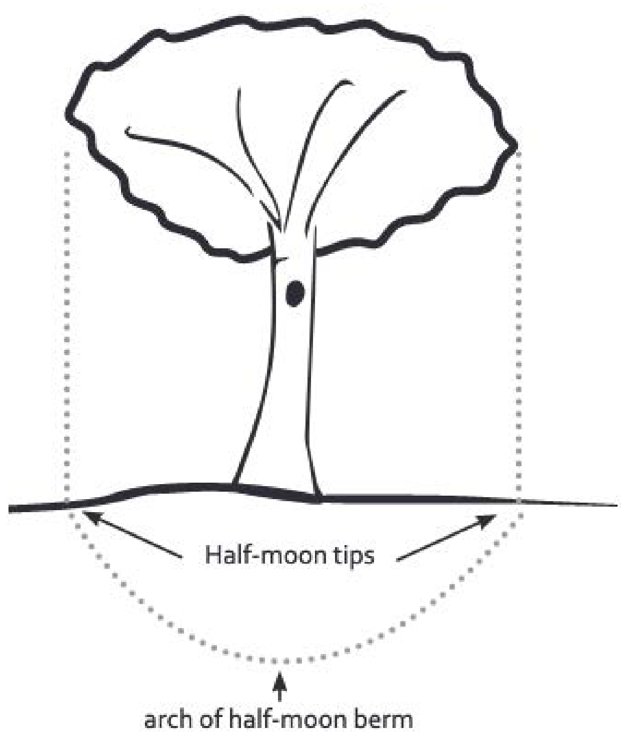
STEP 3

Mark the arch of the half-moon.

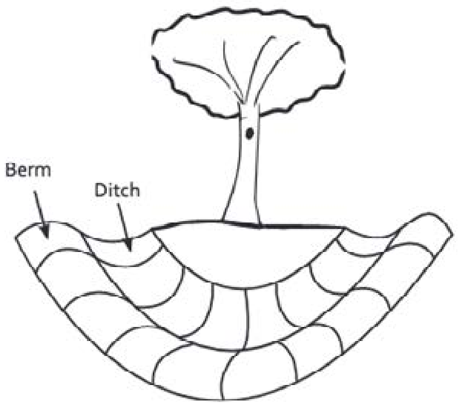
For a new tree: Once the tips are located, use the A-frame to mark the arch by placing one leg of the A-frame at the tree hole then scratch an arch in the soil from one marked tip to the other.

For an existing tree: Go out along the contour from the tree trunk using an A-frame to the outer edge of the crown in both directions and make a mark or peg. Scratch the arch between the two marks/pegstips along the approximate downslope edge of the crown. For trees that have been pruned, extend the berm beyond the crown as needed to create an adequate catchment.

Marking the half-moon berm for an existing tree



Digging the ditch



STEP 4
Dig a ditch on the upslope side of the marked arch, using the marked line as a guide. Use the excavated soil to create a berm. Dig deeper at the lowest downslope part of the excavation to ensure the berm is higher than the waterline.

STEP 5
Ensure the sides of the berm are well rounded. Use a small A-frame to find the waterline to make sure the berm is high enough to retain water. Start by placing a peg at the upslope point where the tip of the half-moon meets the native soil. This is the place where water will "spill" when the structure is full of water. Create the waterline by marking the contour along the inner side of the berm, pegging as you go. Ensure the berm has a minimum of 15 cm height above the waterline. Since the tips of the half-moon berm are on the same contour, they should both spill evenly in high water events. If you desire to have the spilling of water only from one side, add more to the berm on one edge to bring the tip higher than the contour of the desired spillway.

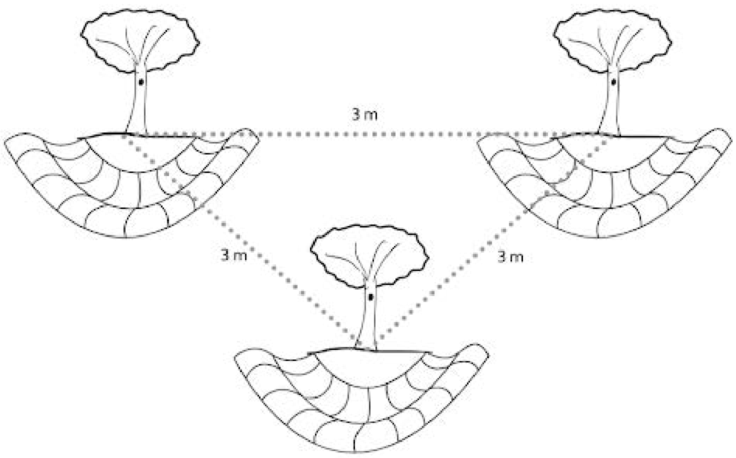
STEP 6
Dig the tree hole. In dry climates, place the tree hole below the contour line between the tips. In wet climates, place the tree hole above the contour line. Dig the tree hole at least 30 cm in diameter and 30 cm deep. Place the excavated soil downslope to create a small half-moon berm right at the edge of the tree hole to support the tree's early growth. Leave the upslope area open to allow for water and nutrients to flow into the half-moon berm. Loosen the next 30 cm of soil in the hole for a total of 60 cm depth of un-compacted soil.

Photo Credit: Thomas Cole, contracted by Mercy Corps, Kenya

Photo Credit: Thomas Cole, contracted by Mercy Corps, Uganda

STEP 7

Amend, plant, and mulch the half-moon. Add a diversity of soil amendments (at least several large handfuls) to the lower 30 cm of loosened soil. These amendments can include diverse animal manures, leaves, charcoal dust, crushed bone, and other chopped organic plant matter. Make sure the soil is sufficiently moist, then seed and/or plant seedlings on the berm. The berm can be planted with a variety of fodder or vegetables. Pumpkins are a good ground cover that can be integrated by planting along the inner waterline of the berm. It is important that the berm is planted with primarily perennials (i.e. pigeon peas, trees, bunch grasses, etc.) to ensure its long-term structural integrity. Mulch the berm and around the tree, taking care to not place mulch directly on the tree trunk as mulching materials may rot the tree base. Mulch materials can include animal manures, cut branches, leaves, grasses, sticks, other organic matter, or stones.



STEP 8

When doing multiple half-moon berm structures, pattern them in a net or triangle pattern. For a 1.5 m wide half-moon, space the tree holes 3 m apart. Tie three pieces of string together to make a triangle. Have three people each hold a knot and stretch the string into a triangle to determine the approximate location of each tree hole. Mark each hole. This works well for marking out larger numbers of structures over a broad area, however it is also possible to pace out the triangle by foot.

HOW TO

Construct a Mulch Basin

STEP 1
Determine areas in the compound where wastewater is being generated. Often these areas are found near the kitchen, where clothes are being washed, around the bathing area, or where ablution water is being used. Locate the basin(s) near these water sources and make sure there is adequate space around the structures for plants to grow.

STEP 2
Gather dry mulch material and the seedlings that will be planted around the mulch basin.

STEP 3
Mark the location of the basin by drawing a 1-2-m circle in the soil. Make sure there is another 1 meter of free space around the circle for the excavated soil.

STEP 4
Dig the basin approximately 1 m deep and pile the excavated soil in a circle around the pit leaving the upslope area open to incoming rain flows.

STEP 5
Shape and smooth the excavated soil into a berm that circles the basin.

STEP 6
Break up any large clumps of soil and add manure or compost to the berm.

STEP 7
Add different types of mulch materials to fill the basin all the way to the top of the surrounding berm. Make sure the material in the basin is not compressed by layering in a few sticks as well.

STEP 8
Mark three planting holes on the outer slope of the berm for either banana, papaya, or both kinds of plants. These overstory plants should be located equidistant from each other, thus forming a triangle. If needed, only a single banana can be used as an overstory.

STEP 9
Begin by digging planting holes for the overstory plants. Make sure the soil is loose and amended with compost or dry manure within the first 40-60 cm of the planting hole. Add water to the bottom of the hole and plant the banana suckers or papaya seedlings.

STEP 10
Plant sweet potato cuttings, taro, watermelon, or other water-tolerant plants on the inner face of the berm.

Additional Tips

If a large amount of wastewater is expected, such as at an ablution block, marketplace or communal hand-washing area, a system can be built that drains water directly into a mulch basin or other growing area. It is important to ensure the basin can hold the expected water. One cubic meter of excavated space can hold 1,000 liters of water. Calculate how much wastewater will be generated daily to make sure the basin is big enough.

STEP 11
Plant more drought-tolerant vegetables on the outer face of the berm. Plants help stabilize the soil of the berm and use all the wastewater provided. The berm can be intensively planted on its inner face and outer face so that two layers of plants are created – the overstory and the shrub layer underneath.

STEP 12
Mulch the berm to protect the soil and minimize evaporation.

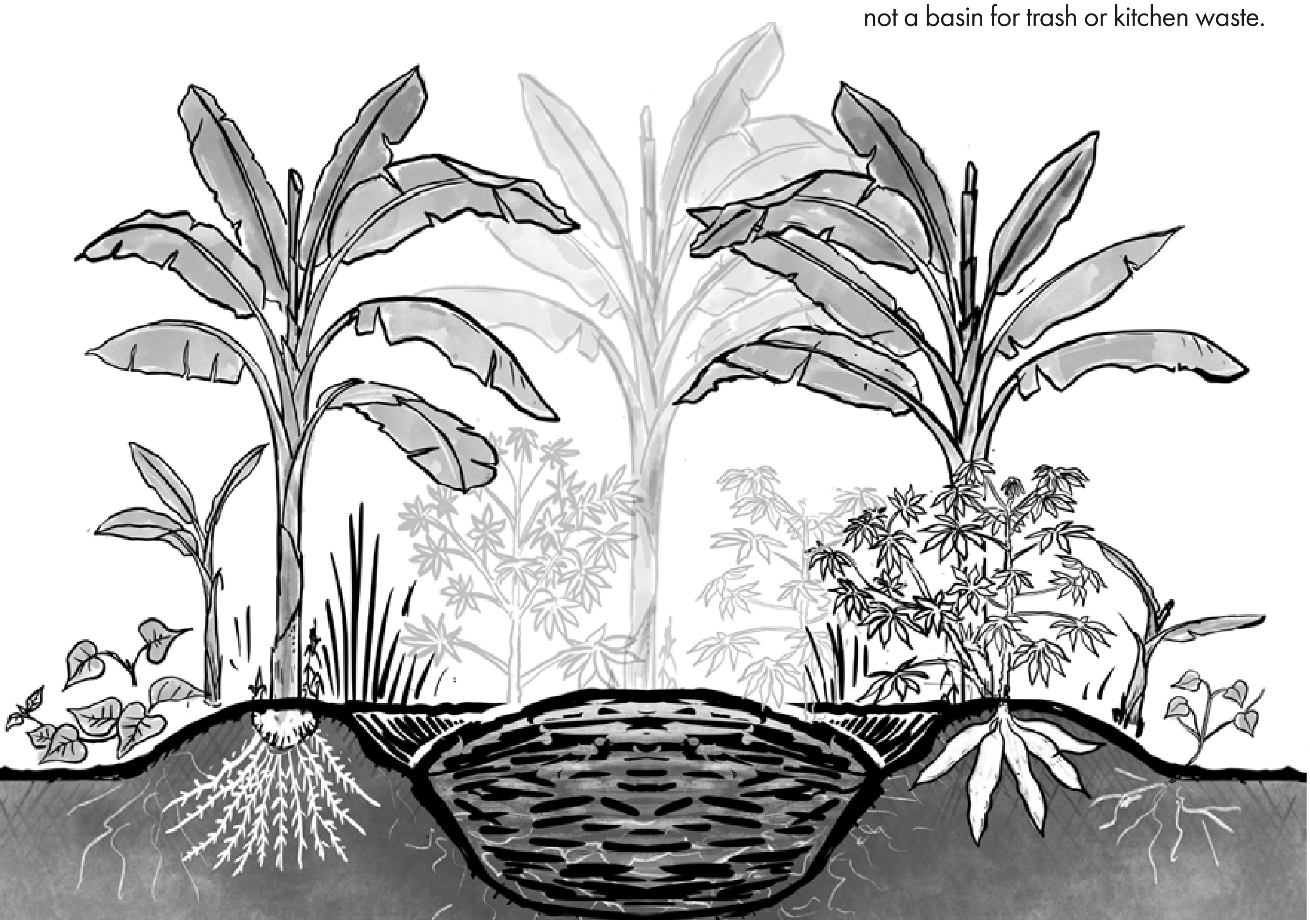
STEP 13
Add enough water to the basin to saturate the mulch and soil at the bottom of the basin.

STEP 14
Ensure the mulch basin is protected from animal and human activity.

STEP 15
Each day, pour the wastewater directly into the mulch at the center of the basin. The plants will most likely need supplemental irrigation until they are firmly established and their roots can reach the wastewater in the basin.

STEP 16
Add more dry mulch material as needed to keep the mulch even with the berm.

STEP 17
Make sure the household members know that this is a basin specifically for wastewater and not a basin for trash or kitchen waste.



HOW TO

Do a Rainfall Calculation

STEP 1
Determine the size of an average farm in the region in square meters.

STEP 2
Find the annual rainfall for the region in millimeters through an online search or conversation with a local extension agent.

STEP 3
Multiply the farm size (sq mt) by the annual rainfall (mm) to get the total liters of water that falls on an average farm every year.

STEP 4
Convert this amount of rain to jerrycans by dividing by 20. This number can be further divided by 365 to find the number of jerrycans per day that are provided through rainfall alone.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Example Rainfall Calculation

Farm size (sq mt) x Annual rainfall (mm) = Total Liters of water that falls on farm every year

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Total Liters of water that falls on farm every year ÷ 20L ÷ 365 days = **# of jerrycans per day** provided by rainfall rather than the farmer

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For example, a quarter-hectare farm (2,500 sq mt) in eastern Congo will recieve on average **1,200 mm** of rain every year:

2,500 sq mt x 1,200 mm = 3,000,000 liters of water that falls on farm every year

3,000,000 L ÷ 20L ÷ 365 days = **410 of jerrycans per day** provided by rainfall alone

HOW TO

Prepare and Amend a Double-Dug Bed

1. GATHER SOIL AMENDMENTS

STEP 1
Gather some sacks to collect organic materials to amend the soil. Materials can include different types of manures, living and dead leaves, grasses (no seeds), crop residue, bones, shells, food scraps, charcoal dust, compost, wood chips, ash, and so on.

STEP 2
Gather all the materials collected next to the beds and cut or chop the bigger materials into smaller pieces.

STEP 3
Make distinct piles for the different types of materials near the garden bed site.

2. DETERMINE THE SIZE OF THE BEDS

The size of the beds should be determined by:

- The available space in the compound
- The amount of water available
- Level of energy the farmer is willing to commit

Permagarden beds can be as small as 1 m x 2 m and as large as 1 m x 10 m. It is however better to start smaller and add more space later once a household has the understanding and skills needed to manage a garden effectively.

3. MARK OUT THE GARDEN BEDS

STEP 1
Use the design map to identify where the beds should be located. Beds should be below a water harvesting swale and oriented in the same direction as the swale.

STEP 2
Mark out the number of beds indicated in the design. Each bed should be no more than 1 m wide, but the length and the number of beds will depend on each site. Scratch deeply in the ground to mark out the beds or use string and pegs.

STEP 3
Check that the garden beds are oriented along the contour and follow the shape of the swale that is upslope.

STEP 4
After marking out the beds, check that there is adequate space between the beds for walking pathways and room to work in the garden area.

Photo Credit: Thomas Cole, contracted by CARE, Zimbabwe

4. DOUBLE DIG AND AMEND THE BEDS

STEP 1
Begin by marking the edge of the garden beds to double-dig with sticks and string or by marking the edges of the bed in the dirt with a hoe or shovel. Make sure that all the beds, pathways, swales and berms are measured and marked before beginning to dig. Ideally, the bed preparation would be done with multiple people to spread out the workload.

STEP 2
Once a bed is marked, measure 40 cm segments along the bed lengthwise. Put small stakes at the 40 cm marks or simply mark the dirt with a hoe or shovel.

STEP 3
Remove 20-30 cm of topsoil from the first 40 cm section, digging down until the subsoil is reached. The removed topsoil should be kept at the end of the bed.

STEP 4
Dig the next 20-30 cm of subsoil from the same section, loosening and digging but not removing the soil. Keep loosening the whole section until most of the larger pieces of soil have been broken up. In dry regions, the subsoil layer can be moistened with water to ease the digging process.

STEP 5
Add a diversity of soil amendments to the loosened subsoil. One shovel or several handfuls of each amendment is enough.

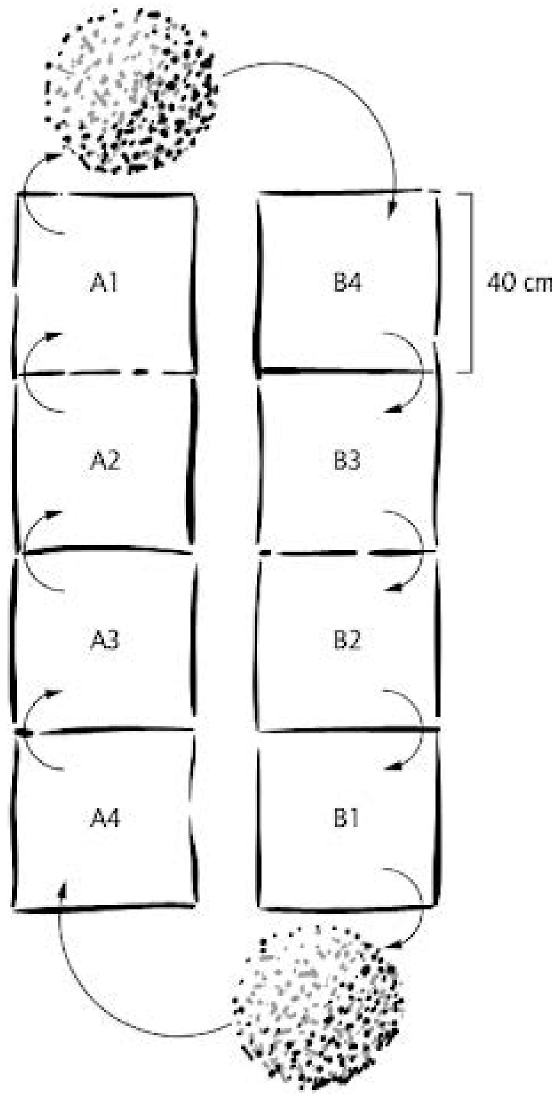
STEP 6
Using a hoe or shovel, mix these amendments into the subsoil.

STEP 7
Dig 20-30 cm of topsoil in the next 40 cm section. As it is dug up and loosened, place this topsoil on top of the subsoil section that was just amended. Make sure that all the topsoil is removed in the new section being dug.

STEP 8
Loosen the subsoil as in Step 4.

STEP 9
Amend the soil, following Steps 5-6.

STEP 10
Repeat Steps 3-6 until the bed is complete. The saved topsoil from the start of the bed should be used to build up the bed in the last 40 cm section.



5. APPLY TOP DRESSING TO THE BEDS

STEP 1

Once the double digging process has been completed, add more organic material to the top of the finished bed. Add one shovel or several handfuls every 40 cm and work it into the top 20 cm of the bed by hand.

STEP 2

Pull out any rocks or large clumps and smooth out the top with a rake or hoe or by hand to create a flat planting space. The garden is now ready for planting or seeding.

STEP 3

Each season, check the compaction within the bed by pushing a stick into the bed; if the stick can be pushed 40-60 cm into the bed, then it does not need to be redug. If the garden bed is becoming compacted over time, consider planting a deep-rooted crop, like maize, pumpkins, or watermelons, in the bed. The roots will help loosen the soil without the need for redigging the bed. If the soil is still compacted after planting deep-rooted crops, re-dig the beds by following the steps above in the section titled Double dig and amend the beds.


Photo Credit: Thomas Cole, contracted by Mercy Corps, Uganda


Photo Credit: Mercy Corps

HOW TO

Make a Hot Compost Pile

STEP 1
Select a place in the shade. Too much sun dries out the compost pile and slows down the decomposition process.

STEP 2
Gather brown and green organic materials. A properly made compost pile contains one-third green materials and two-thirds brown materials arranged in layers. Large pieces should be chopped into smaller pieces to speed the decomposition process and release moisture and minerals.

STEP 3
Put down an initial 5-15 cm layer of coarse sticks. This helps aerate the pile from below, enabling air movement through the pile during the initial stage of decomposition.

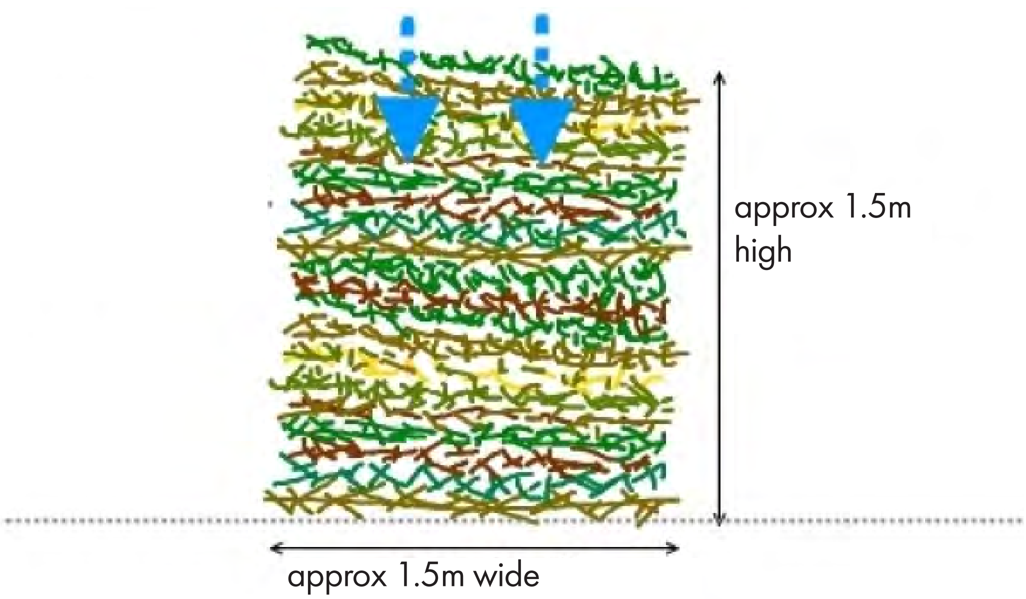
STEP 4
Put down a 20 cm layer of brown material to form the first layer of brown.

STEP 5
Add a 10 cm layer of green on top of the brown.

STEP 6
Add a 2 cm of topsoil, manure, or finished compost (approximately 6 large handfuls) on top of the brown.

STEP 7
Sprinkle the pile with water to moisten well.

STEP 8
Repeat Steps 4 through 6 until the pile is 1.5 m wide by 1.5 m deep by 1.5 m high.



STEP 9
Cap the pile with soil and then protect from moisture loss or excessive rain with materials like grasses, banana leaves, or a plastic sheet. Do not add more material to the pile after this.

STEP 10
Poke a stick that is 2-3 cm in diameter and at least a meter long into the pile in multiple locations to create pathways for air to enter and exit the pile. When finished aerating, leave the stick inserted in the center of the pile to use as a temperature gauge.

STEP 11
After two days, pull the stick out and check to see if the pile is hot in its center. If the stick is hot to touch, this means that the bacteria are working to break down the materials. DO NOT MIX. A well-made compost pile heats to 49-60° Celsius (120-140° Fahrenheit) after just two days.

STEP 12
Wait one week and then uncover the pile. Turn it into a new pile by mixing the layers and adding more water to keep moist if needed. To test the moisture level, squeeze a handful of the compost; ideally only one drop of water will drop out. Then cover the pile well.

STEP 13
Wait another week and then mix and apply water again if material appears dry. Cover well.

STEP 14
Allow the pile to rest for at least two weeks before mixing again. Cover well.

STEP 15
Continue to mix every second week, watering and covering until the inside of the pile is brown, crumbly, and cool to the touch. At this point, the compost is ready to be mixed into the garden soil.


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

HOW TO

Construct a Household Sweepings Pit


Photo Credit: Thomas Cole, contracted by Danish Refugee Council, Somalia

STEP 1
Locate the household sweepings pit near an area that gets swept often, such as the kitchen, the house, and the goat and chicken pens.

STEP 2
Each pit should be approximately 60-75 cm wide and between 75-100 cm deep.

STEP 3
Sweep organic materials directly into pits. Kitchen waste can also be added. Designate a separate pit to hold the inorganic waste (plastics, batteries, glass, non-biodegradable materials, etc.). Be sure inorganic waste does not get put into the household sweepings pit.

STEP 4
Moisture is crucial to the decomposition process. Rainwater can be directed into the pits and/or wastewater applied in dry times.

STEP 5
Once a pit is filled, the material should be left to decompose for several months. A new pit can be constructed for use while the old pit is left to decompose.

STEP 6
The more usable compost is usually found at the bottom of the pit and can be harvested when needed. Once the compost is removed, daily sweepings can again be added to the pit.

HOW TO

Plant a Biointensive Garden

STEP 1
Choose the growing bed to be planted. Prepare it with double digging and amend it with organic materials.

STEP 2
Select seedlings for planting or seeds to direct sow.

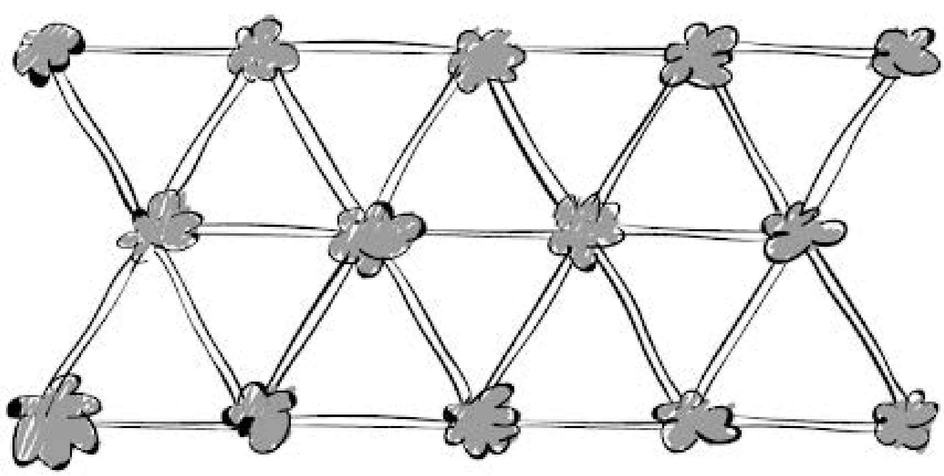
STEP 3
Locate a straight stick that is the length of the desired distance between the crop variety being planted.

STEP 4
Start in one of the corners of the bed and use the stick to mark planting locations along that end of the bed. Dig those holes by hand.

STEP 5
Use the stick to form a triangle between two of the holes and a point further into the bed. Dig a new hole at that point. All three sides of the triangle should be the same length.

SEED SPACING FOR DIRECT-SEEDED CROPS

CROP	SPACING IN GARDEN BED (cm)
Amaranth (seed/greens)	Broadcast lightly, thin to (30 cm/15 cm)
Beans (dry/green) and cowpeas	15 cm
Carrots	Broadcast lightly, thin to 5 cm
Chickpeas (Garbanzo Beans)	10–15 cm
Garlic (cloves)	10 cm
Groundnuts	22 cm
Irish potatoes (sprouted tubers)	25 cm
Maize	30 cm
Millet	15 cm
Onions (use roots from past crop)	15 cm
Pumpkins	100 cm (allow to spread)
Radishes	5 cm
Sweet Potatoes (stem cuttings)	25 cm
Wheat	12 cm
Zucchini	45 cm (can plant two per hill)



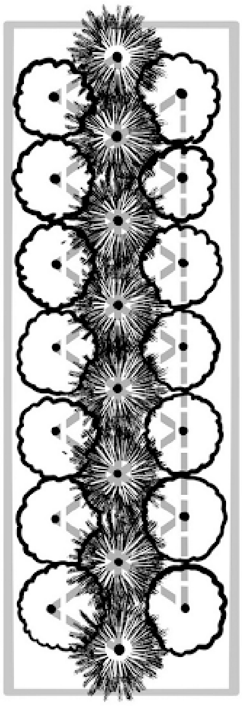
STEP 6
Continue until all holes have been marked and dug. After the entire bed is completed, the pattern should appear as many small triangles.

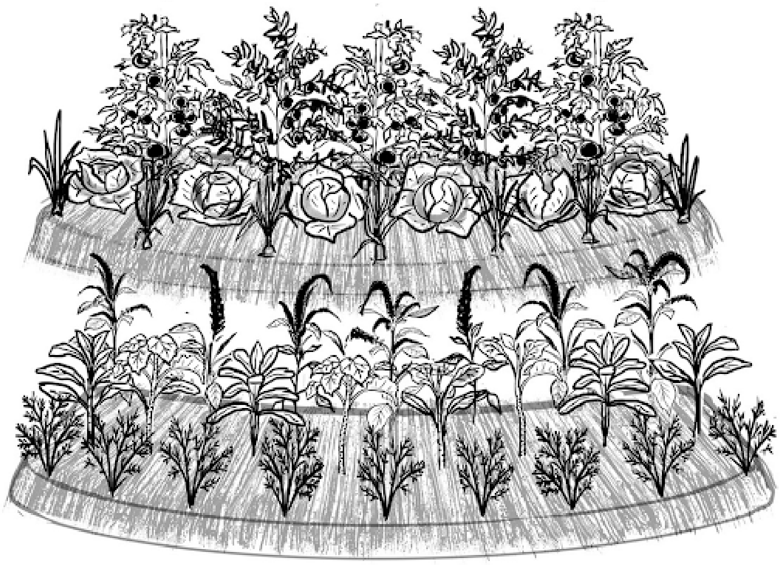
STEP 7
Place one seed or seedling in each hole. Brush soil around the seedling so that the seedling is covered up to the point where it was submerged in the nursery bed. Lightly press the soil around the seedling to get good contact between the soil and the roots. Water the seedlings or seeds. Keep the soil moist over the next several days.

STEP 8
Mulch the bed. Ensure that the bare soil is covered but that the mulch does not touch the base of any seedling.

SEED SPACING (IN TRAYS) FOR TRANSPLANTED SEEDLING

CROP	SPACING IN SEED TRAY (cm)	SPACING IN GARDEN BED (cm)
Broccoli	5 cm	45 cm
Cabbage	5 cm	45 cm
Cucumber	5 cm	30 cm (train to grow up trellis)
Eggplant	5 cm	45 cm
Kale	5 cm	20 cm
Head Lettuce	Broadcast then thin to 6 cm	25 cm
Onion	5 cm (or less)	15 cm
Pepper	5 cm	45 cm
Spinach	Broadcast then thin to 6 cm	12 cm
Swiss Chard	5 cm	20 cm
Tomato	5 cm	45 cm (stake up with poles)





HOW TO
Make and Apply Botanical and Manure Teas


Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

1. TITHONIA FERTILIZER TEA

Tithonia (*Tithonia diversifolia*) is a shrub often found in abundance throughout sub-Saharan Africa. Since the plant accumulates large amounts of nitrogen and phosphorus from the soil, its green biomass is one of the best natural sources of fertilizer for a permagarden. The best time to use tithonia is when the leaves are dark green and the plant is just about to flower.

STEP 1
Chop 5 kg (about one large basin) of dark green tithonia leaves.

STEP 2
Soak chopped leaves in 10 L of water for two weeks, stirring every 3-5 days. After two weeks, most of the nutrients will have dissolved into the water and the mixture should be dark green.

STEP 3
Dilute with 2 or 3 parts water to 1 part tithonia tea.

STEP 4
Apply a minimum of 100 ml of diluted fertilizer to the leaves or use to water vegetables, young trees, and grain crops as a root drench.


Photo Credit: Elin Duby

2. MORINGA FERTILIZER TEA

Moringa (*Moringa spp.*) are multipurpose trees that have been planted widely throughout the world. Apart from its widespread use as a food source, moringa leaf liquid fertilizers contain many plant nutrients and a growth-stimulating compound that increases crop yields.

STEP 1
Grind young moringa shoots (not more than 40 days old) and mix with water, following the ratio of 1 kg of fresh shoots per liter of water. Make enough for only one application, as the compounds in the tea break down within five hours of extraction.

STEP 2
Strain the solids out of the solution. This can be done by placing the solution in a cloth and wringing out the liquid. The solid matter, which will contain 12-14% protein, can be used as livestock feed.

STEP 3
Dilute the extracted tea with water, adding 30 cups of water for every 1 cup of tea.

STEP 4
Spray or splash directly onto plants immediately after extraction. Apply approximately 2 tablespoons of diluted tea per plant. The spray can be applied to any plant leaves 10 days after the first shoots emerge from the soil and again prior to any flowering period.

3. MANURE FERTILIZER TEA

Manures from cows, goats, sheep, chickens, ducks, rabbits, horses, donkeys, and camels are used extensively around the world as a fertilizer. Manure teas are a way to apply the nutrients from manure to plants mid-season when it is not possible to add additional soil amendments. Manure teas can be added to the soil or sprayed onto crop leaves.

STEP 1
Gather manure and place in a breathable burlap sack.

STEP 2
Place the closed burlap sack holding the manure in a bucket, modified jerry can, or barrel. Use a rock or heavy object to hold the sack in place.

STEP 3
For every 1 kg of manure in the sack, add 8 L of water to the container so that the sack is submerged.

STEP 4
Soak for 3 weeks, making sure that the sack is aerated and stirred every 4 or 5 days.

STEP 5
At the end of 3 weeks, pull out the sack. The manure that remains can be added to a compost pile or used to fertilize fruit trees.

STEP 6
Dilute the manure tea until what is left is light brown. This is now ready to be applied to plants as a root drench. Apply a minimum of 100 ml per plant.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Photo Credit: Thomas Cole, contracted by World Dance, Rwanda

HOW TO

Make and Apply Organic Pesticides

Photo Credit: Thomas Cole, contracted by HIAS, Chad

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

1. GARLIC AND CHILI PEPPERS RECIPE #1

STEP 1
Gather the following ingredients:

- 1 bulb of garlic
- 1 small onion
- 3 hot chili peppers
- 50 g soap

STEP 2
Crush 1 garlic bulb together with 1 small onion.

STEP 3
Add 3 crushed chili peppers and mix with 1 L of water.

STEP 4
Let soak for 1 hour and then filter out the solids.

STEP 5
Dissolve 50 g of soap in a small amount of warm water and then add to the filtered garlic and pepper solution. Mix thoroughly.

STEP 6
Spray the entire plant with the solution, including the undersides of the leaves.

2. GARLIC AND CHILI PEPPERS RECIPE #2

STEP 1
Gather the following ingredients:

- 2 hot chili peppers
- 2 large onions
- 1 bulb of garlic
- 1 liter of glycerin soap

STEP 2
Mix all ingredients together in a bucket or other container.

STEP 3
Cover with warm water and allow the mixture to steep for 24-36 hours.

STEP 4
Strain the mixture to filter out the solids.

STEP 5
Dilute 1 part mixture to 1 part water.

STEP 6
Spray or splash on infected areas. The solution will wash off in the rain or after watering.

Photo Credit: Rudy Kumvuidi Nkombo, Mercy Corps, DRC

3. OIL RECIPE #1

STEP 1
Gather the following ingredients:

- 1 cup cooking oil, such as canola or vegetable oil
- 1 tablespoon liquid dishwashing soap

STEP 2
Mix all ingredients together in a bucket or other container.

STEP 3
Dilute 1 tablespoon of this mixture in 1 cup of water.

STEP 4
Sprinkle on affected leaves with a grass brush or bundled twigs. Can be used weekly.

4. OIL RECIPE #2

STEP 1
Gather the following ingredients:

- 25 ml of baking soda or bicarbonate of soda
- 15 ml cooking oil, such as canola or vegetable oil
- 15 ml vinegar
- 25 ml liquid soap or 15 ml glycerin soap
- 1.5 liters warm water

STEP 2
Thoroughly mix all ingredients together with warm water.

STEP 3
Sprinkle on affected leaves with a grass brush or bundled twigs. Can be used weekly.

5. TEPHROSIA, NEEM, AND MELIA LEAVES: INSTRUCTIONS FOR CROP PROTECTION

STEP 1
Crush 2 kg green leaves of tephrosia, neem, or melia.

STEP 2
Mix crushed leaves in 5 L of water. Soak for 24 hours.

STEP 3
Filter the solution.

STEP 4
Spray on plants affected by aphids and other sucking/chewing insects.

6. TEPHROSIA, NEEM, AND MELIA LEAVES: INSTRUCTIONS FOR POST-HARVEST PROTECTION OF STORED GRAIN

STEP 1
Dry tephrosia, neem, or melia leaves in the shade.

STEP 2
Once leaves are dry, grind them into a powder.

STEP 3
Mix powder with stored grain, using a mixture ratio of 2 kg of powder for every 20 kg of grain.

7. NEEM OR MELIA OIL

STEP 1
Collect, de-pulp, and rinse clean the ripe seeds of neem or melia.

STEP 2
Dry the seeds in the shade for 3-7 days. Any bad seeds should be thrown out.

STEP 3
Crush seeds in a mortar or other vessel. Mortars used for edible crops should not be used.

STEP 4
Mix crushed seed with water, using a mixture ratio of 50 g of seed per 1 L of water. Let the mixture sit overnight.

STEP 5
Filter the liquid through a cloth and put it in a container for use. Liquid can be used directly. If a concentration greater than 50 g seed to 1 L water is used, the mixture should be diluted before application. Using a sprayer or brush. Experiment with different levels of concentrations in field trials.

STEP 6
Use no more than once a week; every 10-15 days is the optimal interval.


Photo Credit: Rudy Kumvuidi Nkombo, Mercy Corps, DRC

HOW TO

Construct a Living Fence

STEP 1
Mark where the fence will be constructed with a stick. Be sure to leave enough room inside the fence to navigate around the garden beds, kneel down for harvesting and weeding, and carry tools in and out of the garden.

STEP 2
Determine where the access gate will be along the fence line and mark it clearly.

STEP 3
Along the fence line, plant mature seedlings or cuttings of trees 1 m apart.

STEP 4
In the space between the trees, plant shrubs such as lantana or a spiky sisal plant.

STEP 5
In a line outside of the trees and shrubs, plant perennial grasses such as Vetiver grass.

STEP 6
Use thorny branches or strips of bamboo to help close off the garden until the trees and shrubs mature.

STEP 7
Allow the trees to grow to a height of 2 m before pruning to establish a strong root system. Then cut the trunk at 2 m height, using the branches and leaves as kindling or biochar and the leaves as green manure, composting material, or fodder for animals.

STEP 8
As the tree continues to grow from the cut top, new stems and branches will emerge and can be harvested.

STEP 9
Prune and train the side branches over time to make the fence more dense and secure. Meanwhile, prune and shape the grasses and shrubs as they mature to fill in the gaps.

Plant the Fence with a diversity of shrubs, trees and vines to make the fence productive and long lasting.

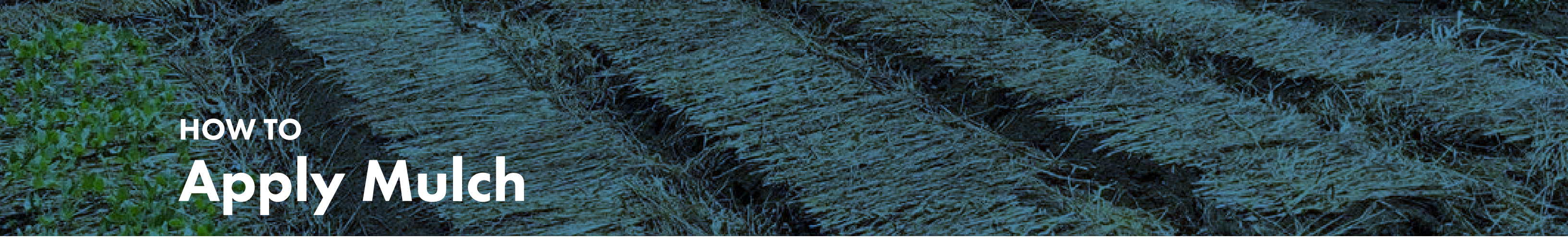
Erythrina, Gliricidia, Jatropha curcas, Moringa oleifera, or Moringa stenopetala can be used as corner posts.

Plants with stickers or spines can be used for protection.

Passion fruit, cassava, pigeon pea and fruit trees can be planted for shade and production.

Tithonia diversifolia can be planted as a bush around the fence.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda



HOW TO

Apply Mulch

STEP 1

Gather dry or green mulch material. If green mulch is used, it should not be placed too close to the stems or leaves of growing plants as it can cause them to rot or create fungal problems. Place green mulch 0.5 meters away from tender stems and leaves.

STEP 2

Place a 3–5 cm deep layer of mulch material over all exposed soils in the growing beds, pathways, tree basins, and swales. All bare ground should receive some form of mulch. When possible, mulch should be thicker (5–10 cm) to help suppress weeds and retain moisture.

STEP 3

Any mulch material not placed around the plants can be left on the soil surface to protect the soil and minimize evaporation.

Photo Credit: Thomas Cole, contracted by African Women Rising, Uganda

Photo Credit: Warren Brush, contracted by African Women Rising, Uganda